Towards Sustainability in the Chinese Construction Industry: A Transition Approach

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List of Abbreviations

ANOVA	one-way analysis of variance
ANT	actor network theory
AoD	arena of development
AQSIQ	General Administration of Quality Supervision, Inspection and Quarantine (China)
ASCE	American Society of Civil Engineers
BAT	best available techniques
BM	business model
BREEAM	Building Research Establishment Environmental Assessment Methodology
BREF	BAT (best available techniques) Reference Document
CASS-CSR	Chinese Academy of Social Sciences-Corporate Social Responsibility Guidelines
CCCC	China Communications Construction Company Ltd
CCIA	China Construction Industry Association
CED	Committee for Economic Development
CHINCA	Chinese International Contractors Association
CIB	International Council for Research and Innovation in Building and Construction
CNY	Chinese yuan (currency)
CO_2	carbon dioxide
CRM	customer relationship management
CS	corporate sustainability
CSA	critical sustainability aspect
CSCEC	China State Construction Engineering Corp. Ltd
CSP	corporate social performance
CSR	corporate social responsibility
DRIFT	Dutch Research Institute for Transitions
EID	Economic Information Daily
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
FFF	foreign-funded firm

GCP	Global Construction Perspective
GDP	gross domestic product
GHG	greenhouse gases
GOV	gross output value
GRI	Global Reporting Initiative
GVA	gross value added
GVAI	Gross Value Added Index
HE	huge enterprise
high-tech	high-technology
HMTFF	Hong Kong, Macao and Taiwan-funded firms
ICCREM	International Conference on Construction and Real Estate Management
IISD	International Institution of Sustainable Development
IPA	importance–performance analysis
ISO	International Organization for Standardization
IT	information technology
IUCN	International Union for Conservation of Nature and Natural Resources
LE	large enterprise
LEED	Leadership in Energy & Environmental Design
m^2	square metre
ME	medium enterprise
MHUD	Ministry of Housing and Urban-Rural Development (China)
MIP-SR	major infrastructure projects' social responsibility
MLP	multi-level perspective (on transitions)
MOF	Ministry of Finance (China)
MOST	Ministry of Science and Technology (China)
MPC	multi-phase concept (of transition)
NBS	National Bureau of Statistics (China)
NDRC	National Development and Reform Commission (China)
NGO	non-governmental organization
NO_X	nitrous oxide
NPC	National People’s Congress of China
OE	Oxford Economics
OECD	Organisation for Economic Co-operation and Development

OHS	occupational health and safety
OTDF	other types of domestic firms
R&D	research and development
RIV	relative importance value
RPV	relative performance value
SAL	sustainability attitude level
SASAC	State-owned Assets Supervision and Administration Commission
SBM	sustainable business model
SCC	State Council of China
SE	small enterprise
SEM	structural equation modelling
SNM	strategic niche management
SOE	state-owned enterprise
SO_X	sulphur oxide
SPL	sustainability performance level
SWOT	strengths, weaknesses, opportunities, threats
TBL	triple bottom line
TEF	triple embeddedness framework
TM	transition management
TPS	transition pathway/s towards sustainability
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
URC	urban and rural collective
US/USA	United States of America
WBCSD	World Business Council for Sustainable Development
WCED	World Conservation on Environment and Development
WTO	World Trade Organization

Abstract

Despite the massive scale of the Chinese construction industry, there is a lack of adequate awareness of sustainable development within this industry. This study aims to analyse the current status of, and the motivations for and barriers to, the sustainability transitions of Chinese construction enterprises.

Firstly, as the policy environment could significantly influence sustainability transitions, this study holistically examined China's policy landscape for facilitating the transition to sustainable construction. Regulation and control, economic incentives and supporting activities have been identified as the main policy instruments for facilitating sustainable construction in China. Two critical challenges of the policy system are revealed, namely, a lack of consideration of the economic and social dimensions of sustainable construction, and the ineffectiveness of some policies.

This study then examined the transition processes towards sustainability in three leading Chinese construction firms from 2009 to 2013. In total, 29 critical sustainability aspects and 92 sub-aspects of sustainability practices implemented by the case firms were identified. By comparing the implemented sustainability practices with the requirements of three sustainability guidelines, this study revealed that the three firms presented different strategic sustainability behaviours, and that practices towards environmental sustainability are weak compared with practices towards economic and social sustainability.

Subsequently, to investigate how various construction firms in China, other than only the leading firms, perceive and perform in relation to sustainability, a questionnaire was developed based on the 29 sustainability aspects identified from the case study. The questionnaire survey results revealed that quality management and customer service are perceived by the firms as not only the most important but are also the best-performed aspects while supporting community development is the least important and worst-performed aspect. Sustainability attitude is positively correlated with performance, and larger firms tend to have better sustainability performance than smaller firms. However,

larger firms do not necessarily believe sustainability is more important than is the case among smaller firms. Based on k-means cluster analysis and importance–performance analysis, this study then classified the investigated firms into three groups according to their sustainability performance, namely, low-performing, medium-performing and high-performing firms, and identified the transition pathways from low-performing to high-performing firms.

Last but not least, after discovering the transition pathways, this study investigated the various factors driving and prohibiting these transitions, based on an integrated conceptual framework built on the multi-level perspective and triple embeddedness framework of sustainability transitions. The results show that for low-performing firms, the key stimulus for sustainability comes from external socio-political pressures, while economic and industry issues, for example, inadequate incentives present the biggest hindrance. Even though medium-performing firms also regard external socio-political pressures as key drivers, they start to recognize the benefits brought by sustainability, for example, improved corporate image as key drivers. Although high-performing firms clearly acknowledge the economic benefits of sustainability, they still experience complex barriers to sustainability, for example, the inconsistency of policies and the culture of conservatism. Thus, this study shows that China has a long way to go to facilitate sustainable practices in the construction industry.

Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and, where applicable, any partner institution responsible for the joint award of this degree.

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Publications that Emanated from This Research

[1] Rui-Dong Chang, Jian Zuo, Veronica Soebarto, Zhen-Yu Zhao, George Zillante, Xiao-Long Gan (2016). Sustainability Transition of the Chinese Construction Industry: Practices and Behaviors of the Leading Construction Firms. ***Journal of Management in Engineering***. DOI: 10.1061/(ASCE)ME.1943-5479.0000439.

[2] Rui-Dong Chang, Veronica Soebarto, George Zillante, Zhen-Yu Zhao (2016). Facilitating the Transition to Sustainable Construction: China's Policies. ***Journal of Cleaner Production***. DOI: 10.1016/j.jclepro.2016.04.147.

[3] Rui-Dong Chang, Jian Zuo, Veronica Soebarto, Zhen-Yu Zhao, George Zillante, Xiao-Long Gan (2016). Discovering the transition pathways towards sustainability in construction enterprise: An importance–performance analysis. ***Journal of Construction Engineering and Management*** (*accepted on 08/11/2016*).

[4] Rui-Dong Chang, Jian Zuo, Veronica Soebarto, Zhen-Yu Zhao, George Zillante, Xiao-Long Gan (2016). Approaches for Transitions towards Sustainable Development: Status Quo and Challenges. ***Sustainable Development*** (*accepted on 05/09/2016*).

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[6] Rui-Dong Chang, George Zillante, Zhen-Yu Zhao, Jian Zuo (2015). Research on Sustainability and Construction Firms: Current Status and Future Agenda. 2015 International Conference on Construction and Real Estate Management, Luleå, Sweden, 2015. 8.11-8.12.

[7] Rui-Dong Chang, George Zillante, Veronica Soebarto, Zhen-Yu Zhao (2015). Transition to a Sustainability-Oriented Construction Industry in China: A Critical Analysis from the Multi-Level Perspective. 2015 International Conference on Construction and Real Estate Management, Luleå , Sweden, 2015. 8.11-8.12.

[8] Rui-Dong Chang, George Zillante, Zhen-Yu Zhao, Jian Zuo (2015). Niche-innovations to Promote Sustainable Construction in China: A Critical Assessment. 2015 International Conference on Energy and Environment Engineering, Nanjing, China, 2015. 4.11-4.12.

Chapter 1 Introduction

1.1 Introductory background

The construction industry has significant implications for our planet economically, socially and environmentally. Economically, in most countries of the world, the built environment normally contributes, to more than half of total national capital investment (CIB, 2002). Socially, this sector is one of the largest industrial employers in most countries, accounting for around 7% of total employment worldwide (Horta et al., 2013). With regard to the environment, the construction industry is a significant contributor to various environmental problems, such as loss of soil and agricultural land, as well as contributing to air pollution. It is also a major user of the world's non-renewable energy sources and minerals (Spence and Mulligan, 1995). For instance, buildings and infrastructure account for approximately 30% of raw materials and 25% of water used annually in the United States of America (USA) (Kucukvar and Tatari, 2013). Similarly, the construction industry is accountable for 50% of carbon emissions, 50% of water consumption, 35% of landfill waste and 13% of all raw materials utilized in the United Kingdom (UK) (Akadiri and Fadiya, 2013).

Since the implementation of the opening-up policy in 1979, China's economy has rapidly developed with its average annual growth rate of gross domestic product (GDP) consistently being around 10% in the past three decades (NBS, 2013b). This tremendous economic expansion is highly dependent on the growing construction industry. China overtook the USA to become the world's largest construction market in 2010, and is expected to increase its global share from 18–26% in 2025 (GCP and OE, 2013). After the manufacturing industry, the construction industry is the second largest industrial employer in China, providing more than 40 million jobs (NBS, 2014). The steel consumption of the Chinese construction industry comprises more than 20% of the world's total consumption, and the construction waste accounts for 45% of the total waste in China (MOST, 2012). Energy use in the building industry accounts for 27.5% of the national total in China. If energy consumption caused by the manufacture of construction material is included, energy consumption related to the construction industry constitutes more than 40% of total consumption in China (MOST, 2012).

China's urbanization rate has increased dramatically in the past three decades, from 19% in 1979 to 53.73% in 2013 (Chen et al., 2013). Although compared to an average of 78% in high-income countries, China's current urbanization rate is still low (NBS, 2013a). In March 2014, the Chinese central government released *China's New-style Urbanization Plan (2014-2020)*, revealing the ambitious goal that by 2020 the urbanization rate should reach 60% (NDRC, 2014). The construction industry needs to continue to play its important role in developing infrastructure and residential buildings for the future urbanization process in China.

1.2 Statement of the problem

The concept of "sustainable construction" emerged following the commitment to move towards "sustainable development", historically marked by the release of the Brundtland Report (WCED, 1987). Similar to "sustainable development", "sustainable construction" covers three main domains: environmental protection, social well-being and economic prosperity (Tan et al., 2011). More specifically, it focuses on the application of sustainable development principles to the comprehensive construction cycle, from the extraction of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and the management of the resultant waste (Tan et al., 2011). To stress the importance of sustainability for the construction industry, the Chinese government has developed and implemented a number of laws, regulations and policies, such as the *Environmental Impact Assessment Law* (NPC, 2002); *Regulation on Energy Conservation in Civil Buildings* (SCC, 2008a); and *Action Plan for Promoting Green Buildings* (NDRC and MHUD, 2013).

Despite the booming construction industry and the various supporting policies, there is a lack of adequate awareness of sustainable development within Chinese construction enterprises. Previous studies have highlighted various sustainability challenges to the Chinese construction industry. For instance, economically, the lack of well-trained human resources is one of the most serious weaknesses leading to the poor business performance of many construction enterprises in China (Zhao et al., 2009). Socially, Shen et al. (2010a) argued that some social factors, for example, cultural factors, are given limited or no consideration at all in the feasibility studies of many projects in China, while very few contractors undertake all the prescribed green practices in their studies. Environmentally, Qi et al. (2010) identified 11 green construction practices, for example, the implementation of water saving and noise control plans, and discovered that only very few of the surveyed Chinese contractors undertook all of the mentioned sustainability practices.

Some scholars have attempted to investigate the reasons why many Chinese construction enterprises are reluctant to embrace sustainability even though policies are in place that encourage them to do so. For instance, Zhang et al. (2011a) analysed the additional cost of three types of green buildings and found that the higher costs have hindered the extensive application of green technologies in China. Shi et al. (2013) concluded that the three most critical barriers prohibiting the popularization of sustainable construction in China are “additional cost”, “incremental time” and “limited availability of green suppliers and information”. Qi et al. (2010) argued that managerial concerns and government regulatory pressures are the two most important driving forces of green construction in China, while it appears that project stakeholder pressures do not have a significant effect on green construction practices.

1.3 Gaps of knowledge

Previous studies have offered valuable references for understanding the sustainability of the Chinese construction industry. However, several critical gaps in knowledge exist which need to be further explored.

First, the perceptions and performance of sustainability of Chinese construction enterprises are lacking systematic investigation in a holistic manner covering the economic, social and environmental dimensions of sustainability. Various studies tend to focus on only one dimension of sustainability. For instance, competitiveness studies (e.g. Lu et al., 2008) focus mainly on the economic dimension of sustainability, while another strand of studies investigates the various facets of environmental sustainability, for example, energy consumption efficiency (Xue et al., 2015), green construction (Qi et al., 2010), green buildings (Zhang et al., 2011a) and carbon reduction (Zhang and Zhou, 2015). Very few studies attempt to holistically identify the critical sustainability aspects covering the economic, social and environmental dimensions of sustainability, and investigate construction enterprises' perceptions and performance on these aspects. This holistic approach is of vital importance as the prerequisite of improving sustainability performance of construction enterprises is firstly to understand their current perceptions and performance on sustainability and then to identify their strengths and weaknesses.

Furthermore, even though China has implemented various policies and regulations to promote sustainable construction, few studies specifically aim to analyse these policies and thereby to systematically identify China's strategies and approaches to promote sustainable construction. The underlying logic and challenges of these strategies remain unknown. A deeper understanding of government policy is important as the government's strategy and policy could strongly influence the development direction of the construction industry.

More fundamentally, some studies (e.g. Zhang et al., 2011a; Shi et al., 2013) investigate the drivers for and barriers to the popularization of sustainability practices in the construction industry. However, few of these studies succeed in revealing the underlying mechanisms of transforming the construction industry towards sustainability. In these studies, although empirical information was collected, there is lack of effort to explain the underlying theories. As a consequence, numerous factors have been identified for driving, or impacting on, the uptake of sustainability practices in the construction industry, such as government policy, additional costs, awareness, stakeholder pressure and technology. Very few studies attempt to explain how these factors interact with each other. This offers little insight for answering several critical questions. How do these factors jointly impact on the uptake of sustainability practices? What are the key mechanisms driving or impeding the uptake of sustainability practices? How does the influential power of these factors change during the transition process of the industry towards sustainability?

In response to the above gaps of knowledge, this study adopts a unique approach, namely, the transition approach, to analyse the sustainability of Chinese construction enterprises. Originating in the Netherlands, the research field of socio-technical transitions digs into historical transitions, such as that from horse-drawn carriages to automobiles, to explore how these shifts take place, thereby providing insights into contemporary sustainability issues. This approach highlights multi-dimensional interactions between the industry, technology, markets, policy and culture, capturing the complexity of systemic changes towards sustainability (Geels, 2012). Sustainability transitions are defined by Markard et al. (2012) as "… long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable alternatives". The promotion of sustainability practices in the construction industry is indeed a transition process as it works to change the behaviours of enterprises to substitute or complement the existing unsustainable ways of construction with sustainability practices. It takes time for construction enterprises to transition towards sustainability: at different transition stages, enterprises may have different perceptions towards sustainability and face different motivations and hindrances. It is imperative to understand and describe the process so measures can be developed to facilitate the transition process towards sustainability.

As sustainability is a global challenge and is being promoted by many economies in their construction industries, a study of sustainability transition in the Chinese construction industry, the largest construction industry in the world, offers a valuable lesson for other countries, especially the emerging economies.

1.4 Research objectives

This study aims to explore the sustainability perceptions and performance of Chinese construction enterprises with a holistic approach and identify the key drivers for and barriers to the sustainability transition of these enterprises. To achieve this overarching aim, a series of detailed objectives are identified:

- Objective 1: To review the theories and existing studies on the sustainability of enterprises, sustainability of construction enterprises and sustainability of Chinese construction enterprises.
- Objective 2: To review the approaches to sustainability transition.
- Objective 3: To examine China's policy system for facilitating the transition towards sustainable construction.
- Objective 4: To investigate the evolution of the leading Chinese construction firms' sustainability behaviours and practices.
- Objective 5: To holistically examine the sustainability perceptions and performance across construction enterprises on different scales and with different sustainability levels.
- Objective 6: To analyse the drivers for and barriers to sustainability transitions of construction enterprises with different sustainability levels.

1.5 Research focus

The word "construction" can be interpreted in various ways. These interpretations include: 1) construction as a specific stage of the project cycle, that is, the site activities that lead to the realization of a building or other construction project (e.g. road, bridge or dam); 2) construction as the comprehensive cycle of a construction project, covering key stages such as feasibility, design, build, operation, decommissioning, demolition and disposal; 3) construction as a sector of the economy which, in turn, is linked to allied sectors and industries in materials production and distribution, as well as service sectors such as transport and finance; and 4) construction as the broad process/mechanism for the realization of human settlements including land identification, planning, design and implementation processes for human settlements (CIB, 2002). The term "Chinese construction enterprises" in this study denotes the set of firms that are directly involved in the comprehensive cycle of a construction project, in accordance with the second interpretation. Various design, survey and project consultancy firms operating in China are included in the scope of construction enterprises in this study. However, as suggested by international and Chinese industry classification standards, manufacturers of construction materials are excluded in the scope of this study.

1.6 Significance of research

This research is significant from three perspectives, namely, its theoretical implications, its empirical implications and its practical implications. Theoretically, this study integrates the various factors influencing the uptake of sustainability practices, that is, the technological, cultural and political factors, into one overarching framework, enhancing the conceptualization of the key mechanisms behind the transition towards sustainability in the construction industry. In addition, this research enriches the areas of application of sustainability transition by applying it in the context of the construction industry. Previously, the transition approach has been applied in areas such as land transport (Geels, 2005), shipping (Geels, 2002), the sewer system (Geels, 2006), and the energy industry (Moallemi et al., 2014). However, the application of the transition approach to the construction industry has been rarely explored in existing studies. Empirically, this study systematically investigates the policy system for sustainability transitions, the leading firms' sustainability practices, and sustainability perceptions and performance of construction firms of different scales and with different sustainability levels in China. This contributes to the empirical knowledge of sustainability issues in Chinese construction enterprises.

More importantly, this research offers important practical references for policy makers and industry actors. China is undergoing a rapid process of urbanization which requires the construction industry to continuously provide the infrastructure and buildings that are needed. The rapid development of the construction industry has brought significant challenges, for example, tremendous energy consumption, severe environmental problems and various social issues. China faces a significant challenge to transition the construction industry towards sustainability. By investigating the perceptions and performance of sustainability and the key drivers for and barriers to the sustainability transition of construction enterprises with different sustainability levels, this study provides practical implications for both policy makers and enterprises. For instance, this study identifies which sustainability aspects had the best or worst performance and which were deemed the most and least important by construction enterprises. This provides information to the government in its allocation of the limited resources (e.g. subsidies) so that support is provided to those aspects which had the worst performance yet which were judged as important. The key theoretical, empirical and practical implications of this study are discussed in detail in Chapter 9.

1.7 Thesis structure

The thesis structure is presented visually in Fig. 1.1. The literature review section comprises Chapters 2 and 3, responding to objectives 1 and 2, respectively. Chapter 4 discusses the methodology of this study. The actual research work is displayed from Chapter 5 to Chapter 8, responding to objectives 3 to 6, respectively, with Chapter 9 concluding the thesis.

The research work presented in Chapters 5 and 6 has already been published as journal articles. The research work presented in Chapter 7 has already been accepted for publication in a leading journal. To be specific, the research results of the policy system (Chapter 5) have been summarized in the paper "Facilitating the transition towards sustainable construction: China's policies", which has been published in the ***Journal of Cleaner Production*** (Chang et al., 2016a). Please see this publication in Appendix D. The research results of the leading firms' sustainability behaviours and practices (Chapter 6) have been summarized in the paper "Sustainability transition of the Chinese construction industry: Practices and behaviours of the leading construction firms", which has been published in the ***Journal of Management in Engineering*** (Chang et al., 2016b). This publication is presented in Appendix E. The research on transition pathways towards sustainability (Chapter 7) has been presented in the paper "Discovering the transition pathways towards sustainability for construction enterprises: An importance–performance analysis", which has been accepted for publication in the ***Journal of Construction Engineering and Management***. In addition, the relevant sections of the literature review have been presented and published as review articles. For instance, the review of sustainability research on construction enterprises in Chapter 2 has been published as a conference paper "Research on sustainability and construction firms: current status and future agenda" (Chang et al., 2015). The review of the various approaches to sustainability transitions has been accepted for publication as a journal article "Approaches for transitions towards sustainable development: Status quo and challenges" in ***Sustainable Development***. The acceptance letters for those journal articles currently in press are presented in Appendix F.

It is important to note that the design of the research procedure is informed by the relevant theory of sustainability transition. This introduction aims to provide an overview of this thesis, without further explaining the detailed logic of the research design. This is why the detailed contents of Chapters 5, 6, 7 and 8 are not displayed in Fig. 1.1. The design of the research plan is specifically discussed at the end of Chapter 3, and the design of the research procedures and methods following the research plan is specifically discussed in Chapter 4.

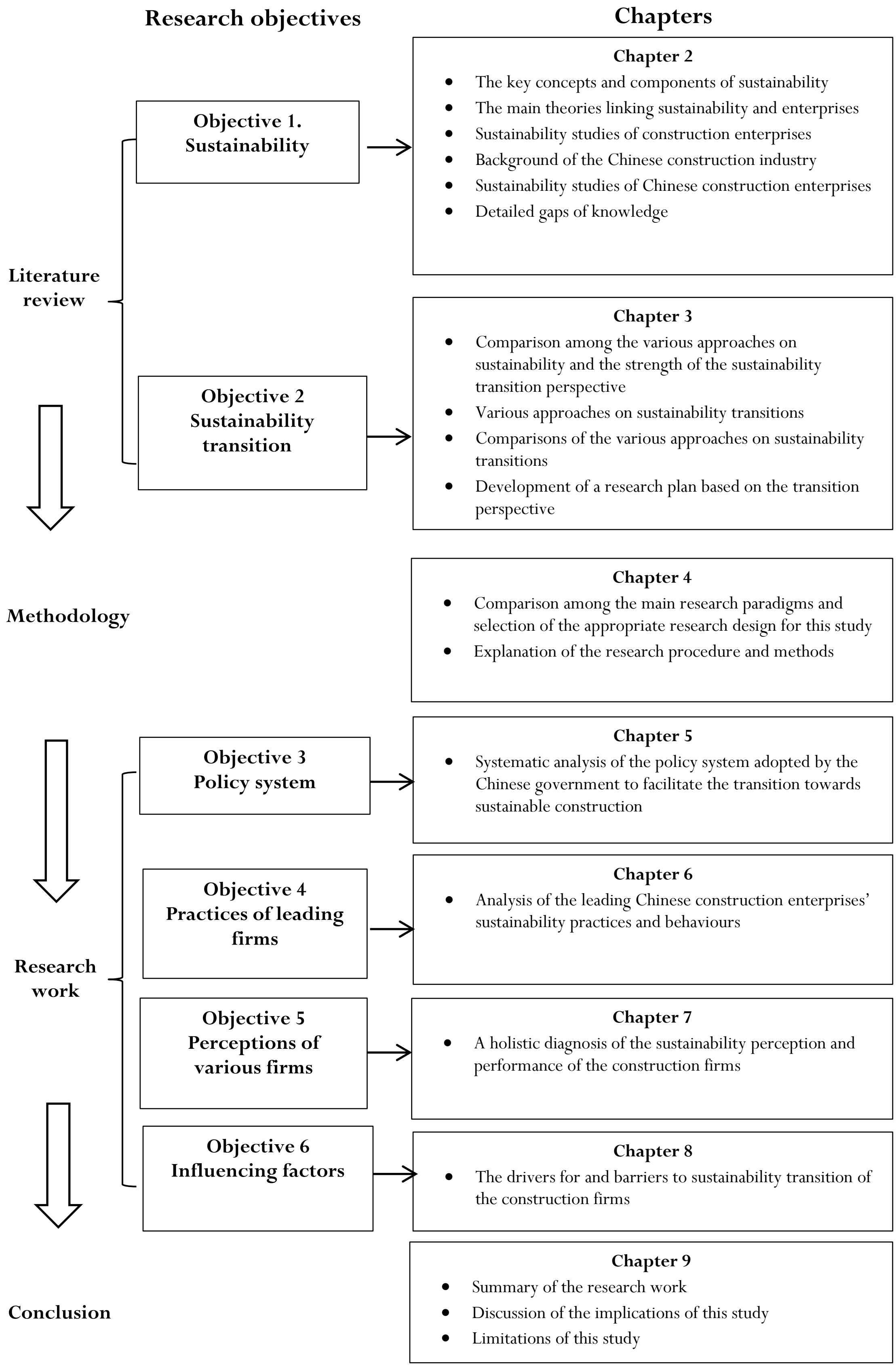

Figure 1.1 Structure of this thesis

Chapter 2 Sustainability and construction enterprises

2.1 Introduction

This chapter provides a literature review relevant to this study as a response to ***Research Objective 1***. As the focus of this research is the sustainability of Chinese construction enterprises, the literature review was conducted systematically from general to specific, comprising: 1) the concept of sustainability; 2) the evolving theories about sustainability and enterprises; 3) sustainability studies of construction enterprises; and 4) the background of and studies on Chinese construction enterprises.

Specifically, to understand the concept of sustainability, firstly, the key events which trigger the emergence of sustainability are reviewed, followed by discussions on the various concepts and components of sustainability. This chapter then goes deeper to investigate the evolving sustainability thinking in enterprises, from corporate social responsibility (CSR) and stakeholder theory, to corporate sustainability (CS) and green policies. After examining these general theories, this chapter examines the sustainability issues of construction enterprises. The significant impacts of the construction sector are discussed, and the existing sustainability studies on construction firms are critically analysed. The background of the Chinese construction industry is then introduced, and the literature on the sustainability issues of Chinese construction enterprises is critically discussed. Finally, the gaps of knowledge in sustainability research on construction enterprises are discussed in detail.

2.2 Concept of sustainability

This section systematically reviews the concept of sustainability. Prior to the review, the relationship between the terms "sustainability" and "sustainable development" should be clarified. There is no consensus on the differences between the two terms. Some scholars believe that "sustainability" is a goal and "sustainable development" is a process of moving towards that goal (Dovers and Handmer, 1992; Gallopín, 2003). Other scholars believe there are no distinct differences between the two terms (Lee et al., 2000). As a consequence of the loose application of these terms, the terminology of "sustainable development" has become synonymous with "sustainability" (Santillo, 2007). Therefore, these two terms are used interchangeably in this thesis.

2.2.1 Emergence of the concept

The appearance of the sustainability concept has been triggered by a series of key events, as shown in Fig. 2.1. These key events reflect four stages that have contributed to the emergence of sustainability, namely: 1) increasing awareness of environmental protection; 2) development and conservation seen as incompatible; 3) development and conservation viewed as inseparable and 4) sustainability should include economic, social and environmental dimensions.

Stage 1: growing awareness of environmental protection. The first organized environmental movement was started by John Muir, a Scottish immigrant to the United States of America (USA). In his first book, published in 1894, he describes the natural wonders of California and the loss of biological diversity due to the pressure of development (Muir, 1894). Later in 1962, Rachel Carson published *Silent Spring* which pointed out that human technologies may have unpredicted consequences on human life and the environment (Carson, 1962). In

1968, ecologist Garrett Hardin published *The Tragedy of the Commons* which indicated that, with increasing population, our rules of society may need to be changed to avoid tragedy (Hardin, 1968). Population growth and many associated problems were perceived as threatening to our survival. These events indicate that the public's awareness of environmental protection is improving and that development has been questioned.

Stage 2: development and conservation are incompatible. The Limits to Growth, translated into 28 languages with nine million copies sold, argued that economic growth causes environmental destruction and that the finite amounts of fossil fuels and minerals available on the earth will be used up by the middle of the 21st century (Meadows, 1972). However, when the authors modelled a future with zero population growth and zero capital growth, the model produced an ultimate stable state (Meadows, 1972). Similarly, in 1972, the experts involved in the United Nations (UN) Conference on the Human Environment argued that the development pattern needed to be altered to respond to the environmental issues. This conference, for the first time, acknowledged that the environment is also a development issue (Dresner, 2008). However, at this stage, development and environmental protection were still regarded as incompatible with improving the environment considered as meaning compromising the economy.

Stage 3: development and conservation are inseparable. The concept of "sustainable society" emerged at the Conference on Science and Technology for Human Development. This conference listed four conditions of the sustainable society, namely: equitable distribution of scarce resources, sufficient ecosystem ability to absorb pollutants, controlled use of non-renewable resources and good global climate. Later, in 1980, in the World Conservation Strategy published by the International Union for Conservation of Nature and Natural Resources (IUCN), the term "sustainable development" emerged. This report indicated that development could be a threat unless resources were effectively used and, thus, development has to be integrated with conservation. Conservation could not be achieved without the eradication of poverty by development. At this stage, development and conservation are deemed to be closely linked and the lack of one will impede the realization of the other.

Time

Major contributions to the emergence of sustainability	Key events in the emergence of sustainability
	Stage 4: sustainability should include economic, social and environmental dimensions
Sustainable development was defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs". The illustration of sustainable development in the Brundtland Report addressed the links between the social, economic and environmental dimensions of development. However, what is defined as "needs" varies in different countries.	**1987** World Conservation on Environment and Development (WCED) "Our Common Future"
	Stage 3: development and conservation are inseparable
The term 'sustainable development' came forth: "[t]he integration of conservation and development to ensure that modifications to the planet do indeed secure the survival and wellbeing of all people". This definition does not involve the political and economic changes needed to bring about the goal of sustainable development. It only addressed environmental sustainability, and viewed conservation and development as an integrated concept.	**1980** International Union for Conservation of Nature and Natural Resources (IUCN) World Conservation Strategy
The concept of sustainable society emerged. It started with the principle of equitable distribution, which was to be the cornerstone of the Brundtland Report's approach.	**1974** Conference on Science and Technology for Human Development
	Stage 2: development and conservation are incompatible
The idea that the environment was a critical development issue was accepted and environmental problems were placed on the international agenda for the first time. The current economic form should be altered.	**1972** UN Conference on the Human Environment-Stockholm
Based on computer models, this report shows that if the current trends of exponential growth in population and demand for non-renewable resources continued, the world would face severe shortages of food and non-renewable resources by the middle of the 21st century. Development and conservation are seen as opposite.	**1972** Club of Rome The limits to growth
	Stage 1: growing awareness of environmental protection
Pay attention to human population growth and increasing consumption of natural resources	**1968** Garrett Hardin The tragedy of the commons
The limits to control environmental problems and the global environmental crisis	**1962** Rachel Carson The new environmental movement
The establishment of Yosemite as a national park and the Sierra Club founded to defend the park	**1890** John Muir The first organized environmental movement

Figure 2.1 Key events contributing to the emergence of sustainability
Source: created by the author based on *The Principles of Sustainability* (Dresner, 2008)

Stage 4: sustainability should include economic, social and environmental dimensions. In 1983, a commission called the World Conservation on Environment and Development (WCED) was developed by the UN General Assembly. This commission released a report in 1987, "Our Common Future", often referred to as the Brundtland Report. The issuance of the report is a landmark event in the history of the sustainability concept (Dresner, 2008). In this report, "sustainable development" was defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, Chapter 2, Clause 1). The Brundtland Report stressed the importance of integrating environmental decisions into central economic decision making. At the same time, it emphasized that a healthy environment is not possible in a world marked by extreme poverty. For instance, when illustrating the concept of sustainability, the Brundtland Report states that:

> *Meeting essential needs depends in part on achieving full growth potential, and sustainable development clearly requires economic growth in places where such needs are not being met. … But growth by itself is not enough. High levels of productive activity and widespread poverty can coexist, and can endanger the environment. Hence sustainable development requires that societies meet human needs both by increasing productive potential and by ensuring equitable opportunities for all.* (WCED, 1987, Chapter 2, Clause 4)

2.2.2 Concepts and components of sustainability

The previous section shows that several key events triggered the emergence of the sustainability concept. Although "sustainable development" can be traced back to the concept of sustainable societies which appeared in 1974 (Dresner, 2008), it was the Brundtland Report which brought it to mainstream politics (Reid, 1995). However, the definition of sustainability in the Brundtland Report obscured the underlying complexities of sustainability (Redclift, 2005). The vagueness of the concept, combined with its increasing level of importance in national and international policy making, has led to extensive debate and a wide variety of definitions (Hopwood et al., 2005; Mebratu, 1998). Approximately 300 definitions of "sustainability" and "sustainable development" have been put forward, either directly or indirectly (Santillo, 2007). Some of the representative definitions are summarized in Table 2.1.

Table 2.1 Representative definitions of sustainability

Definitions	Source
• "development which meets the needs of the present without compromising the ability of future generations to meet their own needs"	World Commission on Environment and Development (WCED) (1987)
• "sustainability is the ability of a human, natural or mixed system to withstand or adapt to endogenous or exogenous change indefinitely"	Dovers and Handmer (1992)
• "sustainability is a relationship between dynamic human economic systems and larger dynamic, but normally slower-changing ecological systems, in which (a) human life can continue indefinitely, (b) human individuals can flourish, and (c) human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the diversity, complexity, and function of the ecological life support system"	Costanza (1992)
• "improving the quality of human life while living within the carrying capacity of supporting eco-systems"	Munro and Holdgate (1991)
• "sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality and social equity. Companies aiming for sustainability need to perform not against a single, financial bottom line but against the triple bottom line"	Elkington (1997)
• "sustainability is an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations. It can also be expressed in the simple terms of an economic golden rule for the restorative economy: Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do"	Hawken (1993)

All these definitions emphasize that sustainability concerns the promotion of the indefinite existence of human systems. In order for this to be achieved, a balance is required between the carrying capacity of the eco-system and human economic and social systems. To identify the key components of sustainability, White (2012) presented an insightful analysis by using the word cloud technique to comprehensively study the similarities and frequencies of keywords in various definitions of sustainability. He used 103 definitions of sustainability and discovered that the top 10 most frequent keywords[1] in sustainability definitions are: environment, social, economic, life, system, nature, resources, human, development and needs. Fig. 2.2 shows the results of his research with those words with larger letters being the ones with the highest frequency in definitions.

1 Excluding the terms "sustainability" and "sustainable development"

Figure 2.2 Word cloud of sustainability

Notes: The frequency of "sustainability" was expressed as 150% of the most frequently-occurring words in the sample to improve readability and appearance. Source: White (2012)

The high frequencies of *environment*, *social* and *economic* indicate that most of these definitions now acknowledge that sustainability should include the economic, social and environmental dimensions. *Life*, *nature* and *resourc*es are high-frequency terms, reflecting the high importance of the environmental dimension of sustainability. This is not surprising as people's increasing environmental awareness significantly contributes to the emergence of the sustainability concept. Some of the most serious environmental changes, such as climate change, have been addressed by international treaty such as *United Nations Framework Convention on Climate Change* negotiated at the Earth Summit in Rio de Janeiro from 3 to 14 June 1992 (UN, 1992b), and the following efforts such as the *Paris Agreement* (French: *Accord de Paris*) that went into effect on 4 November 2016 (UN, 2015a). These efforts further illustrate the importance of protecting *life*, *nature* and *resources* for sustainable development. The presence of *human*, *development* and *needs* in the top 10 words indicates the central role of people in the sustainability concept. This is echoed by the *Rio Declaration on Environment and Development* which lists 27 principles for sustainable development, with the first principle being: "human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature" (UN, 1992a). To summarize, the study by White (2012) of the 103 definitions of sustainability suggests that the core principles of sustainability are: (1) achieving balance between the environment, society and economy; and (2) meeting the needs of current and future generations thereby achieving long-term development of the human race. This is further supported by the *United Nations 17 Sustainable Development Goals*, which specify that countries should adopt a set of goals to end poverty, protect the planet, and ensure prosperity for all (UN, 2015b).

2.3 Sustainability and enterprises: evolving theory

The sustainability of enterprises has become an important research area as firms are the productive resources of the economy. Without support from firms, sustainable development could not be achieved (Barkemeyer et al., 2014). To promote sustainable development, firms have a critical role to play.

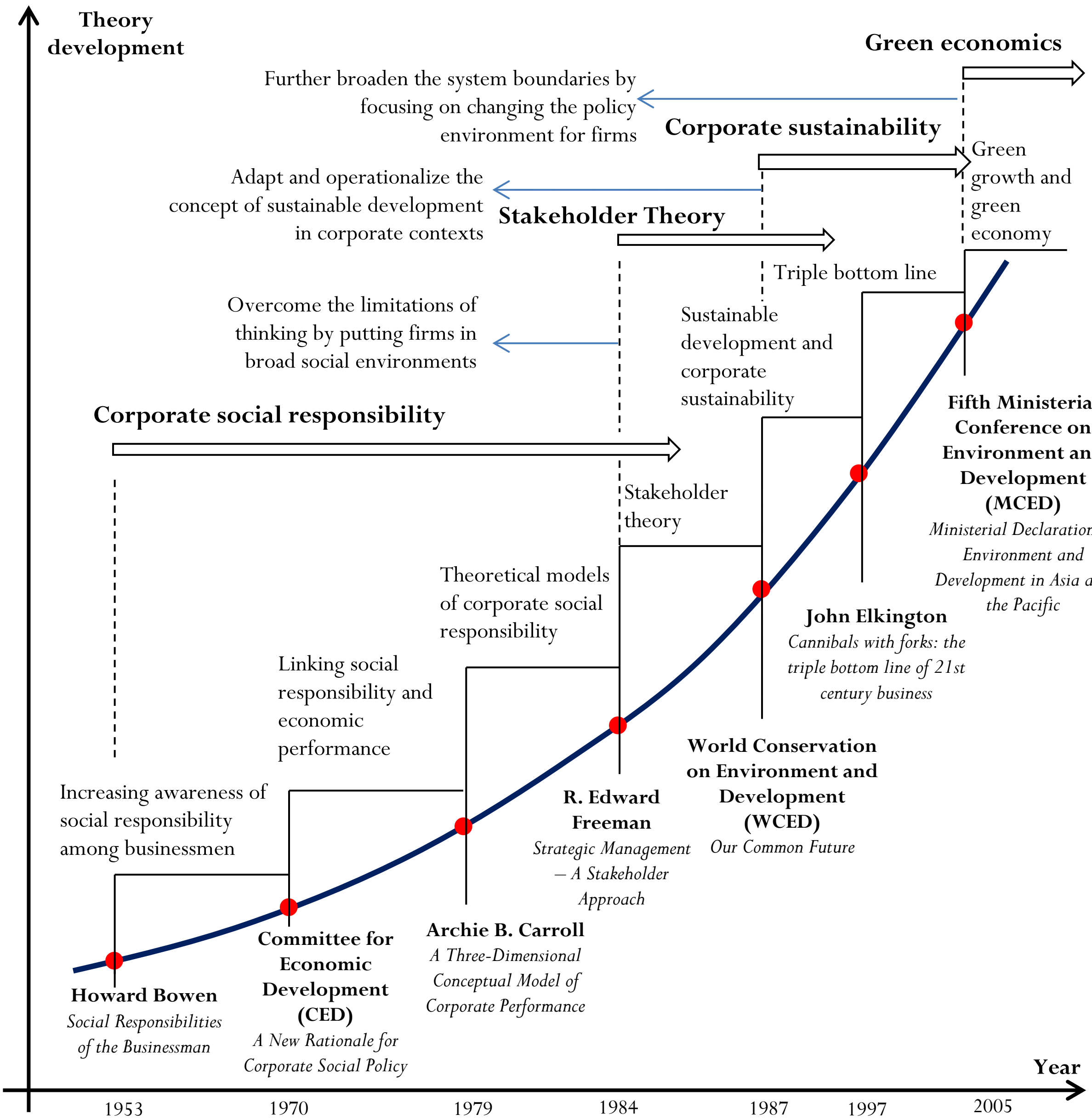

Figure 2.3 Milestone documents and evolving theories explaining sustainability issues in corporations

Source: created by the author based on Linnenluecke and Griffiths (2013), Lee (2008) and Carroll (1999)

The consideration of sustainability in managing firms emerged in the 1930s, well before the release of the Brundtland Report (Carroll, 1999). Since then, the sustainability-related thinking of firms has evolved with a number of theories linking sustainability and firms having been proposed and continuing to emerge. As the current research investigates the sustainability issue associated with Chinese construction enterprises, it is necessary to review the evolving theory of sustainability and enterprises to form a solid theoretical underpinning for this study.

This section offers a critical review of the evolving mainstream theories on sustainability and firms. Four major theories are identified: corporate social responsibility (CSR), stakeholder theory, corporate sustainability (CS) and green economics. The evolving theories and associated milestone documents are summarized in Fig. 2.3. Other specific research areas related to sustainability and firms include marketing research which mainly examines the impacts of sustainability strategies on customers and buying decisions (Linnenluecke and Griffiths, 2013). These specific management studies are excluded in this literature review as they have little relevance to the current research.

2.3.1 Corporate social responsibility

Sustainability thinking related to firms can be traced back to the 1930s, when some articles about the social responsibility of business first appeared (Carroll, 1999). However, most scholars agree that it was in 1953 when Howard Bowen published *Social Responsibilities of the Businessman* that the relationship between firms and society was first theorized (Lee, 2008). Bowen believed that large firms were critical centres of power; therefore, the strategies and actions of these firms can significantly influence the lives of citizens in many aspects (Bowen and Johnson, 1953). He offered this definition of the term "social responsibilities of businessmen": "[i]t refers to the obligations of businessmen to pursue those policies, to make those decisions, or to follow those lines of action which are desirable in terms of the objectives and values of our society" (Bowen and Johnson, 1953, p.6). Since then, the term "social responsibility of businessmen" has gradually evolved to become "corporate social responsibility" (CSR). However, this concept was not widely recognized in the 1950s and 1960s, and it has attracted various criticisms. One of the most prominent critics was Milton Friedman who argued that the real social responsibility of a corporation is to make money for its shareholders and, thus, the social responsibility proposed by Bowen threatened the very foundation of free enterprise society (Friedman, 1962). Table 2.2 lists some representative definitions of corporate social responsibility (CSR). All of these definitions indicate that CSR describes the responsibilities of a firm for economic gains, society and the environment.

Table 2.2 Representative definitions of corporate social responsibility (CSR)

Definitions	Source
• "the firm's consideration of, and response to, issues beyond the narrow economic, technical, and legal requirements of the firm to accomplish social and environmental benefits along with the traditional economic gains and to fairly balance the needs and concerns of various stakeholders"	Davis (1973)
• "encompasses the economic, legal, ethical and discretionary expectations that society has of organizations at a given point in time"	Carroll (1979)
• "corporate commitment to contribute to sustainable economic development, employees and their families, local communities and the whole society in order to improve their quality of life"	World Business Council for Sustainable Development (WBCSD) (1999)
• "achieving commercial success in ways that honour ethical values and respect people, communities and the natural environment"	Business for Social Responsibility (BSR) (2003)
• "the responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behaviour"	International Organization for Standardization (ISO) (2010)

A breakthrough in rationalizing CSR did not come until 1970 when the Committee for Economic Development (CED) published *A New Rationale for Corporate Social Policy* (Lee, 2008). This book demonstrates that, if the surrounding society deteriorates, firms will lose their important support structure and, therefore, it is in accordance with corporations' long-term interests to promote the well-being of society (Baumol et al., 1970). Apart from justifying the importance of CSR, some scholars took a further step by putting forward CSR theoretical frameworks. A typical example of these efforts is *A Three-Dimensional Conceptual Model of Corporate Performance* (Carroll, 1979). The nature of CSR, social issues and corporate social responsiveness were integrated through this three-dimensional model into one concept which is termed "corporate social performance (CSP)". According to Carroll, the nature of CSR can be classified into four categories: "economic responsibility, legal responsibility, ethical responsibility and discretionary responsibility" (Carroll, 1979). Social issues are the topic areas of these responsibilities, and Carroll listed some of these topic areas, such as consumerism, the environment, discrimination, product safety, occupational safety and shareholders (Carroll, 1979). The term "corporate social responsiveness" describes the strategies of corporations in responding to social issues, and Carroll identified four typical strategies, namely, reaction, defence, accommodation and proaction (Carroll, 1979). Carroll's seminal work served to ignite the interest of researchers in studying the theoretical frameworks of CSR and, as a result, it has been widely cited in the field of business and society research (Lee, 2008).

Currently, one of the major research areas in the CSR field is examining the effect of CSR on corporate economic performance (see Horváthová, 2010; Iwata and Okada, 2011; Lo and Sheu, 2007; Moneva et al., 2007; Orlitzky et al., 2003). For instance, Orlitzky et al. (2003) suggested that an apparent relationship exists between corporate social performance (CSP) and financial performance. The reason given is that a responsible company can benefit from its improved reputation with the public and the business community, thereby increasing its ability to attract capital. However, in the study by Iwata and Okada (2011), it was shown that financial performance was not significantly affected by CSR issues, for example, waste emissions. The actual relationships between CSR and the economic performance of corporations are indeed complex and debate is ongoing on this issue.

2.3.2 Stakeholder theory

A key perspective in theorizing a new role for firms is stakeholder theory which was introduced during the late 1970s (Loorbach and Wijsman, 2013). This theory was introduced by Freeman (1984) through his book, *Strategic Management – A Stakeholder Approach* (Linnenluecke and Griffiths, 2013). In this seminal work, Freeman argued that companies need to understand their relationships not only with traditional groups, such as suppliers, customers and employees, but also with non-traditional groups, such as the government, environmentalists and special interest groups, in order to manage their organizations more effectively (Freeman, 1984). According to Freeman (1984, p.46), a stakeholder is "any group or individual who can affect or is affected by the achievement of the organization's objectives". The two types of stakeholders are primary stakeholders and secondary stakeholders (see Table 2.3), with primary stakeholders either having a more direct influence or being influenced more by the company than secondary stakeholders (Castka and Prajogo, 2013). Originally, stakeholder theory had its main focus on social stakeholders; however, recently, non-social stakeholders have started to be incorporated to address environmental issues (Lozano et al., 2014).

Table 2.3 Examples of a firm's stakeholders

	Primary Stakeholders	Secondary Stakeholders
Social	Shareholders and investors	Government and regulators
	Employees and managers	Civil institutions and general public
	Customers	Social pressure groups
	Suppliers and other business partners	The media and academia
	Unions	Trade bodies
	Local communities	Competitors
Non-social	The natural environment	
	Future generations	

Source: adapted from Lozano et al. (2014)

What is fundamental to the stakeholder approach is that "firms are actors in the social environment and thus should respond to pressures and demands from their stakeholders, to achieve their strategic objectives" (Linnenluecke and Griffiths, 2013). In contrast to the shareholder approach which states that the firm's main purpose is to maximize profits for its shareholders (Friedman, 2007), the stakeholder approach indicates that the fundamental obligation of a corporation is to ensure its long-term survival while considering the needs of multiple stakeholders (Hasnas, 1998; Lozano et al., 2014). According to stakeholder theory, the critical issue of a firm is the survival of the firm, with this affected not only by shareholders, but also by various other stakeholders, such as employees, governments, customers and the general public (Lee, 2008). With its innovative perspective, stakeholder theory has significantly influenced the CSR research field, with efforts having been made to incorporate CSR principles into stakeholder research. For instance, with regard to the construction industry, Zhao et al. (2012), after identifying the key stakeholders of construction corporations, developed a CSR indicator system which explicitly specifies suitable indicators for every stakeholder of construction corporations.

2.3.3 Corporate sustainability

Since the release of the Brundtland Report, the concept of sustainable development has increasingly been applied as a corporate concept under the name of corporate sustainability (CS) (Steurer et al., 2005). However to date, there has been no universal definition of corporate sustainability (CS). Table 2.4 lists some representative definitions. These definitions of corporate sustainability (CS) all emphasize the importance of meeting stakeholders' needs and balancing the economic, environmental and social dimensions of corporate performance.

Table 2.4 Representative definitions of corporate sustainability

Definitions	Source
• "adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining, and enhancing the human and natural resources that will be needed in the future"	International Institution of Sustainable Development (IISD) (2002)
• "meeting the needs of the firm's direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities, etc.), without compromising its ability to meet future stakeholder needs as well"	Dyllick and Hockerts (2002)
• "demonstrating the inclusion of social and environmental concerns in business operations and in interactions with stakeholders"	Van Marrewijk and Werre (2003)
• "a business and investment strategy that seeks to use the best business practices to meet and balance the needs of current and future stakeholders"	Artiach et al. (2010)
• "sustainability is a company's capacity to prosper in a hypercompetitive and changing global business environment. Companies that anticipate and manage current and future economic, environmental and social opportunities and risks by focusing on quality, innovation and productivity will emerge as leaders that are more likely to create a competitive advantage and long-term stakeholder value"	RobecoSAM (2013)

Corporate sustainability (CS) is usually operationalized through the triple bottom line (TBL), a concept developed by Elkington (1997). The three dimensions of the TBL are social, environmental and financial. In traditional accounting, the "bottom line" is profit. The concept of the TBL adds two more "bottom lines" for corporations in reporting, namely, social and environmental bottom lines. This is significantly different from traditional reporting frameworks (Slaper and Hall, 2011). The TBL approach has gained wide support. For instance, Jamali (2006) suggested that an organization can facilitate its movement towards sustainable development by integrating the TBL with its management approach. Markley and Davis (2007) provided evidence to support the notion that organizations can improve their competitive advantage with the TBL as their focus. However, some researchers have questioned the TBL's usefulness. Gray (2010), for example, indicated that TBL reports have very little to do with what sustainability is really about, arguing that it is impossible to reconcile the tension between sustainability and the need to maintain profit.

Apart from the TBL which operationalizes the concept of sustainability in the business context, sustainable business models (SBMs) offer another important approach to corporate sustainability (CS). The business model (BM) is of key importance in promoting corporate sustainability (CS). The business model (BM) describes how firms obtain their competitive advantage through their product or service, and sustainable business models (SBM) are those business models (BMs) which incorporate the TBL approach and consider the interests of various stakeholders (Bocken et al., 2014). The use of SBMs helps firms to gain competitiveness by promoting and embedding sustainability into their business purpose and process (Bocken et al., 2014). Various studies have been conducted to examine how sustainability could contribute to the competitive advantage of firms through establishing SBMs (e.g. Birkin et al., 2009; Svensson et al., 2011).

It is widely recognized that CSR and corporate sustainability (CS) are closely related. While many scholars believe these two concepts are interchangeable, others have argued that there are subtle differences between them (Steurer et al., 2005). Montiel (2008) conducted an extensive review to specifically investigate the evolution of the concepts of CSR and corporate sustainability (CS). He suggested that the management literature should use both CSR and corporate sustainability (CS) to refer to social and environmental management issues, and that the conceptualizations and measures of CSR and corporate sustainability (CS) are converging. To date, no clear distinction has emerged between the two terms (Montiel, 2008). He concluded that: "we should determine whether we need to more accurately distinguish CSR and CS or, on the contrary, whether we should merge them into one construct" (Montiel, 2008, p.245).

2.3.4 Green economics

Currently, the methodology of green economists dominates policy discussions on sustainability (Geels, 2012). The concept of green growth was brought into the context of intergovernmental discussions for the first time at the Fifth Ministerial Conference on Environment and Development (MCED) in Asia and the Pacific held in 2005. Since then, the importance of the green economy and green growth has been increasingly recognized in international and national policy making. The United Nations Environment Programme (UNEP) defines a green economy as one that results in "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2010, p.5). According to the UN's Economic and Social Commission for Asia and the Pacific (ESCAP), green growth plays a critical role in building a green economy in the context of sustainable development and poverty reduction (UN, 2013). The fundamental assumption of green growth is that environmental progress currently cannot be separated from economic growth and development. Green growth results from investment in the upgrading of the entire production system to implement environmental and resource-saving processes and products (Jänicke, 2012). Several green economy policy frameworks and guides have been developed, such as "Towards Green Growth" published by the Organisation for Economic Co-operation and Development (OECD) in May 2011 (OECD, 2011), and ''Europe 2020'' issued by the European Union (EU)'s European Commission (European Commission, 2010).

The green economy should not be regarded as a substitute for sustainable development (Borel-Saladin and Turok, 2013). Rather, it is a pathway to sustainability as sustainability can only be achieved by adjusting the economy and the way in which investment decisions are made (OECD, 2011). If the true value of ecosystem services was reflected in the market, economic activity would be more resource-efficient and less environmentally damaging, in other words, more sustainable. This requires extensive use of market-based and pricing instruments. Appropriate regulation, active technology support policies and voluntary approaches may also be useful to complement market instruments.

Green policies could profoundly change the business environment for firms as various policy instruments could be developed to redirect investment from activities employing environmentally harmful means to greener industries and businesses. According to Borel-Saladin and Turok (2013), the same policy and pricing measures are available to enable green growth: 1) institutions, norms, regulations and behaviour-based policies; 2) innovation and industrial policies; 3) education and labour market policies; 4) natural capital, agriculture and ecosystem services management; and 5) infrastructure, building, urbanism, transport and energy policies. Many scholars have contributed to the debate on green policies. For instance, Vergragt (2012) argued that the green economy would contribute to strengthening democracy and possibly would engender new social movements; however, it would also require simultaneous fundamental changes in government institutions. Schmalensee (2012) suggested that all green growth policies require more than voluntary actions from business. Van der Ploeg and Withagen (2012) argued that green growth will contribute to economic growth through several channels, such as improved labour productivity, as a consequence of better health, and improved energy efficiency.

2.3.5 Synthesis of the theories

Based on the above review of the evolving theories, a theory landscape can be generated, as shown in Fig. 2.4.

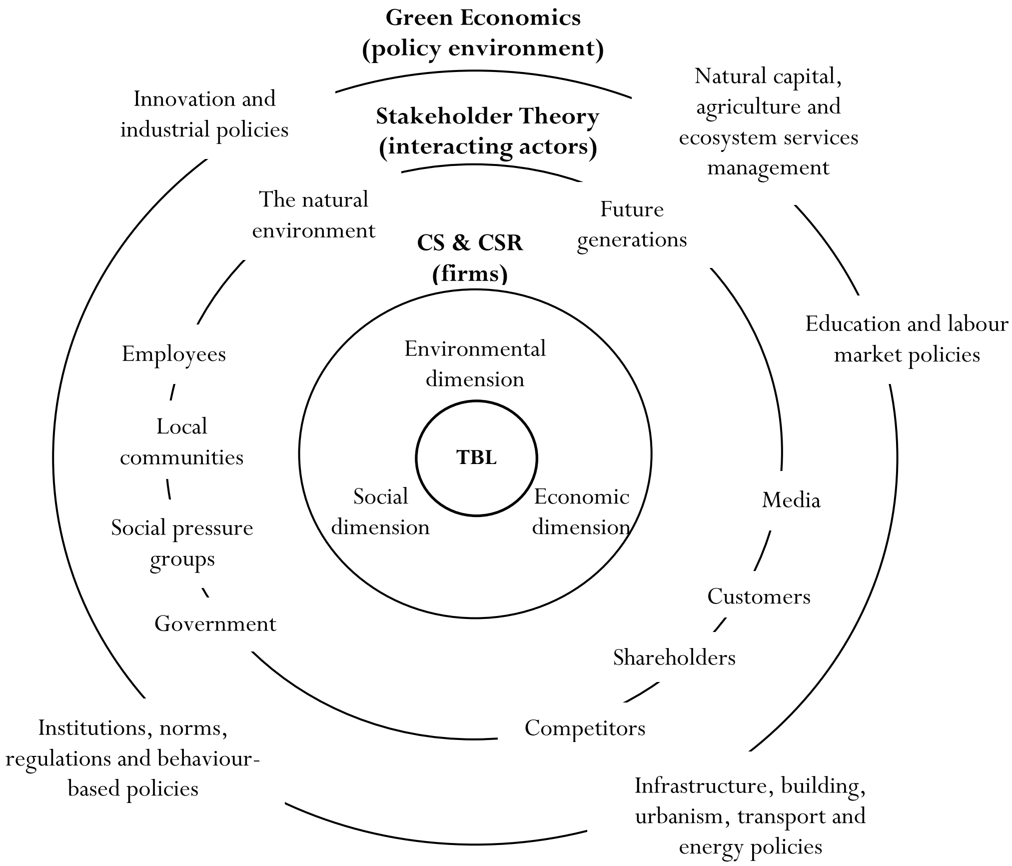

Figure 2.4 Theory landscape of sustainability and business

The theories of corporate social responsibility (CSR), stakeholder theory, corporate sustainability (CS) and green economics emerged in chronological order as listed, forming the main theory landscape of sustainability and firms. At the centre of this landscape is the TBL approach which operationalizes the concept of corporate sustainability (CS) in the corporate context. As CSR is very similar to corporate sustainability (CS), the TBL also contributes to CSR's implementation. As demonstrated in the various definitions of CSR and corporate sustainability (CS), the sustainability of firms is concerned with the balance of the economic, social and environmental dimensions of corporate performance. Surrounding firms are their various stakeholders who, in turn, are surrounded by government policies; thus, stakeholders and policies influence the sustainability of firms, as emphasized by stakeholder theory and green economics, respectively. The theory overview and landscape (Figs. 2.3 and 2.4) help scholars to gain a clear and systematic understanding of the evolving theories on sustainability and firms.

2.4 Sustainability and construction enterprises

The above section reviews the evolving theory of sustainability and firms. This section links the sustainability issues with enterprises in the construction industry. Firstly, the impacts of the construction industry are introduced. The existing studies on sustainability and construction firms are then reviewed to identify the research gaps in this area.

2.4.1 Construction industry and its impacts

It is well recognized that the construction industry is involved in creating the physical assets which are the basis of virtually every aspect of development; thus, it is involved in the creation of much of the world's man-made capital (Spence and Mulligan, 1995). In many countries in the world, the built environment generally constitutes more than half of total national capital investment (CIB, 2002). This sector is one of the largest employers in most countries, accounting for around 7% of total employment worldwide (Horta et al., 2013). More importantly, the labour-intensive nature of construction activities presents opportunities for poverty alleviation (CIB, 2002). Specifically, in Europe, the construction sector generates almost 10% of gross domestic product (GDP) and provides 20 million jobs (European Commission, 2012). In the UK, the sector employs around 3.1 million people, representing 10.5% of UK employment and contributes up to 8% of the GDP (Akadiri and Fadiya, 2013). After the manufacturing industry, the construction industry is the second largest industrial employer in China, providing more than 40 million jobs (NBS, 2014).

However, the construction industry is also one of the biggest exploiters of resources and has major impacts on the living and working environment (Bourdeau, 1999; Spence and Mulligan, 1995). It is a significant contributor to many environmental problems such as loss of soil and agricultural land, loss of forests and wilderness, and air pollution, and it is also a major user of the world's non-renewable energy resources and minerals (Spence and Mulligan, 1995). About 25% of virgin wood and 40% of raw stone are used by construction work worldwide (Udayangani et al., 2006). Similarly, energy consumption of buildings in developed countries comprises 20–40% of total energy consumption (Pérez-Lombard et al., 2008). As stated by Akadiri and Fadiya (2013), in the UK, the construction industry is accountable for 50% of carbon emissions, 50% of water consumption, 35% of landfill waste and 13% of all raw materials utilized. The steel consumption of the Chinese construction industry comprises more than 20% of the world's total consumption, while construction waste accounts for 45% of China's total garbage (MOST, 2012). As has been previously mentioned, building energy consumption accounts for 27.5% of the national total in China: with the addition of energy consumption caused by construction materials manufacturing, energy consumption related to the construction industry constitutes more than 40% of the total consumption in China (MOST, 2012). As the construction industry has such enormous global impacts economically, socially and environmentally, the sustainability of this industry is of vital importance to the overall sustainability of our planet.

2.4.2 Sustainability research on construction enterprises

This research aims to investigate the sustainability issues of the Chinese construction industry. Thus, it is necessary to review the literature about corporate sustainability (CS) in the construction industry. Three common research themes are identified as relevant to sustainability and construction firms: principles and practices of sustainable construction; corporate sustainability (CS) and CSR; and drivers for and barriers to sustainability in construction firms. It is worth noting that this research reviews only the literature that examines the awareness, general practices, driving forces and barriers, and performance of sustainability in construction corporations. Studies that are more specific in nature, for example, on a new technology or illustrating how to assess the degree of sustainability of a particular kind of construction project, are not reviewed due to having little relevance to this research.

2.4.2.1 Principles and practices of sustainable construction

The concept of "sustainable construction" was first put forward by Kibert at the First International Conference on Sustainable Construction held in Tampa in 1994 (Bourdeau, 1999). Kibert defines sustainable construction as "the creation and responsible maintenance of a healthy built environment based on resource efficient and ecological principles" (Kibert, 1994). Subsequently, several other definitions emerged, with some representative definitions listed in Table 2.5. Du Plessis (2007) summarized the various definitions of sustainable construction as having the following common interpretations: 1) it requires a broad interpretation of construction as a cradle-to-grave process; 2) it emphasizes both environmental protection and value creation; and 3) it embraces not just technological responses but also non-technical aspects related to economic and social sustainability.

Table 2.5 Representative definitions of sustainable construction

Definitions	Source
• "sustainable construction is the creation and responsible management of a healthy built environment based on resource efficient and ecological principles"	Kibert (1994)
• "sustainable construction is seen as a way for the building industry to respond towards achieving sustainable development on the various environmental, socio-economic and cultural facets"	International Council for Research and Innovation in Building and Construction (CIB) (1999)
• "sustainable construction is a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity"	International Council for Research and Innovation in Building and Construction (CIB) (2002)
• "sustainable construction refers to the integration of environmental, social and economic considerations into construction business strategies and practices. It is the application of the principles of sustainable development to the comprehensive construction cycle from the extraction of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste"	Tan et al. (2011)

Apart from examining the concepts of sustainable construction, another way of understanding sustainable construction is to inspect its principles and actual practices. According to Hill and Bowen (1997), the principles of sustainable construction can be divided into four 'pillars' comprising: 1) social pillar of sustainable construction, such as improving human health through a healthy and safe working environment, implementing skills training and capacity enhancement of disadvantaged people and seeking equitable distribution of the social benefits of construction; 2) economic pillar of sustainable construction, such as ensuring financial affordability for intended beneficiaries, promoting employment creation and choosing environmentally friendly suppliers and contractors; 3) biophysical pillar of sustainable construction, such as reducing the use of energy, water, materials and lands, maximizing resource reuse and minimizing air, land and water pollution; and 4) technical pillar of sustainable construction, such as constructing durable, reliable and functional structures, pursuing quality in creating the built environment and humanizing larger buildings.

In terms of the practices of sustainable construction, Tan et al. (2011) comprehensively summarized sustainable construction practices into six categories: 1) compliance with sustainability legislation, including environmental requirements and social responsibility requirements; 2) design and procurement, such as improving the project's whole life value through sustainable design; 3) technology and innovation, which increase the sustainability of both the construction process and its resultant assets; 4) organizational structure and process, which if re-organized, will facilitate the implementation of a sustainability strategy; 5) education and training, which will increase an organization's commitment to sustainable construction; and 6) measuring and reporting, which help to identify the areas for improvement.

In addition, other scholars and organizations have contributed to research on the principles and practices of sustainable construction. For instance, CIB listed the main issues of sustainable construction: 1) process and management issues; 2) product and building issues; 3) resource consumption; 4) sustainable urban development; 5) environmental burdens; and 6) social, cultural and economic issues (CIB, 1999). However, these main issues, as listed by CIB, have many overlaps and focus heavily on the environmental dimension of sustainable construction. Similarly, Sev (2009) listed three principles for sustainable construction: 1) resource management; 2) life-cycle design; and 3) design for human beings. However, these principles are proposed from the perspective of designers and also largely neglect the economic dimension of sustainable construction. Compared to these studies, the principles proposed by Hill and Bowen (1997) and the practices proposed by Tan et al. (2011) are deemed to be comparatively more holistic.

2.4.2.2 Corporate sustainability and corporate social responsibility

Regarding the strand of corporate sustainability (CS) research, Zuo et al. (2012) used content analysis to investigate the sustainability policies of the world's top international contractors and discovered that sustainability policy development varied from case to case. Energy efficiency and conservation, greenhouse gas (GHG) emission reduction and integration of renewable energy resources into projects are among the common themes of sustainability policies disclosed by construction contractors (Zuo et al., 2012). Similarly, Jones et al. (2010) discovered that sustainability appears to mean different things to different companies. The environmental pillar was the most frequently emphasized by construction corporations engaged in the industrial sector, such as transportation equipment owners, industrial contractors and design firms, while the social pillar of sustainability was most frequently emphasized by commercial contractors and design firms (Jones et al., 2010).

Presley and Meade (2010) presented a framework to assist construction firms in incorporating sustainability measures into their benchmarking efforts, while Sarkis et al. (2012) introduced a decision model for subcontractor selection and team formation based on the TBL approach. Wang et al. (2013) investigated sustainability in a social housing project in the UK from a whole life project management perspective, and suggested 23 success strategies for sustainable project management. The above studies have focused on how to enhance the sustainability performance of firms.

Regarding the CSR strand, Barthorpe (2010) provided a general overview of the origins, development and rise in the importance of CSR, demonstrating how CSR has been incorporated and implemented in the UK construction industry. He discovered that, although CSR may not be formally embedded in the mainstream construction industry, ample evidence of exemplary CSR in practice has been demonstrated by UK developers and contractors for decades. Similarly, Lu et al. (2015) examined the CSR/corporate sustainability (CS) reports of the top 50 international construction companies, and discovered that emissions, effluent and waste; community; and occupational health and safety (OHS) are the three most frequently reported CSR indicators. Zhao et al. (2012) developed a CSR indicator system which addresses the following key stakeholders of construction corporations: employees, shareholders, customers, suppliers and partners, the government, resources and environment, local community, competitors and non-governmental organizations (NGOs).

Lichtenstein et al. (2013) found that profitable construction firms in Ghana place more emphasis on CSR issues than is the case with unprofitable firms. According to Petrovic-Lazarevic (2008), large construction companies develop CSR to maintain an image of being a good corporate citizen. His research indicated that, to be recognized as a socially responsible business, corporations should apply a corporate governance structure that: takes working environment concerns into consideration; pays attention to OHS measures, and enhances the relationships with suppliers. In South Africa, Othman (2009) found that, while the concept of CSR is perceived and applied by most architectural design firms, they are implementing different CSR practices. The obstacles that hindered some design firms from adopting CSR were found to be: the lack of integration of CSR into the internal governance of their firms; limited government incentives for supporting CSR; and the negative perceptions of time, cost and energy constraints involved in the adoption of CSR (Othman, 2009). In summary, this research strand focuses on investigating the implementation situation of CSR in construction corporations.

2.4.2.3 Barriers to and drivers for sustainability

The research strand on the barriers to and drivers for sustainability has newly emerged in recent years. In terms of the barriers to sustainability, Zainul Abidin (2010) suggested that, in Malaysia, only large developers are beginning to pay attention to sustainable implementation in their projects. Due to limited understanding of sustainability and concerns about costs, many developers are still reluctant in relation to the pursuit of sustainability (Zainul Abidin, 2010). In Chile, Serpell et al. (2013) argued that Chilean construction firms are in an early stage of achieving sustainable construction and that their practices towards sustainability are highly dependent on the company's size and its core business. The main barriers include the lack of financial incentives and the lack of integrated design (Serpell et al., 2013).

In terms of other parts of the world, Zhang et al. (2012) adopted a case study approach to investigate the barriers hindering the implementation of extensive green roof features in Hong Kong: they indicated that the lack of promotion and incentives from the government and the high maintenance cost are the top barriers to implementation. Hwang and Ng (2013) identified the major challenges for green construction in Singapore as being: the longer time required during the pre-construction process; difficulty in the selection of subcontractors; uncertainty with green materials and equipment; and high costs of green materials and equipment. In contrast, Häkkinen and Belloni (2011), surprisingly, found that cost-related issues are not considered as significant barriers to sustainable buildings and that clients have a realistic understanding about the cost. This contrasts to similar studies in China, for example, the work of Qi et al. (2010).

Some scholars have investigated the drivers for sustainability in construction corporations. For instance, Yip Robin and Poon (2009) measured the extent of change to a sustainable culture among participants in Hong Kong’s construction industry. Their study showed that the influential power of various stakeholder groups is a crucial factor that may change the sustainable outcome of the built assets, and that stakeholders should make better use of their influential power to enhance the sustainability outcome (Yip Robin and Poon, 2009). Son et al. (2011) surveyed constructors from the USA and Korea, finding that government policy and local environmental and social issues have a significant impact on the sustainability knowledge of constructors. According to Heffernan et al. (2015), in the UK, legislative and economic drivers are much more significant than drivers within the industry for zero carbon homes. In particular, the strongest supporting mechanism for zero carbon homes is identified as enhancing public awareness and occupants’ education. This shows that it is hard for firms acting on their own to actively embrace sustainability. Rather, it is the interactions between firms and the socio-political and economic environments that drive the sustainability transition (see also Serpell et al., 2013).

2.5 Sustainability of Chinese construction enterprises

The above section has discussed the sustainability research on construction enterprises in general. This section specifically analyses the sustainability of Chinese construction enterprises. From 1989 to 2010, China’s average quarterly GDP growth was 9.31%, reaching a nominal GDP of $5.87 trillion in 2010, making it the world’s second-largest economy after the United States (USA) (Lu et al., 2013a). With this rapid economic development, along with the unprecedented urbanization process, China’s construction industry has experienced tremendous growth overtaking its counterpart in the US to become the world's largest in 2010 (GCP and OE, 2013). For instance, thousands of hydroelectric power plants operate worldwide with 50% of them located in China (Zhao et al., 2009).

2.5.1 Development history of the Chinese construction industry

Some scholars have studied the development history of the Chinese construction industry. Huang et al. (2013), for instance, indicated the three milestone events in its development history: the opening-up policy in 1979; the construction industry reform initiated in 1992; and, in 2001, China joined the World Trade Organization (WTO). This section reviews the development history of the industry after the adoption of the opening-up policy. Considering the importance of the three milestone events identified by Huang et al. (2013), this section divides the history into three stages: 1978–1991, 1992–2001 and 2002 to the present, as shown in Fig. 2.5.

Five indicators are used to illustrate the development of the industry. The gross output value (GOV) of the construction industry refers to the total of construction products and services expressed in monetary terms, while the gross value added (GVA) refers to GOV minus intermediate consumption. Thus, GVA is the pure value generated by the industry (NBS, 2013c). However, as the prices of labour, materials or energy changes, when comparing the GVA values in different years, the influence of price fluctuation should be considered. Thus, the Gross Value Added Index (GVAI) was introduced by the National Bureau of Statistics (NBS) of China. The value of this index in 1978 was set to be 100: for instance, in 1991, the value of this index was 327.4, meaning that the actual economic scale of the industry tripled from the original scale in 1978. In addition, the number of enterprises in the construction industry and the employment data are used to illustrate industry development, as shown in Fig. 2.6. Statistics have been retrieved from the database of the National Bureau of Statistics of China (see NBS, 2014).

Figure 2.5 Development of the Chinese construction industry: the GOV, GVA and GVAI

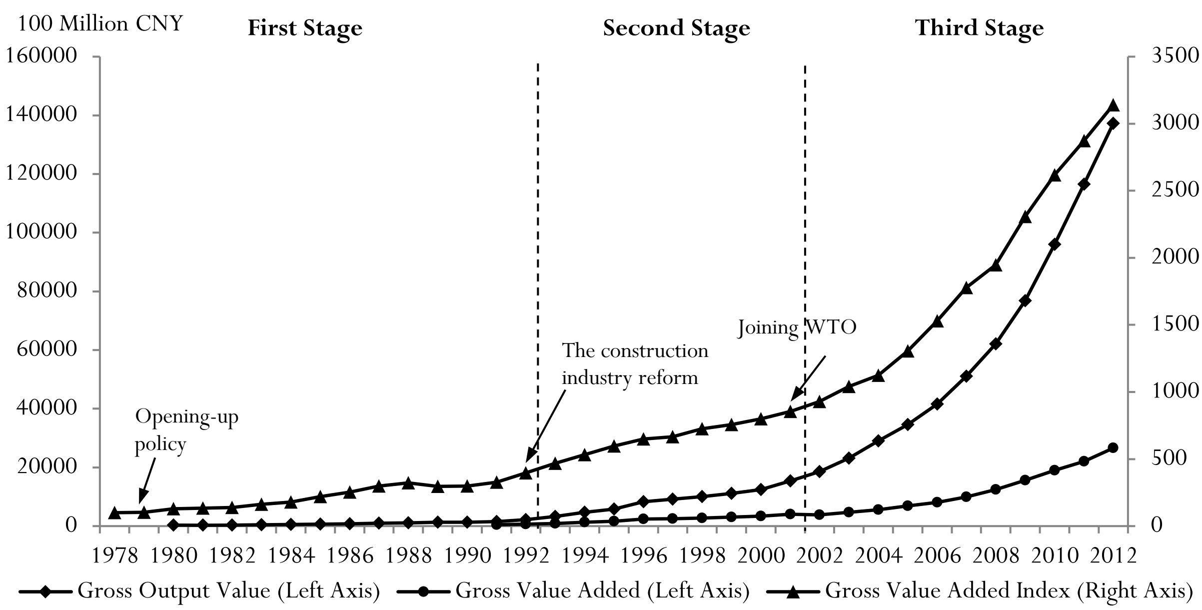

Figure 2.6 Development of Chinese construction industry: number of enterprises and employment

2.5.1.1 First stage: preliminary exploration of construction industry reform

China was known as a socialist country and, on the basis of the Marxism-Leninism ideology, a centralised planned economic system was established before 1979 (Lu et al., 2013a). Shortly after the Cultural Revolution, the central government decided to implement the Chinese economic reform (also known as the opening-up policy, or open-door policy), introducing market principles to provide stimulus for the economy (Huang et al., 2013).

From 1979 to 1992, the construction industry underwent three major reforms: 1) devolution of powers to corporations; 2) decreasing the amount of money paid to the government by corporations; and 3) introducing competition mechanisms to the project procurement process in the industry (from government assignment to tendering and bidding) (Li, 2009). Under these reforms, the GOV and GVA of the construction industry experienced a steady increase during this period (see Fig. 3.1). In 1980, the GOV was 28.6 billion Chinese yuan (CNY) but, by 1991, it had increased to 156.4 billion CNY. Similarly, the GVAI increased to 327.4 in 1991, indicating that the actual scale of the industry tripled compared to what it had been in 1978. Along with the increasing economic scale of the industry, the number of enterprises and the associated employment also experienced steady growth, from 6604 and 6.4 million in 1980 to 13825 and 10.5 million in 1991, respectively. However, before 1992, even though some exploration of construction industry reform had been made, the opening-up policy did not bring mature reform to the construction market over which the centralised government control still had a dominant influence (Shen et al., 2004).

2.5.1.2 Second stage: market-oriented construction industry reform

A turning point in the construction industry reform appeared in 1992, when Mr Deng Xiaoping, the Chairman of China at that time, proposed that: the "[p]lan does not equal socialism, and the market does not equal capitalism" (Li, 2009). Later in the 14th National Congress of the Communist Party of China held in 1992, the establishment of the "socialist market economy" was confirmed as the goal of the Chinese economic reform and, correspondingly, "market-oriented" became the reform direction of the construction industry (Brandt and Rawski, 2008). Before 1996, China had no unified construction law (Huang et al., 2013). In 1997, the Construction Law was issued and Mr Hou Jie, the Minister of the Construction Ministry at that time, stated that, when drafting this law, the first principle was that this law must establish the key market mechanisms for the Chinese construction industry to contribute to the overall socialist market economy (Hou, 1996). The Construction Law established many market mechanisms such as project approval procedures and tendering and bidding mechanism (SCNPC, 1997). Later, in 1999, the Tendering and Bidding Law and the Contract Law were issued which further promoted the market-oriented reform of the construction industry. After the Tendering and Bidding

Law was introduced, it became a legal requirement to award all public contracts through bidding procedures (Shen et al., 2004; SCNPC, 1999). The market-oriented reform has been successful in terms of stimulating the economic growth of the industry. In 1992, the GOA and GVA of the construction industry were 217.4 billion CNY and 61.4 billion CNY, respectively, and in 2001, they soared to 1536.1 billion CNY and 402.3 billion CNY, increasing by an astonishing 607.8% and 559.0%, respectively. The GVAI was 853.3 in 2001, indicating that, excluding the influence of price fluctuation, the actual economic scale of the Chinese construction industry in 2001 increased by 753.3% compared to what it had been in 1978. In 2001, the employment generated by the construction industry exceeded 20 million for the first time.

2.5.1.3 Third stage: internationalization and increasing economic competitiveness

In December 2001, China was formally admitted to the World Trade Organization (WTO) and made the commitment to liberalize the construction market (Xu et al., 2005). Constraints on foreign participation were gradually abolished and, at the same time, a growing number of Chinese construction firms entered the international market (Huang et al., 2013). The increasing internationalization of the Chinese construction industry is providing opportunities for Chinese firms to learn from their more advanced foreign peers and China is perceived to be the country gaining from this internationalization process (Lu et al., 2013a). Commencing from 2001, the construction of a large number of high-technology (high-tech) and iconic projects have been completed in China, such as the Three Gorges Dam, Beijing National Stadium, CCTV headquarters, Jiaozhou Bay Bridge, Qinghai–Tibet Railway, etc. The leading Chinese construction corporations have the capability to construct these megaprojects, reflecting the increasing economic competitiveness of the industry. In order to develop these complex projects, advanced technologies are researched and adopted (Zhao et al., 2009). The Ministry of Housing and Urban-Rural Development (MHUD) has identified China’s technological strength in the construction industry in the industry’s 12th strategic development plan. According to this plan, China currently is a leader in many technological areas, including the construction of super high-rise and long-span buildings; the construction of long-span bridges; the design, construction and installation of large industrial facilities; the construction of massive concrete dams; the construction of sophisticated steel structures; and the design and construction of high-speed railways and ultra-high voltage transmission projects (MHUD, 2011a). Many large construction corporations have increased their investment in research and development (R&D), by establishing technology development management systems and centres (MHUD, 2011a). On a global scale, five Chinese construction firms have been ranked in the top 10 global contractors for many years, and China has the most international construction firms in a list of the top 225 firms (Huang et al., 2013).

2.5.2 Evolution of industry composition

Since 1995, China has differentiated three major types of firms in its collection of statistical information, namely, domestic-funded firms, foreign-funded firms (FFFs) and Hong Kong, Macao and Taiwan-funded firms (HMTFFs) (Huang et al., 2013). The domestic funded firms are further divided into many categories: in the construction industry, three kinds of domestic funded firms are differentiated, namely, state-owned enterprises (SOEs), urban and rural collectives (URCs) and other types of domestic firms (OTDFs) which are usually owned by the private sector (NBS, 2013d). The statistical information from 2005 on these kinds of construction firms can be found in the database of the National Bureau of Statistics (NBS) of China (see NBS, 2014). Fig. 2.7 shows the evolution of the number of these firms from 1995.

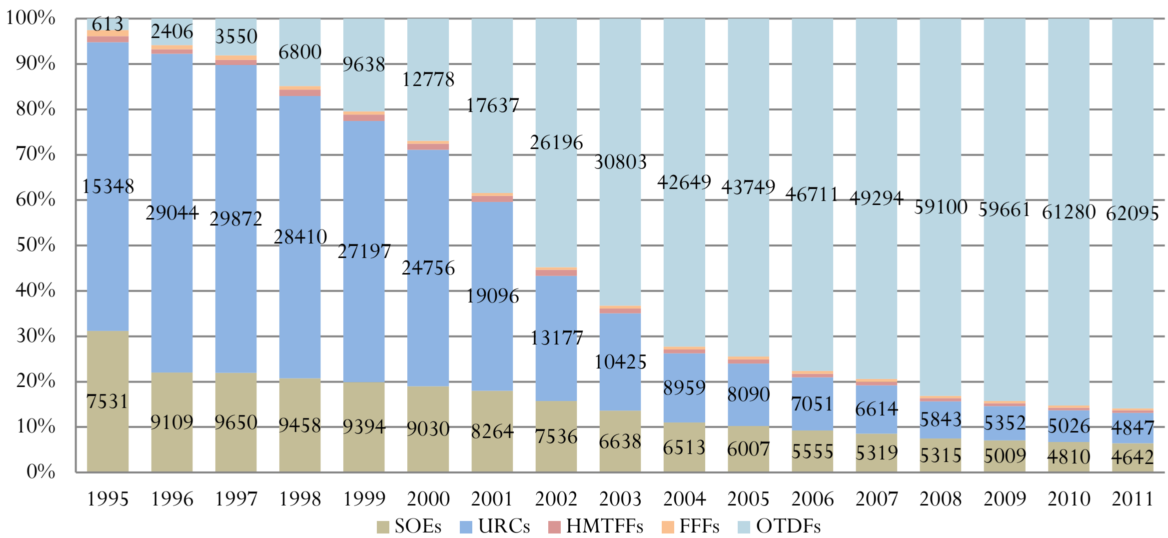

Figure 2.7 Evolution of construction industry composition

As is clearly shown on Fig. 2.7, the structure of the Chinese construction industry experienced a dramatic change during the last two decades. In 1995, the dominant types of firms were URCs and SOEs, comprising more than 90% of construction enterprises. However, in 2011, the percentage of these two types of firms drastically decreased to around 10% while the OTDFs become the dominant firm type in the construction industry, accounting for almost 90% of all firms. This industry structure transformation can be explained by the market-oriented reform of the industry that started in 1992, when the government began to strongly promote private firms (Huang et al., 2013). However, even though the number of SOEs accounted for only 6.4% of all construction firms in 2011, SOEs contributed to 17.5% of the total GOV of the industry, indicating that the average scale of SOEs is much larger than that of OTDFs (NBS, 2014). It is also clearly shown in Fig. 2.7 that the numbers of HMTFFs and FFFs are very small compared to other types of firms. In 2011, only 393 HMTFFs and 303 FFFs were operating in China, accounting for 0.96% of the total firms. Many factors have led to the low market share of FFFs in China. Shen et al. (2006b) list some key challenges facing FFFs operating in China, including: higher production cost; limited channels for market information; lack of knowledge on regulation; and limited business relationships. Similarly, Zhao et al. (2011) indicate that the Chinese government is promoting the growth of domestic private enterprises and, consequently, FFFs face severe competition from the increasing number of domestic firms.

2.5.3 Sustainability research on Chinese construction enterprises

Various studies have been conducted to investigate the Chinese construction industry’s sustainability issues, for example, exploring sustainable construction practices (Mao et al., 2013; Tan et al., 2011; Zuo and Zhao, 2014) and driving forces for and barriers to sustainability (Shi et al., 2013; Zhang et al., 2011a; Zhang et al., 2012). To demonstrate whether Chinese construction enterprises embrace sustainability, this section summarizes the relevant literature into the three dimensions of sustainability: economic, social and environmental dimensions.

2.5.3.1 Economic sustainability

Economic sustainability involves the economic performance of construction firms and the factors influencing performance, such as quality management, human resources and technology. Specifically, the employees of Chinese construction enterprises are mainly unskilled workers who previously were farmers and who have had no proper training for construction (Xu et al., 2005). The lack of well-trained human resources is one of the most serious weaknesses contributing to the poor business performance of many construction corporations in China (Zhao et al., 2009). Similarly, the applications of information technology (IT) and e-commerce are progressing relatively slowly (Xu et al., 2005). Mao et al. (2013) discovered that Chinese developers are reluctant to adopt off-site construction technologies due to the lack of government incentives and the dependence on traditional construction methods. In addition, the 12th Five-Year Development Plan of the Construction Industry[2], issued by the central government, indicates that many irregular practices commonly exist in the industry, including contracting out projects to contractors who have no qualifications or whose qualifications do not meet legal requirements, failure to enforce compulsory standards, using the name of another enterprise to undertake projects (*gua kao*), using inferior materials and conducting fake bidding processes (MHUD, 2011a).

The competitiveness research field specifically focuses on economic performance. Shen et al. (2006a) reviewed the contractor competitiveness indicators presented in previous studies and compiled them into a comprehensive list of 45 contractor competitiveness indicators. They surveyed Chinese contractors and discovered that the top 10 most important indicators are: construction time, tendering price, site management ability, experience in operating similar projects, quality plan, construction method, technology capacity, availability of key personnel, construction program and existing human resources (Shen et al., 2006a). Similarly, Lu et al. (2008) identified 35 critical success factors for

[2] China's Five-Year Plans are a series of social and economic development initiatives which are established for the entire country and normally contain detailed economic development guidelines for all its regions. Proposed by the Ministry of Housing and Urban-Rural Development (MHUD), the 12th Five-Year Development Plan of the Construction Industry provides guidelines for the construction industry during 2011–2015.

contractor competitiveness and investigated Chinese contractors' perceptions on these factors. Their study found that the most critical success factors for the surveyed contractors include bidding strategy, competitive strategy and relationship with the government, while factors such as health and safety management, and environmental management were not highly ranked. This is echoed by the 12th Five-Year Development Plan of the Construction Industry which states that:

> *the development of the construction industry is highly dependent on the high fixed asset investment in China and 1) the industrialization and standardization level of the industry is still low; 2) the industry consumes tremendous resources and causes high emissions; 3) many firms still invest too little on research and 4) trained and experienced professionals are still inadequate and frontline employees lack required skills*. (MHUD, 2011a, p.2-3)

2.5.3.2 Social sustainability

Even though little agreement has been reached on the components of social sustainability, the social aspects of sustainability generally involve various social issues, such as safety, community engagement, human rights, etc. Existing studies have suggested that social sustainability needs to be strongly promoted in the Chinese construction industry. For instance, some social factors, for example, cultural and heritage conservation, and safety standards, are given limited or no consideration at all in the feasibility studies of many projects in China (Shen et al., 2010a). An insightful study was conducted by Wang (2014) who analysed the economic, social and environmental impacts of the construction industry in China. His study concluded that various social sustainability issues are associated with the industry including labour crises, health and safety hazards, and poor awareness of social responsibility. Ye et al. (2015) examined the effect of market competition on the sustainability performance of the Chinese construction industry. They discovered that market competition plays a positive role in social sustainability. In addition, they highlighted that little agreement on the concepts and components of social sustainability is apparent in the literature; thus, an all-inclusive definition of social sustainability is urgently needed (Ye et al., 2015). In a preliminary response to this gap of knowledge, Zeng et al. (2015) developed a systematic framework for major infrastructure projects' social responsibility (MIP-SR) in China. They suggested that the key issues for MIP-SR include immigrant settlement, pollution control, ecological protection, OHS, anti-corruption, disaster prevention and mitigation, and poverty eradication.

In terms of specific aspects of social sustainability, with regard to anti-corruption, Le et al. (2014) investigated the effects of regulation systems and the industrial climate on the various kinds of corruption vulnerabilities in the Chinese public construction sector, and revealed that regulation systems have a higher influence. With regard to public participation practices, Xie et al. (2014) found that the development of public participation practices in public infrastructure and construction projects in China remains relatively slow, despite the urgent need to promote this mechanism for solving socio-economic and environmental disputes. With regard to social risks, Shi et al. (2015) provided an example of the social risk assessment of an infrastructure project in China. They indicate that social risk can be generated by various issues, for example, unfair house demolition compensation, construction impacts on residents, construction safety and management problems.

2.5.3.3 Environmental sustainability

The environmental sustainability of the Chinese construction industry has received the most attention from existing studies, with various studies illustrating that the industry's environmental performance needs to be significantly improved. For instance, Xue et al. (2015) measured the changing energy consumption efficiency of the Chinese construction industry from 2004 to 2009, with effective improvement in energy consumption efficiency found in only one province, Guangdong, in the whole reference period. It has also been discovered that the sustainability awareness of most Chinese construction corporations is low. Similarly, Qi et al. (2010) identified 11 green construction practices, such as the implementation of water saving and noise control plans, and discovered that only very few of the surveyed Chinese contractors undertook all the mentioned sustainability practices. Zuo et al. (2012) pointed out that, in the world's top 50 international contractors, most of the Chinese contractors do not have dedicated websites on sustainability, while all of the Japanese contractors have websites addressing sustainability issues.

Studies have been undertaken to investigate the barriers to the implementation of various environmental practices in Chinese construction enterprises. For instance, Zhang et al. (2015) conducted three case studies to investigate the implementation of environmental management in Chinese construction enterprises. They suggested that implementation was not satisfactory due to significant barriers, such as the conflict between cost and environmental performance, the passive response culture within the industry and the lack of support and coordination by clients. Jiang et al. (2013) analysed the barriers to energy conservation and carbon reduction in China's commercial buildings, and indicated that most investors do not assign the improvement of energy efficiency as a priority, while constructors have to deal with a number of barriers related to technology, risks, maintenance and costs. Similarly, Du et al. (2014) discovered stakeholders' reluctance to use energy-saving technologies and their high initial cost are the most significant barriers to the adoption of these technologies in the Chinese building sector. Focusing on an examination of owners, Gan et al. (2015) identified that issues related to economic feasibility, awareness and legislation are the most important factors impeding owners from pursuing sustainability. With regard to green buildings, Zhang et al. (2011a) analysed the additional costs of three types of green buildings and found that the higher costs have hindered the extensive application of green technologies in China. With regard to green construction practices, Shi et al. (2013) adopted a questionnaire survey approach to investigate the most critical barriers and found that the three most critical barriers are "additional cost", "incremental time" and "limited availability of green suppliers and information".

Likewise, another array of studies has explored the driving forces for environmental sustainability in the Chinese construction industry. For instance, Zhang et al. (2011b) explored the benefits of applying green strategies in the process of housing development and facilities management. They discovered that housing developers believe that the application of green technologies can contribute to reputation gains, reduction in construction and operation costs, receiving favourable land prices and having more channels available for financing. Qi et al. (2010) provided evidence that managerial concerns and government regulatory pressures are the two most important driving forces for green construction. However, it appeared that project stakeholder pressures do not have a major significant effect on green construction practices (Qi et al., 2010). Similarly, Zhang and Zhou (2015) argued that carbon reduction regulations positively correlate with Chinese construction contractors' carbon reduction awareness and behaviours.

2.6 Gap of knowledge in research on sustainability in construction enterprises

Even though various studies have been conducted, broadly, on sustainability issues in construction enterprises and, specifically, on Chinese construction enterprises, several key gaps of knowledge exist in this field of research. This section provides a critical reflection on the literature reviewed in Sections 2.4.2 and 2.5.3, and discusses the four major gaps of knowledge.

2.6.1 Sustainability perceptions and performance

> [*Gap 1: What are the construction enterprises' perceptions of and performance on the holistic sustainability concept including the economic, social and environmental dimensions?*]

It has been reported that the uptake of sustainability practices in construction industries is relatively low in many countries, such as Chile (Serpell et al., 2013), South Africa (Othman, 2009) and China (Qi et al., 2010). There is no lack of studies examining the social or environmental aspects of sustainability in construction enterprises. However, there is a lack of studies that have holistically considered all the three dimensions of sustainability. Existing studies in the construction industry have predominantly focused on the environmental dimension of sustainability, such as energy conservation and green construction technologies. In contrast, few studies have attempted to holistically explore the economic, social and environmental dimensions of sustainability in the construction industry. Furthermore, existing studies have placed much emphasis on the technological innovations of sustainability, such as energy-saving technologies, while studies on social and managerial practices, and the behaviours of construction firms are largely overlooked. Without a holistic approach, existing studies have been inadequate in capturing the complete picture of sustainability in construction enterprises.

Moreover, few existing studies have explicitly differentiated the sustainability perceptions and performance of construction enterprises. The sustainability aspects that are deemed to be important by these enterprises do not necessarily lead to their high-performance levels. Some studies have investigated firms' perceptions of the importance of sustainability, for example, Zainul Abidin (2010) who suggested that, for many developers in Malaysia, survival is assigned a more important priority than environmental sustainability. Some studies have investigated how the implementation of sustainability practices reflects the performance levels of sustainability, for example, Qi et al. (2010). Few studies have simultaneously investigated the importance and performance of the holistic sustainability concept in construction enterprises, thereby comparing the perception and performance levels.

Existing studies have also suggested that firms' sustainability perceptions and performance may be associated with firm size. Small businesses tend to have fewer technological options and, thus, face greater capability barriers to the adoption of sustainability (Kostka et al., 2013). Previous studies, for example, Zainul Abidin (2010) have argued that larger construction firms tend to have higher awareness of environmental sustainability than their smaller counterparts. However, these studies have not been based on statistical evidence, focusing only on the environmental aspects without holistically examining the impact of firm size on the sustainability concept covering economic, social and environmental dimensions.

These questions are particularly important for China where there is a lack of empirical studies exploring the influences of firm size on the sustainability perceptions or performance of Chinese construction firms. Current national programs and policies in China that are related to sustainability issues, such as energy conservation, predominantly focus on regulating large, state-owned enterprises (Kostka et al., 2013). It is well known that government policies play a critical role in improving the sustainability perceptions and performance of firms (Zeng et al., 2011). Meanwhile, pressures from the public and the media could also be stronger for larger firms. Zeng et al. (2011) argued that, in China, the impacts of environmental organizations and media attention on large enterprises are much stronger than those on small and medium-sized enterprises. As a result, it is likely that, compared to small and medium-sized enterprises, larger construction firms in China could attach more importance to sustainability issues. On the other hand, Du et al. (2014) examined obstacles to the adoption of energy-saving technologies in the Chinese construction industry, with their study indicating that large firms surprisingly perceive stronger barriers than small firms. Du et al. (2014) speculated that large construction firms are more likely to encounter operational barriers due to their diverse businesses. It remains unclear how firm size is associated with firms' sustainability perceptions and performance in the Chinese construction industry.

2.6.2 Policy instruments

[Gap 2: What are the measures taken by governments to facilitate sustainability movement in construction industries and the associated strengths and weaknesses?]

Many factors have been identified that influence the adoption of sustainable construction practices. One of the most important factors is argued to be government policy. From a driving force perspective, Son et al. (2011) surveyed constructors from the US and Korea, and discovered that government policies have significant impacts on the sustainability knowledge of constructors. Similarly, Circo (2007) argued that "meaningful progress towards sustainability in the U.S. building industry requires state-level legislation that promotes, and sometimes even mandates, green building standards at the regional and local levels."

In the context of China, Qi et al. (2010) demonstrated that government regulatory pressures and managerial concerns are the two most important driving forces for green construction. Similarly, Zhang and Zhou (2015) argued that carbon reduction regulations positively correlate with Chinese construction contractors' carbon reduction awareness and behaviours. The important role of policy in providing financial incentives and promoting green procurement in China was also illustrated by Shi et al. (2013) and Gan et al. (2015).

From a barrier perspective, the lack of financial incentives from the government in Chile was found to be a prominent barrier to sustainable construction (Serpell et al., 2013). Similarly, Zhang et al. (2012) found that, in China, the lack of promotion and incentives from governments is one of the most crucial barriers to the implementation of extensive green roof features in buildings. Despite these previous studies, little work has been undertaken to investigate the actual laws, regulations and policies used by governments to promote sustainable construction. This is particularly important for China. Traditionally, China has adopted a centrally planned economic system, with the market-oriented reform of the construction industry starting in 1992. However, the market economy in China is a socialist market economy on which the government policy has a strong influence. For instance, even though most of the state-owned construction corporations became isolated from their ministries after the economic reform, they continue to be controlled by the State Council through the State-owned Assets Supervision and Administration Commission (SASAC). Senior management members of most important state-owned corporations, including many construction corporations, are appointed by the SASAC, rather than selected by the corporations (Lu et al., 2013a).

To promote sustainability in the construction industry, the Chinese government has developed and implemented a number of laws, regulations and policies, such as the *Environmental Impact Assessment Law* (NPC, 2002); the *Regulation on Energy Conservation in Civil Buildings* (SCC, 2008a); and the *Action Plan for Promoting Green Buildings* (NDRC and MHUD, 2013). However, few existing studies have specifically investigated how the Chinese government is responding to the sustainability issues of construction enterprises. What are the measures that the Chinese government has taken to promote sustainability in the construction industry? What are the strengths and weaknesses of these measures? These questions need to be further explored.

2.6.3 Transition towards sustainability under constrained resources

[Gap 3: How could construction firms with constrained resources transition towards sustainability?]

In addition to the importance of the government policy as identified above, existing studies on the drivers for and barriers to sustainability also predominantly suggest that substantial barriers related to capability and resources exist which impede construction enterprises worldwide from adopting sustainability practices. For instance, Du et al. (2014) pinpointed stakeholders' reluctance to use energy-saving technologies and their high initial cost to be the most significant barriers to their adoption in the Chinese building sector. In

Malaysia, small developers are not paying attention to sustainable implementation in their projects due to the limited understanding of sustainability and their concerns about extra cost (Zainul Abidin, 2010). Similarly, in Chile, Serpell et al. (2013) argued that Chilean construction firms are at an early stage of achieving sustainable development and their practices towards sustainability are highly influenced by their technological capability and financial strength, with this reflected by their firm size. Due to constraints and limitations of various resources, for example, monetary, technological and human resources, Chinese construction enterprises also experience difficulties in implementing sustainable construction practices (Shi et al., 2013).

However, even though the existence of resource barriers to sustainability is well recognized, few studies have provided strategic guidance for construction enterprises about how they could efficiently transition towards higher sustainability levels under constrained resources. In particular, with different strategic choices and business conditions, firms will have different levels of sustainability performance. For instance, firms' strategic sustainability behaviour could range from resistant and reactive, to anticipatory and innovation-based, and, finally, to sustainability-rooted (Klewitz and Hansen, 2014). Given this complexity, it is imperative to explore the sustainability perceptions and performances of construction firms with different levels of performance in sustainability. Do construction enterprises with different performance levels have different sustainability perceptions? What are the priorities for firms with different performance levels? More importantly, for firms with low sustainability levels, how can they improve their sustainability levels under the constraints of the various capability and resource barriers? These important questions remain underexplored in the literature.

2.6.4 Theory and mechanisms

[Gap 4: How can one gain an understanding of the complex mechanisms behind transformation towards sustainability in the construction industry?]

In the research fields of corporate sustainability (CS) and CSR in construction enterprises (Section 2.4.2), existing studies have mainly addressed the following three themes: what corporate sustainability (CS) or CSR means to construction firms (Jones et al., 2010; Zuo et al., 2012); how construction firms performed in CSR and corporate sustainability (CS) (Othman, 2009; Barthorpe, 2010); and how to improve firms' sustainability performance (Presley and Meade, 2010; Sarkis et al., 2012). However, it is important to note that knowing how to improve sustainability performance does not necessarily lead to actual improvement in sustainability. For instance, Petrovic-Lazarevic (2008) argued that to be recognized as a socially responsible business, construction corporations should emphasize their OHS measures and enhance their relationships with suppliers. However, some corporations may not even want to be socially responsible corporations (e.g. see the literature on corporate social irresponsibility such as Lange and Washburn, 2012; Wagner et al., 2008) or they are willing but fail to do so owing to enormous resource and capability barriers (Section 2.6.3).

The research studies on drivers for and barriers to sustainability aim to provide insights on how to motivate construction enterprises to adopt sustainable construction practices. However, few of these studies are underpinned by solid academic theories and, thus, they remain very unsystematic and fragmented. For instance, most of these studies on drivers and barriers have employed questionnaire surveys. Various questionnaires have been developed to collect empirical information. However, few studies have attempted to explain the underlying theories supporting these questionnaires. The consequence of the lack of coherent theory in this field is that different scholars find different key factors driving or impacting on the sustainability of construction enterprises, such as government policy, costs, awareness, stakeholder pressure, technology, local environmental and social issues, risks, etc. As a large number of factors has been found, the core mechanisms impacting on the transformation towards sustainability in the construction industry seem very obscure.

As a coherent description or explanation of phenomena, theories explore why and how acts, events and thoughts occur, helping researchers to understand, describe, explain and predict phenomena (Colquitt and Zapata-Phelan, 2007; Gioia and Pitre, 1990; Sutton and Staw, 1995). Thus, theories play a significant role in human inquiry. To respond to the deficiencies of the existing studies on drivers for and barriers to sustainability, it is urgent that an appropriate theory be identified, with this theory capable of not only synthesizing all the different drivers and barriers in order to generate a holistic understanding, but also able to reveal the core mechanisms behind sustainability movements in the construction industry.

2.7 Summary

This chapter has systematically reviewed: 1) the concept of sustainability; 2) the theories explaining sustainability in enterprises (CSR, stakeholder theory, corporate sustainability [CS] and the TBL, and green policies); 3) sustainability research in the construction industry in general (sustainable construction, corporate sustainability [CS] and CSR research, drivers for and barriers to sustainability); and 4) the Chinese construction industry and the sustainability research on this industry. Based on this holistic literature review, this chapter concluded with a critical discussion of the existing sustainability studies of the construction industry, including the Chinese construction industry. Four gaps of knowledge have been identified. Thus, this chapter has fulfilled ***Research Objective 1***. In accordance with the four gaps of knowledge, the four major implications for the following chapters can be summarized as follows:

- A holistic examination of the various sustainability aspects (comprising the economic, social and environmental dimensions of sustainability) needs to be conducted to investigate Chinese construction firms' perceptions and performance on these various aspects. Based on the data, it is also possible to explore the associations between firm size, sustainability perceptions and sustainability performance.
- The review of green economics has shown that green policies can promote sustainability practices in industries through altering the business environment. The review of the construction studies also indicates that government policy is one of the most important factors influencing construction firms' sustainability strategies. Thus, it is important to explore the policy system that China has developed to promote sustainability in construction firms.

- Resource and capability barriers have been extensively discussed but few studies have explored how construction firms with resource constraints could transition towards sustainability. Contributions could be made in this area of research.
- Few of the studies on drivers and barriers are underpinned by academic theories, leading to the fragmentation of this research area. It is urgent that a theory be identified that could explain the underlying mechanism of promoting sustainability in the construction industry.

Chapter 3 Approaches to sustainability transition

3.1 Introduction

In response to ***Research Objective 2*** (to review the approaches to sustainability transition), this section aims to systematically introduce the various approaches to sustainability transition and to develop a research plan for this study. The previous chapter has illustrated that a lack of theory has led to fragmentation and poor conceptualization of sustainability movements in the existing literature. The transition perspective introduced in this chapter could enhance the existing literature on this aspect.

To be specific, firstly, a comparison of the sustainability transition perspective with other approaches to sustainability is provided to explain the features and strengths of the transition perspective. The concepts of transition and sustainability transition are then explained, followed by the various approaches that emerged in the transition literature, which included the multi-phase concept, multi-level perspective, strategic niche management, transition management and the triple embeddedness framework. A comparison is provided between these various approaches to sustainability transition, with a summary presented of the key mechanisms of transition towards sustainability implied by these approaches. This chapter then links the transition literature with the construction literature discussed in the previous chapter, to analyse how these two strands of studies could inform each other and the possibility of adopting the transition perspective to study the sustainability of Chinese construction enterprises. A research plan built on this discussion is developed for this study, the findings of which could contribute to the body of knowledge in both the construction and transition fields. The literature review presented in this chapter has been summarized into the paper, *"Approaches for transitions towards sustainable development: Status quo and challenges"*, which has already been accepted for publication *in* ***Sustainable Development*** (please see p.299).

3.2 Sustainability transition perspective: strengths and concepts

3.2.1 Comparison of sustainability transition perspective with other sustainability approaches

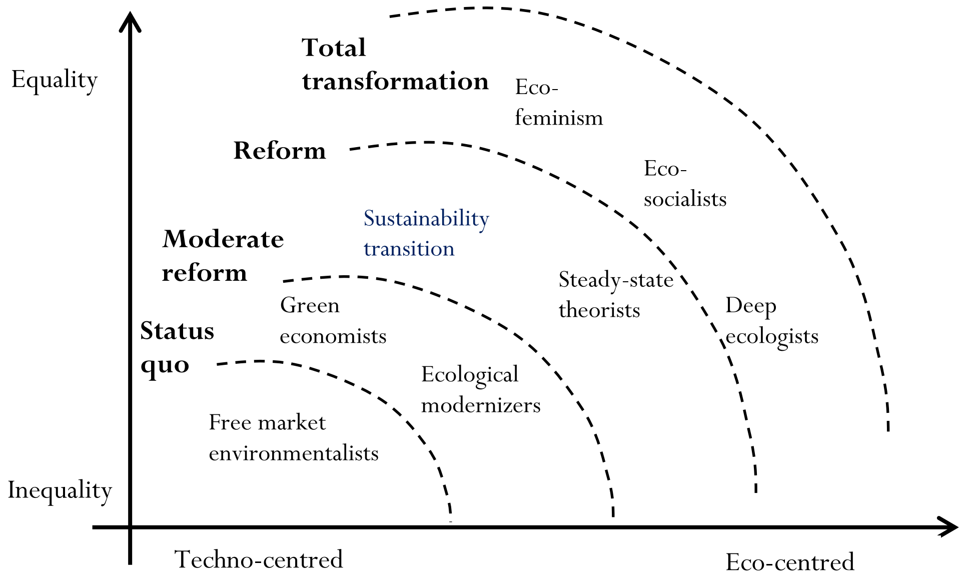

Figure 3.1 Mapping of different approaches to sustainability
Sources: adapted from Geels et al. (2008), McManus (1996) and Hopwood et al. (2005)

Table 3.1 Key points of different approaches to sustainability

Approaches	Dominant background	Critique of	Main argument
Free market environmentalists	Economists, Business People	Government intervention	Environmental problems can be solved by private ownership of the "commons" for the pursuit of profit which requires a free market.
Green economists	Economists	Market imperfection	Environmental problems are negative externalities resulting from market failures which need to be tackled through changing incentives such as taxes.
Ecological modernizers	Socialists	Unenlightened self-interest	Smart innovations and clean technologies need to be strongly promoted to achieve sustainable development.
Steady-state theorists	Economists	Growth	Continuous economic growth has limits, and to achieve sustainability, the economy should feature stable population and stable consumption that remain at or below carrying capacity.
Eco-feminism	Feminists	Patriarchy	There is a relationship between the degradation of the environment and the subordination of women.
Eco-socialists	Marxists	Capitalism	The expansion of capitalism is the cause of social exclusion, poverty and environmental degradation.
Deep ecologists	Ecologists	Anthropocentrism	Environmental problems are fundamentally related to the values of modernity which should be rejected and replaced with deep green lifestyles.

Sources: created by the author based on Geels et al. (2008), McManus (1996) and Hopwood et al. (2005)

To explain the strengths of the transition approach, it is necessary to briefly review existing approaches to sustainability and compare them with the transition approach. Fig. 3.1 provides a visual representation of these approaches, which are differentiated based on two dimensions, namely, the degree of environmental concern (from techno-centred to eco-centred) and the degree of equality concern (from inequality to equality) (Hopwood et al., 2005). These different approaches are further divided into four groups based on the magnitude of changes that they imply: status quo, moderate reform, reform and total transformation. It is important to note that Fig. 3.1 is a broad conceptual presentation rather than a precise mapping (the latter is not the purpose of this section). Thus, the different approaches are roughly located against the two axes. It is also important to note that Fig. 3.1 by no means represents an exhaustive coverage of all approaches to sustainability. However, it does represent the common response strategies to sustainability. The key points of the approaches displayed in Fig. 3.1 are summarized in Table 3.1.

According to free market theory, all forms of capital have unlimited substitutability which means that human-made capital and natural capital are interchangeable. In neoclassical economic theory, prices and outputs are determined by supply and demand, and the underlying mechanism of this determination is a hypothesized maximization of utility by individuals and profits by firms based on rational choices (Gravelle, 2004). For firms, human capital and natural capital are inputs for the production of goods. Even though natural capital is damaged, as long as human capital is growing, production can be maintained and human beings can be sustained. The fundamental assumption of this substitutability is the usefulness of our technology (Clapp, 2011). In this approach, limits to growth are not seen as necessary as they can be overcome by technologies. Free market environmentalists believe that the major drivers for current environmental degradation are the lack of economic growth and the lack of freedom in our economy (Clapp, 2011). They believe that, as the economy is not strong enough, poverty arises which causes environmental problems. The lack of freedom in the economy and the ambiguity in property rights weaken the technological innovation ability. If the economy grows to a certain degree and the property rights of natural resources are clearly specified, environmental problems will be automatically eradicated by the economy and technology.

Compared to free market environmentalists, green economists also believe in the so-called free market, but they realize that the market does not always send appropriate signals (McManus, 1996). This inability to send appropriate signals is market failure. Weber and Rohracher (2012) adopted a sustainability transition perspective to summarize all kinds of key failures by our society in dealing with sustainability innovation. According to their research, the three major types of failures are: market failures, structural system failures and transformational system failures. To be specific, market failures include information asymmetry, knowledge spill-over, externalization of costs and over-exploitation of the commons (Weber and Rohracher, 2012). Unlike free market believers, green economists insist that the government should intervene in the market to respond to these market failures. Possible interventions could be establishing green taxes, putting forward green incentives, increasing the prices of natural resources, etc. Also in the moderate reform category is the approach of the ecological modernizers whose focus is clean technologies. Based on the idea of enlightened self-interest, which means that people who act to further the interests of others will ultimately serve their own self-interests ("do well by doing good"), ecological modernizers argue that the economy and ecology can be favourably combined through adopting green innovations, such as reuse and recycling, eco-efficiency, dematerialization and the closing of materials loops (Geels et al., 2008).

Unlike the approaches in the status quo and moderate reform, approaches to reform and total transformation advocate more drastic changes. To be specific, steady-state economists insist on controlling the size of the population to achieve a zero growth state, and believe that trade should be conducted on a regional scale rather than on an international scale to avoid excess consumption of resources (McManus, 1996). Eco-feminism criticizes the male-dominant society which, in this approach, is viewed as inevitably generating hierarchies and violence, while non-male-centred society places its emphasis on nurturing and participation (Harcourt, 1994). Eco-feminism calls for the reconstruction of the whole society based on non-competitive human relationships. Eco-socialists attempt to develop conceptions of a sustainable future based on socialist approaches and values (McManus, 1996). Deep ecologists relate environmental problems to the failures of modernism, capitalism and, especially, of anthropocentrism: they advocate cultural change towards eco-centrist approaches, such as the "mirror of nature" approach (Geels, 2012). The "mirror of nature" approach is commonly associated with physicists, biologists and some deep ecologists who believe that human society should be totally changed to mimic the process of nature, as nature is seen as perfection in sustainability. All four of these approaches indicate that the current operation of society needs to be drastically reformed, or even totally transformed, as a response to the issue of sustainability.

Despite the valuable insights on sustainability movements, these approaches have several deficiencies. To be specific, within the category of total transformation, eco-feminism, eco-socialists and deep ecologists argue for drastic changes which restricts the feasibility of these approaches. In the current background of population growth, it is also unlikely that a steady-state economy can be achieved within a short period of time. In neglecting the existence of market failures, free market environmentalists have been criticized as they have no method of dealing with collective problems such as natural resource depletion (Friedman, 1992). Currently, therefore, the methodology of green economists dominates policy discussions (Geels, 2012) (see also Section 2.3.4). The main argument of green economists is that sustainability issues lead to the scarcity of resources which translates into their higher prices which will, in turn, motivate customers and firms to find optimal solutions: thus, the government should internalize external costs to accelerate these price changes (Geels, 2012). However, the price mechanism advocated by green economists is not adequate for promoting radical sustainability innovations which feature a high level of uncertainty (Geels et al., 2008), nor is it able to cope with the complex nature of various sustainability issues, such as climate change (Hoffmann, 2011). Similarly, even though ecological modernizers focus on green innovations, including radical innovations, they offer few insights on how to disseminate green innovations to facilitate large-scale societal changes towards sustainability.

More fundamentally, various lock-in mechanisms stabilize many existing systems. This means that, once adopted, an activity provides an increasing level of benefits. Thus, over time, it becomes increasingly difficult to "transform the pattern and select previously available alternatives" (Mahoney, 2000). For instance, previous studies have shown that not only industrial economies but also rapidly industrializing countries, such as China and India, are becoming locked into fossil fuel-based technological systems (Unruh and Carrillo-Hermosilla, 2006). None of the approaches discussed above offer insights into how existing systems stabilized by various lock-in mechanisms can be reconfigured, transformed or even replaced to become more sustainable. Consequently, a genuine transformation towards sustainability has not yet begun (Helne and Hirvilammi, 2015).

Compared to the approaches discussed above, the sustainability transition approach pays more attention to deeply exploring the complexity involved in changing existing systems that are stabilized by lock-in mechanisms. Originating in the Netherlands, the research field of socio-technical transitions aims to respond to the deficiencies of other approaches to sustainability by digging into historical transitions, for example, from horse-drawn carriages to automobiles, to explore how these shifts take place, thereby providing insights into contemporary sustainability issues. The concept of "socio-technical" is adopted as it is only in association with human agency and social structures that technologies fulfil functions (Geels, 2002). This approach highlights the multi-dimensional interactions between the industry, technology, markets, policy and culture, capturing the complexity of systemic changes towards sustainability (Geels, 2012). A sustainability transition takes place if sustainability is the direction of a certain socio-technical transition. Thus, the transition approach is selected as the theoretical foundation of this study. The following sections will elaborate this approach in detail.

3.2.2 Definitions of socio-technical transitions towards sustainability

The concept of "transitions" was first described by Alex de Tocqueville in the 19th century. He used this concept to describe changes in master–slave relationships and defined it as a period in history in which the ruling class no longer had the strength to stay in power (Lachman, 2013). Later, the term was gradually adopted in other research areas, such as evolutionary biology, demography, technology, the environment, the economy, and studies on power relations (Lachman, 2013; Wilson, 2007). In the 1990s, the "transition" concept was introduced in research on socio-technical systems, and the term "socio-technical transition" emerged (Lachman, 2013). In more recent socio-technical research papers, the term "transition" implicitly denotes "socio-technical transition" as, within this research field, there is no need to stress "socio-technical" (e.g. see Geels, 2005; Geels, 2012; Geels et al., 2008; Markard et al., 2012; Rotmans et al., 2001). However, for scholars in other research fields, the differences between "socio-technical transitions" and "transitions" should be made clear, as there are other "transitions", such as "demographic transitions". For this study, only "socio-technical transitions" will be discussed.

The various definitions of socio-technical transitions include the definition that transitions are shifts from one socio-technical system to another (Grin et al., 2010). A more complex definition is that a transition is a gradual, continuous process of change where the structural character of a society (or a complex sub-system of a society) transforms (Rotmans et al., 2001). Similarly, Alkemade et al. (2011) defined a transition as a fundamental change in the fulfilment of societal needs that can take 25–50 years to complete. Even though these definitions are expressed differently, they have the common interpretations of socio-technical transitions:

1) involving far-reaching changes along different dimensions: technological, organizational, political, economic, behavioural, belief systems and socio-cultural (Markard et al., 2012; Rotmans et al., 2001);
2) requiring interactions between multiple actors, such as the industry, the government, users and social groups (Grin et al., 2010);
3) a long-term process which takes decades to unfold (Geels, 2012; Rotmans et al., 2001);
4) requiring the development and diffusion of a wide range of innovations, including new technologies, policies, standards and social practices (Geels et al., 2008).

In simple terms, a transition is a set of connected changes. These changes need to be completed by various actors in many different areas through the adoption of innovations and, thus, a transition is a long-term process (Rotmans et al., 2001). In the course of a socio-technical transition, new products, services and business models emerge, complementing, or substituting for, existing ones (Geels and Schot, 2007; Markard et al., 2012). Many historical developments have been studied based on a socio-technical transition perspective, for instance, the transition from sailing ships to steamships (Geels, 2002); from horse-drawn carriages to automobiles (Geels, 2005); and from cesspools to sewer systems (Geels, 2006). The usefulness of the socio-technical transition approach has been justified and the main theoretical models of this approach, for instance, the multi-level perspective, have been tested and refined (Geels, 2004, 2011, 2012; Geels and Kemp, 2007; Geels and Schot, 2007; Markard et al., 2012).

The increasing importance of the sustainability concept gradually influenced the debate on socio-technical transitions, and the concept of "sustainability transition" emerged. Sustainability transitions are defined by Markard et al. (2012) as long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption. In other words, sustainability transitions are changes of socio-technical systems towards more sustainable alternatives (Geels, 2011).

3.3 Approaches to sustainability transition

This section explains the mainstream approaches to sustainability transition, including multi-phase concept of transition, transition management, strategic niche management, the triple embeddedness framework and the multi-level perspective of transitions. Firstly, these approaches and the associated key literature are introduced, followed by a comparison of these different approaches to sustainability transitions. Subsequently, the key mechanisms behind sustainability transitions, as indicated by these approaches, are summarized. It is important to note that the field of sustainability transition is rapidly developing, with new approaches constantly appearing. This section only reviews the five common approaches based on the evolutionary ontology which currently is a dominant perspective on transitions and has been widely employed in empirical studies. Other perspectives on transitions are available with these based on other ontologies, for example, relationism. These perspectives are still at the stage of theoretical development and have not been widely utilized in empirical studies. The researchers of this study acknowledge that it will be possible to study the sustainability transition of the construction industry from other newly emerged approaches in the future, with this discussed in the section of "Suggestions for future research" in Chapter 9.

3.3.1 Multi-phase concept (MPC) of transition

Rotmans et al. (2001) systematically illustrated an ideal transition process using the multi-phase concept (MPC) of transition which can be represented by the S-shaped curve and contains four different phases: the predevelopment phase, take-off phase, breakthrough phase and stabilization phase (see Fig. 3.2). In the predevelopment phase, no visible changes happen in the status quo but many sustainability experiments are conducted. In the take-off phase, changes occur and the current system begins to shift. In the breakthrough phase, visible structural changes in various dimensions, for example, cultural, economic, ecological and institutional changes, take place. During the stabilization phase, the pace of change slows down while a new equilibrium emerges (Loorbach 2007). However, transitions of socio-technical systems may not achieve the planned stabilization or may even fail entirely. In considering the MPC of transition, Van der Brugge and Rotmans (2007) proposed other possible pathways.

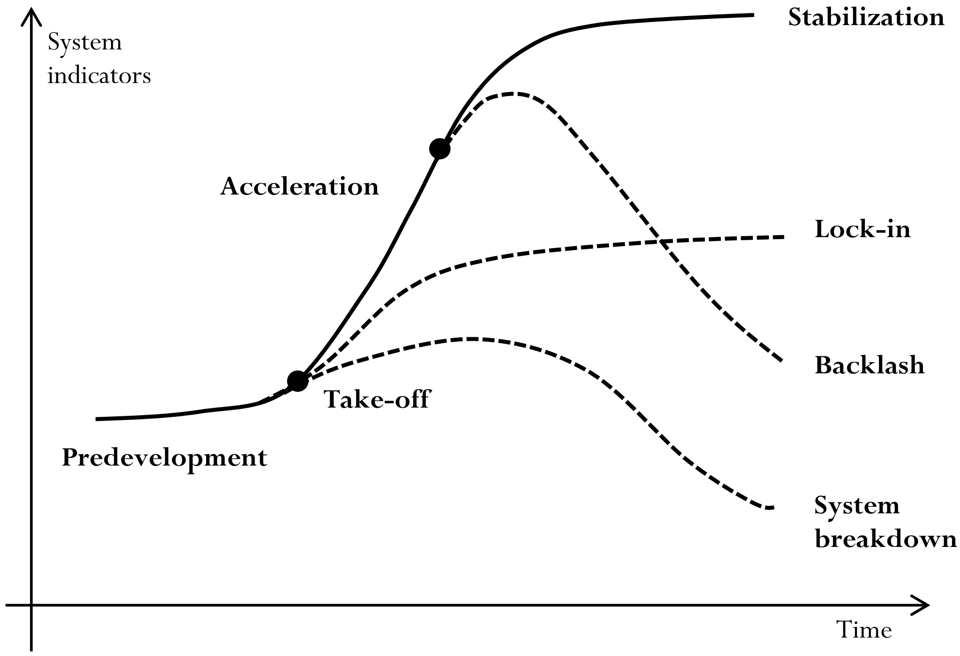

Figure 3.2 Alternatives to S-shaped curve of transition
Source: adapted from Van der Brugge and Rotmans (2007)

According to Van der Brugge and Rotmans (2007), the key for the take-off phase to occur is that sustainability innovations strengthen each other and align into stable innovation networks which succeed in maintaining and reproducing their own organizations. However, in the take-off phase, three outcomes are possible: 1) the innovation networks share a similar goal and they reinforce each other to become strong enough to compete with the existing systems (stabilization); 2) the innovation networks compete with each other which results in less satisfactory outcomes (lock-in); and 3) the innovation networks are all not capable of becoming self-sustaining and, therefore, the transitions fail (system breakdown). Even if the take-off phase has occurred, there is still no guarantee that the transition will be successful. It is possible that the promoted sustainability innovations in the take-off phase have fatal drawbacks that were not well understood and are only revealed in the acceleration phase. Choices made early on can also reduce the diversity of options which would otherwise have helped to make up for the deficiencies (Grin et al., 2010). As a result, a backlash may take place in the acceleration stage.

It is important to clarify that the MPC of transition is not intended as a deterministic concept and cannot be used to predict the course of transitions. Rather, it is a descriptive framework for describing the certain generic patterns of transitions. Grin et al. (2010) argued that to influence the transition, scholars may first need to understand these patterns. Some scholars have recognized the usefulness of the MPC of transition. Frantzeskaki and de Haan (2009), for instance, explained that the MPC of transition distinguishes the transition process in distinct phases with different dynamics, thereby enabling scholars to identify different transition processes in these phases. Nevens and Roorda (2014), and Nevens et al. (2013) used the MPC of transition to explain the application of transition management in creating sustainable cities in Belgium.

3.3.2 Multi-level perspective (MLP) on transitions

Despite its capabilities to identify the four phases of transition, the MPC of transition does not explain why transitions occur. The multi-level perspective (MLP) on transitions provides a useful approach to explain why transitions occur. The initial idea of the MLP on transitions was proposed by Rip and Kemp (1998), while the MLP framework on transitions, which is widely researched today, was developed by Geels (2002). The MLP on transitions views them as non-linear processes that result from the interactions between developments at three levels: the niche, regime and landscape (see Fig. 3.3).

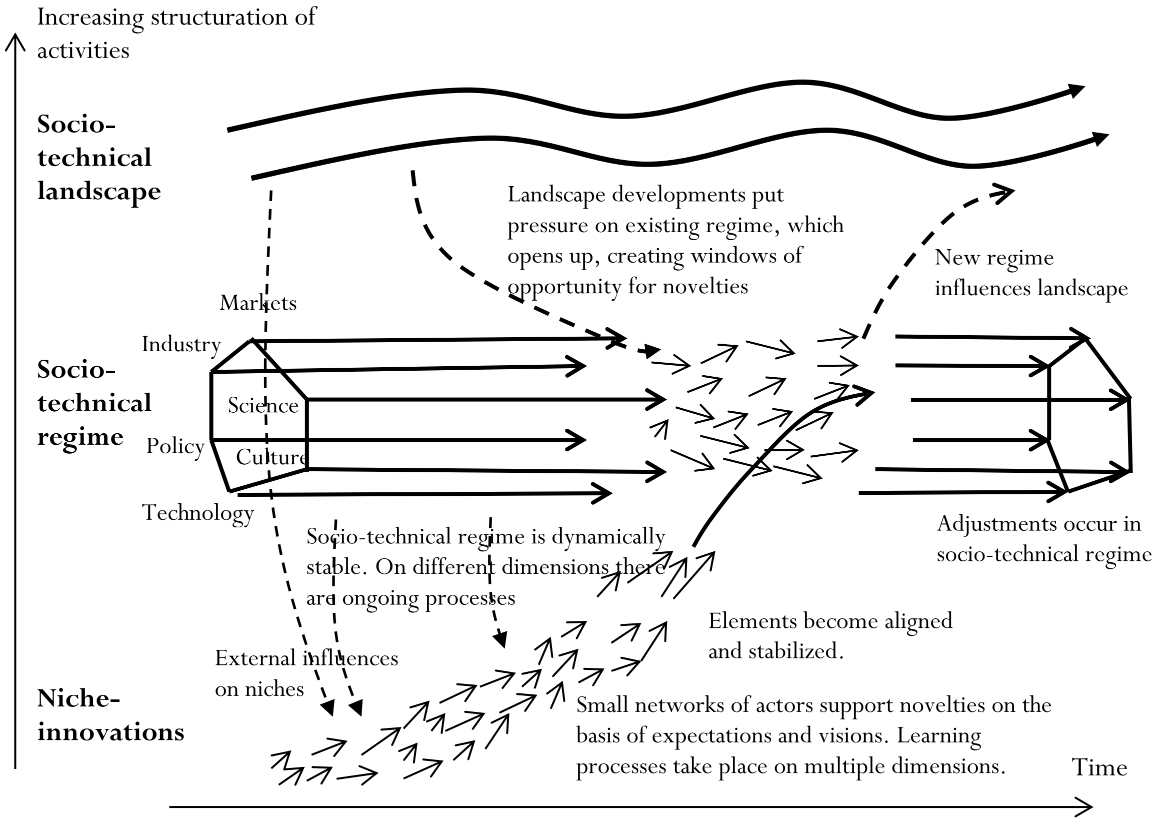

Figure 3.3 Multi-level perspective on transitions
Source: adapted from Geels and Schot (2007)

According to the MLP on transitions, the existing socio-technical systems may change because innovations emerge and challenge the existing systems. Niches are the "protected spaces" of sustainability innovations, for example, subsidized demonstration projects (Geels, 2011). Niches are incubation rooms where innovative activities take place and where time-limited protection is offered to help novelties sustain against selection pressures from the market (Grin et al., 2010; Lachman, 2013). Niches, in essence, provide the seeds for transitions. The actors in niches aim to spread their novelties in the existing system or even to replace it (Geels, 2012).

Even though niches may challenge the current systems, transitions do not easily come about, as existing systems are stabilized by many lock-in mechanisms, in other words, deep-rooted rules (Grin et al., 2010). The established rules and practices form the socio-technical regimes (Geels, 2004). This concept builds on the idea of the technological regime proposed by Nelson and Winter (1977) who argued that cognitive routines are shared in a community of engineers. Geels (2002) widened this idea further by taking more social groups into consideration, such as policy makers, social groups, suppliers and scientists, explaining that the activities of these groups are all guided by rules. Due to these established rules, namely, the socio-technical regimes, the existing systems have stability which makes them difficult to change.

The landscape is the wider context which influences niche and regime dynamics (Rip and Kemp, 1998). According to Driel and Schot (2005), the three types of landscape are: (1) factors that do not change (or change very slowly) (e.g. natural climate); (2) rapid external shocks (e.g. wars); and (3) long-term changes in a particular direction (e.g. climate change). These factors can be analysed in a single "landscape" category as they form the macro context that actors cannot influence in the short term (Grin et al., 2010) and, thus, the landscape represents the greatest degree of structuration beyond the control of individual actors (Geels, 2012). However, this does not mean that the landscape is not associated with human agency as it comprises the aggregations of multitudes of actions that bring about urbanization, globalization and cultural changes (Grin et al., 2010).

The key mechanisms of transitions proposed by the MLP on transitions are that: (1) niche innovations accumulate internal momentum, through learning processes, performance improvements and support from powerful groups; (2) the landscape level creates pressure on the regime, tensions in the regime appear and the regime becomes destabilized; (3) the destabilized regime opens windows, that is, opportunities for niche innovations which then diffuse into the regime (Geels, 2002). To offer a more specific description of different scenarios of transitions, Geels and Schot (2007) further enriched the MLP on transitions by developing a typology of four transition pathways based on different multi-level interactions. These pathways are the: transformative path, reconfiguration path, de-alignment and re-alignment path, and technological substitution.

The MLP approach on transitions has been proposed based on the analysis of many historical case studies of transitions (Geels, 2002; Rip and Kemp, 1998). However, it has great potential to be employed in studying sustainability transitions in contemporary or future contexts, for example, in electricity systems (Foxon et al., 2010; Yuan et al., 2012), in science systems (Schneidewind and Augenstein, 2012) and in transport systems (Geels, 2012). These contemporary studies usually adopt the MLP approach on transitions to explain the ups and downs of niche innovations and the struggles against existing regimes on multiple dimensions (Geels, 2011).

Even though the MLP approach on transitions explains why transitions happen, it mainly operates as a research tool as it does not intend to investigate how to influence or even manage transitions. This issue is addressed by the strategic niche management approach and the transition management approach.

3.3.3 Strategic niche management (SNM)

Proposed by Kemp et al. (1998), strategic niche management (SNM) aims to identify the features of successful niches. Kemp et al. (1998) defined SNM as

> *the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of (1) learning about the desirability of the new technologies and (2) enhancing the further development and the rate of application of the new technology*. (Kemp et al., 1998, p.186)

The work by Kemp et al. (1998) and the later SNM literature distinguished three internal processes for successfully developing a technological niche: the articulation of expectations; the building of social networks; and a multi-dimensional learning process.

To be specific, with regard to the articulation of expectations, Kemp et al. (1998) stated that, in the early years of development, the advantages of a new sustainable innovation are usually not apparent; in addition, it faces many barriers. Expectations of the new technology from the interested actors are crucial provided they are shared, specific and linked to particular societal problems which the existing technology is not able to solve (Kemp et al., 1998). The construction of a social network is another important process. Considering that the development of a new technology may be slowed down or even stopped by regime actors, that is, the actors promoting traditional technologies, new networks should be developed to ensure that the new technology can function as desired (Kemp et al., 1998). In the network, actors' expectations, beliefs, practices and visions should share the same direction and become more explicit and consistent (Hoogma, 2000). Finally, SNM scholars argue that, to eliminate various barriers, learning processes at multiple dimensions are needed, such as learning the possibility and constraints of the innovation, application domains and suitable regulation policies (Caniels and Romijn, 2008).

Kemp et al. (1998) stated that SNM differs from the old “technology-push” approach, by bringing the knowledge of users and other actors into the innovation process and generating interactive learning processes and institutional adaptation. However, some scholars have argued that SNM focuses too much on technological innovation, neglecting a broad visioning process for sustainability. Harborne et al. (2007), for instance, argued that to have a more radical impact, demonstration projects may need to be driven by a clearer guiding vision. Advocated by Rotmans, Loorbach and others, the transition management (TM) approach responds to this deficiency of the SNM approach, emphasizing the importance of creating visions prior to niche-level experiments.

3.3.4 Transition management (TM)

The interest in transition management (TM) has rapidly grown in past decades as an innovative method to tackle complex societal problems (Rotmans et al., 2007). By means of integrating long-term thinking with short-term action, it attempts to manage transitions towards sustainable development (Lachman, 2013). Transition management (TM) combines the socio-technical transition studies with insights from complex systems theory and the governance approach (Markard et al., 2012).

The core of transition management (TM) is a cyclical process model (see Fig. 3.4). This model consists of four components: 1) structuring the sustainability problem and establishing the transition arena; 2) developing a transition agenda (i.e. a vision of sustainable development) and possible transition pathways; 3) establishing and carrying out transition experiments and mobilizing the resulting transition networks; 4) monitoring, evaluating and learning lessons from the experiments, and making adjustments in the vision, agenda and coalition (Loorbach, 2010; Rotmans and Loorbach, 2009). In essence, transition management (TM) creates a social movement about sustainability through new alliances and networks (Loorbach and Rotmans, 2010).

The last decade has witnessed growing attention on transition management (TM) at regional and local levels (Markard et al., 2012). Actual implementation of transition management (TM) has been undertaken, such as in the transition of Parkstad Limburg, a former mining region in the south of the Netherlands (Loorbach, 2007); the roof transition program initiated by the ESHA Group (Loorbach and Wijsman, 2013); the health care transition program initiated by the Dutch Ministry of Health, Welfare and Sports (Loorbach and Rotmans, 2010); and the sustainability transition of the city of Ghent in Belgium (Nevens et al., 2013). In addition, the possibility of applying transition management (TM) in different domains has been explored, such as in higher education (Stephens and Graham, 2010), energy (Meadowcroft, 2009) and water resources (Voß et al., 2009).

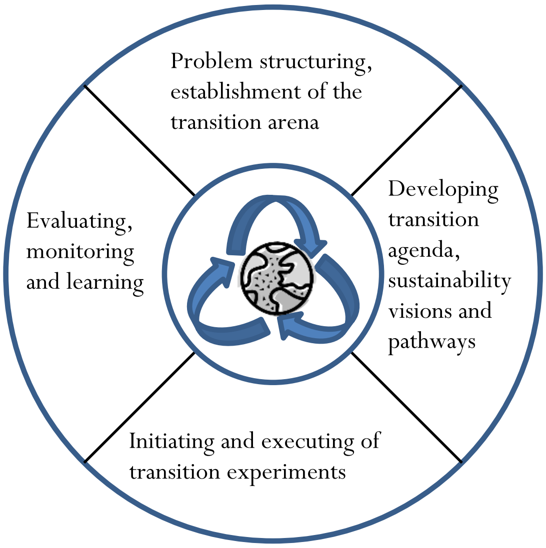

Figure 3.4 Cyclical process model of transition management
Source: adapted from Loorbach and Rotmans (2010)

3.3.5 Triple embeddedness framework (TEF)

Even though SNM and transition management (TM) propose some strategies that attempt to enable the transition process, most of their attention is at the niche level. However, the MLP on transitions implies that, to enable a transition, empowerment at the niche level is not the only element, as developments at the regime and landscape levels are also important. In fact, most scholars in the debate on socio-technical transitions to sustainability focus on the emergence and empowerment at the niche level, such as wind turbines, biofuels and electric vehicles, while the destabilization of existing regimes is assumed to happen along the way and has received far less attention (Turnheim and Geels, 2012, 2013).

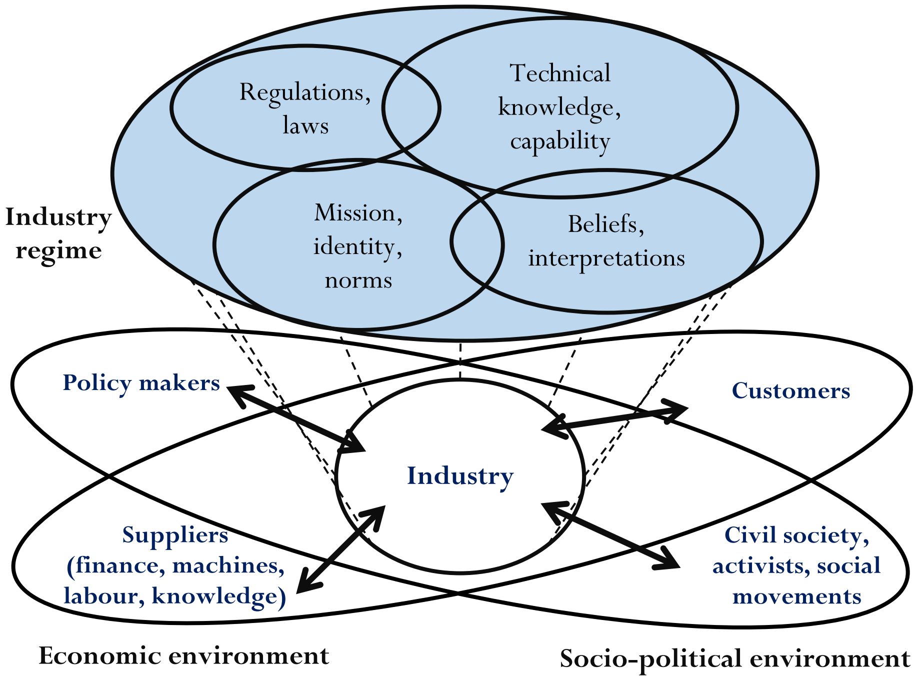

Figure 3.5 Triple embeddedness framework of industries
Source: adapted from Geels (2014)

To explore the mechanisms of regime destabilization, the triple embeddedness framework (TEF) is proposed and, it is argued, is insightful (Geels, 2014; Penna and Geels, 2012; Turnheim and Geels, 2012; Turnheim and Geels, 2013). This framework has been developed to explain the co-evolution between firms and their business environments (Geels, 2014). The three key components involved are: the industry regime, the economic environment and the socio-political environment, as shown in Fig. 3.5 (Geels, 2014). Industries have stability due to the established industry regime, that is, the technical knowledge, mindsets, values and regulations in the industry. However, the industry regime can be gradually changed through the interactions between firms and the economic and socio-political environments (Penna and Geels, 2012). It is the interaction between external business environments and the endogenous strategic responses of firms that drives the transition of industries. The TEF implies that sustainability transition mainly involves two interrelated evolutionary processes, namely: (1) the evolution of the economic and socio-political environments towards sustainability and (2) the evolution of firms' strategic responses to sustainability. These two processes are interrelated to each other and form the co-evolutionary process of sustainability transitions (Geels, 2014; Penna and Geels, 2015).

In terms of business environments evolving towards sustainability, Penna and Geels (2012) proposed a five-phase dialectic issue life-cycle model: (1) affected groups and activists first articulate concerns and criticisms about a sustainability problem; (2) concerns spill over to public debates which put pressure on policy makers; (3) public debates spill over to policy debates and policy makers engage in debates, hearings and investigations; (4) policy makers introduce legislation to address the problem; (5) when public debates and tough policies lead to changes in consumer preferences, thereby changing the firm's economic environment, sustainability may become part of the firm's core beliefs (Penna and Geels, 2012). Rivoli and Waddock (2011) explored how firms react to public issues related to social responsibility, which could be described as a public issue life cycle: first they ignore you, then they laugh at you, then they fight you and then you win. These phase models suggest that it is the socio-political environment which evolves first and then exerts influence on the economic environment which evolves next.

Firms could adopt various strategies to respond to the evolving environment. Geels (2014) proposed four stages for the strategic reorientation of firms towards sustainability: (1) in the first stage, firms tend to deny or downplay sustainability issues raised by actors in socio-political environments, with firms often arguing that problems are temporary and measures to respond to the issues are costly and infeasible; (2) in the second stage, when sustainability issues can no longer be denied, firms engage in a local search for solutions, such as cost-cutting, tighter control, downsizing and incremental technical innovation; (3) in the third stage, firms start to recognize that sustainability issues are structural rather than temporary, and engage in a distant search for solutions, such as changes in the range of products and radical technology innovation; and (4) in the fourth stage, the continuation of sustainability issues triggers firms to rethink their taken-for-granted beliefs, such as their business models, corporate values and core competencies. Firms' strategic reorientation towards sustainability was also illustrated by other phase models. For instance, Klewitz and Hansen (2014) proposed that firms' strategic sustainability behaviour is an evolutionary process, ideally evolving from resistant and reactive, to anticipatory and innovation-based, and finally to becoming sustainability-rooted.

3.3.6 Comparison of the five approaches to transition

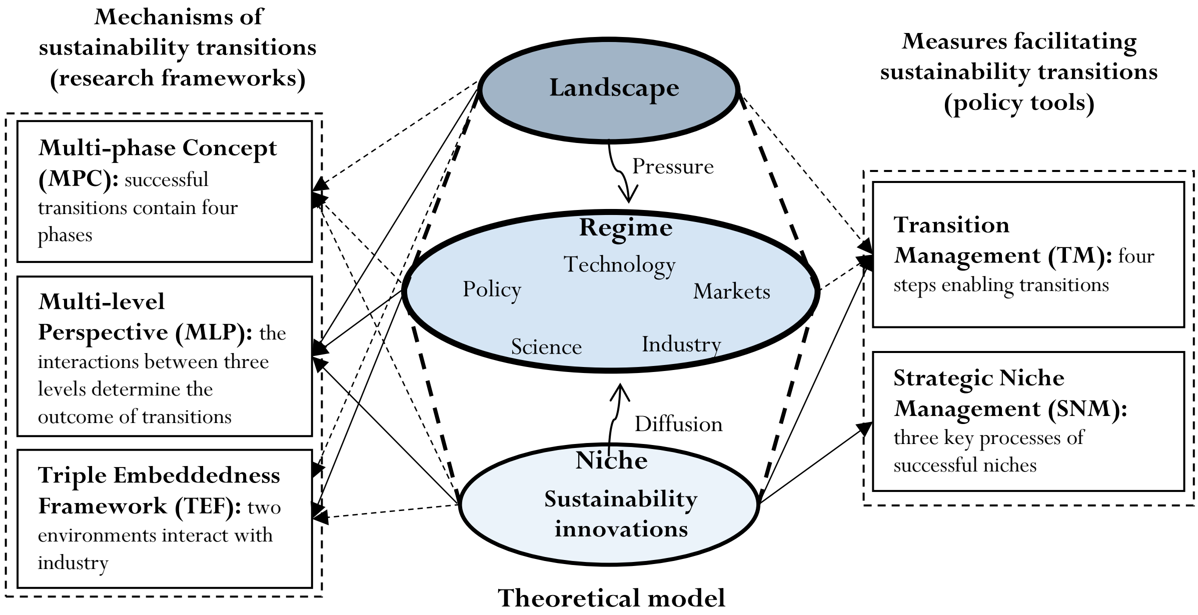

Figure 3.6 Comparison of the different approaches

These five approaches examine sustainability transitions from different perspectives, with the MPC of transitions, the MLP on transitions and the TEF having been primarily used as research tools to describe and analyse various historical and contemporary transitions. Specifically, the MPC of transition identifies the four phases of transitions while the MLP on transitions uses three levels to explain why transitions take place. The TEF explores the interactions between industries and the economic and socio-political environments to provide insights on regime destabilization. By contrast, even though SNM and transition management (TM) have been used as research frameworks, they were proposed primarily as policy instruments to proactively manage transitions. Specifically, SNM has identified three key processes of successful niche experiments, and transition management (TM) provides a framework to govern transitions. Thus, these five approaches can be grouped into two categories: research frameworks and policy tools, as shown in Fig. 3.6. Research frameworks provide a deeper theoretical basis for the policy tools while empirical studies on the policy tools help to refine the research frameworks.

Another core issue is the different emphasis of the approaches at the three levels of niche, regime and landscape (see Fig. 3.6). It is the MLP approach on transitions that explicitly denotes that the interplay between the three tiers determines the transition processes and, thus, the MLP on transitions emphasizes all three levels. It is also evident that the SNM approach focuses on the niche-level dynamics and, thus, only emphasizes the niche level. It seems unclear how the three levels were reflected by the MPC of transition which proposes the transition phases but without further exploration of the reasons why transitions happen. However, the existence of the three structural levels and the way in which they relate to the transition phases were implied by the MPC approach. For instance, when illustrating the MPC approach, Rotmans et al. (2001) explained that every domain has its own dynamics, with culture only changing slowly (landscape), economy changing fast (niche), and institution and technology changing in between (regime). The transition management ™ approach, on the other hand, seems to emphasize all three levels as it aims to influence the broad transition process. However, transition management (TM) particularly focuses on nurturing new sustainability coalitions and networks that are actually situated at the niche level. In terms of the TEF, even though it focuses on regime destabilization, it does not ignore the niche and landscape dynamics that influence the regime destabilization.

These five dominant approaches are largely complementary to each other and, thus, have been used jointly by many previous studies. For instance, Stephens and Graham (2010) employed the MPC, MLP, SNM and transition management (TM) approaches to propose an empirical research agenda for sustainability in higher education, treating these approaches as mainly complementary. Similarly, Raven et al. (2010) argued that both SNM and transition management (TM) contribute an important role within experiments. Consequently, they proposed a competence kit of sustainability transitions for practitioners based on both SNM and transition management (TM). The MLP and TEF, in particular, were both proposed or developed by Geels, and are largely complementary to each other.

3.3.7 Summary of the key mechanisms behind transitions implied by the MPC, the MLP and TEF

The above section has reviewed the five common approaches to sustainability transitions, three of which are classified as research frameworks while two are classified as policy tools.

As illustrated in the previous chapter, a theory is needed to explain the underlying mechanisms behind the sustainability movements of the construction industry. This study, as an explorative study on the sustainability transitions of Chinese construction enterprises, has mainly built its theoretical basis on the research frameworks, namely, the MPC, the MLP and the TEF. The application of the policy tools, that is, SNM and transition management (TM) in the Chinese construction industry will not be explored by this study. However, a critical discussion on developing a systematic model to facilitate sustainability transition is provided at the end of Chapter 8 (see Section 8.5.3), in which the deficiencies and possibilities of applying SNM and transition management (TM) in the construction industry are highlighted as areas of research for future studies.

The key mechanisms and processes of sustainability transitions implied by the MPC, the MLP and the TEF can be summarized as three phases: stabilization of the existing system (corresponding to "predevelopment" in the MPC); transition of the existing system (corresponding to "take-off" and "acceleration" in the MPC); and consolidation of the transitioned system (corresponding to "stabilization" of the MPC).

3.3.7.1 Stabilization of the existing system

Existing socio-technical systems are stabilized through various lock-in mechanisms (Arthur, 1989). These include the following: technical standards or government policies may favour existing technologies; it is difficult to change the business network of corporations; the engineering practice, consumer preferences or ways of doing business are all deeply embedded in the existing institutions or infrastructures, etc. (Geels, 2014; Markard et al., 2012). The existence of these mechanisms determines that the firms in industries and their economic and socio-political environments have a certain level of stability, with this conceptualized as the outcome at the regime level in the MLP on transitions. This stability presents a huge challenge when it comes to dealing with sustainability issues. For instance, both industrial economies and rapidly industrializing countries are becoming locked into fossil fuel-based technological systems (Unruh, 2000; Unruh and Carrillo-Hermosilla, 2006).

The implication of the TEF is that activists and affected groups in the socio-political environment may articulate concerns about sustainability issues to which the industry should respond. However, firms tend to ignore these concerns and, at the beginning, resist any changes that are required as a result of these lock-in mechanisms. Other phase models of corporate strategic responses to sustainability issues also indicate that resistance is the initial stage, even though different labels are used in different models, such as "non-compliance strategy" proposed by Ghobadian et al. (1998); "resistant" proposed by Klewitz and Hansen (2014); and "reactive response" proposed by Winsemius and Guntram (1992). Rivoli and Waddock (2011) emphasized the difficulty of facilitating a change towards sustainability in industries, stating that firms can easily ignore the sustainability issues discovered or raised by a small number of people who are without power.

As industries resist taking measures to respond to the issues, activists and affected groups may coalesce into a social movement to attract the public's attention and evoke public concerns which then leads to policy makers' increased attention and to political debate about the sustainability issues (Penna and Geels, 2012). However, it is still difficult to enable changes in industries to bring about responses to the issues. Due to the lack of public awareness, firms could argue that the issues are temporary and minor, and that the measures to solve the issues are infeasible and costly (Geels, 2014). This is compounded by a certain level of dependence of the local economy on industry actors (Luger, 2005).

Such debates are mainly in the socio-political environment and most clients' preferences are not changed during this phase. Thus, firms could maintain competitiveness by adopting traditional strategies and not addressing sustainability issues. For instance, as clients do not have a clear preference for sustainable projects, firms could maintain competitiveness by focusing on minimizing costs, regardless of the social and environmental consequences. If firms adopt sustainability innovations at this phase, the additional costs and risks generated by these innovations could impede their competitiveness, and thus firms have little motivation to be sustainable. Therefore, the MLP on transitions indicates that, at the beginning, even though there may be some niche innovations of sustainability in the industry, the innovations face great difficulty in diffusing into the regime.

3.3.7.2 Transition of the existing system

In this phase, sustainability issues become increasingly important and receive growing public attention. The niche innovations experience further performance improvement and become increasingly stabilized. Thus, a niche market of sustainable products emerges that slightly changes the mainstream economic environment, facilitating local searches for solutions to sustainability issues. Policy makers engage in hearings and investigations and introduce legislation to address the sustainability issues (Penna and Geels, 2012). If tough policies are introduced, for example, tax instruments or financial incentives, the economic environment could be further altered thus favouring sustainable firms. The TEF indicates that, generally, the economic environment has a greater influence on corporate strategy than the socio-political environment as firms will rarely change themselves merely to solve societal challenges. Similarly, when public debates and tough policies lead to changes in consumer preferences, sustainability may become part of firms' core beliefs (Penna and Geels, 2012). However, public opinion in the socio-political environment should not be overlooked as it exerts pressures on policy makers, influencing the cultural legitimacy of industries and the feasibility of policy reform (Turnheim and Geels, 2012).

Under growing pressures from both the socio-political environment and the economic environment, firms start to actively engage in sustainability improvements. Rivoli and Waddock (2011) stated that, as the new norms become accepted practices, industry-wide capabilities will lower the costs of the associated practices. According to Berry et al. (2013), large green projects could gradually nurture the development of the green supply chain. Implementing sustainable construction may generate risks and additional responsibilities for maintenance. However, if incentives are in place, firms could implement these sustainability practices as, overall, their competitiveness is enhanced. Empirical evidence has been found for the critical role of the economic and socio-political environments in driving the sustainability transitions of firms. According to Heffernan et al. (2015), in the UK, legislative and economic drivers are much more significant than drivers within the industry for zero carbon homes. In particular, enhancing public awareness and occupant education is identified as the strongest supporting mechanism for zero carbon homes. This shows that it is hard for firms alone to actively embrace sustainability. Rather, it is the interactions between firms and the socio-political and economic environments that drive sustainability transition (see also Serpell et al., 2013). Under growing pressures from the economic and socio-political environments, firms in the regime could increasingly adopt the innovations at the niche level. However, the MLP on transitions indicates that, to successfully challenge the regime, innovations at the niche level must align with networks and also succeed in becoming self-sustaining.

3.3.7.3 Consolidation of the transitioned systems

In this phase, sustainability is addressed by most firms in the industry and, thus, the industry is fundamentally transformed. To maintain competitiveness and to be selected by the new economic and socio-political environments, firms have to become sustainable. Peng and Kerry (2013) argued that, with the implementation of new policies, all firms will eventually be required to achieve a certain level of sustainability. Under new economic and socio-political environments, promoting sustainability becomes the mainstream practice and the firms which are competitive in the new business environment must also be sustainable. At this phase, firms integrate sustainability with competitiveness and they have various features, such as business models rooted in sustainability, proactive solutions to sustainability issues and strong interactions with external actors (Klewitz and Hansen, 2014). To respond to the sustainability challenge and meet customers' needs, firms optimize their functioning and integrate sustainability into business strategy to achieve economic, social and environmental values (Ghobadian et al., 1998; Winsemius and Guntram, 1992).

This calls for a paradigm shift in which sustainability needs to be integrated into the core beliefs and missions of firms. Firms' business models may also need to be fundamentally transformed to effectively address sustainability issues. The TEF indicates that, compared to technology and policy, core beliefs, missions and business models are fundamental regime elements that are more difficult to change (Turnheim and Geels, 2012). To facilitate the change of core beliefs and missions in the industry thereby consolidating the transitioned system, a certain level of pressure from the economic and socio-political environments is required. Examples of the sources of such pressure include: (1) public attention on sustainability issues increases dramatically and the mainstream market preference changes favouring sustainable alternatives in the industry; (2) the government issues strong incentive policies substantially changing regulations, subsidies and taxes to encourage firms to conduct sustainability innovations and consumers to purchase the new products; and (3) the technological risk of the sustainable alternative at the niche level is gradually reduced and the associated cost drops, making it a better choice for consumers than the traditional unsustainable products.

The transition process indicated by the MLP and the TEF demonstrates the ideal situation. In reality, it is possible that the pressures generated by the economic and socio-political environments are not strong enough to facilitate the transition process; thus, the industry is stuck in the unsustainable mode, with this illustrated by the various alternative scenarios in the MPC approach.

3.4 Development of a research plan for this study

This section aims to link the transition approaches discussed above with the sustainability literature on construction enterprises discussed in Chapter 2, thereby developing a research plan for this study. In the previous chapter, four gaps of knowledge have been identified. They are used in this section, together with the transition perspective, to generate the research plan.

3.4.1 Rationale for examining sustainability of construction firms from the transition perspective

Gap 4, as identified in the previous chapter, could be responded to with the transition perspective. As previously explained, due to the lack of solid theory, existing studies on the drivers for and barriers to sustainability remain very unsystematic and fragmented. Several factors have been identified which affect the uptake of sustainable construction practices in construction firms but few existing studies have revealed the key mechanisms driving the transition process towards sustainability in the construction industry. Fortunately, the transition literature specifically investigates this issue. The MLP approach reveals that it is the interactions between the various processes at the niche, regime and landscape levels that determine the transition outcome. The TEF further reveals that to enable the transition process, sustainability innovations at the niche level need to diffuse into the regime level to replace or complement the dominant practices. This requires the destabilization of the regime which is facilitated by the interactions between the industries and the economic and socio-political environments.

These key mechanisms have not been adequately explored by existing studies on the sustainability of construction enterprises. Many studies on the drivers for or barriers to environmental sustainability only focus at the niche level, that is, on the factors influencing the maturity of the sustainability innovation, such as cost, while largely neglecting the dynamics at the regime level. As indicated by the MLP, to enable the transition, a successful niche is not sufficient as the regime needs to be destabilized to provide opportunities for the niche. By solely focusing on the niche level, existing studies lose the opportunity to holistically examine the various factors influencing the sustainability of construction enterprises. However, the transition approaches are not without limitations. Most existing transition studies have adopted a qualitative case study approach to investigate the dynamics of transitions. Few studies have attempted to adopt the use of quantitative data to analyse sustainability transitions. Chapter 2 identified gap 1, namely, a lack of holistic diagnosis of construction enterprises' perceptions of and performance on the economic, social and environmental dimensions of sustainability. A questionnaire survey could be an appropriate approach to address this question. The challenge is how to use a questionnaire survey and the associated statistical analysis to investigate the complex sustainability transitions which have normally been studied by qualitative case studies in the existing literature.

Furthermore, Chapter 2 has identified that the critical gaps of knowledge are a lack of studies on the policy system and a lack of attention on overcoming the resource and capability barriers under constrained resources. The transition perspective has also justified the importance of responding to these two gaps. The TEF has highlighted the important role of government policy in facilitating transitions, as government policy can alter both the economic and socio-political environments for firms. Similarly, the transition perspective has highlighted that, with the increasing maturity of niche innovations through the multiple learning processes in the industry, the cost and risks of adopting the innovations will drop, and the government may provide strong incentive policies for firms to adopt the innovations. Thus, firms with limited resources have the opportunity to adopt sustainability innovations under appropriate strategic planning of their goals and strategies.

The key is to holistically identify the strengths and weaknesses of the construction firms in terms of their sustainability performance on the economic, social and environmental aspects, thereby allocating the valuable resources to the weak, yet important, sustainability aspects.

Therefore, a research plan for this study has been developed. In following this research plan, not only can this study contribute to the existing body of knowledge in the area of the sustainability of construction firms (particularly in China), but it can also demonstrate the possibility of studying sustainability transitions based on a mixed methods research approach combining qualitative and quantitative data which has seldom been done in existing studies. The contribution of this study to the body of knowledge is specifically discussed in Chapter 9.

3.4.2 Development of the research plan

Based on the four gaps of knowledge identified in Chapter 2 and on the sustainability transition perspective reviewed in this chapter, a research plan was developed to study the sustainability transition of Chinese construction enterprises. The sustainability transition of construction enterprises is, in its nature, a complex process with various actors influencing this process. Due to the stringent time limit of this study (three years), its research endeavours have had to be distributed unevenly among the various actors, with the central actors receiving a higher level of emphasis. Fig. 3.7 shows the actors' network of sustainability transitions as suggested by the triple embeddedness framework (TEF). Table 3.2 summarizes the analysis strategies for the actors. As shown in Table 3.2, this study placed high-level emphasis on researching Chinese construction enterprises, medium-level emphasis on the policy for sustainability transition and low-level emphasis on other actors, for example, suppliers and clients. The current section has focused on explaining the research plan. The detailed research methodology is presented in the next chapter, with this following the research plan presented here. As can be seen, this study is composed of four sections of research, namely: 1) a study of China's policy system for sustainability transition; 2) sustainability transition of the leading construction firms; 3) transition pathways towards sustainability for various construction firms; and 4) the drivers for and barriers to sustainability transitions.

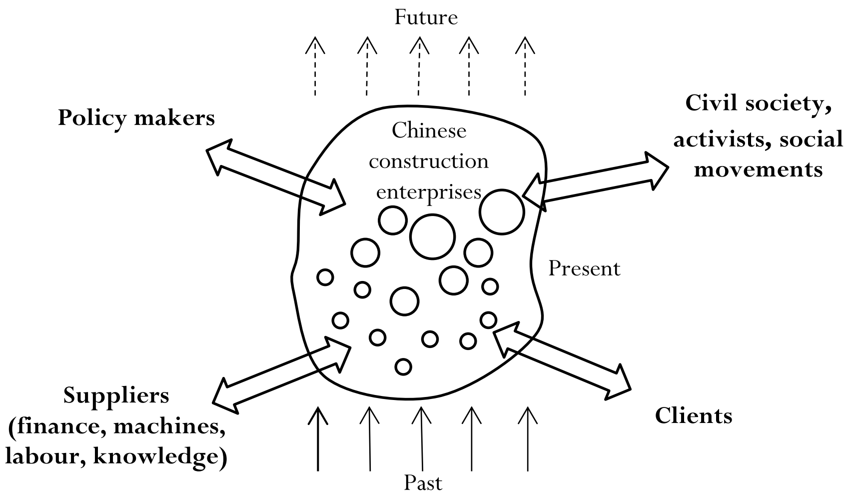

Figure 3.7 Analysed actors involved in sustainability transition of the construction enterprise

Table 3.2 Analysis strategies for the actors

Analysed actors	Degree of emphasis	Strategies of analysis
Chinese construction enterprises	High	Chinese construction enterprises are the focus of this study. The sustainability behaviours and strategies of the leading construction firms are studied to identify the sustainability aspects that form the basis for the questionnaire survey of a larger sample that follows. Statistics are used to diagnose the surveyed firms' perceptions and performance on the aspects of sustainability.
Policy makers	Medium	Government policy could strongly influence the sustainability strategies of construction firms. The policy system that China has developed to promote the sustainability transition of the construction industry should be thoroughly studied.
Suppliers, civil society and clients	Low	Suppliers, clients and civil society organizations are not the focus of this study. However, they influence the transition process and, thus, also need to be investigated. The investigation is conducted through the questionnaire survey.

3.4.2.1 China's policy system for transition towards sustainable construction

The importance of government policy in promoting the sustainability transition of construction firms has been adequately illustrated by existing sustainability studies on construction and the literature of sustainability transition. Section 2.6.2 has specifically explained the necessity of researching China's policy system for sustainable construction. Thus, this study, in response to gap 2, firstly examined the government policy to obtain a general understanding about how the Chinese government is facilitating the transition towards sustainability. ***Research Objective 3***, as stated in Chapter 1, was proposed for this reason. For this kind of study, the qualitative approach is appropriate.

3.4.2.2 Sustainability transitions of leading construction firms

Section 2.6.1 specifically explained the importance of a holistic diagnosis of construction firms' sustainability perceptions and performance. In developing the survey instrument, it was necessary to first explore how the sustainability of construction firms could be de-composed into various sustainability aspects covering the economic, social and environmental dimensions. Therefore, an explorative study was conducted of the leading construction firms' sustainability transitions to identify the critical sustainability aspects (CSAs), thus partly responding to gap 1.

In the context of China, large construction firms are usually state-owned and have a huge market influence in the industry. The leading construction firms, in particular, are usually multinational enterprises that are amongst the main 'creators' of new technology (Crescenzi et al., 2015). Furthermore, as leading firms perform much better than the average, the practices of leading construction firms are often regarded as the benchmark or "learning model" by other firms. Thus, the study of the sustainability transitions of the leading construction firms in China could significantly contribute to the knowledge about what constitutes the best sustainability performance and practices in the Chinese construction industry. This section of the current research analyses whether the leading construction firms have transitioned towards sustainability, and what sustainability practices and behaviours they have adopted in the transition process. Their adopted sustainability practices are summarized into a list of critical sustainability aspects that are the used in the following section of this research. This is the reason why ***Research Objective 4*** was proposed in Chapter 1.

3.4.2.3 Identification of transition pathways towards sustainability (TPS) based on a holistic diagnosis of construction firms’ sustainability perceptions and performance

Based on the critical sustainability aspects (CSAs) identified in the previous step, the study planned to develop a survey instrument thereby facilitating the empirical investigation of the construction firms’ sustainability perceptions and performance, and responding to gap 1. The surveyed construction firms were expected to present different perceptions and performance on sustainability. Thus, an appropriate method needed to be identified to capture this heterogeneity. In addition, Section 2.6.1 specifically illustrated the necessity of exploring the association between firm size, sustainability perceptions and sustainability performance. This could be achieved using appropriate statistical methods.

More importantly, for construction enterprises to transition towards sustainability means that the groups of aspects with low performance levels, that is, the weaknesses of the firms, need to be improved. Through the holistic diagnosis of the most important and least important sustainability aspects and those that are the best performed and the worst performed, as perceived by construction firms, construction firms could allocate their valuable resources firstly to the worst performed, yet important, sustainability aspects, then to other aspects. Therefore, gap 3 could also be responded to by this step of the study. Based on this holistic diagnosis, this study could propose the transition pathways towards sustainability, showing which aspects should be improved for various construction enterprises. This is the reason why ***Research Objective 5*** was proposed in Chapter 1.

3.4.2.4 Drivers for and barriers to sustainability transitions of construction firms

In addition to government policy, other factors interact with construction firms and influence their sustainability transitions, namely, factors associated with suppliers, clients and the society. This step holistically identifies the key factors driving and prohibiting the sustainability transition of construction firms, and then investigates the construction firms’ perceptions on these factors, in response to gap 4. With the previous step having identified various construction enterprises’ perceptions and performance on the critical sustainability aspects, after this step, the linkage between construction firms’ sustainability performance and their perceptions on the drivers for and barriers to their sustainability transition could be established. This is the reason why ***Research Objective 6*** was proposed in Chapter 1.

3.5 Summary

This chapter has systematically reviewed: 1) the various approaches to sustainability and their limitations; 2) the concepts of sustainability transitions; and 3) the five approaches, namely, the MPC, the MLP, SNM, transition management (TM) and the TEF, within the sustainability transition field. Based on the above review and in response to the research gaps identified in Chapter 2, this chapter has developed a research plan for examining the sustainability of Chinese construction firms based on the transition perspective. Thus, this chapter has adequately responded to ***Research Objective 2*** as proposed in Chapter 1. The major contribution of this chapter to the following chapters is the research plan developed in Section 3.4. Beginning with the methodology chapter, the following chapters present this study step by step in accordance with the research plan developed.

Chapter 4 Methodology

4.1 Introduction

This chapter aims to provide an overview of the research design and the techniques used in this study. Firstly, the three common research paradigms are introduced and an appropriate paradigm is chosen. An appropriate research design within the chosen research paradigm is then determined. Finally, the various research methods and techniques of the research design are introduced. As a variety of methods has been employed in each of the following research chapters, this chapter on the study's methodology only provides an overview of these methods. The details of how the methods were implemented are explained in the Methods section of the corresponding research chapters.

4.2 Research paradigm and design of this study

4.2.1 Overview of research paradigms

In terms of the frameworks for designing a research study, although different types and terms exist in the literature (Creswell, 2013), the shared opinion is that the three major research paradigms are quantitative research, qualitative research and mixed methods research (Creswell, 2013; Johnson et al., 2007). How does one choose an appropriate research paradigm for a research study? Creswell (2013) suggested that three factors need to be considered, namely, the match between the research problem and research paradigm; the researchers' experience and skills; and the audience of the research. The first factor, in particular, is critical as certain types of research problems call for specific approaches. As suggested by Creswell (2013), Collins and Hussey (2003), and Glesne and Peshkin (1992), quantitative research, qualitative research and mixed methods research should be adopted to respond to the following types of research questions:

- If the research aim is to identify factors that influence outcomes, to understand the best predictors of outcomes, and to test a theory or hypothesis, a quantitative approach is suitable. Quantitative research usually has a larger sample than qualitative research thus providing better generalizability of the results.
- If the research question is related to exploring the complexity of a concept or phenomenon, qualitative research should be adopted. Qualitative research is also suitable for theory construction as it can be used to identify relevant factors or variables for further quantitative research.
- If researchers want to have both good generalizability of the findings and the development of a detailed view of the meaning of a phenomenon or concept, then mixed methods research is the best research paradigm to use. The advantages of collecting both closed-ended quantitative data and open-ended qualitative data can be achieved in mixed methods research.

Mixed methods research has increasingly been adopted by scholars due to its capability to provide both a detailed interpretation of concepts and the generalizability of research results. Schwandt (2000) indicated that "it is highly questionable whether such a distinction (between qualitative inquiry and quantitative inquiry) is any longer meaningful for helping us understand the purpose and means of human inquiry". As the current study is investigating the sustainability transition of Chinese construction enterprises which has not been systematically studied by scholars, it was considered that qualitative research methods should be adopted to explore the complexity of the process. However, at the same time, this research needed to assess the sustainability performance of construction enterprises, so it was considered that quantitative methods should also be adopted. The goal of mixed methods research is to draw on the strengths and to weaken the weaknesses of both the quantitative and qualitative research approaches (Johnson and Onwuegbuzie, 2004). Considering this study's research questions and the rising significance of mixed methods research in human inquiry, the mixed methods research paradigm was adopted in this study. A detailed explanation of this paradigm is offered in the next section.

4.2.2 Sequential mixed methods research

Following the guidance of Creswell (2013), after choosing mixed methods research as the research paradigm for this study, the strategy of inquiry (research design) and detailed methods then needed to be determined. To choose an appropriate strategy of inquiry for this study, the existing research design approaches within the mixed methods research paradigm needed to be reviewed in order to identify a suitable approach for this study. Before undertaking this review, the detailed concepts of mixed methods research needed to be clarified. In their study, Johnson et al. (2007) offered a valuable analysis by holistically examining the concepts of mixed methods research. They contacted 36 leading methodologists who apply mixed methods research to obtain their definitions of mixed methods research, and summarized their opinions into a total of 19 definitions. Based on a detailed comparison of these 19 definitions, they defined mixed methods research as:

> *Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (Johnson et al., 2007, p.123).*

Therefore, in mixed methods research, the mixing of methods can happen in both the data collection and data analysis stages. After the definition is clarified, the detailed research design within mixed methods research can be explored. Two types of mixed methods research, namely, sequential research and parallel research, are identified in accordance with the timing of when the methods are mixed (Leech and Onwuegbuzie, 2009; Maxwell and Loomis, 2003). In parallel research design, the collection and analysis of both qualitative and quantitative data sets are carried out concurrently, and the findings are not compared or consolidated until the interpretation stage. In contrast, in sequential research design, data are collected and analysed in a particular sequence with the purpose being that the first method is then used to inform the other method (Onwuegbuzie and Teddlie, 2003). A sequential mixed methods research design has been adopted in this study.

In a sequential mixed methods research design, the two sequences, generally, are qualitative + quantitative and quantitative + qualitative (Leech and Onwuegbuzie, 2009). For instance, researchers can undertake quantitative research first to obtain general information about an issue, and then conduct the qualitative part to obtain the detailed interpretation of the issue. In contrast, the researchers can do the qualitative part first to explore a new area and obtain an initial understanding, and then do the quantitative part to see how the issue is understood in a large sample (Leech and Onwuegbuzie, 2009). Creswell and Plano Clark (2007), who are leading methodologists in mixed methods research, labelled these two types of sequential design as explanatory sequential design and exploratory sequential design, respectively. In explanatory sequential design, the researcher begins by conducting a quantitative phase and follows up on specific results with a qualitative phase to further elaborate the results in more depth. Conversely, in exploratory sequential design, the researchers start by qualitatively exploring a topic before building up to the second phase which is quantitative (Creswell and Plano Clark, 2007). The two methodologists pointed out that exploratory sequential research is especially suitable for use when: 1) measures or instruments are not available; 2) the variables are unknown; and 3) there is no guiding framework or theory (Creswell and Plano Clark, 2007).

Therefore, for this study, exploratory sequential mixed methods research design was considered to be very suitable as no measures or instruments were available to study the issue of the sustainability transition of Chinese construction enterprises. In this study, it was determined that qualitative methods should be used first to explore and identify the related measures before the quantitative survey was conducted.

4.3 Research methods

After choosing the appropriate research design, researchers still need to determine the detailed research methods. Based on the researchers' research experience and the research objectives presented in Chapter 1, several detailed methods were chosen for conducting this study. Creswell and Plano Clark (2007) indicated that the research process of exploratory sequential mixed methods research design can be divided into four phases: the qualitative phase; the connection (mixing) phase; the quantitative phase; and the interpretation phase. Fig. 4.1 illustrates the four phases and the research methods in this research, clearly demonstrating that Chapters 5 and 6 mainly use qualitative methods and that Chapter 7 uses quantitative methods. Both qualitative and quantitative methods are used in Chapter 8, with the qualitative content analysis identifying the drivers for and the barriers to sustainability transition and quantitative statistical methods analysing the respondents' ratings on these drivers and barriers. The detailed research procedure and techniques are explained in the Methods section of each chapter. The aim of this section is to provide an overview of the research methods used in the four research phases.

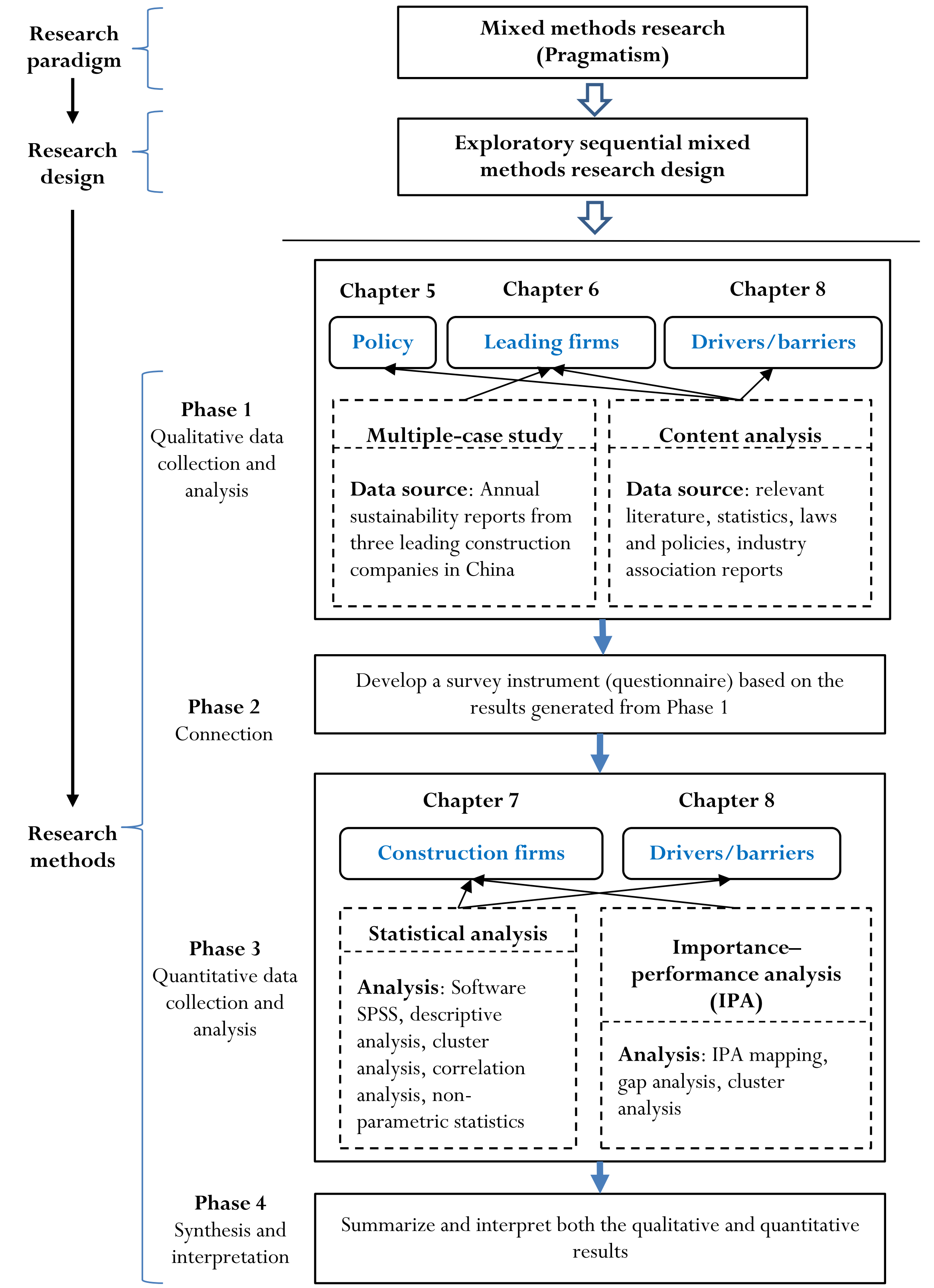

Figure 4.1 Visual model of exploratory sequential mixed methods design adopted in this study

4.3.1 Phase 1: Qualitative data collection and analysis

As suggested in the established research plan, government policy, leading construction firms, and drivers for and barriers to sustainability transition need to be explored. Two primary methods are adopted to investigate these issues, namely, a multiple-case study approach and qualitative content analysis, both of which are discussed below.

4.3.1.1 Qualitative content analysis

As one of today's most extensively employed analytic tools, content analysis has been used fruitfully in a wide variety of research applications, including information and library science, nursing and health, the media and communication, sociology, psychology, business and construction (Elo and Kyngäs, 2008; Graneheim and Lundman, 2004; Zhang and Wildemuth, 2009; Zuo et al., 2012). Content analysis is a method used to analyse written, verbal or visual communication messages (Cole, 1988). It is used to analyse both quantitative data and qualitative data (Graneheim and Lundman, 2004). Initially, the utilization of content analysis was predominantly quantitative; in other words, text data were coded into specific categories and then described by statistics (Hsieh and Shannon, 2005). Recently, qualitative content analysis has gained momentum, leading to its increased popularity (Hsieh and Shannon, 2005). Unlike quantitative content analysis, qualitative content analysis goes beyond merely counting words to examine meanings, themes or patterns that may be latent (Zhang and Wildemuth, 2009). Qualitative content analysis was adopted in this project to investigate texts for different purposes including: 1) examining government policies for sustainability; 2) examining corporate documents of the leading construction firms; and 3) examining the relevant literature and reports to identify the drivers for and barriers to sustainability transition.

Qualitative content analysis focuses on the contextual meaning of the text, with the text in verbal, print or electronic form (Hsieh and Shannon, 2005). The three types of qualitative content analysis, namely, conventional content analysis, directed content analysis and summative content analysis (Hsieh and Shannon, 2005), can be explained as follows.

- In conventional content analysis, researchers avoid using preconceived categories or theories, instead allowing the categories to emerge from the data. Conventional content analysis is usually adopted when existing theory on a phenomenon is limited.
- In directed content analysis, researchers use existing theory to identify key concepts or variables as initial coding categories. Any text that could not be categorized in the initial coding scheme is given a new code. Directed content analysis can also be referred to as deductive content analysis.
- In summative content analysis, researchers firstly quantify certain words using statistics. This quantification is not an attempt to infer meaning, but to explore usage. The researchers then conduct latent content analysis to explore the underlying meaning of the words.

Specifically, conventional content analysis was used to study the policy documents, while directed content analysis was used to examine the corporate reports of the leading construction firms and to identify the drivers for and barriers to sustainability transition. Several scholars have suggested the major steps for conducting conventional and directed content analysis. The detailed procedure of the content analysis, including data collection and analysis, is explained in the corresponding chapters.

The policy documents and the corporate reports of the leading Chinese construction firms were written in Chinese. The author of this PhD research and two supervisors, namely, Prof. Zhen-Yu Zhao and Assoc. Prof. Jian Zuo, are native Chinese speakers. The translation and interpretation of the documents was conducted by the author and examined by the two supervisors who have confirmed the accuracy of the translation and interpretation.

4.3.1.2 Holistic multiple-case study approach

This study has adopted a multiple-case study approach to explore the sustainability transitions of the leading Chinese construction enterprises. Various definitions have been proposed for the term "case study". For instance, Yin (2014) defined case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used". Gerring (2004) defined case study as "an intensive study of a single unit for the purpose of understanding a larger class of (similar) units". Collins and Hussey (2003) offered another definition of case study: "a methodology that is used to explore a single phenomenon (the case) in a natural setting using a variety of methods to obtain in-depth knowledge".

The advantages of the case study approach are reflected in two aspects: an in-depth understanding and the openness to methods. Regarding an in-depth understanding, Gummesson (2000) argued that a case study enables researchers to study many different aspects of a process. Benbasat et al. (1987) stated that by adopting a case study, researchers can understand the nature and complexity of the process taking place and generate theories from practice. Cavaye (1996) summarized by stating that a case study uses cases to investigate a predefined phenomenon but does not involve the explicit control or manipulation of variables, with the focus on an in-depth understanding of the phenomenon and its context. Regarding the openness to methods, many scholars have argued that, unlike grounded theory or ethnography, case studies are open to the use of theory or conceptual categories that guide the research and the analysis of data (Meyer, 2001). A case study can be used to achieve various research aims, such as to provide descriptions of a phenomenon, to develop theory and to test theory (Darke et al., 1998). Benbasat et al. (1987) offered an insightful comment that a case study can take a deductive or inductive approach, use qualitative or quantitative methods and investigate one or more cases. This research has adopted the case study approach to investigate the sustainability practices of the leading construction firms for the following reasons:

- As sustainability practices involve multiple dimensions (technical, managerial, social, etc.), investigating these practices in a systematic manner calls for an approach which can offer an in-depth understanding.
- As this study is based on the concepts of sustainability and the theory of sustainability transition, the approach adopted to inquire into the practices of the leading firms should be open to the use of theory or conceptual categories.

Therefore, a case study approach was chosen to investigate the leading construction firms. Several methodologists who are proponents of the case study approach have developed procedures for conducting rigorous case studies, with the researcher of the current study deciding to choose a holistic multiple-case design. In line with the multiple-case design, it was determined that three leading Chinese construction corporations were to be the cases. The sustainability reports released by the firms were the data source. Explanations of the detailed case study methods used in the data collection and data analysis are provided in Chapter 6. After conducting the case study, a list of critical sustainability aspects (CSAs) for construction enterprises was identified for further exploration in a larger sample.

4.3.2 Phase 2: Connection

In sequential research, data are collected and analysed in a particular sequence with the purpose being that one method will inform the other method (Onwuegbuzie and Teddlie, 2003). Therefore, the results generated from the qualitative phase of this study needed to inform the quantitative phase. Based on the results of the qualitative research, an online questionnaire for the Chinese construction industry was developed. This questionnaire comprised three sections. Firstly, the background of this study and the basic concept of sustainability were introduced, followed by a section which collected the respondents' demographical information, for example, the size of their firm. The second section aimed to investigate respondents' opinions on the degree of importance and performance of the various CSAs identified in the multiple-case study. The third section aimed to explore respondents' opinions on various factors driving or prohibiting the sustainability transition of Chinese construction enterprises. The results of Chapters 5 and 6 were used in the second and third sections of the questionnaire, thereby connecting the qualitative and quantitative phases.

Likert scales have been widely adopted in previous studies on the sustainability issues of the construction industry. For instance, Bevan and Yung (2015) adopted a five-point Likert scale to measure the implementation levels of CSR in Australian small and medium-sized construction enterprises. Similarly, Shen et al. (2010b) employed a five-point Likert scale to measure the sustainability level of infrastructure projects. As in these previous studies, a five-point Likert scale was adopted in the questionnaire in the current study to solicit respondents' opinions. Specifically, in the second section of the questionnaire, respondents were asked to evaluate the relative importance of the identified critical sustainability aspects from 1 (“very unimportant”) to 5 (“very important”). After completing the importance evaluation, each respondent was asked to evaluate their enterprise’s performance on these aspects, also on a five-point Likert scale from 1 (“very bad”) to 5 (“very good”). For the third section of the questionnaire, statements of the drivers for and barriers to sustainability transition had been developed with respondents similarly asked to evaluate their degree of agreement on the statements from 1 (“strongly disagree”) to 5 (“strongly agree”).

4.3.3 Phase 3: Quantitative data collection and analysis

4.3.3.1 Data collection

Before disseminating the questionnaire, the issue of ethics associated with the questionnaire was examined by the Human Research Ethics Committee of the University of Adelaide, and the questionnaire was subsequently approved, with the approval being H-2014-255. Appendix C presents the ethics approval letter for this project (p. 272-273). To enable respondents to accurately understand the meaning of the questions, Chinese was the language used in the questionnaire. The translation between Chinese and English in the questionnaire design was examined and confirmed by two supervisors, namely, Prof. Zhen-Yu Zhao and Assoc. Prof. Jian Zuo, who are native Chinese speakers. Please see the online questionnaire in Chinese and its English version in Appendix A and B respectively (p. 256-270).

With the population of the entire Chinese construction industry unknown, conducting a true probability sampling (e.g. simple or stratified random sampling) was neither feasible nor cost-effective. The approach adopted in this study was that of a web survey with convenience sampling. The largest and most reputable academic online survey platform in China, www.sojump.com, was employed in this study to collect the responses, with this platform having been extensively utilized by construction researchers (e.g. Mao et al., 2013; Xiang et al., 2015; Luo et al., 2015). In addition, the platform has maintained panels of registered enterprises operating in various industries in China, for example, those in the energy, information technology (IT) and construction industries. The sampling frame for this study comprised construction enterprises registered on this platform, with a total of 4500 questionnaires distributed within this sampling frame from May to June 2015. A total of 262 questionnaires were returned with valid responses, resulting in a response rate of 5.8%. Fan and Yan (2010) indicated that response rates of web surveys could be affected by various factors such as content of web questionnaires, contact delivery modes, use of pre-notifications and reminders, incentives, and survey software. Compared to the other approaches to questionnaire surveys, web surveys tend to have a lower response rate due to factors which include: the time and resource limitations; the geographical separation between researchers and respondents; the voluntary nature of survey completion; and the large number of potential respondents. Regarding this study, the potential reasons for the response rate of 5.8% are: 1) the topic was of low interests to some people); 2) the survey was perceived to be too long; 3) only email invitations were used without the adoption of pre-notification and reminders; 4) increasingly robust spam-blocking tools used by email software e.g. Outlook and Gmail; and 5) there was no incentives attached to the questionnaire. Similar response rates have been observed in other construction studies using web surveys, such as 2.9% (Said, 2015) and 8% (Al Qady and Kandil, 2013).

The valid responses in the current study were collected from various construction enterprises on different scales and with different business focuses, such as China Railway Group Ltd, etc.

4.3.3.2 Statistical analysis

Various techniques were employed to analyse the data and test the hypotheses. To determine the relative ranking of the CSAs, the relative importance value (RIV) and relative performance value (RPV) of each aspect were calculated. The statistical techniques used comprised: 1) correlation analysis including both Kendall's rank correlation and Spearman's rank correlation; 2) the Kruskal–Wallis test and, as a follow-up, the Mann–Whitney U test; 3) one-way analyses of variance (ANOVAs); 4) cluster analysis; and 5) the averaged means. These techniques were used to serve different purposes. For instance, correlation analysis was adopted to investigate the association between construction firms' sustainability attitude and performance. To classify the surveyed construction firms into different groups according to their ratings on the performance levels of the sustainability aspects, cluster analysis was used. The Kruskal–Wallis test was used to investigate the differences between the sustainability attitude and performance across construction firms of different sizes, as well as to analyse the differences in the ratings on the drivers and barriers across the construction firms at different levels of sustainability.

As multiple statistical techniques were employed in a certain manner in each step of the analysis, this section aims to provide an overview of the statistical methods used in the whole study rather than explaining clearly and in detail which techniques were used and how they were used in each step. Detailed explanations of the techniques used in each step are provided in the Methods section in the corresponding chapters.

4.3.3.3 Importance–performance analysis

The importance–performance analysis (IPA) technique, proposed by Martilla and James (1977), provides a useful tool for identifying the most crucial attribute with regard to the need for managerial action. It helps decision makers to set management priorities and to determine how scarce resources might best be allocated. As a result of its ease of application and ability to present strategic recommendations together with data (Lai and To, 2010), the IPA technique has been applied in various areas, such as tourism (Pan, 2015), but it has not been adequately utilized in the context of the construction industry. The IPA technique was adopted in this study to classify the identified CSAs according to their perceived levels of importance and performance, thereby facilitating the development of the transition pathways towards sustainability for construction enterprises.

The IPA model is graphically presented as a grid divided into four quadrants which have been interpreted as "keep up the good work", "concentrate here", "low priority" and "possible overkill" (Martilla and James, 1977), as shown in Fig. 4.2 The X-axis illustrates the enterprises' performance on the attributes and the Y-axis denotes the importance of the attributes (Sörensson and von Friedrichs, 2013). Each attribute is shown according to its mean rating on the importance and performance scales:

- *Concentrate here*. Attributes in Q1 are perceived to be of high importance, with relatively low performance levels, which indicates that efforts should be concentrated here to make performance improvements.

- *Keep up the good work*. Attributes in Q2 are perceived to be of high importance, with enterprises also having high performance levels on these attributes, suggesting a message of "keeping up the good work".
- *Low priority*. Attributes in Q3 are of low importance and, thus, even though enterprises also have low-performance levels on these attributes, this is not considered an issue.
- *Possible overkill*. Attributes in Q4 are of low importance, but enterprises have high performance levels on these attributes, indicating that they have expended much more effort than was actually needed.

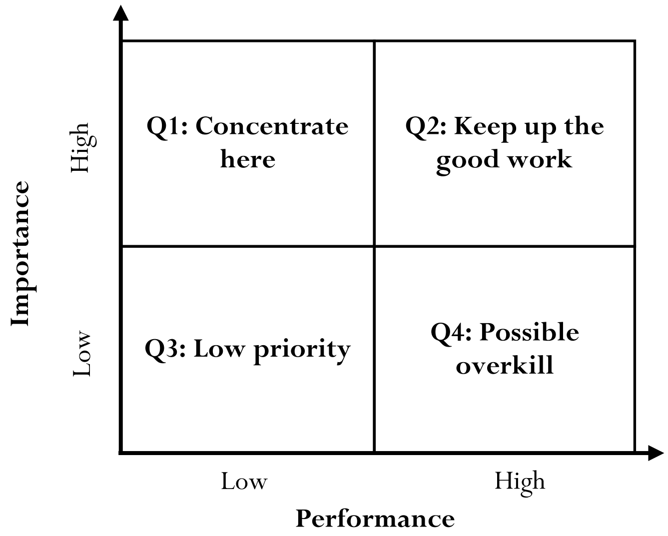

Figure 4.2 Importance–performance analysis (IPA) grid
Source: adapted from Martilla and James (1977)

An IPA is conducted in four stages: (1) collecting the key attributes, that is, items that can be characterized by the levels of importance and performance; (2) conducting a survey to measure the perceived importance and performance levels of the items; (3) determining the means of the importance and performance scores for each item, and (4) plotting the items according to their mean importance and performance scores in the IPA grid (To et al., 2015).

As the target population often presents a heterogeneity of importance and performance perceptions, segmentation was found to be a necessary component of an IPA in order to identify differences between distinct groups that allow for more accurate decision making (Bruyere et al., 2002). An IPA conducted without differentiating the respondents will produce results for an "average group" which often does not actually exist; thus, average importance and performance ratings are of limited practical value (Griffin and Edwards, 2012). An IPA without segmentation can lead researchers to make inaccurate conclusions (Bruyere et al., 2002). Segmentation can be accomplished by performing cluster analysis, with the IPA carried out on each cluster (Bacon, 2003). The current study has followed this method by performing the IPA after obtaining the cluster analysis results.

The performance gap analysis reflects the urgency of performance improvement for each attribute. The performance gap is defined as the mean performance ratings minus the mean importance ratings, with a positive gap (performance exceeds importance) suggesting "satisfactory" while negative gap (performance is lower than importance) indicates "management attention needed" (Taplin, 2012). Attributes with a larger negative gap indicate more urgent management attention is required.

In the current study, in the first instance, cluster analysis was conducted to classify the surveyed construction firms into a number of groups according to their sustainability performance. The IPA was then undertaken to classify the CSAs for each of the identified firm groups. The detailed methods are explained in Chapter 7.

4.3.4 Phase 4: Synthesis and interpretation

After each step of the analysis, the results obtained were compared with similar studies on construction enterprises in China or in the context of other countries. Similarities and differences between the results obtained in this study and other studies were critically discussed. After completing the qualitative and quantitative research, the theoretical, empirical and practical implications of the study were then critically discussed. The limitations of the study were also thoroughly highlighted to illuminate the opportunities for further research in this area.

4.4 Summary

This chapter has introduced the methodology of the current study. Mixed methods research was chosen as the research paradigm. The appropriate research design strategy was determined to be exploratory sequential mixed methods research design which included four phases: the qualitative phase; the connection (mixing) phase; the quantitative phase; and the interpretation phase. Content analysis and a multiple-case study were the primary research methods employed in the qualitative phase, while various statistical techniques and importance–performance analysis (IPA) were adopted to analyse questionnaire data in the quantitative phase. The implementation of these methods are explained in the corresponding following chapters.

Chapter 5 Facilitating the transition to sustainable construction: China's policies

5.1 Introduction

To promote sustainable construction, the Chinese government has released a number of laws, policies and regulations. In response to ***Research Objective 3***, this chapter investigates the policy system in China which aims to facilitate the transition to sustainable construction. The related laws, policies and regulations are analysed and the following three main functions are identified: regulation and control, economic incentives and supporting activities. This chapter provides a useful reference for construction corporations and policy makers in China in promoting sustainability in the construction industry. Likewise, as China has one of the largest construction industries in the world, a study of the policy system that is being used to facilitate the transition to sustainable construction in China could offer a valuable lesson for other emerging economies. Through this reference, policy makers in other emerging economies can understand how sustainability is being promoted in the Chinese construction industry. The research work of this chapter has already been published in the ***Journal of Cleaner Production*** (Chang et al., 2016a). Please see Appendix D for the full text of the publication (p.273-282).

5.2 Method

Some studies have attempted to explore China's policy system based on a specific issue, for example, the prevention and control of air pollution (Feng and Liao, 2016) or nuclear safety (Mu et al., 2015). A review of these policy studies reveals that generally three main steps are involved in a study on the policy system: the identification of relevant policy, the description and analysis of the policy, and the discussion of challenges related to the policy. To identify the policy issued by the Chinese government that is relevant to the sustainability issues of construction enterprises, a thorough review of the policy database of related authorities was conducted which included the policies issued by State Council, Ministry of Housing and Urban-Rural Development (MHUD), Ministry of Finance (MOF), etc. These authorities have maintained policy databases including MHUD Policy Database (http://www.mohurd.gov.cn/fgjs/fl/index.html), MOF Policy Database (http://www.mof.gov.cn/zhengwuxinxi/caizhengwengao/), and State Council Policy Database (http://www.gov.cn/zwgk/index.htm). Policies issued by these authorities were manually screened, and those highly relevant to sustainability in construction enterprises were selected. A total of 27 items in the form of laws, regulations, plans and provisions were identified as being of importance in promoting sustainability in construction enterprises.

After identifying the various policies which form the database of this study, the qualitative content analysis approach was employed to analyse the policies. Content analysis focuses on exploring the contextual meaning of texts, and it has been adopted in previous policy studies (e.g. Mu et al., 2015; Zuo et al., 2012). As explained in the previous chapter, the three main types of qualitative content analysis are: conventional content analysis, directed content analysis and summative content analysis (Hsieh and Shannon, 2005). This study has adopted conventional content analysis which identified the themes of the policy system through a coding process applied to the policies. Following the process of conventional content analysis, as suggested by Elo and Kyngäs (2008) and Zhang and Wildemuth (2009), the texts of these policies were systematically analysed and compared, and the main aspects of sustainability addressed by these policies were identified. By comparing the main aspects addressed by the policy system with the concept and principles of sustainable construction, the challenges facing China's policy system for sustainability in construction enterprises were then critically discussed.

Specifically, with regard to the conventional content analysis (inductive category development) procedure, the main steps are: 1) preparing the data; 2) defining the unit of analysis; 3) developing coding categories; and 4) testing the coding scheme (Zhang and Wildemuth, 2009). In this study, the research data were the main sections of the policy documents, with the secondary sections, such as the Introduction, excluded. Themes were the unit of analysis, rather than physical linguistic units. Qualitative content analysis has shown wide adoption of the use of individual themes as the unit of analysis (Zhang and Wildemuth, 2009). By using themes as the unit of analysis, researchers can assign a code to a text chunk of any size, as long as that chunk represents a single theme. In the current study, the researchers firstly randomly selected and examined 25 policy documents from the total of 27 policy documents to identify individual themes. The number of themes was then reduced by collapsing either similar or dissimilar themes into higher-order categories. After this category development process, a list of the policy measures (themes) was identified and summarized into a policy gear model. The two remaining policy documents were then used as sample texts to test the clarity of the identified themes. As the contents of the two remaining policy documents could be appropriately coded by using the identified list of themes, the clarity and comprehensiveness of the list were reaffirmed.

5.3 China's policy system for sustainability in construction enterprises

To facilitate the transition of the construction industry towards sustainability, the central government in China has developed a number of laws, regulations, plans and provisions. In all, 27 policy items were identified and are summarized in Table 5.1.

Table 5.1 China's policy system for sustainable construction

Types	Items	Issued by department/Year of publication
Framework policies	1. 12th Five-Year Plan for Energy Conservation and Emission Reductions	SCC/2012
	2. 12th Five-Year Plan for the Construction Industry	MHUD/2011
	3. Environmental protection law	NPC/2007
	4. Energy conservation law	NPC/2007
	5. Renewable energy law	NPC/2005
	6. Law on prevention and control of environmental pollution by solid waste	NPC/2004
	7. Environmental impact assessment law	NPC/2002
Supporting regulations	8. Regulation on the construction of barrier-free environments	SCC/2012
	9. Regulation on energy conservation in civil buildings	SCC/2008
	10. Regulation on energy conservation in state-funded institutions	SCC/2008
	11. Administrative regulation on the work safety of construction projects	SCC/2003
	12. Administrative regulation on the environmental protection of construction projects	SCC/1998
Specific instructions	13. Circular of the State Council on strengthening urban infrastructure	SCC/2013
	14. Notice on the implementation of green affordable housing	MHUD/2013
	15. Circular of the State Council on accelerating the development of the environmental production industry	SCC/2013
	16. 12th Five-Year Plan for Green Building and Low-Carbon Urban Development	MHUD/2013
	17. Action plan for promoting green buildings	NDRC, MHUD/2013
	18. Opinions on accelerating green building development	MOF, MHUD/2012
	19. 12th Five-Year Plan for Technology Development of Green Buildings	MOST/2012
	20. Notice on organizing the demonstration of photovoltaic applications in buildings in 2012	MOF, MHUD/2011
	21. Notice on organizing the demonstration of renewable energy applications in buildings in 2012	MOF, MHUD/2011
	22. Notice on further promoting renewable energy applications in buildings	MOF, MHUD/2011
	23. Notice on the organization and implementation of the demonstration of photovoltaic applications in buildings	MOF, MHUD/2011
	24. Opinions on accelerating the implementation of photovoltaic applications in buildings	MOF, MHUD/2009
	25. Interim measures on the management of the subsidies for photovoltaic applications in buildings	MOF/2009

26. Bulletin of promoted, restricted and prohibited technologies in the construction industry	MHUD/2007
27. Interim measures on the management of the special funds for renewable energy applications in buildings	MOF, MHUD/2006

Abbreviations: SCC=State Council of China; MHUD=Ministry of Housing and Urban-Rural Development; NPC=National People's Congress of China; NDRC=National Development and Reform Commission; MOF=Ministry of Finance; MOST=Ministry of Science and Technology

The above laws, policies and regulations for sustainable construction can be divided into three categories: (1) framework policies, (2) supporting regulations and (3) specific instructions. Seven policies can be regarded as framework policies, providing overall guidance to sustainable construction. Of these, the *12th Five-Year Plan for the Construction Industry*, combined with the *12th Five-Year Plan for Energy Conservation and Emission Reductions*, put forward strategic foci and development priorities for sustainable construction during the 12th Five-Year Plan period (2010–2015) (MHUD, 2011a; SCC, 2012a). The other five pieces of law in the framework policy category regulate the environmental protection activities in all industries, including the construction industry.

Compared to framework policies, supporting regulations more specifically focus on the various dimensions of sustainability in the construction industry. The *Regulation on the Construction of Barrier-free Environments* provides the legal basis for constructing barrier-free facilities for persons with disabilities (SCC, 2012b), while the *Regulation on Energy Conservation in Civil Buildings* and the *Regulation on Energy Conservation in State-funded Institutions* stipulate that energy conservation strategies should be adopted in both civil and state-funded buildings (SCC, 2008a; SCC, 2008b). Similarly, safety management and the environmental management system of construction corporations are also emphasized by some supporting regulations (SCC, 1998; SCC, 2003).

Furthermore, to provide detailed instructions, the central government released many specific instructions. A total of 15 specific instruction regulations were identified. The urban infrastructure and affordable housing construction were strengthened by the *Circular of the State Council on Strengthening Urban Infrastructure* and the *Notice on the Implementation of Green Affordable Housing*, respectively (SCC, 2013b; MHUD, 2013c). In addition, specific instructions and incentives for renewable energy applications in buildings were found in many regulations such as the *Notice on the Organization and Implementation of the*

Demonstration of Photovoltaic Applications in Buildings, the *Notice on Organizing the Demonstration of Photovoltaic Applications in Buildings in 2012* and the *Notice on Further Promoting Renewable Energy Applications in Buildings* (MHUD and MOF, 2011d; MHUD and MOF, 2011a; MHUD and MOF, 2011b).

How the above laws, regulations and instructions generate an effective stimulus for sustainable construction is of importance. Based on the content analysis results, this study proposes a policy gear model to illustrate the inner support mechanisms for sustainability in construction enterprises that are formed by these policies, as shown in Fig. 5.1. Various functions of these policies are categorized into three groups: regulation and control, economic incentives and supporting activities, all of which are discussed below.

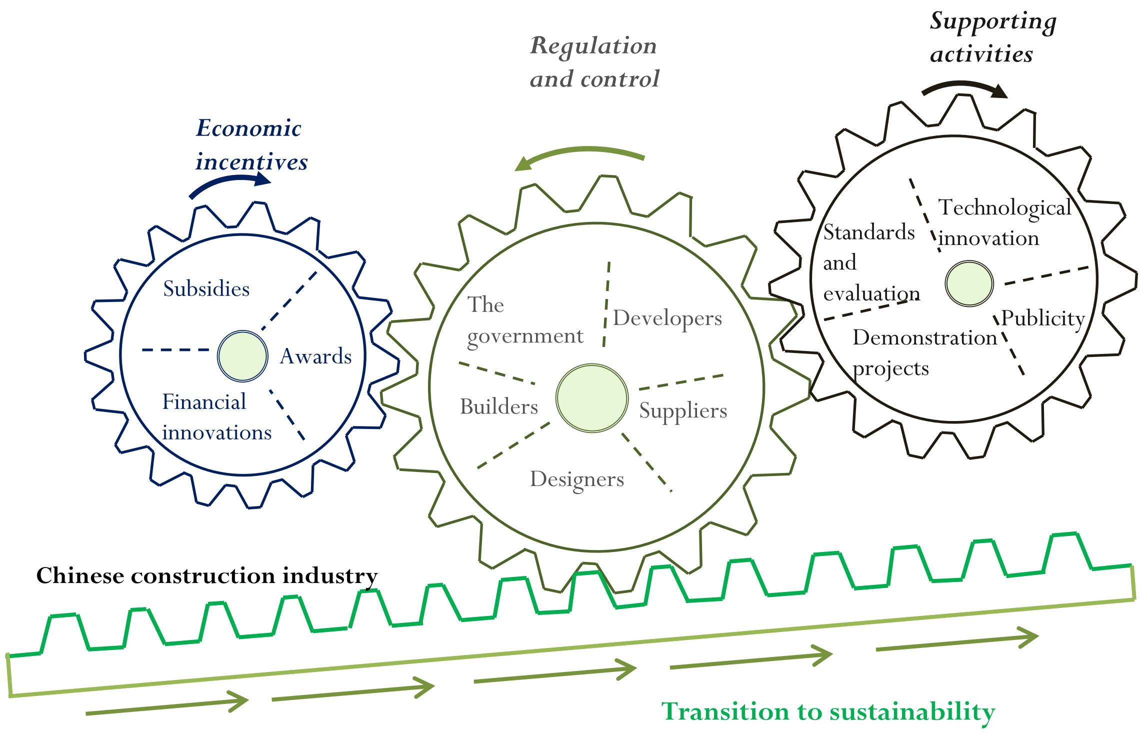

Figure 5.1 Policy gear model of sustainable construction in China

5.3.1 Regulation and control

The establishment of regulation and control is the traditional function of government (Spence and Mulligan, 1995). Especially in China, the control and regulatory instrument is considered to be the most efficient type of policy owing to its long execution period (Huang et al., 2016). The key participants in the construction industry include the central and local governments, developers, suppliers, designers and builders. Various policies have been proposed to prevent these participants, including the government itself, from harmful behaviours which are detrimental to the sustainability of projects, as shown in Table 5.2.

As the central and local governments have the right to approve construction projects, the approval practices must be regulated and controlled. The *Energy Conservation Law* stipulates that if the design documents of construction projects do not comply with mandatory energy standards, the government cannot issue the construction permits (NPC, 2007). Before issuing construction permits, the government also needs to examine whether safety measures are planned for the construction. If the construction permits are issued to unprepared builders, the corresponding officers in the government will be punished (SCC, 2003).

Apart from project approval, the government is also responsible for urban planning. Recent years have seen the continuous emergence of luxurious public buildings and government office buildings in China. In 2013, the State Council of China (SCC) issued the *Circular of the State Council on Strengthening Urban Infrastructure* which forbids the construction of unrealistic "image projects" and "achievement projects" (SCC, 2013b). Similarly, the rights of vulnerable groups, such as disabled people, are also given some attention in urban planning, indicated by policies such as the *Regulation on the Construction of Barrier-free Environments* (SCC, 2012b). This regulation stipulates that if public buildings, public transport facilities and residential areas which are already built do not meet relevant accessibility standards, the governments shall be responsible for organizing the renovation of these facilities (SCC, 2012b).

Table 5.2 Key policies of regulation and control

Participants	Key policies of regulation and control	Policy source
The governments	Must not approve project plans which are not in accordance with the compulsory energy standards.	Energy Conservation Law
	Need to examine whether safety measures are planned by builders for the construction.	Administrative Regulation on the Work Safety of Construction Projects
	The construction of unrealistic "image projects" and "achievement projects" should be forbidden and the actual economic and social conditions of cities must be considered in urban planning.	Circular of the State Council on Strengthening Urban Infrastructure
	The governments above the county level are responsible for preparing and implementing a development plan for a barrier-free environment for disabled people.	Regulation on the Construction of Barrier-free Environments
Developers	Need to prepare an environmental impact assessment document for the proposed project.	Environmental Impact Assessment Law
	Must arrange solid waste management facilities which must be designed, constructed and put into place along with the main project.	Law on Prevention and Control of Environmental Pollution by Solid Waste
	If the project has the potential to produce huge negative impacts on the environment and the public, the developers must arrange hearings or other forms of meetings to acquire expert and public opinions about the proposed project.	Environmental Impact Assessment Law
Builders	Must effectively remove the construction waste they generate.	Law on Prevention and Control of Environmental Pollution by Solid Waste
	The materials and equipment delivered to the construction site need to be checked to see whether they comply with the energy conservation requirements indicated by the design documents.	Regulation on Energy Conservation in Civil Buildings
	Safety accountability systems and safety education systems should be established, and safety management personnel should regularly conduct safety checks and maintain safety inspection records.	Administrative Regulation on the Work Safety of Construction Projects
Designers	Should obey relevant compulsory energy standards.	Energy Conservation Law
Suppliers	The Ministry of Housing and Urban-Rural Development (MHUD) regularly publishes technology catalogues, showing which technologies in the construction industry are promoted, restricted or prohibited by the government.	Bulletin of Promoted, Restricted and Prohibited Technologies in the Construction Industry

Developers are crucial actors in the construction industry as their project requirements usually have to be met. However, developers' needs must not be harmful to the public and the environment. Therefore, the government has issued some policies to clarify the obligations of developers, with these policies mainly concerned with the environmental dimension of sustainable construction, such as preparing environmental impact assessment documents (NPC, 2002); arranging solid waste management facilities (NPC, 2004); and organizing meetings to acquire expert and public opinions about proposed projects (NPC, 2002). Similarly, the importance of builders in contributing to sustainable construction is emphasized by the policies, as good design and good project plans need to be correctly implemented in the construction process. In addition to removing construction waste, builders need to check the materials and equipment delivered to the construction site (SCC, 2008a) and establish safety management systems (SCC, 2003).

Compared to developers and builders, designers and suppliers receive much less attention in policy documents. For designers, fulfilling the requirements of compulsory energy standards is important as, according to the *Energy Conservation Law*, if they seriously violate building energy standards, their level of qualifications may be lowered and their qualification certificates may even be revoked (NPC, 2007). For suppliers, one important policy is the *Technology Promotion, Restriction and Prohibition Policy*. According to the latest technology catalogue published by the MHUD, there are: 1) 326 promoted technologies, such as mineral wool insulation technology and planted roof technology; 2) 37 restricted technologies, such as slurry wall insulation material and spiral plate heat exchangers; and 3) 32 prohibited technologies, such as grey cast iron long wing radiators and slate knife switches (MHUD, 2007). Suppliers should therefore pay attention to these policies and adjust their production direction accordingly.

5.3.2 Economic incentives

In addition to regulation and control which prevent the misbehaviour of participants in the construction industry, the central government tries to encourage construction corporations to actively transition themselves to become more sustainable corporations, mainly through a series of economic incentive policies, providing subsidies, awards and innovative financing solutions (MOF, 2009; MHUD and MOF, 2012).

5.3.2.1 Subsidies

In 2006, the Ministry of Finance (MOF) and the MHUD jointly released the *Interim Measures on the Management of the Special Funds for Renewable Energy Applications in Buildings* which is the first policy on a subsidy for sustainable construction issued by the central government. This policy indicates that, each year, the two ministries will determine the subsidy values for different kinds of renewable energy applications in buildings and, in this determination, will consider various factors, such as the incremental cost, market price fluctuation and technical sophistication of the applications (MOF and MHUD, 2006). Moreover, subsidies are provided to support research and development (R&D) of key technologies, energy efficiency testing and improving the technical standards around renewable energy applications in buildings (MOF and MHUD, 2006).

Furthermore, since 2006, the government has released many regulations strengthening the subsidies for renewable energy applications in buildings. In 2011, the *Notice on the Organization and Implementation of the Demonstration of Photovoltaic Applications in Buildings* was issued. According to this document, 50% of the bid price of the key components, such as the crystalline silicon components, grid inverters and energy storage lead-acid batteries, will be paid directly by the local finance department to the suppliers (MHUD and MOF, 2011d). Also issued in 2011, the *Notice on Organizing the Demonstration of Photovoltaic Applications in Buildings in 2012* indicates that, to support the large-scale application of photovoltaic systems in buildings, the central government is encouraging the local governments to develop green urban areas, where the photovoltaic systems need to be extensively adopted (MHUD and MOF, 2011b).

5.3.2.2 Awards

The government subsidies mainly provide financial support for renewable energy applications in buildings, while a broader concept of “green buildings” seems to be neglected by subsidy policies. However, in order to provide monetary support to green buildings, in 2012, the MOF and the MHUD jointly released *Opinions on Accelerating Green Building Development*. This document indicates that the central government will establish a monetary award system for high-rated green buildings. In accordance with this policy, in

2012, the developers of Two-Star buildings received an award of 45 CNY/square metre (m^2) and the developers of Three-Star buildings received an award of 80 CNY/m^2 (MHUD and MOF, 2012). The amount of the award is annually adjusted based on cost fluctuation and the technology improvement situation (MHUD and MOF, 2012). Apart from the awards provided by the central government, some local governments offer awards to green building developments. For instance, in Shandong province, One-Star green buildings can receive an award of 15 CNY/m^2 (People's Daily, 2013).

5.3.2.3 Financial innovations

The construction of infrastructure often needs a large investment which traditionally comes from the government. Driven by the rapid urbanization process in China, the amount of infrastructure projects that need to be built is increasing dramatically and it is unsustainable that the government continues to be the sole investor. In order to alleviate the monetary pressure the government was facing, in 2013, the SCC issued the *Circular of the State Council on Strengthening Urban Infrastructure* which indicated that the government would establish a sustainable investment and financing system for urban infrastructure by attracting private capital (SCC, 2013b). Modern project financing approaches, such as build-operate-transfer, build-own-operate-transfer and build-own-operate, would be strongly promoted to increase the economic sustainability of infrastructure projects (SCC, 2013b). In addition, other financial innovations would be examined to further support sustainable construction. For instance, whether a private company's concessions from the government could be regarded as collateral for business loans would be explored (SCC, 2013a).

5.3.3 Supporting activities

While economic incentives may encourage corporations to start a transition to sustainability, other obstacles still remain, such as the lack of core technologies, lack of relevant standards, low awareness of green buildings among the public and lack of evaluation methods for sustainable construction. The Chinese government, in recognizing the existence of these obstacles, has issued a number of policies and regulations trying to reduce and eventually eliminate them.

5.3.3.1 Technological innovation

Issued in 2012 by the Ministry of Science and Technology (MOST), the *12th Five-Year Plan for Technology Development of Green Buildings* offers comprehensive technology development strategies for green buildings. According to this document, three major areas of technology are considered to be important, and research relating to these areas will be strongly supported by the government (MOST, 2012). These areas of technology are summarized in Fig. 5.2. Various aspects of sustainable construction, such as planning and design, construction, assessment and information systems, are supported by the technology development plan.

The objective of innovative technology development in China is to improve the sustainability level of the Chinese construction industry. Among the technologies listed in Fig. 5.2, the research on the "technical information service system for green buildings" is very important and strongly supported by the government. As there are many green technologies available, the holistic sustainability assessment of these technologies plays a crucial role in informing developers so they can choose the appropriate technology for their projects (Huang et al., 2012). Similar to the function of the BAT (best available techniques) Reference Document (BREF) in guiding technology development in European construction industries, this information service system in China will summarize and compare different materials and technologies for various kinds of construction projects, helping developers to choose appropriate technologies for their projects.

The *12th Five-Year Plan for Technology Development of Green Buildings* indicates that, in order to implement the technology development plan, six measures need to be undertaken: 1) strengthening the sectoral coordination between relevant governmental departments; 2) establishing state key laboratories and research centres on green buildings; 3) supporting enterprises to increase research and development (R&D) in green buildings; 4) improving the awareness of corporate social responsibility (CSR) in construction corporations; 5) promoting international exchanges and cooperation; and 6) gradually establishing long-term mechanisms supporting the technology development of green buildings (MOST, 2012).

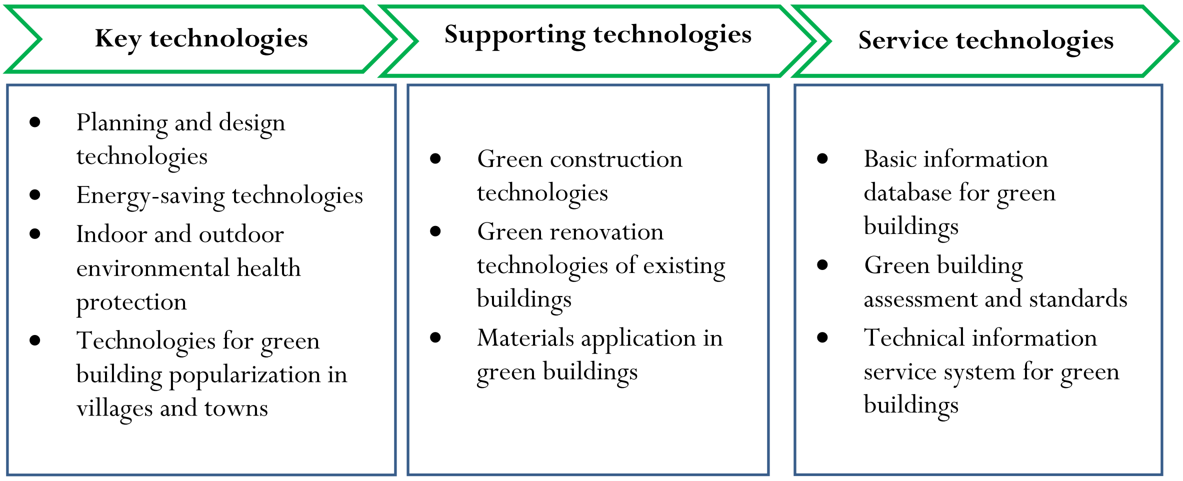

Figure 5.2 China's technology development plan for green buildings
Source: adapted from MOST (2012)

5.3.3.2 Standards and evaluation

The standards for sustainable construction in China have undergone a significant improvement during recent years. Table 5.3 summarizes the main sustainable construction standards which respond to the sustainability issues in various phases of construction projects.

Table 5.3 Main sustainable construction standards in China

Serial number	Standard	Effective date
JGJ59-2011	Standard of construction safety inspection	1 July 2012
JGJ/T264-2012	Code for operation and maintenance of building-mounted photovoltaic system	1 May 2012
GB/T50640-2010	Evaluation standard for green construction of buildings	1 October 2011
JGJ/T229-2010	Green design standard of civil buildings	1 October 2011
CJJ134-2009	Technical code for construction & demolition waste treatment	1 July 2010
GB50189-2005	Design standard for energy efficiency of public buildings	1 July 2005

Among the listed standards, two standards are related to the design phase: the *Design Standard for Energy Efficiency of Public Buildings* and the *Green Design Standard of Civil Buildings* (MHUD, 2010a; MHUD and AQSIQ, 2005). The other four standards regulate the construction and operation phases. Many articles in these standards are compulsory which helps to provide the impetus for sustainable construction in China. For instance, the *Technical Code for Construction & Demolition Waste Treatment* has four compulsory articles, such as the requirement to cover construction waste during transportation and the requirement to not deliver domestic garbage and hazardous waste to construction waste landfill and recycling sites (MHUD, 2009b). The *Standard of Construction Safety Inspection* stipulates that construction corporations which do not meet the standards of safety inspections must take measures to rectify the problems within the specified time (MHUD, 2011b).

The evaluation system for green buildings in China has also experienced significant improvement as shown in Fig. 5.3. The development of China's green building evaluation system can be divided into three stages. Firstly, in 2006, the MHUD and the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) released the *Evaluation Standard for Green Buildings* which has been used to evaluate normal residential and business buildings. According to this document, a Three-Star system is used to assess the greenness degree of buildings, with six categories of indicators used to evaluate the buildings: (1) land conservation and outdoor environment; (2) energy conservation and application; (3) water conservation and application; (4) materials conservation and application; (5) indoor environmental quality; and (6) operation management (MHUD and AQSIQ, 2006). In the second stage, from 2007 to 2009, several supplementary documents were issued to refine the evaluation standard, and two kinds of assessment were differentiated: green building planning and design evaluation for projects in the design phase; and green building operation evaluation for completed projects (MHUD, 2008; MHUD, 2009a). The third stage began with the issue of the *Guidelines for Green Industrial Building Evaluation* which expanded the types of buildings that could be evaluated (MHUD, 2010b). In addition to industrial buildings, high-rise buildings and affordable housing were specifically given attention by the government (MHUD, 2012, 2013b).

Compared to evaluation tools used in other countries, the government in China has more control over the Three-Star system. Mao et al. (2009) argued that the cultural and political differences between the East and the West lead to the differences in the organizations that provide the rating tools for green buildings. The Leadership in Energy & Environmental Design (LEED) and Building Research Establishment Environmental Assessment Methodology (BREEAM) rating tools, that originated in the USA and the UK, respectively, were established by organizations independent from the US and UK governments (Mao et al., 2009). By contrast, the Three-Star system in China and the Green Mark in Singapore were both developed by the relevant governmental departments. The Three-Star system in China is even formalized as a national standard by the Chinese government. As a result, the rating system forms an integral part of China's supporting policies for sustainable construction.

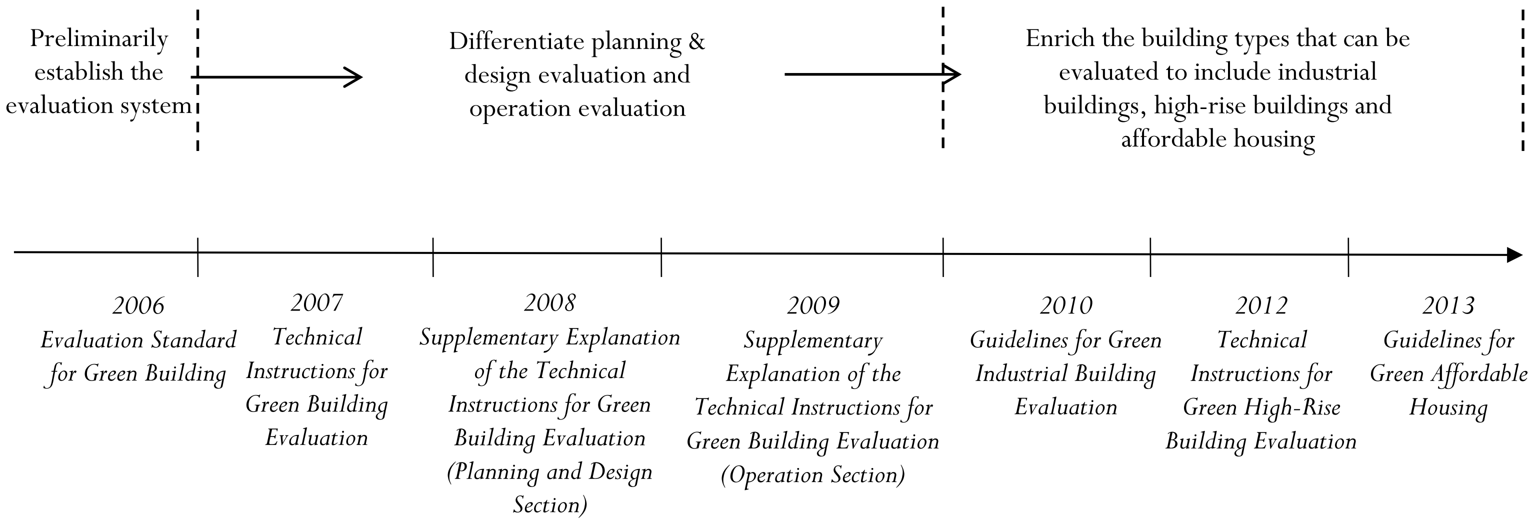

Figure 5.3 Major governmental documents for green building evaluation

5.3.3.3 Demonstration projects

In addition, the Chinese government has made efforts to popularize sustainable construction through the use of demonstration projects. In 2012, the following two important documents were issued concerning demonstration projects: the *Notice on Organizing the Demonstration of Photovoltaic Applications in Buildings in 2012* and the *Notice on Organizing the Demonstration of Renewable Energy Applications in Buildings* (MHUD and MOF, 2011b, 2011c). Under the impetus of these policies, a few provinces, cities, counties and urban areas became concentrated areas for demonstration projects. For instance, in 2012, eight provinces, including Jiangsu, Qinghai and Xinjiang, became photovoltaic building demonstration provinces, and a total of 21 cities and 52 counties were determined to be renewable energy building demonstration cities and counties, respectively (MHUD, 2013a). Eight urban areas were selected as green urban areas, including Zhongxin district in Tianjin and Guangming district in Shenzhen (MHUD, 2013a).

Demonstration projects in China include not only renewable energy applications in buildings and green buildings, but also projects which are built through green construction methods. Under the guidance of the MHUD, the China Construction Industry Association (CCIA) has selected three batches of green construction demonstration projects, including 11 projects in the first batch, 81 projects in the second batch and 278 projects in the third batch, with these projects distributed in 21 provinces (CCIA, 2011, 2013). By illustrating new building and construction techniques based on sustainability principles, these demonstration projects have largely improved the awareness in the industry of sustainable construction.

5.3.3.4 Publicity

Strengthening the publicity campaign has been covered by many policies. The *Circular of the State Council on Accelerating the Development of Environmental Production Industry* stipulates that the local governments need to publicize the concept of ecological civilization and spread the knowledge of an energy-saving and low-carbon lifestyle to gradually trigger the formation of low-carbon production and consumption by the public (SCC, 2013a). The *Action Plan for Promoting Green Buildings* mentions that the concept of green buildings needs to be strongly propagated in National Energy Conservation Week, Science and Technology Week, World Water Day and World Environment Day (NDRC and MHUD, 2013). This action plan suggests that various aspects in relation to green buildings should be propagated, such as green building regulations, economic incentive policies on green buildings, and the advantages of green buildings. The *12th Five-Year Plan for Green Building and Low-Carbon Town Development* indicates that the government needs to take full advantage of various media, such as television, newspapers and the internet, to publicize the advantages and urgency of promoting green buildings (MHUD, 2013d).

5.4 Emerging challenges

The current policies provide a strong stimulus for the Chinese construction industry to transition towards sustainability; however, these policies are still not without challenges. This section identifies two prominent challenges related to: 1) the economic and social dimensions of sustainable construction and 2) the effectiveness of the current policies.

5.4.1 Economic and social dimensions of sustainable construction

Sustainable construction practices pursue a balance between economic, social and environmental performance in implementing construction projects (Shen et al., 2010a). Thus, a well-developed policy system for promoting sustainable construction should balance various dimensions, such as economic, social and environmental. However, this study has revealed that the current policies related to sustainability in the construction industry in China heavily focus on the environmental aspects of sustainable construction, such as popularizing green buildings; promoting renewable energy applications in buildings; requiring energy conservation; and regulating the solid waste management practices of construction corporations. In contrast, the economic and social dimensions of sustainability receive much less attention from the policies. It has been argued that, underlying the development of the building sector in China, there is the lack of a coherent national policy framework that integrates multiple objectives of sustainability (Li and Shui, 2015). Specifically, even though the policies have paid attention to safety management and modern project financing approaches, the large number of other social and economic factors is ignored, such as cultural and heritage conservation, local community engagement, financial affordability and economic impacts for the public.

It is well recognized that more social factors should be considered in future policy making. According to Hill and Bowen (1997), some of the main social principles of sustainable construction include: improving human health through a healthy and safe working environment; implementing skills training and capacity enhancement of disadvantaged people; and seeking equitable distribution of the social benefits of construction. These important social principles should be highlighted in future policies. Similarly, more research should be conducted to examine the impacts of implementing sustainability practices on the economic competitiveness of construction corporations in China as, traditionally, the profit-driven culture has been dominant in the industry and cost, quality and schedule have been the determinants ensuring maximum benefits to the construction business (Shen et al., 2010a). Tan et al. (2015) conducted a preliminary study which revealed the complex interrelationships that exist between sustainability performance and business competitiveness of international construction contractors. The issue of how sustainability practices affect the cost, quality and schedule of construction projects, especially in the context of China, could be further explored to inform future policy making that targets the economic dimension of sustainable construction in China.

5.4.2 Effectiveness of current policies

During the implementation of the current policies, some doubts questioning their effectiveness gradually emerged among the public. For instance, little attention by the current green building evaluation standards has been given to regional differences in economic development. It has been reported that for developed regions in China, such as Beijing and Shanghai, the requirements of the evaluation standards are too low and many developers can easily meet the standards, while for regions where economic development is lagging behind, such as Guizhou and Gansu, the requirements in the standards are too high and few developers can meet them (EID, 2010). Similarly, China is a vast country with various climate zones, thus also leading to the need to set up different energy-saving standards for construction projects in different regions (Huang et al., 2016). Furthermore, the *Environmental Impact Assessment Law* stipulates that the developers must arrange hearings or other forms of meetings to acquire expert and public opinions about the proposed project (NPC, 2002). However, the public's access to environmental information about large construction projects is still restricted and developers usually only comply by consulting experts to fulfil the requirements of the law (Li et al., 2012).

In future policy revision and policy-making processes, this negative feedback from the public should be given sufficient attention. To support the future work of revising the current green building evaluation standards, a multi-dimensional post-occupancy evaluation of existing green buildings should be conducted to investigate and research the geographical distribution of the buildings; the users' feedback; the actual environmental performance of the buildings; the economic performance of the buildings; and the developers' experience and attitudes about developing green buildings. Similarly, detailed policies are required to improve public participation in the environmental impact assessment process of construction projects. The legal obligations of the government and developers to organize public participation should be researched and determined (Li et al., 2012). The supervision of the participatory process and the penalty for inappropriate activities during the process, such as bribing the representatives of the public, should be reflected in future policies.

5.5. Summary

This chapter has identified a total of 27 important policy documents issued by the Chinese government to enable the transition to sustainability in the construction industry in China. They were further divided into three categories: framework policies, supporting regulations and specific instructions. To show how these different policies join together to generate effective driving forces for sustainable construction, the current study proposed a policy gear model which illustrates three important measures of the policy system: regulation and control, economic incentives and supporting activities. Thus, ***Research Objective 3***, as proposed in Chapter 1, is achieved.

This chapter has systematically examined the policy system that the Chinese government has developed to promote sustainability in the construction industry. It is expected that the current research will help participants in the Chinese construction industry to understand the policy environment on sustainability with which they are faced, and that it will help policy makers in China to better promote sustainable construction in the future urbanization process. More importantly, as sustainable development is extensively regarded as the direction of development worldwide, the policy system including the laws, regulations, plans and provisions examined in this chapter can provide useful references for policy makers in other emerging economies.

Chapter 6 Sustainability transitions of leading Chinese construction enterprises: A multiple-case analysis

6.1 Introduction

Within an industry, a large number of firms are in operation and, thus, firms may adopt different strategies to respond to sustainability. The literature examining strategic sustainability behaviours of corporations reveals that corporations can be classified into different categories according to their sustainability strategies, and that this strand of literature can offer a valuable reference for understanding the heterogeneity of corporations. For instance, Winn and Angell (2000) proposed that corporate sustainability (CS) responses can be classified into four categories: deliberate reactive, unrealized, emergent active and deliberate proactive. Ghobadian et al. (1998) identified five theoretical options for firms with regard to environmental issues: non-compliance strategy; compliance strategy; compliance plus; commercial; and environmental excellence and leading edge. Similarly, Klewitz and Hansen (2014) classified the strategic sustainability behaviours of corporations into five categories: resistant; reactive; anticipatory; innovation-based and sustainability-rooted.

To respond to ***Research Objective 4*** (to investigate the evolution of the leading Chinese construction firms' sustainability behaviours and practices), this chapter analyses the sustainability transitions of three leading construction firms by digging into their evolving sustainability practices and their strategic sustainability behaviours based on a multiple-case study approach. How did the leading construction firms in China react to sustainability? Are they transitioning themselves towards sustainability? What sustainability practices have they adopted? What are their strengths and weaknesses in responding to sustainability? Using a multiple-case study approach, this chapter aims to holistically identify the sustainability behaviours and practices adopted by leading construction firms in China, thereby establishing a basis for understanding the sustainability transition of other Chinese construction enterprises. The research work presented in this chapter has already been published in the ***Journal of Management in Engineering*** (Chang et al., 2016b). Please see Appendix E for the full text of the publication (p. 283-296).

6.2 Method

The research methodology adopted in this chapter is a multiple-case study approach using directed content analysis. Based on the research procedures proposed by Yin (2014) and Baxter and Jack (2008), the research procedure was developed as shown in Fig. 6.1.

Several advantages are associated with the multiple-case design compared to the single-case design. The single-case design is vulnerable as researchers have put "all their eggs in one basket"; thus, the evidence from multiple cases is often considered to be more compelling and the overall study is regarded as being more robust (Yin, 2014). Multiple-case design allows cross-case analysis and comparison, and the investigation of a particular phenomenon in diverse settings. Therefore, multiple-case design was adopted in this study.

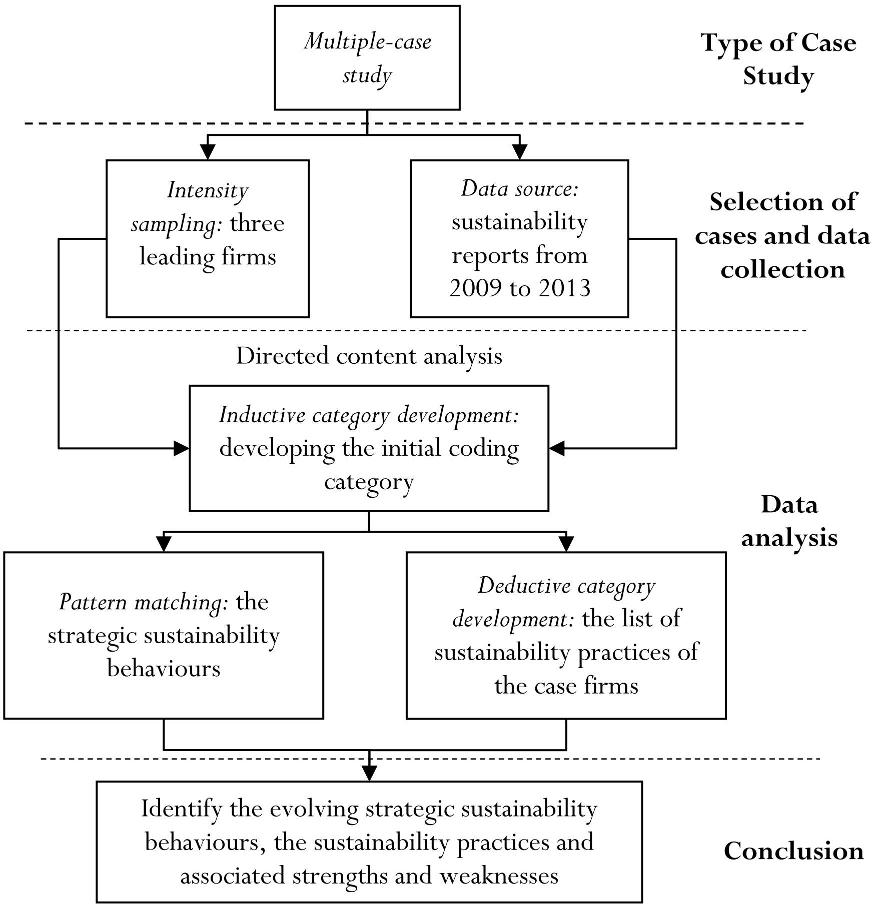

Figure 6.1 Research procedure and methods in this chapter

6.2.1 Intensity sampling and data source

Data in a case study can be collected via several methods, such as interviews, documentation, a questionnaire and observation (Baxter and Jack, 2008). For the current study, it was decided that documents would be used as the data source. Interviewing employees in construction corporations may generate detailed information; however, it is restricted by the interviewees' personal work experience and may induce response bias (Tellis, 1997). More importantly, one research aim of this study is to identify the evolution of the strategic sustainability behaviours of the case firms. These behaviours need to be based on detailed historical records and cannot be achieved by means of interviews. Some leading construction corporations in China have published annual sustainability reports presenting their sustainability practices in a systematic manner. As these reports are published annually by the corporations, changes in chronological order of their sustainability practices can be investigated by means of analysing these reports, with this not able to be achieved by means of interviews. These reports are usually developed by senior managers of sustainability or social responsibility departments in corporations, and assessed by a third-party evaluation agency: this ensures the authenticity of the information in these reports. Many case studies published in high ranking journals have adopted documentation as the data collection method. For instance, Säynäjoki et al. (2014) examined how Finnish central business district developments are designed to facilitate environmental sustainability by using the official plan reports as the main source of data. Murguía and Böhling (2013) examined a mining conflict in Argentina's Bajo de la Alumbrera open pit mine based on content analysis of Alumbrera's Sustainability Report (SR), primarily from 2009, but complemented with insights from the 2010 and 2011 reports. Lozano and Huisingh (2011) proposed a new category of sustainability indicators by analysing the sustainability reports from three selected case companies.

As sustainability reports are the main data source of this multiple-case study, corporations which have released their sustainability reports for a longer term than others should be selected to fulfil the information-richness requirement of purposeful sampling. The logic of sampling cases is fundamentally different from that of statistical sampling: sampling cases is theoretical (purposeful) sampling, in which the goal is to choose the cases that can illuminate a phenomenon and replicate or extend theory, or to fill theoretical categories and provide examples (De Massis and Kotlar, 2014; Meyer, 2001; Perry, 1998). Unlike statistical sampling which selects a random and statistically representative sample, purposeful sampling is more appropriate in qualitative case studies, selecting information-rich cases for in-depth study (Patton, 1990). According to Patton (1990), intensity sampling selects information-rich cases that intensely manifest the investigated phenomenon. Intensity sampling was adopted in this study to select leading construction firms which have adequate experience in sustainability practices and in dealing with sustainability issues, as reflected by their detailed and information-rich sustainability reports.

Table 6.1 Process used to select the case firms

Rank 2014	Rank 2013	Firm	2013 Total revenue (US$m)	Firms which release sustainability reports	Firms which started to release sustainability reports before 2010	Firms chosen as cases
1	3	China State Construction Engineering Corp., Beijing	97,870.2	√	√	√
2	1	China Railway Construction Corp. Ltd., Beijing	96,195.0	√	√	
3	2	China Railway Group Ltd., Beijing	88,944.0	√	√	
4	6	China Communications Construction Group Ltd., Beijing	54,181.7	√	√	√
10	9	China Metallurgical Group Corp., Beijing	27,256.3	√		
11	13	Shanghai Construction Group, Shanghai	24,820.1			
14	14	Sinohydro Group Ltd., Beijing	20,674.7			
32	36	China National Chemical Eng'g Group Corp., Beijing	10,119.2			
37	42	China Gezhouba Group Co. Ltd., Wuhan City, Hubei	8,921.7	√	√	√
39	48	Zhejiang Constr. Investment Group Co. Ltd., Hangzhou	8,908.3	√		
46	**	Beijing Urban Construction Group, Beijing	7,431.0			
47	52	Qingjian Group Co. Ltd., Qingdao, Shandong	7,359.0			
49	45	Dongfang Electric Corp., Chengdu, Sichuan	7,302.5	√	√	
50	51	China Yunan Construction Eng'g Group Co., Kunming	7,291.6			

Following the logic of intensity sampling, in the first instance, the 14 Chinese construction firms ranked in the top 50 global contractors in 2014 by *Engineering News-Record* were screened (see Table 6.1). As a result, eight Chinese companies were identified that had released sustainability reports. Six of these eight companies had started to release sustainability reports before 2010. Three of these six companies were chosen for further study, namely: China State Construction Engineering Corp. Ltd (CSCEC) (Firm A); China Communications Construction Company. Ltd (CCCC) (Firm B); and China Gezhouba Group Co., Ltd (CGGC) (Firm C). The reasons for choosing these firms were: 1) they have diverse business areas, covering most project types in the construction industry; and 2) a preliminary examination of the sustainability reports of these six firms suggests that the selected three firms produced much more detailed reports than the others, with the extra detail much more intensively manifesting sustainability. Choosing three cases is a widely adopted approach in terms of the number of cases in multiple-case studies, such as the studies by Van der Laak et al. (2007), Smith (2004), Almahmoud et al. (2012) and Säynäjoki et al. (2014). The process of case selection is presented in Table 6.1. The details of the selected case firms are shown in Table 6.2.

Table 6.2 Details of the case firms

Case firm	Position in global contractors in 2013	Business scope	Main project types
Firm A CSCEC	Top 10	Residential construction, international project contracting, real estate development and investment, infrastructure construction and investment, survey and design	• Houses, roads
Firm B CCCC	Top 10	Infrastructure design and construction, dredging, heavy machinery manufacturing, and investment	• Ports, docks, channels, roads, bridges, railways and municipal roads
Firm C CGGC	Top 40	Infrastructure design and construction, low-carbon cement manufacturing, investment, property development and civil explosives manufacturing	• Hydropower plants, railways, nuclear power, airports, ports, wind power

6.2.2 Inductive category development

To holistically identify sustainability practices implemented by the case firms, the data analysis approach needed to be capable of examining the contextual meanings of the sustainability reports and developing a category for the sustainability practices. Qualitative content analysis is an approach that could fulfil these research requirements. The Methodology chapter has explained that the three main approaches in qualitative content analysis are: conventional content analysis (inductive category development); directed content analysis (combination of deductive and inductive category development); and summative content analysis (focusing on examining keywords rather than developing categories) (Hsieh and Shannon, 2005). The current study adopted directed content analysis as the data analysis method. In directed content analysis, an initial coding category is developed based on the existing literature or theory (inductive category development), and the research data are then examined and coded based on the initial coding category (deductive category development). Following the research procedure suggested by Elo and Kyngäs (2008) and Zhang and Wildemuth (2009), directed content analysis was conducted in the current study to systematically analyse the sustainability practices and behaviours of the three case firms.

Firstly, following the standard procedure of inductive category development, the study developed the initial coding category composed of critical sustainability aspects (CSAs) based on a detailed examination of three sustainability guidelines. The "Sustainability Reporting Framework" produced by the Global Reporting Initiative (GRI) is one of the most well-established international standards for corporate sustainability (CS) reporting (GRI, 2014). In China, the widely used guidelines for sustainability reporting are the "CASS-CSR Guidelines", released by the Chinese Academy of Social Sciences (CASS-CSR, 2014). In addition, and specifically for construction firms, a guide entitled the "Guide on Social Responsibility for Chinese International Contractors" is issued by the Chinese International Contractors Association (CHINCA). An outline of these three guidelines is shown in Table 6.3.

Table 6.3 Sustainability reporting guidelines

Corporate sustainability guidelines	Issuing purpose	Main contents
GRI Sustainability Reporting Guidelines	The Global Reporting Initiative (GRI) promotes the use of sustainability reporting as a way for organizations to contribute to sustainable development, involving thousands of professionals and organizations from many sectors and regions.	The GRI Guidelines offer Reporting Principles, Standard Disclosures and an Implementation Manual for the preparation of sustainability reports by organizations. Following the launch of the G4 Guidelines in 2013, the 'Construction and Real Estate Sector Disclosures' document was presented by the GRI in accordance with the G4 Guidelines.
CASS-CSR Guidelines	China's national conditions and the current development status of Chinese corporations determine that, at present, the GRI standard cannot effectively guide Chinese firms. To better service Chinese corporations, CASS released the CASS-CSR Guidelines in China.	Similar to the GRI Guidelines, CASS-CSR 3.0 is also composed of general guidelines and sector guidance. The core components of the general guidelines are the indicator systems of market performance, social performance and environmental performance of firms.
CHINCA Guidelines	CHINCA formulated a sustainability guide to establish a benchmark of social responsibility specifically for the construction industry. The guide incorporates recent best practices in the Chinese construction industry and reflects the common understanding about the sustainability of Chinese international contractors.	The Guidelines list the core subjects of social responsibility for Chinese international contractors, rather than adopting the widely used triple bottom line (TBL) approach to organize sustainability indicators. Seven core subjects have been identified that are closely related to construction corporations.

An examination of the indicator systems and associated requirements presented by the three guidelines reveals that the corporate sustainability (CS) of construction firms is a highly complex construct. The various aspects of sustainability in construction firms include sustainability strategy, wages and welfare, construction waste management, energy conservation, etc. The fact that corporate sustainability (CS) involves so many aspects while existing studies have predominantly focused on environmental sustainability demonstrates the necessity of a holistic examination of the sustainability of construction firms. In addition, as all three guidelines have a unique indicator system for sustainability, it is imperative to compare these systems and identify the main sustainability aspects for construction firms. This was achieved by inductive category development which is composed of four steps: 1) preparing the documents; 2) defining the unit of analysis; 3) developing coding categories; and 4) testing the coding scheme (Zhang and Wildemuth, 2009).

In this step of inductive category development, the documents were the main sections of sustainability guidelines that explained sustainability indicators and associated criteria. Themes were the unit of analysis. In the coding process, the criteria for selecting the critical sustainability aspects were: 1) the aspect is illustrated in a section of an individual title in at least one guideline and 2) themes related to the aspects can be found in at least two guidelines. After the coding category with the critical sustainability aspects was developed, the sustainability reports of Firm A in 2009 and 2010 were used as sample texts to test the clarity of this coding category. As most of the sample texts could be properly coded using the developed coding category, the consistency and clarity of the coding category was reaffirmed. The final coding category of corporate sustainability for Chinese construction firms consisted of 24 critical sustainability aspects (CSAs), as shown in Fig. 6.2.

Economic dimension	**Social dimension**	**Environmental dimension**
• Corporate strategy • Quality management • Supply chain management • Technology development • Corporate governance • Customer service and satisfaction • Communication management • Risk management	• Occupational health and safety • Education and training • Wages and welfare • Anti-corruption and fair competition • Human rights • Support community development • Obey laws and regulations	• Construction waste management • Land use efficiency • Water conservation and harvesting • Materials conservation • Energy conservation • Managing impacts on biodiversity • Emission reduction • Green innovation and green products • Environmental management

Figure 6.2 Critical sustainability aspects (CSAs) identified (N=24)

6.2.3 Pattern-matching analysis

After developing the initial coding category, specific strategies were adopted to analyse the data based on this category. Firstly, to identify the strategic sustainability behaviours of the three case firms, a pattern-matching analysis was adopted. In pattern-matching analysis, the observation of the cases reveals a certain pattern, and the empirically-based pattern is then compared with the pattern suggested by the theory, to reach a judgement about the merit of the theory or to gain a deeper understanding of the empirical cases (Hall, 2006). As most research papers have a section explaining the relevant theory which always imply some type of pattern, the principles of pattern-matching analysis are actually extensively applied subconsciously (Trochim, 1989). Trochim, a leading scholar in pattern-matching analysis, even argued that "all research employs pattern matching principles, although this is seldom done consciously" (Trochim, 1989, p.357). In the current study, the pattern-matching analysis was employed consciously. The procedure of pattern-matching analysis in this study draws on other studies which consciously adopt pattern-matching analysis (Penna and Geels, 2012; Geels and Penna, 2015). In this study, all the sustainability reports of the three firms from 2009–2013 were thoroughly examined and compared with the coding category. By comparing the sustainability practices implemented by the firms with the coding category, an overall understanding was formed about whether the 24 CSAs were adequately addressed by the case firms, as well as identifying the features that the firms had. Consequently, the features revealed by the firms (empirically-based patterns) were compared with the ideal situation of the evolving strategic sustainability behaviours, as suggested by Klewitz and Hansen (2014) (theoretically-based patterns), to identify the strategic sustainability behaviours of the case firms.

The classification developed by Klewitz and Hansen (2014) is considered as more appropriate for adoption in this study as it is more comprehensive compared to that of other studies, for example, Winn and Angell (2000). More importantly, the classification of Klewitz and Hansen (2014) provides more clearly defined criteria to assess sustainability behaviours. For instance, to describe firms which have excellent sustainability performance, Ghobadian et al. (1998) proposed the category of leading-edge firms, the firms that set the standard for other firms. However, this criterion is not easy to apply in empirical studies as it is difficult to assess whether a firm sets standards for other firms. In contrast, Klewitz and Hansen (2014) proposed that the highest sustainability level of firms is that of sustainability-rooted firms, those firms which have their business model rooted in sustainability and which have very strong interaction with their stakeholders. Due to its comprehensiveness and clearly defined criteria, the classification proposed by Klewitz and Hansen (2014) is adopted in this study (see Table 6.4).

The following is an example of pattern-matching analysis. Klewitz and Hansen (2014) suggested sustainability-rooted firms should have a business model rooted in sustainability and show strong interactions with various stakeholders. This pattern corresponds to the features of Firm A since 2012, as Firm A has responded to all 24 CSAs since 2010 and, in 2012, it started to implement the culture-led sustainability model. This is a sustainability-rooted business model and shows strong interactions with various stakeholders. The main features of the three firms from 2009–2013 are likewise compared with the ideal five strategic sustainability behaviours proposed by Klewitz and Hansen (2014). Based on this analysis, the sustainability behaviours of the three case firms from 2009–2013 were identified.

Table 6.4 Strategic sustainability behaviours of corporations

Sustainability behaviour	Features	Conditions to achieve this level
Resistant	• Ignore environmental/social issues beyond compliance	
Reactive	• React to external stimuli • Focus on efficiency	External stimulus to activate
Anticipatory	• Time strategy to realize competitive advantage • Second mover advantages • Piecemeal innovation • No integrative approach	Continuous external stimuli
Innovation-based	• Proactive solutions to environmental/social issues • First mover advantage	Capacity building for sustainability-oriented innovations
Sustainability-rooted	• Business model rooted in sustainability • New innovation principles • Strong interaction with external actors	New business model

Source: Klewitz and Hansen (2014)

6.2.4 Deductive category development

The identification of strategic sustainability behaviours shows the general features of the case firms. Consequently, deductive category development was employed to identify the specific sustainability practices and associated strengths and weaknesses of the case firms. The texts of all of the sustainability reports were reviewed and coded for correspondence to the initial coding category, that is, the 24 CSAs. The texts that could not be categorized in the 24 CSAs were firstly examined to identify new individual themes, and the number of themes was then reduced by collapsing themes that were either similar or dissimilar into higher-order categories. After this category development process, a list of sustainability practices implemented by the case firms was developed.

Reporting the results was the final step of the case study. Reporting a case study can be a difficult task as researchers need to convert a complex phenomenon into a format that is readily understood by the reader (Baxter and Jack, 2008). Yin (2014) offered an insightful analysis in terms of case study reporting by identifying six structures of reporting: linear-analytic, comparative, chronological, theory-building, suspense and sequenced. After carefully comparing these different structures, it was decided that the linear-analytic structure was appropriate for reporting this case study. The linear-analytic structure is a standard approach for composing reports. For the multiple-case study, this structure proceeded in the following sequence: research aims, methods, analysis of individual cases, cross-case analysis, discussion and conclusion.

6.3 Analysis of individual cases

6.3.1 Firm A: China State Construction Engineering Corp. Ltd

China State Construction Engineering Corp. Ltd (CSCEC, 2013) was established on 10 December 2007. It was established with joint investment from the following four leading enterprises: China State Construction Engineering Corp; China National Petroleum Corporation; Baosteel Group Corporation; and Sinochem Group, all of which were ranked among the Fortune Global 500 Enterprises. It inherited the assets and corporate culture of China Construction Engineering Corporation, with the business reaching more than 40 countries and regions in the world (CSCEC, 2013). Being one of the largest construction corporations in China and in the world, CSCEC has completed a large number of landmark projects at home and abroad. A list of its achievements is provided below.

- The largest construction and real estate conglomerate in the world
- The largest housing construction contractor in the world
- One of the top 10 largest global contractors
- One of the Global Top 500 Company ranked by *Fortune* magazine
- One of the state-owned enterprises with an annual profit of more than 10 billion CNY

Under the current construction qualification system implemented in China, CSCEC is the only enterprise which holds three Special Qualification Certificates (the highest level of qualification in China) with these being the special qualification certificates for building construction, road construction and municipal works (CSCEC, 2014). The business scope of CSCEC includes housing construction, international project contracting, real estate development and investment, infrastructure construction and investment, survey and design.

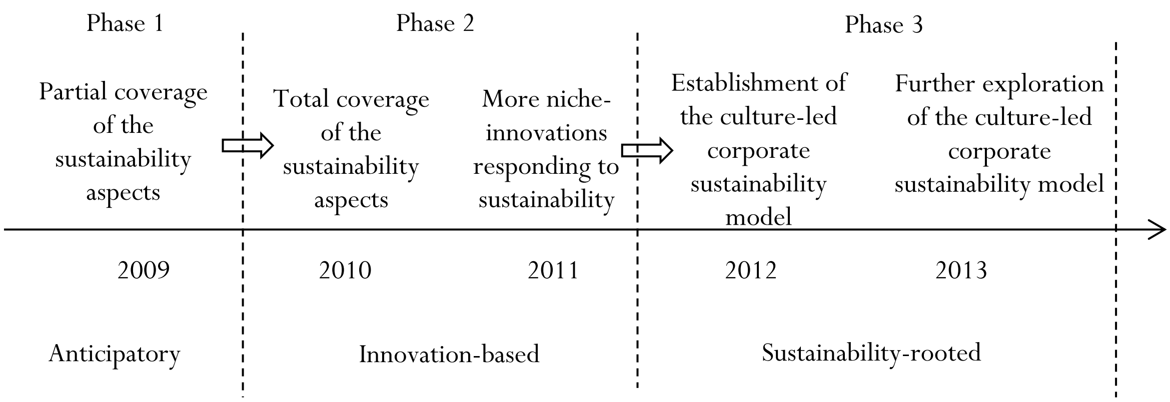

Figure 6.3 China State Construction Engineering Corp. Ltd (CSCEC)'s sustainability transition

The pattern-matching analysis of the sustainability reports issued by CSCEC with the ideal strategic sustainability behaviours suggested by Klewitz and Hansen (2014) showed that the sustainability practices of CSCEC from 2009–2013 experienced a development process which could be divided into three phases: anticipatory, innovation-based and sustainability-rooted, as shown in Fig. 6.3.

6.3.1.1 Phase 1: Anticipatory

In 2009, the development of sustainability practices in CSCEC was in the early stage and far from mature, reflected by the fact that CSCEC's sustainability practices in 2009 only partially covered the 24 critical sustainability aspects (CSAs). Many aspects, such as supply chain management, education and training, human rights and managing impacts on biodiversity, were not adequately emphasized.

Specifically, CSCEC performed relatively well with regard to the economic dimension of sustainability. As a mature construction firm, CSCEC performed well in many economic and managerial aspects, such as corporate strategy, governance, quality management, risk management and communication management. For instance, CSCEC formulated its corporate strategy based on the SWOT analysis tool, a strategic planning method used to assess the internal environment (strengths and weaknesses) and the external environment (opportunities and threats) (Hill and Westbrook, 1997). Likewise, it established a comprehensive risk control system which covered possible financial risk, market risk and legal risk (CSCEC, 2010). It also had a communication system that it used to communicate with various stakeholders such as clients, staff, suppliers, the government and financial institutions (CSCEC, 2010). In contrast, CSCEC did not perform well in supply chain management. The sustainability guidelines suggested that, apart from the traditional economic assessment of suppliers, firms should also conduct environmental assessment, labour practice assessment, human rights assessment and social impacts assessment of suppliers, in order to choose responsible and sustainable suppliers. In 2009, Firm A had not implemented these various assessments of suppliers related to sustainability.

With regard to social and environmental sustainability, in 2009, CSCEC's limited practices led to its weak performance on these aspects. For instance, the firm had not placed emphasis on various social issues that were highlighted by the sustainability guidelines, including an emergency management system, psychological checks of employees, assessment of education and training programs, non-discrimination and freedom of association. Likewise, in 2009, neither had CSCEC emphasized many aspects of environmental sustainability, including managing its impacts on biodiversity, or undertaking water harvesting, energy conservation and materials conservation.

6.3.1.2 Phase 2: Innovation-based

The sustainability practices implemented by CSCEC in 2010 were much more holistic than those in 2009, covering all of the identified 24 key aspects. For instance, the green procurement (supplier selection) policy was implemented in CSCEC in 2010, which emphasized the environmental assessment of suppliers (CSCEC, 2011). In 2010 and 2011, CSCEC's innovation system was also dramatically improved in comparison to what had been in place in 2009. Since 2010, CSCEC has implemented a holistic innovation system covering the whole industrial chain, as shown in Fig. 6.4.

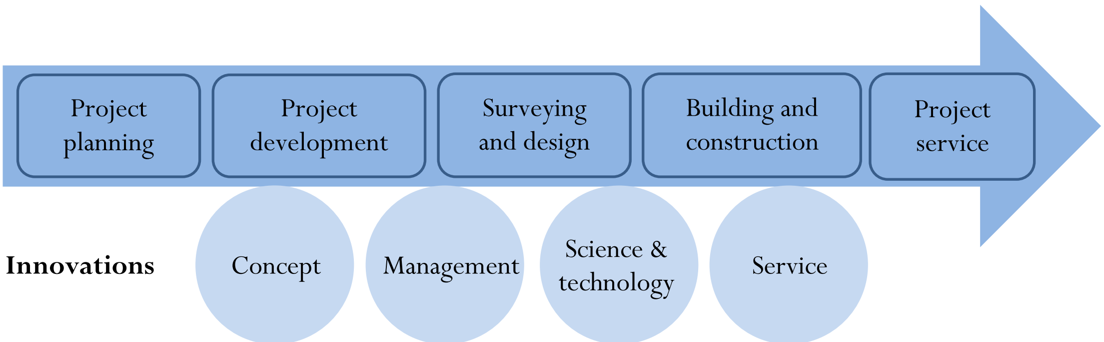

Figure 6.4 Innovation throughout the industrial chain
Source: adapted from CSCEC's 2011 sustainability report (CSCEC, 2012)

The three sustainability guidelines indicated the important role played by technology innovation in contributing to sustainability, but neglected other kinds of innovation such as management or service innovation. However, the literature on sustainability transition indicates that, to enable the transition process, all kinds of innovation need to be promoted. Damanpour and Evan (1984) defined technical innovation as a means of changing and improving the performance of the technical system of an organization. An administrative or managerial innovation, by contrast, denotes changes or improvement in organization structure and in the management of people, such as a new way to recruit personnel, eco-audit and allocate resources (Damanpour and Evan, 1984; Rennings, 2000). Social innovation refers to new activities and services that are motivated by the goal of meeting a social need (Mulgan, 2006). Innovative activities aimed at changing people's lifestyles and consumer behaviour are often defined as social innovations (Rennings, 2000). Sustainability transitions involve many potential solutions rather than just one, two or sometimes three alternatives (Geels, 2010; Lachman, 2013). Therefore, these different kinds of innovations all have a role to play.

The innovation system established by CSCEC contained innovation works in four dimensions: concept innovation, management innovation, technological innovation and service innovation. For instance, in 2011, this firm proposed the concept of "urban complex construction" to provide strategic construction plans for the local governments of towns and cities (concept innovation); promoted a standardized process of management (management innovation); focused on the technologies related to energy conservation and off-site construction (technological innovation); and proposed the service culture of "considerate, professional and harmonious" (service innovation) (CSCEC, 2012).

Based on this holistic innovation system, CSCEC implemented many proactive solutions to environmental and social issues, corresponding to the feature of "innovation-based" behaviour suggested by Klewitz and Hansen (2014). For instance, in 2011, CSCEC invested 113 million CNY in training for 298,370 employees, covering new graduates, project managers, leaders and specialists, with the average training time being 31.8 hours (CSCEC, 2012). In 2011, the firm also established relevant organizations to manage environmental issues, as shown in Fig. 6.5, and invested 200 million CNY in environmental protection. For instance, the firm invested in four kinds of technologies to conserve energy: solar power generation technology, solar water-heating technology, complementary technology of wind and solar power, and a ground-source pump. Water conservation technologies were also introduced, such as water-saving taps, water-saving flush toilets, high-efficient irrigation techniques, pervious concrete pavement technology, grey water recycling techniques and rainwater collection systems.

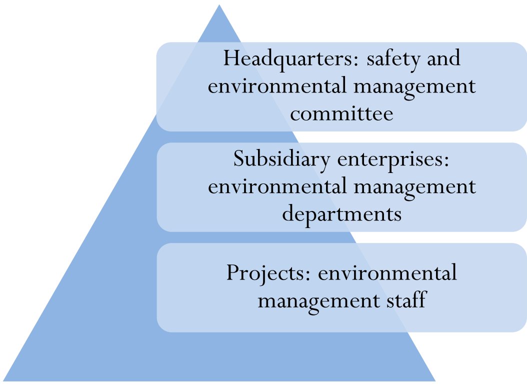

Figure 6.5 Institution building for environmental management
Source: adapted from CSCEC's 2011 sustainability report (CSCEC, 2012)

It has been mentioned that CSCEC had largely neglected managing impacts on biodiversity in 2009. In 2011, specific emphasis was placed on this key aspect, as shown in Fig. 6.6. In addition, to explain its practices, CSCEC provided evidence through actual cases. For instance, before building the Bahamas Island Resort project, CSCEC organized special training on protecting the ecosystem of the Bahamas. In order to improve employees' knowledge on the environment of the Bahamas, all laws and regulations related to wildlife protection in the Bahamas were introduced to staff, especially relevant provisions and penalties related to the harm of fish, birds, sea turtles and other protected animals (CSCEC, 2012). Conclusively, in comparison to its practices in 2009, CSCEC's practices in promoting social and environmental sustainability in 2010 and 2011 were much more holistic, covering all the identified critical sustainability aspects (CSAs).

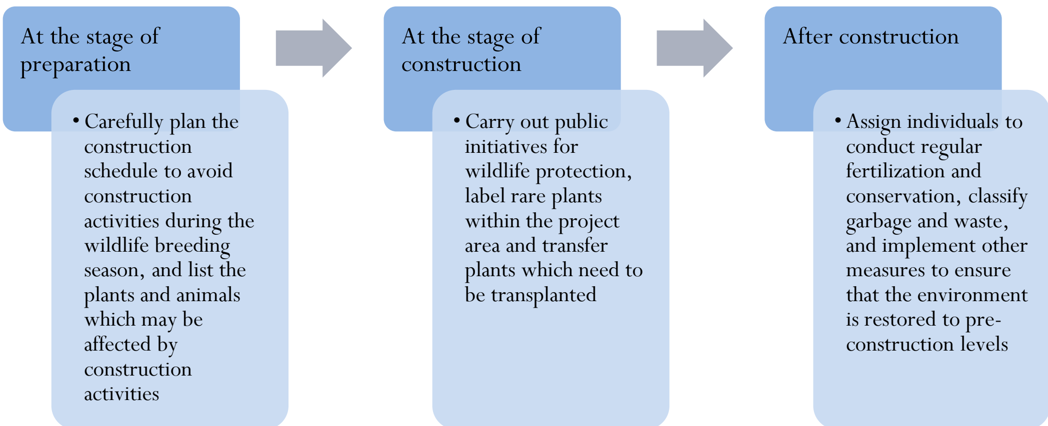

Figure 6.6 Practices used to manage impacts on biodiversity
Source: adapted from CSCEC's 2011 sustainability report (CSCEC, 2012)

6.3.1.3 Phase 3: Sustainability-rooted

Even though CSCEC implemented various practices responding to all of the identified sustainability aspects, it could not be categorized as a sustainability-rooted firm before 2012 as the business model had not been fundamentally transformed. This started to change after 2012 as CSCEC issued and implemented the culture-led social responsibility progression model, as shown in Fig. 6.7. In CSCEC's 2012 Sustainability Report, CSCEC's top managers indicated that, in order to promote sustainability, not only the facts and figures about technologies had to be accumulated, but also the whole corporate culture and business model needed to be transformed (CSCEC, 2013). CSCEC determined that, since 2012, the overall culture and mission of this firm has been "expanding a happy living environment". The 2012 Sustainability Report states that "our mission is to expand a happy living environment which shall serve as the most essential principle for us to handle relations with clients, employees, shareholders, the community and other stakeholders" (CSCEC, 2013). Guided by this mission, CSCEC identified the main expectations of seven key stakeholders, namely, shareholders, customers, the environment, employees, partners, the industry and communities. To meet these expectations, a systematic management structure was established. A social responsibility committee consisting of senior executives and department directors was established in 2012 to guide the overall work of sustainability. Under the committee, a social responsibility office was established which was responsible for developing a sustainability plan, developing and improving the managerial system of sustainability, organizing sustainability practices, and compiling and releasing sustainability reports. For instance, the firm released the *CSCEC CSR Index Management Manual* which provided a framework for all CSCEC departments through which to improve social responsibility management (CSCEC, 2013). In addition, the company released an information management system for sustainability, facilitating the communication between headquarters and subsidiary enterprises.

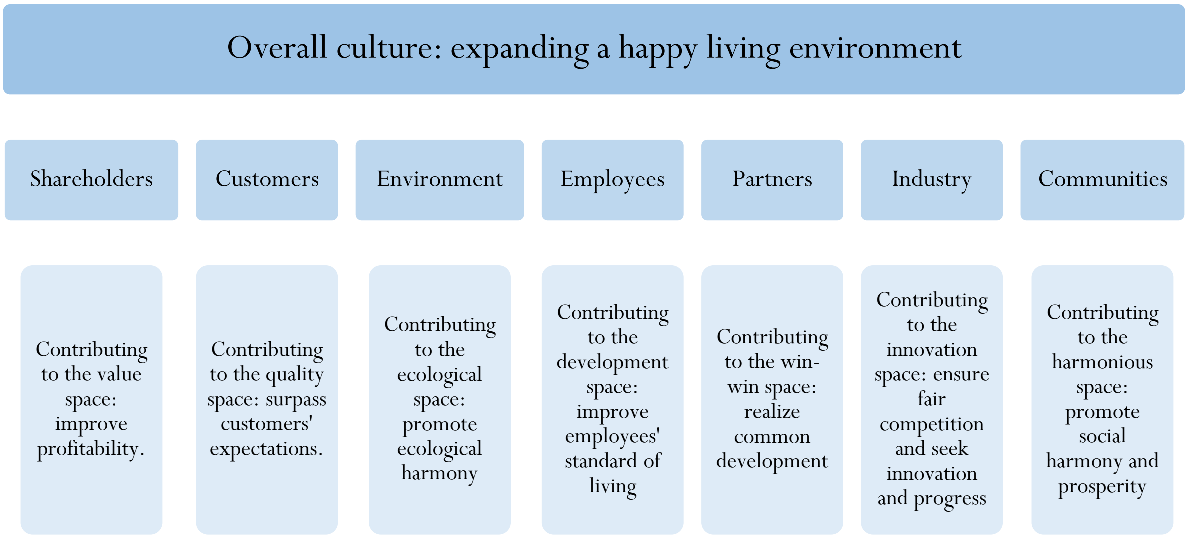

Figure 6.7 CSCEC's culture-led social responsibility progression model
Source: adapted from CSCEC's 2012 sustainability report (CSCEC, 2013)

Cultural changes within CSCEC have led to its increasingly mature approaches to sustainability. For instance, even though the environmental assessment of suppliers was implemented in the firm in 2011, at that time, the firm lacked a holistic approach for improving the sustainability of its supply chain. This was not responded to until 2013 when three main approaches were adopted by CSCEC to holistically emphasize the sustainability issues of its supply chain, comprising the evaluation of the sustainability performance of suppliers, choosing responsible suppliers and helping suppliers to improve their sustainability performance (see Fig. 6.8). For instance, in terms of choosing responsible suppliers, one subsidiary firm of CSCEC adopted the red and yellow card policy (CSCEC, 2014). The firm specifies 23 kinds of "violations of regulations" as red card behaviour. Suppliers receiving one red card are not allowed to participate in the bidding process of CSCEC for half a year. Suppliers getting two red cards in a year are regarded as unqualified suppliers, and are permanently eliminated from CSCEC's list of suppliers. Many other proactive sustainability practices were implemented. For instance, career development is an important aspect of education and training: since 2012, the firm has specified seven career development paths for employees in different occupations. The firm also establishes environmental protection monitoring targets and has incorporated environmental management objectives in the annual assessment system for its managers. In 2013, a total of 24.46 million CNY was invested by CSCEC for protection of the environment (CSCEC, 2014). All these practices show CSCEC's strong motivation to adopt sustainable development.

Figure 6.8 CSCEC's approaches to address supply chain management
Source: adapted from CSCEC's 2013 sustainability report (CSCEC, 2014)

6.3.2 Firm B: China Communications Construction Company Ltd

China Communications Construction Company Ltd (CCCC, 2013) is a large state-owned construction firm that focuses on infrastructural construction. This company is mainly engaged in the development of transportation infrastructure, such as ports, docks, channels, roads, bridges, railways and municipal roads, with the business reaching over 120 countries and regions. This firm is China's largest port design and construction enterprise, involved in the construction of many medium and large-sized ports and docks in China (CCCC, 2013). As revealed by the pattern-matching analysis, from 2009–2013, CCCC evolved from reactive to anticipatory in terms of its strategic sustainability behaviour (see Fig. 6.9). Unlike CSCEC that has systematically nurtured a sustainability-oriented corporate culture since 2012, CCCC did not proceed to the sustainability-rooted stage.

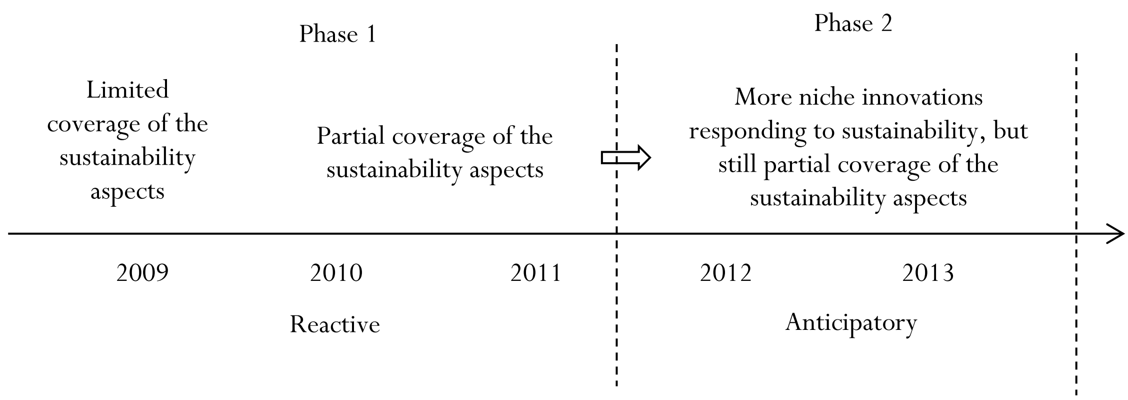

Figure 6.9 China Communications Construction Company Ltd (CCCC)'s sustainability transition

6.3.2.1 Phase 1: Reactive

From 2009–2011, the sustainability performance of CCCC was weak, reflected by the fact that many key aspects of sustainability were not adequately emphasized. In terms of the economic dimension, the risk management system was only established in 2010, and no practices were implemented in relation to the sustainability assessment of suppliers. Furthermore, the corporate strategies of CCCC remained economy-centred. As illustrated in the 2009 report, the goals of CCCC were all related to economic performance, for example, becoming one of the top 10 largest construction companies in the world or the most profitable construction company in China, etc (CCCC, 2010). No socially and environmentally-related content was put into the strategic level of CCCC in this phase.

In terms of the social dimension, CCCC placed little emphasis on the aspects of anti-corruption and human rights, and only moderately emphasized wages and welfare, obeying laws and regulations, and supporting community development. What CCCC did well in this phase were occupational health and safety (OHS), and education and training. The firm drafted its own education and training books for its employees, covering various study majors such as bridge construction and dredging. The firm also invited researchers at China's leading universities to conduct training for its employees. For instance, in 2009, CCCC invited professors from Tsinghua University and the Chinese Academy of Science to conduct training on "Project Management in the International Market" for 200 people

(CCCC, 2010). To better manage the training programs, CCCC even established a corporate college, China Communications Construction College, to manage and implement the vast number of training programs for its employees. To address OHS, a comprehensive safety supervision and management system was established by CCCC, as well as a Safety Management Committee with the latter led by the corporate leader. In 2009, CCCC released the *Standard for Protection Facility in Communication Project Construction*, the first corporate standard related to the protection facility in communication projects in China (CCCC, 2010). In 2010, CCCC invested 640 CNY in safety management, and issued the *Economic Incentive Policy for Safety Management* for its employees (CCCC, 2011). As a result of these efforts, CCCC's mortality rate due to safety accidents has been decreasing every year since 2006, dropping from 0.03 ‰ in 2006 to 0.01 ‰ in 2010 (CCCC, 2011).

Compared to the economic and social dimensions of sustainability, environmental sustainability received much less attention. In this phase, energy conservation and emission reduction were a focus of CCCC's environmental management, with relevant departments established to specifically deal with these areas. Energy and emission indicator monitoring systems, an energy conservation campaign, and education and training related to energy and emissions were implemented in CCCC to promote energy conservation and emission reduction. However, other important environmental aspects related to land, water, materials and construction waste were almost ignored by the firm in 2009 and 2010. Even though more practices were implemented in 2011, such as the practices related to biodiversity protection (CCCC, 2012), CCCC did not have a holistic perspective on environmental sustainability in this phase.

6.3.2.2 Phase 2: Anticipatory

In 2012 and 2013, CCCC further improved its sustainability by implementing more sustainability practices. Corporate strategy is an important aspect of economic sustainability and, from 2012, CCCC started to emphasize business opportunities in green industries, such as the construction of wind power projects. Measures were also adopted to enhance strategic cooperation between CCCC and other partners, such as local governments, suppliers and the media. Sustainability of the supply chain was also emphasized. Social responsibility training was conducted to improve the knowledge of suppliers and contractors about sustainability. In addition, suppliers' sustainability performance was considered when CCCC chose suppliers. Compared to economic sustainability, the social sustainability of CCCC was not improved dramatically in 2012 and 2013 compared to what it was in 2011. In terms of the aspects in which CCCC improved, OHS was further emphasized through establishing the special physical check policy for workers in certain high-risk positions. The firm also strengthened its caring for female employees by various measures, such as establishing milk rooms for new mothers. However, other aspects were not significantly improved: in 2013, a major safety accident even happened at one of CCCC's construction sites, leading to the deaths of 11 employees (CCCC, 2014). After the accident happened, video conferences were organized by the top leaders of CCCC to strengthen safety management.

Some measures were taken to improve environmental sustainability. In 2012, CCCC strengthened its environmental management system by releasing a series of corporate environmental regulations, such as the *Administrative Measures for Environmental Protection, Measures for Handling Environmental Accidents* and *Measures for Examination of Safety and Environmental Protection* (CCCC, 2013). Green offices were also promoted in this phase. For instance, video conferencing and paperless offices were strongly promoted and, in contrast, the use of air conditioning and heaters was strictly managed to save energy. In 2013, documents released in paper form accounted for only 3% of the total amount of released documents (CCCC, 2014). Old equipment that consumed high levels of energy and materials was also gradually abandoned and replaced by energy-efficient equipment. In 2013, CCCC invested 1.69 billion CNY to abandon 1333 pieces of equipment and purchased 1915 pieces of new equipment (CCCC, 2014). In addition, technological innovation was emphasized to promote environmental protection. For instance, CCCC established innovation awards for projects that adopted new technologies to contribute to energy conservation and emission reduction. In 2012, 26 projects received innovation awards and the experiences of these projects were compiled into a book which was distributed throughout the whole corporation (CCCC, 2013). A green campaign was also implemented in CCCC through various platforms including corporate magazines, websites and activities.

For instance, in 2013, CCCC organized Energy Conservation Week to encourage employees to adopt a low carbon life style, for example, by using bicycles to commute (CCCC, 2014). However, as many other aspects were not significantly improved, such as water conservation, the lack of first-mover advantage and holistic coverage of the 24 critical sustainability aspects (CSAs) disqualified CCCC from being considered as an innovation-based firm.

6.3.3 Firm C: China Gezhouba Group Co. Ltd

China Gezhouba Group Co. Ltd (CGGC) is one of the leading corporations in constructing power projects, especially hydropower plants. Since 1949, the firm has completed more than 25% of all of China's hydropower plants (CGGC, 2010). In addition, CGGC is engaged in other types of projects including railways, nuclear power, airports, ports, wind power and residential projects. In terms of internationalization, CGGC has entered more than 30 countries and regions, successfully winning the bids of many flagship projects, such as the Neelum–Jhelum hydropower plant which was the largest construction project (in terms of bidding value) in Pakistan (CGGC, 2012). As was the case with CCCC (Firm B), it was only from 2009 to 2013 that CGGC evolved from a reactive firm to an anticipatory firm, as shown in Fig. 6.10.

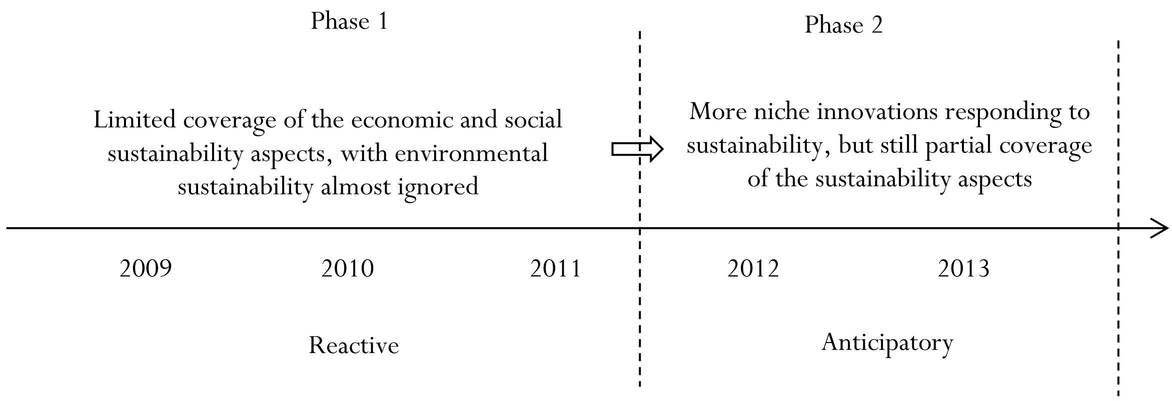

Figure 6.10 China Gezhouba Group Co. Ltd (CGGC)'s sustainability transition

6.3.3.1 Phase 1: Reactive

From 2009–2011, CGGC gradually accumulated facts and knowledge about sustainability. The firm performed well in the economic dimension of sustainability. It paid a large amount of attention to customer service and satisfaction, with these being the key to its economic competitiveness. To ensure that projects could be completed within time constraints and budget, CGGC conducted contract compliance examinations for ongoing projects (CGGC, 2011). After project completion, CGGC regularly contacted the owners of projects to collect information with regard to their satisfaction. Furthermore, CGGC has focused on promoting managerial and technological innovation, producing many niche innovations and winning several major innovation awards at the national level. Even though CGGC performed well in the above-mentioned aspects, it did not respond to many of the detailed requirements suggested by the sustainability guidelines. For instance, whether CGGC has sustainability requirements for its suppliers and subcontractors is not documented in its sustainability reports.

In terms of social sustainability, CGGC recognized that critical elements for corporate success were employees' satisfaction and well-being. The firm adopted a performance-based salary management system for employees: under this system, frontline workers and employees whose positions were high-tech and highly responsible could enjoy high salaries. To ensure employees' health and safety, CGGC established relevant corporate policies, such as categorizing and standardizing the physical checks for employees undertaking different types of work. With regard to supporting community development, CGGC has mainly focused on three types of practices: helping poor people, helping people who have suffered from natural disasters and encouraging employees to be volunteers (CGGC, 2012). Even though CGGC has done a good job in the above-mentioned areas, it did not significantly improve and expand its social sustainability practices from 2009 to 2011. Some aspects, such as anti-corruption and human rights, were not paid much attention during this period.

Compared to the economic and social dimensions of sustainability, environmental sustainability was almost ignored by CGGC in this period. Of the seven sections in CGGC's

2009 sustainability report, only one addressed the environmental aspects, while both the economic and social dimensions were each explained by three sections (CGGC, 2010). In comparison to the 2009 report, the 2010 and 2011 reports were even worse in terms of addressing the environmental aspects with no individual section on the environment. In the 2010 report, only one paragraph related to energy conservation and emission reduction was presented under the section of "protecting suppliers' and clients' rights" (CGGC, 2011). Similarly, in the 2011 report, only one paragraph related to energy conservation was presented under the section of "business management responsibility" (CGGC, 2012). The three reports from 2009 to 2011 indicated that the core of CGGC's environmental management was energy conservation and emission reduction. This is not surprising, as during the 11th and 12th Five-Year Plan period (2005–2015), energy conservation and emission reduction were planned and strongly promoted by the central government which required state-owned enterprises to make contributions. Other aspects of environmental sustainability, such as an environmental management system, construction waste management, land use efficiency and managing the impacts on biodiversity were totally ignored by the sustainability reports from 2009 to 2011.

6.3.3.2 Phase 2: Anticipatory

The 2012 and 2013 reports reflected CGGC's changing understanding of sustainability as these two reports acknowledged that sustainability has three dimensions. Fig. 6.11 shows the structure of the main sections of the 2012 and 2013 sustainability reports. In terms of economic sustainability, CGGC undertook the new practice of network building to enhance its competitiveness. Since 2012, the firm has established strategic cooperative relationships with some enterprises and governments. In 2012, CGGC also released the *Handbook for Comprehensive Risk Management and Internal Control*, based on a systematic identification of its deficiencies about internal control (CGGC, 2013). As has been shown, CGGC did well in customer service before 2012, with customer service further improved in 2012 when the company issued *Requirements for Complaints Handling in the Projects under Construction* to actively respond to negative feedback from clients (CGGC, 2013). In addition, in 2013, CGGC started to gradually improve its supply chain management by incorporating sustainability requirements into the selection criteria for suppliers. The 2013 report stated that the firm planned to release corporate standards about supplier selection, such as *Management Regulation for the Supplier Backlist*, to enhance the assessment of suppliers based on their performance in the past (CGGC, 2014).

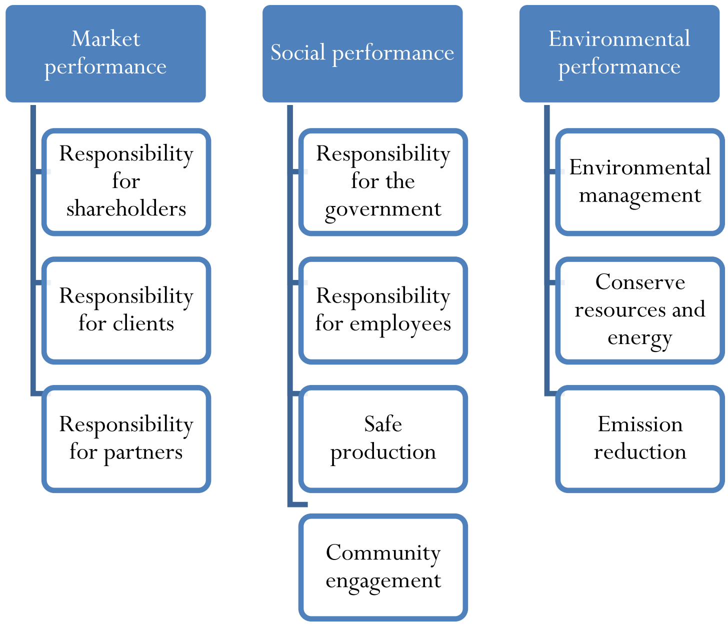

Figure 6.11 Main sections of CGGC's 2012 and 2013 sustainability reports

In 2012 and 2013, CGGC's social sustainability was not significantly improved in comparison to the level that it had been in 2011. One improvement in seeking to establish anti-corruption and fair competition measures was in 2012 when CGGC issued the *Management Approach for Company Insider Registration* which tried to prevent the occurrence of insider trading (CGGC, 2013). Another improvement was education and training. Three career development paths were designed by CGGC for its employees: the management path, the technology path and the skill path, and employees could choose their career paths based on their background and experience. The company also strengthened safety management by identifying projects that had a high level of safety risk and correcting non-standard construction methods. In 2012 and 2013, CGGC's practices about other aspects of social sustainability, such as wages and welfare, and supporting community development were not significantly different from those in 2011.

The greatest change occurred in the environmental dimension of sustainability, to which CGGC paid much more attention in 2012 and 2013 than in 2011. Training programs about environmental protection were incorporated into the annual training program with training program access ensured for all employees. In addition, the company adopted energy-efficient technologies and materials such as new wall materials and solar power in its property development. Moreover, the company started to pay attention to managing impacts on biodiversity by adopting various measures, such as changing the temporary roads of a completed project into lawn. Water conservation and harvesting were another aspect on which CGGC started to work. Since 2012, CGGC has issued various corporate standards about waste water treatment and conservation, such as *Regulations on Waste Water Disposal*, and has adopted advanced technologies to treat waste water (CGGC, 2013, 2014). The firm also established a statistical system for materials and energy consumption to monitor the use of resources. Even though CGGC paid attention to the above-mentioned aspects, other aspects of environmental sustainability were still not adequately addressed in the 2012 and 2013 reports, for instance, the practices to develop green innovations.

6.4 Cross-case analysis

The above case studies have demonstrated the evolving practices of leading Chinese construction firms in order to respond to sustainability. This section aims to compare the three cases to identify differences and commonalities, to summarize the sustainability practices into a comprehensive list, and to compare these practices with the suggestions and requirements of the three sustainability guidelines explained in the Methodology section of this chapter.

6.4.1 Sustainability practices implemented by the case firms

Based on the 24 identified critical sustainability aspects (CSAs), all sustainability practices adopted by the three leading Chinese firms were coded into 77 sub-aspects. A thorough examination of sustainability reports revealed several practices which were not covered by the pre-determined 24 sustainability aspects. A total of five (5) new sustainability aspects and 15 new sub-aspects were identified; thus, the final list of the sustainability practices implemented by the case firms comprised 29 critical sustainability aspects (CSAs) and 92 sub-aspects, as shown in Table 6.7 at the end of this chapter.

As revealed in the current study, the three case firms, as a response to sustainability, implemented managerial, technical and social practices (see Fig. 6.12). To be specific, efforts were made to improve the maturity of corporate management and governance related to sustainability, such as establishing a specific department responsible for corporate sustainability (CS) and implementing customer relationship management (CRM) to improve customer service and satisfaction. Likewise, all three of the firms understood the importance of technological innovations and adopted various technologies, such as renewable energy technologies and rainwater collection systems, to improve sustainability. Many social practices were adopted by the firms to demonstrate their social responsibility, such as culture heritage protection and the employment of rural workers. These three types of sustainability practices interacted with each other and formed a holistic niche-innovation system.

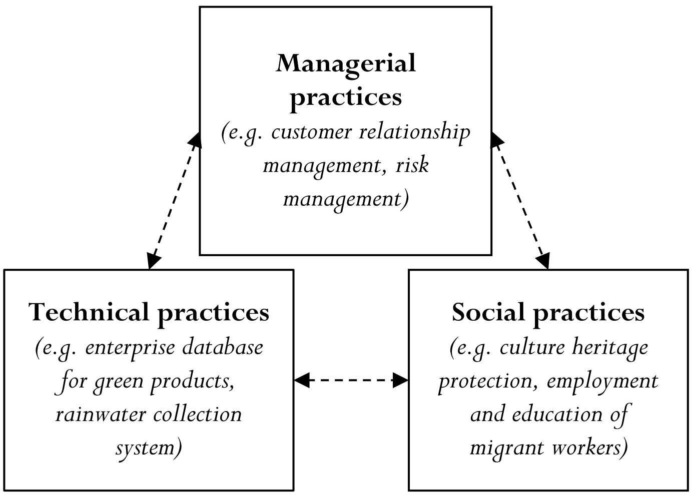

Figure 6.12 Sustainability practices of the case firms

6.4.2 Different performance of the three case firms

All three of these firms are leading construction firms in China, ranked among the top 50 global contractors. However, the sustainability behaviours of the three case firms varied significantly. From 2009 to 2013, CSCEC adopted various sustainability practices to improve its sustainability, covering all the sustainability aspects identified in the sustainability guidelines. It then gradually formed a sustainability-oriented corporate culture. Corporate policies were developed to systematically nurture a sustainability culture in the corporation. In contrast, CCCC and CGGC placed more foci on widening the scope of sustainability practices to respond to various sustainability aspects, and did not proceed to the stage of systematic second-order learning, that is, nurturing the sustainable corporate culture. The sustainability transitions are demonstrated in Fig. 6.13, as reflected by the evolving strategic sustainability behaviour of the three case firms.

From 2009 to 2013, CSCEC evolved from an anticipatory firm to a sustainability-rooted firm, while CCCC and CGGC only evolved from being reactive firms to become anticipatory firms. The existing literature shows that large firms in the construction industry tend to pay more attention to sustainability and perform better in terms of sustainability compared to smaller counterparts (Zainul Abidin, 2010). Therefore, many medium-sized and small construction firms in China may pay little attention to sustainability or may not even be aware of the concept of sustainability. All three of the case firms in China experienced an improvement during the studied period; in other words, they transitioned towards sustainability. However, other firms may remain at the same level of sustainability behaviour or even pay less attention to sustainability over the years. As the largest construction industry in the world, the Chinese construction industry consists of a large number of firms. As a result, this industry is likely to be quite heterogeneous in terms of the sustainability practices and behaviours of firms. How do other construction enterprises in China perceive and perform on sustainability? This question is addressed in the next chapter.

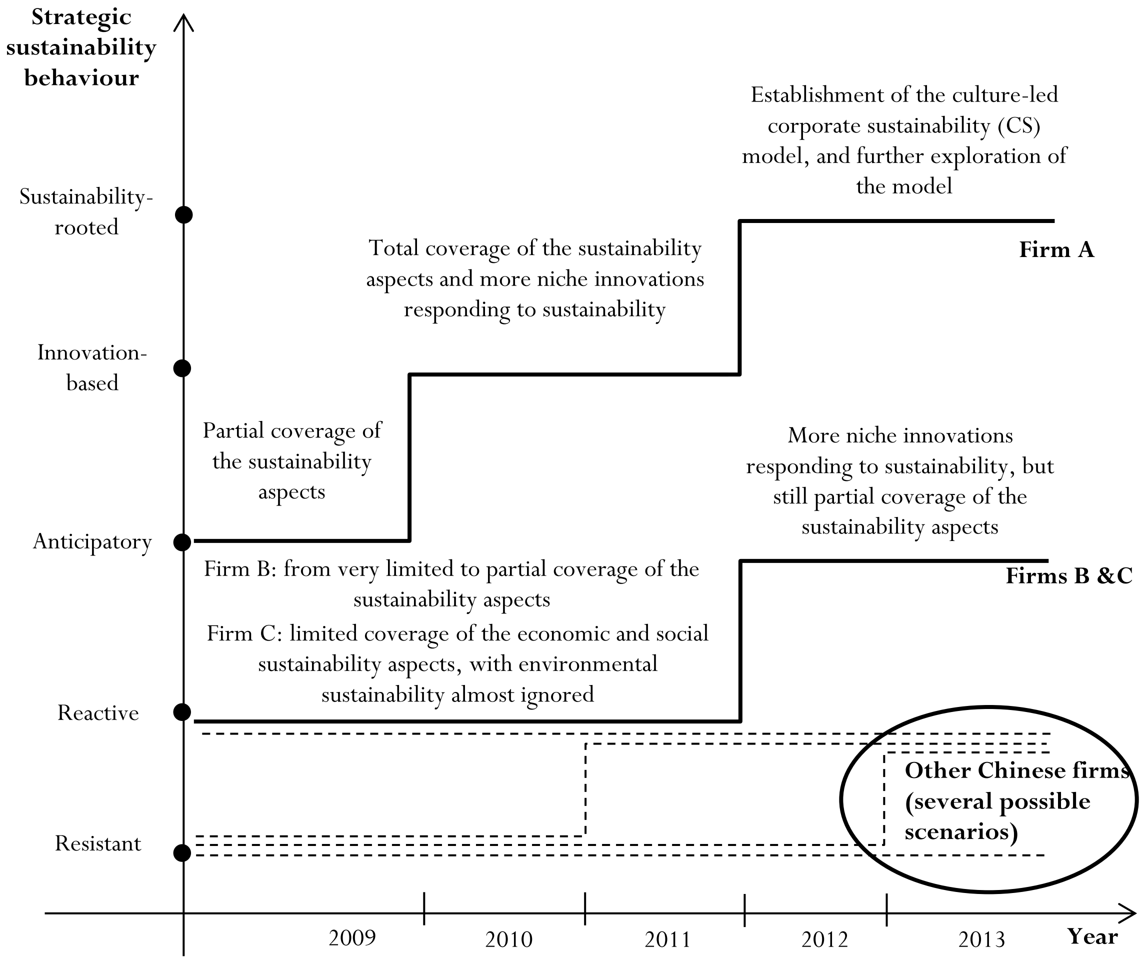

Figure 6.13 Sustainability transitions of the case firms

6.4.3 Comparison of the three case firms with sustainability guidelines

The previous section focuses on illustrating the sustainability transitions of the case firms. This section further elaborates the sustainability practices of the three cases by identifying the strengths and weaknesses of the case firms.

The sustainability practices of the three leading firms are assessed against the requirements of the sustainability guidelines. A three-point scale was employed to rate each of the 29 sustainability aspects for each firm, where 1 represented "cannot fulfil many requirements of the guidelines"; 2 was "fulfil the requirements of the guidelines on the whole"; and 3 indicated "exceed the requirements of the guidelines". For the five newly identified sustainability aspects, three were given to the firms which had relevant practices and two were given to the firms which did not have relevant practices. After rating each sustainability aspect for each firm, an average score for each sustainability aspect was calculated to reflect the overall situation of the three case firms. For each aspect, the average score was between 1 and 3. If the average score was below 2 for a certain sustainability aspect, it would be assumed that the corresponding aspect, in general, was not adequately addressed by the three firms and that the aspect was classified as being weak. In contrast, if the average score was above 2 for a certain aspect, it indicated that, in general, the three firms performed beyond the requirements and expectations of the sustainability guidelines. Fig. 6.14 depicts the assessment of the sustainability practices of the case firms and Table 6.5 illustrates the identified strong and weak sustainability aspects

Table 6.5 Strong and weak aspects of sustainability dimensions in the three case firms

Sustainability dimensions	Strong aspects	Weak aspects
Economic dimension	• Quality management • Innovation system • Communication management • Network building	• Corporate strategy • Supply chain management • Risk management •
Social dimension	• Education and training • Wages and welfare • Supporting community development • Obeying laws and regulations • Caring for all employees • Promoting the development of the industry	• Anti-corruption and fair competition • Human rights
Environmental dimension	• Energy conservation • Light pollution • Noise control	• Construction waste management • Land protection and use efficiency • Water conservation and harvesting • Materials conservation • Managing impacts on biodiversity • Emission reduction

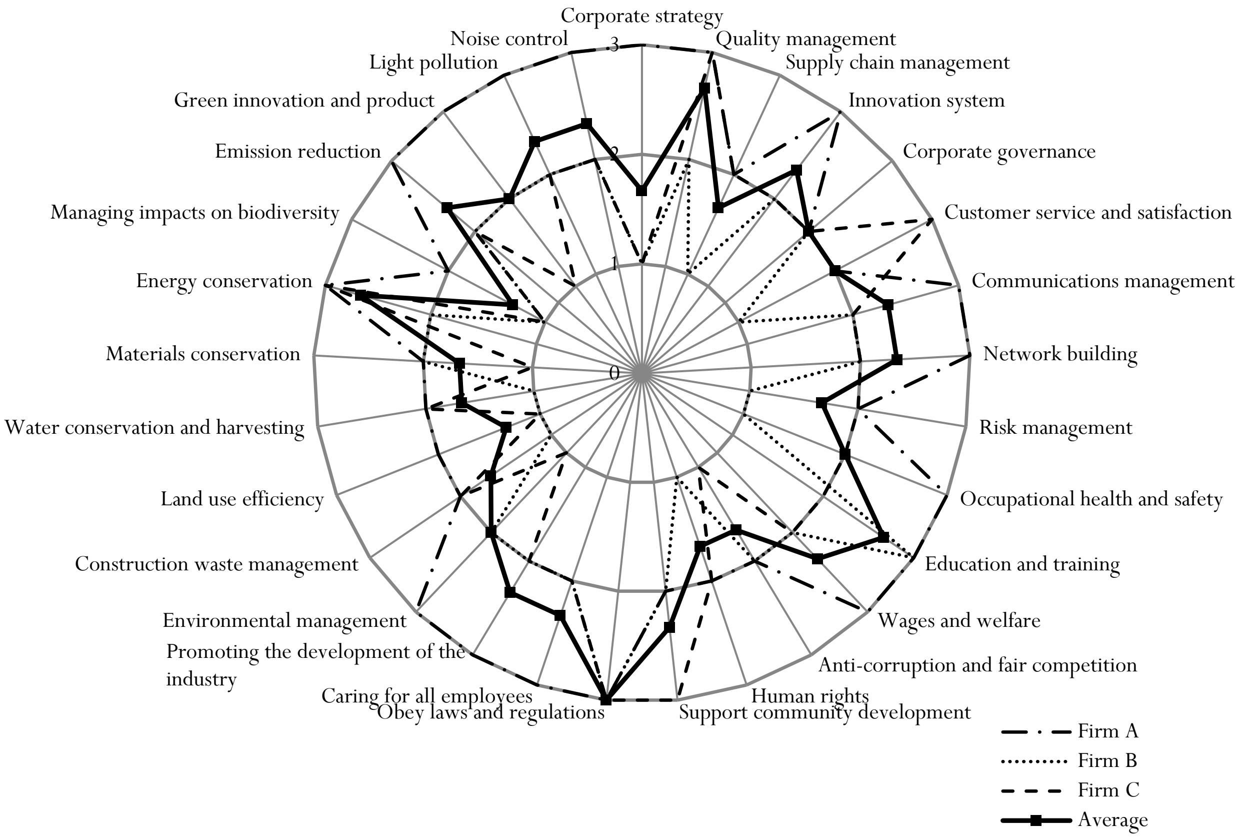

Figure 6.14 Assessment of sustainability performance of the case firms

6.4.3.1 Strong aspects of the case firms

The case firms generally did well in several CSAs, for example, quality management, the innovation system, communications management, education and training, wages and welfare, supporting community development, obeying laws and regulations, and energy conservation. For instance, in terms of quality management, CSCEC had a very comprehensive quality management system, including full process quality control, overall quality management and overall staff capacity building. With regard to education and training, CCCC had developed 40 policies about employee training and even had a corporate college managing the vast number of training programs. Likewise, promoting renewable energy and using energy-efficient equipment were adopted by all three firms to conserve energy.

In relation to the newly identified CSAs, under the category of economic sustainability, one new aspect identified was network building. CSCEC has established strategic corporation relationships with its various partners, including governments, banks, universities and other corporations. With regard to social sustainability, caring for all employees and promoting the development of the industry were identified as new aspects. CSCEC had adopted several practices which could be labelled as caring for all employees, such as providing milk powder for female employees and establishing special funds supporting employees with enormous difficulties. The sustainability guidelines illustrated similar concepts. For instance, the GRI Sustainability Reporting Guidelines indicated that equal remuneration should be offered for men and women. However, no individual section in the guidelines discussed how to ensure that all employees received these benefits. Likewise, the GRI Guidelines suggested that technological innovation may enable industry-wide innovation. However, no individual section in the guidelines addressed promoting the development of the industry. In terms of this aspect, CSCEC specifically illustrated its practices, such as participating in national research projects and drafting industry standards. Environmentally, CSCEC showed that its practices prevented light pollution and noise, with this also not illustrated in individual sections of the guidelines. Thus, the new CSAs were identified as: 1) network building in the economic dimension; 2) caring for all employees in the social dimension; 3) promoting the development of the industry in the social dimension; 4) light pollution control in the environmental dimension; and 5) noise control in the environmental dimension.

6.4.3.2 Weak aspects of the case firms

With an average score below 2, a total of 11 CSAs were identified as weak aspects. To explain how these 11 aspects were not adequately addressed by the case firms, the major requirements of the sustainability guidelines which the case firms failed to fulfil are listed in Table 6.6.

Table 6.6 Major requirements which the case firms failed to fulfil

CSAs	Major requirements which the case firms cannot reach
1. Corporate strategy	• The GRI Guidelines explain that corporate strategy making should be able to identify the key sustainability issues for firms and the factors influencing sustainability priorities.
2. Supply chain management	• The GRI Guidelines suggest that, besides the traditional economic assessment of suppliers, firms should also conduct environmental assessment, labour practice assessment, human rights assessment and social impact assessment of suppliers.
3. Risk management	• The GRI Guidelines suggest that policies and practices need to be implemented for assessing, addressing and managing corporate, operational, regulatory and strategic risk that might impact on financial performance. • The CHINCA Guidelines suggest that construction firms should establish relevant risk management and crisis prevention plans based on their business types.
4. Anti-corruption and fair competition	• There is a whole section entitled anti-corruption in the GRI Guidelines which suggests that three factors relating to anti-corruption should be considered , that is, the number and percentage of operations assessed for risks related to corruption, training on anti-corruption policies and procedures, and confirmed incidents of corruption.
5. Human rights	• In the GRI Guidelines, human rights is a very important issue and a number of subsections are listed under human rights, such as non-discrimination, freedom of association and collective bargaining, freedom from forced or compulsory labour and indigenous rights.
6. Construction waste management	• The GRI Guidelines suggest that construction firms should monitor the total amount of hazardous and non-hazardous waste by the different methods used for disposal. • The CHINCA and CASS-CSR Guidelines suggest that construction firms should pay attention to the recycling of construction waste and the use of advanced construction techniques to reduce the amount of construction waste.
7. Land protection	• In the GRI Guidelines, land protection is emphasized under the section on *Land Degradation, Contamination and Remediation*. This suggests that construction firms should release policy on land assessment and remediation.
8. Water conservation and harvesting	• The GRI Guidelines suggest that construction firms should implement policy and practices on water use management throughout the project life cycle.
9. Materials conservation	• The GRI Guidelines suggest that materials selection and engagement with suppliers on various issues, such as re-usability of materials used, recycled content materials and toxicity of materials, should be researched.
10. Managing impacts on biodiversity	• The GRI Guidelines indicate that firms should be aware of the location of operational sites in relation to protected areas or areas of high biodiversity value, and of the significant impacts of their activities, products and services on biodiversity.

11. Emission reduction	•	The GRI Guidelines explain that practices should be undertaken to reduce various emissions including: 1) greenhouse gas (GHG) emissions; 2) ozone-depleting substances; and 3) nitrous oxide (NO_X), sulphur oxide (SO_X)and other significant air emissions.

A total of 11 CSAs were weak aspects. This indicated that the three leading case firms still have a long way to go to promote their sustainability, even though they are all leading construction firms in China. Specifically, three, two and six aspects were identified to be weak aspects of the case firms in economic, social and environmental sustainability, respectively. For instance, the GRI Guidelines explain that corporate strategy making should be able to identify the key sustainability issues for firms; however, in the strategy of both CCCC and CGGC, the economy-centred feature was obvious and it was unclear how important sustainability was at the strategic level. In terms of supply chain management, the requirements of human rights assessments and social impact assessments of suppliers were not fulfilled by either CCCC and CGGC. Similarly, construction waste management, land protection and materiald conservation were addressed very inadequately by CCCC and CGGC, neither of which had implemented specific policies focusing on these issues.

Compared to economic and social sustainability, environmental sustainability was the weakest sustainability dimension of the three firms, with six weak aspects identified that related to environmental sustainability. As illustrated in Table 6.3, in considering the Chinese context, two local sustainability guidelines were developed in China. Compared to the GRI Guidelines, the two Chinese guidelines placed more emphasis on the governance approach and practices for sustainability. In contrast, the GRI Guidelines require firms to release much quantitative information about sustainability, especially about environmental sustainability. Due to the lack of statistical methods and standards about environmental information, corporate policies on environmental statistics are not issued in most Chinese construction firms. As a result, firms are often not able to quantitatively monitor their environmental impacts. Even in the case of CSCEC, the firm had only started to establish a monitoring system for environmental issues in 2013 and, thus, was still in the early stage in terms of environmental statistics. Indeed, more attention needs to be paid to environmental statistics by Chinese construction firms in the future.

6.5 Summary

This chapter has analysed the sustainability transition and sustainability practices of three leading construction firms in China and, thus, adequately responds to ***Research Objective 4.*** Three key implications can be drawn from the study.

- In all, 92 sub-aspects of sustainability practices implemented by the case firms were identified, suggesting that sustainability is a complex concept and that, in order to respond to it holistically, many practices need to be adopted. This is echoed by Geels (2010) and Lachman (2013) who suggest that sustainability transitions involve many potential solutions and practices.
- Even though all three case firms were leading construction firms in China, their strategic sustainability behaviours were very different, with CSCEC significantly outperforming CCCC and CGGC. Considering the enormous numberof firms engaged in the Chinese construction industry, it is expected that this industry would be heterogeneous in terms of the sustainability behaviours of firms.
- Assessment of the sustainability practices of the three case firms revealed that they generally did well in social sustainability and in some aspects of economic sustainability, but all three firms responded inadequately to environmental sustainability.

The fact that China has sustainability-rooted construction firms (e.g. CSCEC) and various sustainability practices (the identified 92 sub-aspects) suggests that enabling conditions are present in China for the construction industry to transition towards sustainability. The key issue is to expand the influence of sustainability-rooted construction firms in the industry and empower the sustainability practices. As an explorative study, this chapter has analysed three leading Chinese construction firms, thus establishing a research basis for the next chapter. The identified 29 CSAs are used in the next chapter to investigate the sustainability perceptions and performance of a broader sample of construction enterprises. It is important to note that, as the sustainability issue is a global challenge and many other economies are promoting sustainability in their construction industries, the CSAs and sustainability practices (see Table 6.7) identified in this chapter can also be applied as research tools (e.g. assessment frameworks) to examine the sustainability practices of construction firms in other countries which have similar social and cultural conditions to those of China.

Table 6.7 Sub-aspects (N=92) of sustainability practices implemented by the studied case firms

Sustainability dimension	Critical sustainability aspects (CSAs)	Sub-aspects
Economic	Corporate strategy	1. Scientific process and tools for analysing and generating strategy
		2. Clear corporate vision and strategy
	Quality management	3. A comprehensive quality management system, including organization system, institution building, and supervision and assessment
		4. Implement quality control throughout the whole construction process, including design, procurement, preparation for construction, construction and completion of construction
		5. Design and implement various training programs on quality management for all staff
	Supply chain management	6. A clear procurement process
		7. A clear set of criteria to assess and select suppliers, with sustainability principles incorporated into the selection criteria
		8. Conduct training programs for suppliers and establish long-term cooperation with excellent suppliers
	Innovation system	9. Have relevant departments, policies and employees focusing on management innovation, such as whole life-cycle project management
		10. Have relevant departments, policies and employees focusing on technology innovation
		11. Have relevant departments, policies and employees focusing on concept innovation
		12. Have relevant departments, policies and employees focusing on service innovation
	Corporate governance	13. Establish departments responsible for corporate sustainability (CS) and social responsibility
		14. Design and implement a management system focusing on sustainability, such as an assessment standard for evaluating corporate sustainability
	Customer service and satisfaction	15. Establish a management system for customer service and satisfaction, such as a customer relationship management (CRM) system
		16. Conduct satisfaction survey for clients of completed projects
		17. Actively release project information for clients, including adverse information
		18. Meet and surpass the demands of clients, such as introducing new construction technologies for clients
	Communication management	19. Have an individual section on the corporate website that introduces sustainability and the social responsibility of the corporation

		20. Release annual sustainability reports 21. Establish complete communication mechanisms with various stakeholders
	Network building	*22. Cooperate with banks* *23. Cooperate with enterprises* *24. Cooperate with universities* *25. Cooperate with governments*
	Risk management	26. Establish risk assessment criteria and a risk classification system for early warning and emergency response 27. Have response strategies to respond to various risks if they happen, such as financial risks and operational risks
Social	Occupational health and safety	28. Regularly conduct physical checks for employees and establish health records 29. Conduct psychological consultations for employees 30. Establish relevant organizations specifically responsible for safety management 31. Establish a safety inspection and training system 32. Have an emergency response system if accidents happen
	Education and training	33. Have various training programs for employees 34. Design different career development paths for employees
	Wages and welfare	35. Establish a salary distribution system that considers both efficiency and equity 36. Implement a paid leave policy 37. Provide social security and health insurance for employees
	Anti-corruption and fair competition	38. Sign honest contracts with suppliers 39. Carry out anti-corruption campaign to promote honest culture 40. Leaders at all levels to sign letters on their responsibility to be honest and "clean" 41. Establish a transparent information system on procurement
	Human rights	42. Actively listen to the suggestions of employees and guarantee employees' rights 43. Prohibit child labour and forced labour 44. Employees to be treated equally regardless of their gender, race, religion, sexual orientation and marital status
	Support community development	45. Actively identify the demands of key stakeholders in the community 46. Respect and protect the cultural heritage in the community 47. Provide money, technology and education for people living in poor areas 48. Offer help to people who have suffered from natural disasters 49. Encourage employees to attend various volunteer activities 50. Promote the employment of college students and migrant workers
	Obey laws and regulations	51. Establish a corporate general counsel system 52. Information management of domestic laws and regulations

		53. Information management of overseas laws and regulations
	Caring for all employees	*54. Caring for female employees through various activities* *55. Caring for frontline workers* *56. Caring for employees experiencing enormous difficulties, for example, by establishing a health fund for employees with major diseases*
	Promoting the development of the industry	*57. Actively participate in research projects organized by the government* *58. Actively participate in various international industry conferences* *59. Actively participate in various domestic industry conferences*
Environmental	Environmental management	60. Set up environmental department at firm's headquarter 61. Formulate relevant corporate policies about environmental management 62. Set up environmental targets and conduct regular monitoring 63. Implement green office policy to encourage employees to save water, electricity and paper 64. Establish incentive mechanisms to enhance environmental management
	Construction waste management	65. Classify construction waste and recycle as much as possible on site 66. Adopt environmentally friendly materials and advanced techniques to reduce the amount of construction waste
	Land use efficiency	67. Optimize the site design of buildings 68. Rational exploitation of the underground space of buildings 69. Have a policy on land assessment and remediation
	Water conservation and harvesting	70. Reduce water consumption by adopting various approaches, such as using sack moisturizing technology 71. Strengthen water recycling by various approaches, such as using a rainwater collection system
	Materials conservation	72. Use quantitative indicators to manage materials and reduce materials waste 73. Select local building materials if possible 74. Promote structural system with high durability 75. Promote the use of green building materials 76. Optimize construction programs to save materials
	Energy conservation	77. Promote construction technologies which consume low energy 78. Promote the use of energy-saving equipment and tools 79. Promote the use of renewable energy sources, such as wind and solar power
	Managing impacts on biodiversity	80. Before construction, investigate the ecological environment and biodiversity of the construction site and make protection plans 81. Mark the protected species on the construction site to indicate this to employees 82. Conduct education and training for employees about biodiversity protection 83. Maximize the retention of native trees within the construction site

Emission reduction	84. Promote the use of dust-proof nets and sealed cars 85. Set up washing tanks for vehicles at the doors to the construction site
Green innovation and products	86. Establish an enterprise database for green products and technologies 87. Mitigate negative impacts on end-user health through various approaches, such as paying attention to indoor air quality issue
Light pollution	*88. Rational distribution of site lighting to reduce light pollution* *89. Use shielding measures to reduce light pollution*
Noise control	*90. Promote the use of equipment that has low vibration and a low noise level* *91. Use sound insulation and seismic isolation measures* *92. Create a rational schedule to avoid the concentration of noisy operations*

Note: Aspects which are not covered by the initial coding category are indicated as ilactics

Chapter 7 Discovering transition pathways towards sustainability (TPS) for construction enterprises in China: An importance–performance analysis

7.1 Introduction

Integrating sustainability principles and practices into the construction industry is a transition process. However, firms, including construction firms, are usually resource-constrained. This is compounded by the fact that sustainability is such a complex concept covering economic, social and environmental dimensions. To facilitate the sustainability transition of construction enterprises, it is imperative to identify those sustainability aspects that are perceived to be the most and least important, and the worst-performed and best-performed by construction enterprises, thereby allocating the limited resources to the worst-performed, yet important, sustainability aspects. Very few studies have attempted to investigate how the various economic, social and environmental sustainability aspects that constitute the holistic sustainability concept are perceived and performed by construction firms. Proposed by Martilla and James (1977), the importance–performance analysis (IPA) technique provides a useful tool for identifying the most crucial attributes with regard to their need for managerial action; thus, this technique could be applied to classify the sustainability aspects with an efficient pathway identified to facilitate construction firms' transition towards sustainability.

Based on three exploratory cases, the previous chapter identified 29 critical sustainability aspects (CSAs) and the strengths and weaknesses of the three case firms in terms of their CSA performance. This chapter further broadens the scope of analysis by investigating the various construction firms' perceptions towards, and performance on, the identified 29 CSAs based on a questionnaire survey. To adequately achieve ***Research Objective 5*** (to holistically examine the sustainability perceptions and performance across construction enterprises of different scales and with different sustainability levels), three specific research aims were developed. Firstly, this chapter seeks to holistically investigate Chinese construction firms' attitudes towards, and performance on, various aspects of sustainability, thereby identifying those aspects that the firms perceive to be the most and least important, and those aspects considered by the firms to be their strengths and weaknesses. Secondly, by classifying firms according to their scale, this chapter aims to statistically test whether a more positive attitude towards sustainability is associated with better sustainability performance and whether firm size is associated with firms' attitudes towards, and performance on, sustainability. Thirdly, this chapter aims to propose *Transition Pathways towards Sustainability* (TPS) for construction enterprises with different sustainability levels based on the IPA of the identified 29 CSAs. The research work presented in this chapter has already been accepted for publication in the ***Journal of Construction Engineering and Management*** (please see p. 298).

7.2 Method

7.2.1 Identification of critical sustainability aspects (CSAs) and firm size

A list of critical sustainability aspects (CSAs) was developed for Chinese construction enterprises in the previous chapter. The final list of CSAs consisted of 29 aspects, as shown in Table 7.1. The detailed procedure for proposing these sustainability aspects was introduced in the previous chapter.

Table 7.1 List of CSAs for construction enterprises

Critical sustainability aspects	Code	Explanation
Economic		
Corporate strategy	A1	Consider the macroeconomic or political trends affecting the organization and influencing sustainability priorities
Quality management	A2	Implement quality control throughout the whole construction process, including design, procurement, preparation for construction, construction and completion of construction
Supply chain management	A3	Choose suppliers, i.e. materials suppliers, equipment suppliers, subcontractors and labour service companies based on the quality of their products, the safety of their production process, their labour practices, etc.
Innovation system	A4	Enhance technological and managerial innovation to improve economic competitiveness
Corporate governance	A5	Establish a leading working body of sustainability which is directly managed by top leaders of the firm, e.g. the Chief Executive Officer, and several subordinate sustainability working bodies
Customer service and satisfaction	A6	Satisfy the needs of clients, such as the quality, schedule, cost and safety requirements and, at the same time, minimize the risks
Communication management	A7	Identify the firm's stakeholders and clarify their requirements and expectations of the firm, and then communicate appropriately with their stakeholders
Network building	A8	Form strategic alliances with other enterprises, universities and banks
Risk management	A9	Create risk and crisis awareness and establish relevant risk management and crisis prevention plans
Social		
Occupational health and safety	A10	Establish a complete safety management system, and conduct both physical and psychological examinations to check the health status of employees

Education and training	A11	Involves investment in education and training, the type of classes, the assessment of training programs and the types of career paths planned for employees
Wages and welfare	A12	Establish a salary payment distribution system that considers both efficiency and equity, and provide the necessary welfare for employees
Anti-corruption and fair competition	A13	Refuse to receive bribes from subcontractors and establish an anti-corruption mechanism.
Human rights	A14	Employees should be treated equally regardless of their gender, race, religion and marital status, and forced labour and child labour are forbidden.
Supporting community development	A15	Involves localized operations, charitable donations and employee volunteers
Obeying laws and regulations	A16	Conduct training on legislation and regulations, and establish a corporate general counsel system
Caring for all employees	A17	Care for all employees, including female employees, frontline workers and employees experiencing enormous difficulties.
Promoting the development of the industry	A18	Participate in national research projects and in drafting industry standards
Environmental		
Environmental management	A19	Establish an environmental management system and attempt to obtain relevant certification, such as the ISO 14001 certification
Construction waste management	A20	Pay attention to the recycling of construction waste, and adopt environmentally friendly materials and advanced construction techniques to reduce the amount of construction waste
Land use efficiency	A21	Have a policy on land assessment and remediation and optimize the site design of buildings
Water conservation and harvesting	A22	Have a policy on water use management through all stages of the project life cycle to reduce water consumption and enhance water recycling
Materials conservation	A23	Promote the use of green building materials and select local building materials if possible
Energy conservation	A24	Establish a holistic energy management system and actively invest in renewable energy applications in construction
Managing impacts on biodiversity	A25	Protect rare plants and animal species and their natural habitats, reducing the impacts on biodiversity
Emission reduction	A26	Take measures to reduce emissions including greenhouse gas (GHG) emissions, ozone-depleting substances, and NO_x, SO_x and other significant air emissions.
Green innovation and products	A27	Develop green products to mitigate environmental and end-user health impacts.
Light pollution	A28	Use shielding measures and rationally distribute site lighting to reduce light pollution
Noise control	A29	Use equipment which has low vibration and a low noise level, and adopt sound insulation and seismic isolation measures

To achieve the research aims, apart from the identification of sustainability aspects, firm size also needed to be identified. Firm size was reflected by a categorical variable. To determine the criteria for classifying the sizes of construction firms, the relevant national standards in China were analysed and compared, including the *Qualification Standard for Construction Enterprises* (MHUD, 2014b) and *the Criteria for the Classification of Small and Medium-sized Firms* (MIIT, 2011). As a result, in this study, the following four-level classification system, based on annual turnover criteria, was adopted to differentiate the sizes of construction enterprises: 1) small enterprises (SEs): an annual turnover of no more than 20 million CNY; 2) medium enterprises (MEs): an annual turnover of more than 20 million CNY and no more than 200 million CNY; 3) large enterprises (LEs): an annual turnover of more than 200 million CNY and no more than 1.5 billion CNY; and 4) huge enterprises (HEs): an annual turnover of more than 1.5 billion CNY.

7.2.2 Data analysis

7.2.2.1 Relative rankings of CSAs in the whole sample

This study employed a five-point Likert scale to measure the importance and performance levels of the CSAs, as perceived by construction enterprises. Respondents were asked to evaluate the relative importance of the identified 29 CSAs from 1 (“very unimportant”) to 5 (“very important”). After completing the importance evaluation, respondents were then asked to evaluate their enterprise’s performance on these CSAs, also on a five-point Likert scale ranging from 1 (“very bad”) to 5 (“very good”). Details of the questionnaire distribution were explained in the Methodology chapter.

The relative importance value (RIV) and relative performance value (RPV) were used to generate the relative ranking of the CSAs, thereby enabling the identification of the aspects perceived to be the most and least important, as well as firms’ strengths and weaknesses. The RIV has been used in various construction studies as the basis for ranking the relative importance of related factors. For instance, Shen et al. (2016) employed the RIV to identify the critical factors affecting green procurement in real estate development. Chen et al. (2010) adopted one variant of the RIV, the severity index, to rank a list of sustainable performance criteria for construction method selection. Similarly, the RPV has been used in construction studies to investigate the degree of performance or satisfaction, as evaluated by respondents. For instance, Mohit et al. (2010) developed a residential satisfaction index to assess the performance of public low-cost housing projects in Malaysia. Even though there are different names in the literature for the RIV (e.g. relative importance value, severity index, relative importance index, etc.) and for the RPV (e.g. relative performance value, satisfaction index, etc.), the calculation methods are similar. This study adopts the calculation method proposed by Idrus and Newman (2002) to determine the RIV and the RPV of the CSAs. This method allows the ratings on a five-point Likert scale to be converted into a 100-point index which is easy to interpret:

$$\mathrm{RIV}_i = \frac{\sum_{j=1}^{n} A_{ij}}{an} \times 100 \tag{1}$$

$$\mathrm{RPV}_i = \frac{\sum_{j=1}^{n} B_{ij}}{an} \times 100 \tag{2}$$

where i denotes the numbering of the 29 CSAs; j denotes the numbering of the surveyed enterprises; n denotes the number of responses in the investigated sample (which could be the total sample or the samples formed by firms of different sizes); a denotes the highest rating (i.e. 5 in this case); A_{ij} denotes the score given to the ith sustainability aspect by the jth enterprises in the attitude (importance) evaluation; and B_{ij} denotes the score given to the ith sustainability aspect by the jth enterprises in the performance evaluation.

7.2.2.2 Associations between firm size, sustainability attitude and sustainability performance

If an enterprise does not perceive sustainability as an important issue, it will be unlikely to take sustainability seriously or to have excellent sustainability performance. It was assumed that, compared to small and medium-sized enterprises, larger construction firms in China would attach more importance to sustainability issues and, thus, would have higher sustainability performance. Compared to large enterprises, small and medium-sized firms lack the motivation to improve sustainability performance due to various constraints such as limited resources, fewer opportunities to obtain benefits from implementing sustainability strategies, and limited technological capabilities (Torugsa et al., 2012).

Meanwhile, pressures from the public and the media could also be stronger for larger firms. Zeng et al. (2011) argued that, in China, the impacts of environmental organizations and media attention on large enterprises are much more significant than those on small and medium-sized enterprises. Thus, with better capabilities and under higher societal pressures, large firms could attach more importance to, and have better performance on, sustainability than smaller firms. Therefore, it was proposed to statistically test the following three hypotheses:

H1. *There is a positive relationship between construction firms' attitudes towards sustainability and their sustainability performance. The construction firms which perceive that sustainability is of higher importance have better sustainability performance.*

H2. *There is a positive relationship between firm size and construction firms' attitudes towards sustainability. Larger construction firms perceive sustainability to be more important than is the case with smaller firms.*

H3. *There is a positive relationship between firm size and the sustainability performance of construction firms in China. Larger construction firms perform better than smaller ones.*

To test the hypotheses, apart from firm size, the sustainability attitudes and performance of a certain enterprise also needed to be determined. To determine the sustainability attitude level (SAL) and sustainability performance level (SPL) of a certain enterprise, a method similar to that used by Bevan and Yung (2015) was developed and adopted. In the context of multiple-attribute decision making, the weighted sum method is one of the most common methods for integrating scores on multiple attributes into an aggregate value (Zhou et al., 2006). One sustainability aspect was not necessarily more influential than other aspects in determining the overall sustainability level in this study, so equal weights were applied to the CSAs:

$$\mathrm{SAL}_j = \frac{\sum_{i=1}^{b} A_{ij}}{ab} \times 100 \tag{3}$$

$$\mathrm{SPL}_j = \frac{\sum_{i=1}^{b} B_{ij}}{ab} \times 100 \tag{4}$$

where i denotes the numbering of the 29 CSAs; j denotes the numbering of the surveyed enterprises; n denotes the number of responses in the investigated sample (which could be the total sample or the samples formed by firms of different sizes); a denotes the highest rating (i.e. 5 in this case); b denotes the total number of the attributes (i.e. 29 in this case); A_{ij} denotes the score given to the ith sustainability aspect by the jth enterprises in the attitude (importance) evaluation; and B_{ij} denotes the score given to the ith sustainability aspect by the jth enterprises in the performance evaluation.

To test H1, correlation analyses, including both Kendall's rank correlation and Spearman's rank correlation, were conducted. If the SAL was found to be positively correlated with the SPL, H1 would be supported; otherwise, it would be rejected. To test H2 and H3, the Kruskal–Wallis test was carried out and, as a follow-up, the Mann–Whitney U test was conducted. The Kruskal–Wallis test allows the comparison of the scores of variables for three or more groups: it was used in this study to determine whether there was a statistically significant difference in SAL and SPL across several groups defined by the categorical variable of firm size. If a significant result was obtained, the Mann–Whitney U test could be conducted to identify which pair of groups was significantly different from each other.

7.2.2.3 Importance–performance analysis of CSAs for firm groups with different sustainability levels

As the target population often presents a heterogeneity of importance and performance perceptions, segmentation plays a critical role in IPA in identifying differences between distinct groups so the decision-making process can be more accurate (Bruyere et al., 2002). Without differentiating the respondents, IPA will produce results for an "average group" which often does not actually exist; thus, average importance and performance ratings are of limited practical value (Griffin and Edwards, 2012). Segmentation could be accomplished by performing cluster analysis, with IPA then carried out on each cluster (Bacon, 2003).

Cluster analysis was utilized in this study to classify construction enterprises into different groups according to their sustainability performance. Cluster analysis aggregates individuals based on their characteristics, forming groups with the greatest possible internal homogeneity (within groups) and external heterogeneity (between groups) (Carvalho et al., 2015). The performance ratings of the CSAs were used as the input variables in the cluster analysis: they were standardized prior to the analysis to eliminate the potential effects of scale differences (Milligan and Hirtle, 2003). To generate the cluster solutions, the study employed the non-hierarchical *k*-means cluster analysis. Unlike the hierarchical agglomerative methods, the *k*-means cluster analysis adopts the iterative partitioning methods which make more than one pass through the data and can handle large data sets, thereby avoiding the hierarchical agglomerative methods' major drawbacks (Aldenderfer and Blashfield, 1986).

The first step of *k*-means cluster analysis is to form an initial partition by arbitrarily assigning the cases into *k* groups. The value of *k* is user-specified, with the current study attempting the two-, three-, four- and five-cluster solution (*k*=2, 3, 4 and 5). Next, the Euclidean distances were calculated between the cases and the *k*-cluster centroids, which were the multivariate mean of the cases within a cluster, to reassign the cases to the nearest centroid (Aldenderfer and Blashfield, 1986). Once all these reassignments were completed and the centroids of the new clusters were computed, the Euclidean distances were calculated again between the cases and the new centroids, and the cases were reallocated. This step was repeated until no further reassignments occurred. The Euclidean distance is defined as follows (Aldenderfer and Blashfield, 1986).

$$d_{ic} = \sqrt{\sum_{k=1}^{p} (x_{ik} - c_k)^2}$$

where d_{ic} is the Euclidean distance between the case *i* and the centroid; x_{ik} is the value of the k^{th} variable for the i^{th} case; *p* is the total number of the variables (i.e. 29 in this paper); and c_k is the value of the k^{th} variable for the centroid.

Once the firm clusters were obtained, the traditional IPA was conducted. Firstly, the means of both the importance and performance ratings were calculated for the identified clusters, respectively. Performance gap analysis (performance mean minus importance mean) was then conducted for each of the firm clusters to identify those aspects requiring urgent management attention. This was followed by the IPA mapping which allocated the 29 CSAs into the appropriate quadrants and identified the most important, least important, best-performed and worst-performed CSAs for each of the identified clusters, as perceived by respondents. The current study was different from the traditional IPA studies, with the last step developed to integrate the sustainability transition perspective into the IPA, thereby proposing the transition pathways towards sustainability (TPS) for construction enterprises. For a detailed introduction of IPA, please see the Methodology section.

7.3 Results and analysis

Of the 262 effective responses, 4.58%, 56.49%, 27.86% and 11.07% were from small enterprises, medium enterprises, large enterprises and huge enterprises, respectively. Over 79% of respondents had more than five years of experience and 41% had more than 10 years of experience in the industry. The sample group profile indicated that respondents consisted of 79 (30.15%) project managers, 53 (20.23%) corporate managers, 66 (25.19%) engineers, 39 (14.89%) designers and 25 (9.54%) quantity surveyors and supervisors. Around half of the respondents were project or corporate managers who tended to have a holistic understanding of construction projects and corporate operation, while the other half of the respondents focused on the details and various facets of construction projects. As in the study by Bevan and Yung (2015), this balanced respondent profile reduced the selection bias and improved the representativeness of the sample selection (Zhao et al., 2015).

7.3.1 Relative rankings of CSAs in the whole sample

The RIV and RPV were calculated based on the responses from the 262 firms, with the CSAs subsequently ranked, as shown in Table 7.2. For the whole sample, the means of importance for 27 aspects was beyond 80 (which means “important”) while only two aspects had a mean score beyond 80 (which means “good”) in the performance evaluation.

This suggests, in general, the gaps between firms' sustainability attitudes and performance, with this being consistent with previous studies (e.g. Zsóka, 2008).

Table 7.2 Attitude and performance evaluation of CSAs

Code	CSAs	Attitude evaluation		Performance evaluation	
		RIV	Rank	RPV	Rank
	Economic				
A1	Corporate strategy	85.04	4	79.16	4
A2	Quality management	87.25	1	81.53	1
A3	Supply chain management	82.14	19	77.25	8
A4	Innovation system	82.21	18	75.34	16
A5	Corporate governance	81.60	21	75.19	17
A6	Customer service	86.56	2	80.69	2
A7	Communication management	82.67	14	76.26	12
A8	Network building	81.45	22	75.11	20
A9	Risk management	85.11	3	77.94	6
	Social				
A10	Occupational health and safety	84.89	6	78.70	5
A11	Education and training	80.99	25	73.89	23
A12	Wages and welfare	84.81	7	74.27	22
A13	Anti-corruption and fair competition	79.54	28	73.51	25
A14	Human rights	82.60	15	76.79	9
A15	Supporting community development	76.79	29	72.90	29
A16	Obeying laws and regulations	84.96	5	79.39	3
A17	Caring for all employees	81.30	23	73.74	24
A18	Promoting the development of the industry	83.21	11	75.65	14
	Environmental				
A19	Environmental management	82.44	17	75.65	14
A20	Construction waste management	84.43	8	76.11	13
A21	Land use efficiency	84.35	9	77.33	7
A22	Water conservation and harvesting	82.98	12	76.79	9
A23	Materials conservation	82.98	12	76.41	11
A24	Energy conservation	82.60	15	75.19	17
A25	Managing impacts on biodiversity	80.61	27	74.58	21
A26	Emission reduction	82.06	20	73.28	26
A27	Green innovation and products	81.15	24	72.98	28
A28	Light pollution control	80.99	25	73.13	27
A29	Noise control	83.66	10	75.19	17

It can be seen that the top four most important sustainability aspects were all related to the economic dimension. Moreover, these aspects were the strengths of Chinese construction enterprises, clearly reflected in the performance evaluation. *Quality* *management* (A2) and *customer service* (A6) were regarded as the most important aspects by the firms. *Risk management* (A9) and *corporate strategy* (A1) were also ranked high on both the attitude and performance evaluations. This result wass consistent with previous studies on the economic competitiveness of Chinese construction firms (e.g. Lu et al., 2008). However, in comparison to these traditional aspects, many new topics relevant to economic sustainability received less attention, for example, *innovation system* (A4) and *corporate governance* (A5). This echoed the *12^th^ Development Plan for Chinese Construction Industry* which suggested that the standardization level in the industry was low, and that many Chinese construction firms were investing too little on research and innovation (MHUD, 2011a). Compared to other aspects (e.g. project quality, customer service and corporate strategy) which can directly influence the corporate operation, research and innovation may not generate benefits in the short term. However, as these aspects are critical to the long-term sustainable development of the industry, they need to be further strengthened in the industry.

Those social issues that ranked highly in the attitude evaluation were *obeying laws and regulations* (A16) and *occupational health and safety* (A10) which also received high rankings in the performance evaluation. By contrast, *wages and welfare* (A12) ranked as the 7th most important sustainability aspect, while it ranked only 22nd among all 29 CSAs in the performance evaluation. This suggests that the wages and welfare in the Chinese construction industry were still of concern to respondents. Three of the nine social aspects were ranked within the five least important aspects. *Supporting community development* (A15) is one of the primary foci of corporate social responsibility (CSR) but it was rated as the least important aspect. This indicates that the awareness of social responsibility still needs to be significantly improved in the industry. This finding is generally in line with the finding by Wang (2014) that the lack of awareness of social responsibility was a serious issue in the Chinese construction industry. It is interesting to note that the ranking of *anti-corruption and fair competition* (F13) was also very low. This contrasts to the fact that corruption is a serious issue in the industry (MHUD, 2011a). The central government introduced specific policies in 2014 to address anti-corruption measures related to the construction industry: these policies predominantly focus on regulating government officials who work in construction and housing authorities rather than regulating industry professionals (MHUD, 2014a). What remains unclear is how the anti-corruption policy could affect the perceptions and behaviours of construction professionals.

The environmental aspects which received high rankings for importance were *construction waste management* (A20) and *land use efficiency* (A21), while the least important aspect, according to respondents, was regarded as *managing impacts on biodiversity* (A25). With regard to the performance evaluation, the highest ranked environmental aspect was *land use efficiency* (A21) while the lowest ranking was for *green innovation and products* (A27). It seems that the environmental aspects which were directly related to the economic gains of construction enterprises received a high level of attention. Due to the property boom and rapid industrial development, the land cost in China is generally high; thus, construction companies need to adequately utilize the land to obtain profit (Wang, 2014). Therefore, *land use efficiency* (A21) was highly ranked in both the attitude and performance evaluations. Similarly, environmental issues, for example, construction waste management and the conservation of water, materials and energy were highly rated as these issues could generate tangible impacts on construction firms' operational costs. In contrast, issues, such as *light pollution control* (A28) and *managing impacts on biodiversity* (A25) were not directly related to firms' economic competitiveness and they received low rankings. An effective approach to address these issues (e.g. biodiversity protection) would be to incorporate them into the compulsory environmental impact assessment. However, currently not all construction projects have to go through environmental impact assessment in China (Wang, 2014).

7.3.2 Associations between firm size, sustainability attitude and sustainability performance

To examine the relationship between the SAL and the SPL, non-parametric correlation analyses including both Kendall's tau and Spearman's rho were undertaken. It was found that the SAL was positively correlated with the SPL (Kendall's tau b: 0.382; Spearman's rho: 0.536, both significant at 0.01 level): H1 is therefore supported. The implication is that if a positive attitude to sustainability can be nurtured in Chinese construction firms, sustainability performance can be higher. This is consistent with similar studies, for example, the work of Zhang and Zhou (2015) who suggested that carbon reduction awareness among Chinese contractors could lead to their corresponding behaviours.

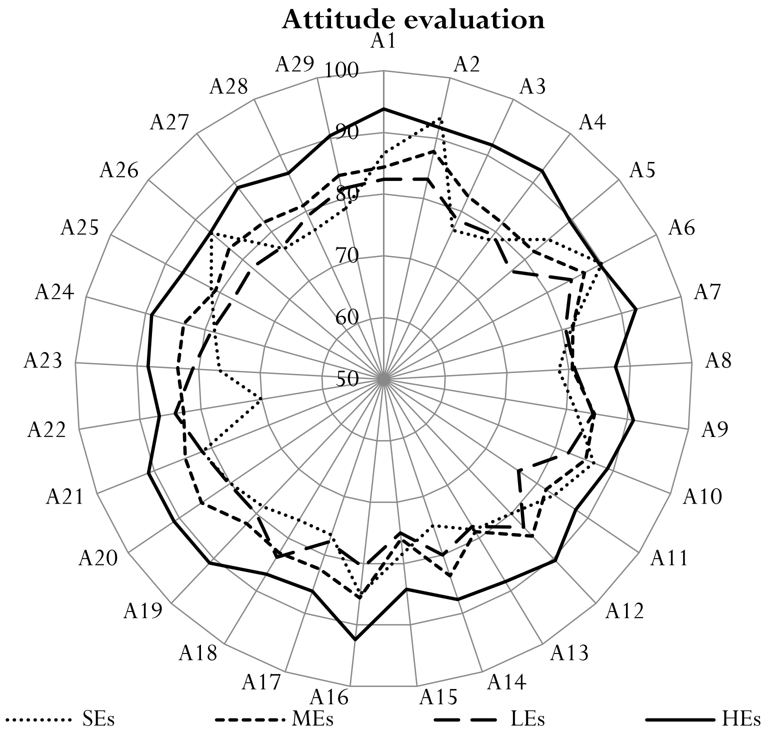

Figure 7.1 Relative importance values (RIVs) of CSAs among construction enterprises of different firm sizes

Note: SEs=small enterprises; MEs=medium enterprises; LEs=large enterprises; HEs=huge enterprises

To examine how firms of different size perceive the relative importance of the CSAs, the RIVs of the CSAs were calculated for the SEs, MEs, LEs and HEs, respectively. As shown in Fig. 7.1, these four groups of firms have very different attitudes towards sustainability. It seems HEs have a higher RIV than the other three groups on almost all the 29 CSAs, suggesting that the overall sustainability attitude (reflected by SAL) could be different in the various group of firms. This was confirmed by the Kruskal–Wallis test which revealed a statistically significant difference (significance level: 0.01) in SAL across all four firm groups. A series of follow-up Mann–Whitney U tests was conducted to identify the particular pairs of groups that have a significantly different SAL, as shown in Table 7.3.

When the results of the Kruskal–Wallis test and the Mann–Whitney U tests are taken together, this suggests that H2 is partially supported. Specifically, HEs have a significantly higher SAL than all other groups of firms, which supports H2. However, MEs and LEs do not have a significantly higher SAL than SEs. More interestingly, Mann–Whitney U tests reveals that, LEs, when compared with MEs, had a significantly lower, rather than a higher SAL. Thus, H2 is only partially supported.

H2 was formulated based on the argument that larger firms perceive sustainability to be more important than is the case with smaller firms as larger firms receive more pressures from the government, the media and the public. However, the current study suggests that this may not be the case for all sizes of firms. This is arguably due to the complex nature of pressures from the public, the media and the government and its associated effect on firms' attitudes towards sustainability. For instance, the policies in China may be effective in driving preventive behaviour, for example, preventing firms from damaging the environment, but not so practicable as to make companies enthusiastic and proactive about environmental protection (Liu, 2009). Likewise, the mechanisms for the ways in which public pressures affect the attitudes of construction firms towards sustainability could be very complex. Further research could be conducted to explore how various factors contribute to the different sustainability attitudes of construction firms of different sizes.

Table 7.3 Results of Mann–Whitney U tests for sustainability attitude level (SAL)

Pairs of groups	SEs vs. MEs	SEs vs. LEs	SEs vs. HEs	MEs vs. LEs	MEs vs. HEs	LEs vs. HEs
M–W U test	0.474	0.9	0.027*	0.041*	0.001**	0.0005**

* Significant at the 0.05 level
** Significant at the 0.01 level

The RIV of the CSAs reveals that for SEs and MEs, the most important factors are *quality management* (A2) and *customer service* (A6), while for HEs, *innovation system* (A4) and *communication management* (A7) received more attention. This suggests that larger firms may pay more attention to innovations and stakeholder relations than smaller firms. It is also important to note that even though, for all groups of companies, social and environmental aspects generally were ranked lower than economic aspects, in HEs, many social and environmental aspects received a much higher RIV than in other groups of firms. For instance, all 11 environmental aspects received a score above 86 in HEs, while, in SEs, none of them received such a high score. This further complements the Mann–Whitney U test which found that HEs had a significantly higher SAL than all the other groups of firms.

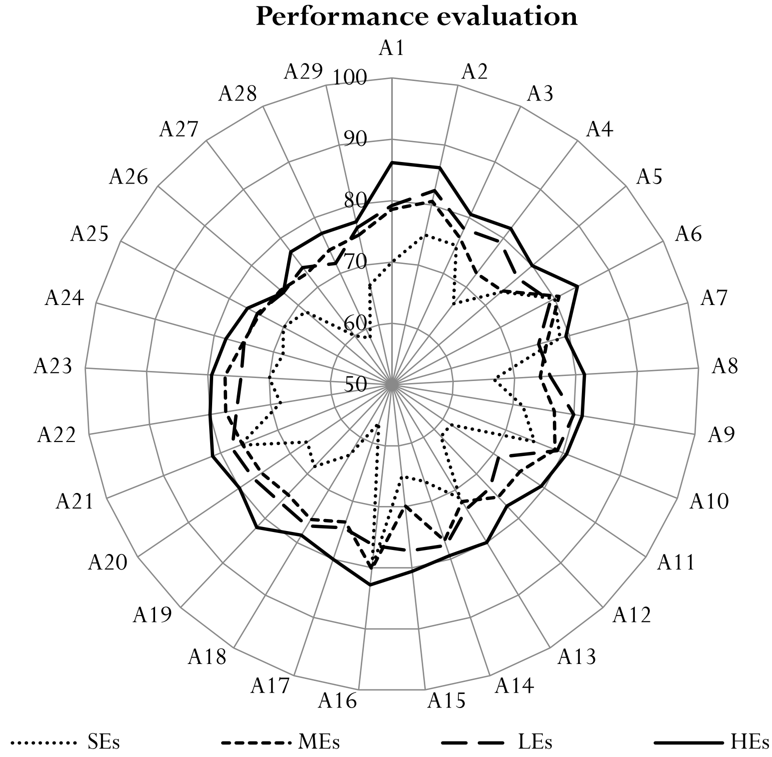

Figure 7.2 Relative performance values (RPVs) of CSAs among construction enterprises of different firm sizes

In terms of the performance evaluation, relative performance values (RPVs) of the CSAs were calculated for SEs, MEs, LEs and HEs, respectively, as shown in Fig. 7.2. The average scores of SPL for SEs, MEs, LEs and HEs were 68.97, 75.64, 76.26 and 80.07, respectively. This indicates that sustainability performance improved steadily along with the increase in firm size. A statistically significant difference (significance level: 0.032) in SPL across four firm groups was revealed in a Kruskal–Wallis test. Thus, a series of follow-up Mann–Whitney U tests was conducted to identify the specific pairs of groups that had significantly different scores (see Table 7.4). The results revealed that HEs had a significantly higher SPL than SEs and MEs. However, other pairs of groups did not have significant differences. Thus, H3 is partially supported. It seems that the pairs of firm groups which had greater differences in firm size tended to have more significant differences in sustainability performance.

Table 7.4 Results of Mann–Whitney U tests for sustainability performance level (SPL)

Pairs of groups	SEs vs. MEs	SEs vs. LEs	SEs vs. HEs	MEs vs. LEs	MEs vs. HEs	LEs vs. HEs
M–W U test	0.123	0.064	0.007**	0.548	0.023*	0.068

* Significant at the 0.05 level
** Significant at the 0.01 level

The average scores of the RPV in the economic, social and environmental aspects, respectively, were calculated for enterprises of different sizes, as shown in Fig. 7.3. Economic sustainability received higher scores than social and environmental sustainability in each group of construction enterprises. This again indicates that the mainstream paradigm of the construction industry in China is still focusing on economic competitiveness. This is consistent with Lu et al. (2008) who identified 35 critical success factors for contractor competitiveness, and discovered that the factors that were most critical were all the economic factors while environmentally-related factors, such as environmental management, were not highly ranked. Compared to other groups of firms, SEs have much lower scores on social and environmental performance, while HEs have much higher scores on these aspects (see Fig. 7.3).

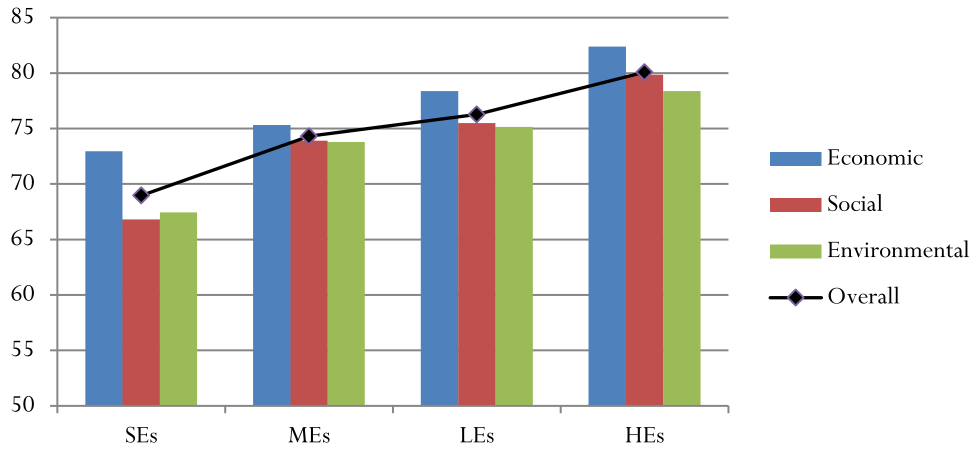

Figure 7.3 Sustainability performance of construction enterprises of different firm sizes

To further identify how SEs and HEs performed differently on the 29 CSAs, a Mann–Whitney U test was conducted on the RPV of specific sustainability aspects. The results showed that these two groups of firms were statistically different in nine CSAs, including 1) *corporate strategy* (A1) and *network building* (A8) in the economic dimension; 2) *education and training* (A11), *caring for all employees* (A17) and *promoting the development of the industry* (A18) in the social dimension; and 3) *environmental management* (A19), *construction waste management* (A20), *green innovation and products* (A27) and *light pollution control* (A28) in the environmental dimension. HEs significantly outperformed SEs in these nine sustainability aspects. Few existing studies have explored the differences in sustainability performance among Chinese construction firms grouped according to their different sizes. This study reveals that HEs have significantly higher performance than SEs on many social and environmental aspects. This could be the reason why HEs have gained sustained growth. Previous studies, for example, Rivoli and Waddock (2011) and Forsman et al. (2013) have suggested that the impacts of social and environmental sustainability on the economic performance of firms are rather complex. In the context of construction enterprises, Lu et al. (2013b) have argued that green construction companies have experienced more rapid growth but could be highly vulnerable to unfavourable economic conditions. Future research could further explore how social and environmental sustainability could be utilized to drive the economic performance of construction firms of various scales.

7.3.3 Importance–performance analysis of CSAs for firm groups with different sustainability levels

After examining various cluster solutions (e.g. the two-, three-, four- and five-cluster solutions), the three-cluster solutions was adopted in the current study based on two criteria: 1) maximum internal homogeneity and external heterogeneity; and 2) parsimony of explanation (Klastorin, 1983). Specifically, the two- and five-cluster solutions were abandoned as the reassignments of the cases were still occurring (i.e. failing to converge) after 10 iterations had been performed. Only the three- and four-cluster solutions were therefore usable. The three-cluster solution was considered superior to the four-cluster solution with this judged according to two criteria. Firstly, one-way ANOVAs relating the cluster membership to the performance ratings of the CSAs indicated that both the three- and four-cluster solutions passed the internal homogeneity and external heterogeneity criteria (significant at the 0.01 level). However, the mean of the *F*-statistics for the three-cluster solution was 69.37 which was larger than 50.08 for the four-cluster solution, indicating that the three-cluster solution significantly outperformed the four-cluster solution in this criterion. Secondly, the three-cluster solution generated very distinct clusters that were easy to interpret, fulfilling the parsimony of explanation criterion.

7.3.3.1 Mapping firm clusters on the importance–performance analysis (IPA) grid

The mean scores of the 29 CSAs for each of the three clusters are shown in Table 7.5: theses were subsequently mapped onto the IPA grid, as shown in Fig. 7.4. As shown in Fig. 7.4, the cross-hairs were placed at the grand means of all the 29 CSAs. Based on the average score of the means for the three clusters shown in Table 7.5, the three firm clusters can be labelled as low-performing firms (low importance and performance ratings); medium-performing firms (medium importance and performance ratings); and high-performing firms (high importance and performance ratings). All the 29 CSAs of high-performing firms were located in Q2, indicating "*keep up the good work*", while all the CSAs of low-performing firms were located in Q3, indicating "*low priority*". This suggests that both the importance and performance scores of the high-performing companies were well above the average of the whole sample, while the opposite applies for the low-performing firms. The sustainability transition of the construction industry is the process in which each firm cluster is moving towards higher sustainability levels, as indicated by the arrows in Fig. 7.4.

Table 7.5 Mean value of importance and performance of CSAs

Code	Critical sustainability aspects	Cluster 1: Low-performing firms (N=43)		Cluster 2: Medium-performing firms (N=108)		Cluster 3: High-performing firms (N=111)	
		I	P	I	P	I	P
A1	Corporate strategy	3.67	3.09	4.25	3.69	4.48	4.56
A2	Quality management	3.84	3.28	4.44	4.11	4.49	4.35
A3	Supply chain management	3.60	3.05	4.10	3.69	4.31	4.34
A4	Innovation system	3.53	3.12	3.98	3.50	4.46	4.28
A5	Corporate governance	3.56	2.93	3.97	3.49	4.39	4.34
A6	Customer service and satisfaction	3.67	3.21	4.30	3.92	4.61	4.47
A7	Communication management	3.60	2.98	4.11	3.74	4.36	4.21
A8	Network building	3.63	2.91	4.00	3.56	4.32	4.28
A9	Risk management	3.67	3.09	4.23	3.69	4.50	4.41
A10	Occupational health and safety	3.58	2.93	4.13	3.71	4.61	4.54
A11	Education and training	3.51	2.86	3.99	3.43	4.32	4.28
A12	Wages and welfare	3.60	2.67	4.21	3.50	4.51	4.32
A13	Anti-corruption and fair competition	3.14	2.77	3.94	3.44	4.33	4.25
A14	Human rights	3.53	2.98	4.06	3.60	4.43	4.41
A15	Support community development	3.14	2.74	3.56	3.31	4.38	4.32
A16	Obey laws and regulations	3.58	3.07	4.28	3.94	4.48	4.35
A17	Caring for all employees	3.47	2.58	4.00	3.64	4.36	4.16
A18	Promoting the development of the industry	3.47	2.79	4.18	3.68	4.41	4.27
A19	Environmental management	3.30	2.67	4.07	3.56	4.49	4.43
A20	Construction waste management	3.60	2.79	4.26	3.69	4.42	4.32
A21	Land use efficiency	3.58	2.67	4.24	3.82	4.44	4.37
A22	Water conservation and harvesting	3.42	2.81	4.09	3.69	4.49	4.38
A23	Materials conservation	3.42	2.81	4.12	3.69	4.46	4.33
A24	Energy conservation	3.35	2.79	4.20	3.66	4.36	4.23
A25	Managing impacts on biodiversity	3.09	2.81	4.05	3.55	4.38	4.26
A26	Emission reduction	3.49	2.81	4.06	3.53	4.38	4.13
A27	Green innovation and products	3.28	2.67	4.01	3.42	4.41	4.25
A28	Light pollution	3.05	2.53	4.12	3.57	4.37	4.17
A29	Noise control	3.14	2.72	4.28	3.61	4.50	4.31
	Average	3.47	2.87	4.11	3.64	4.43	4.32

Note: I=importance; P=performance

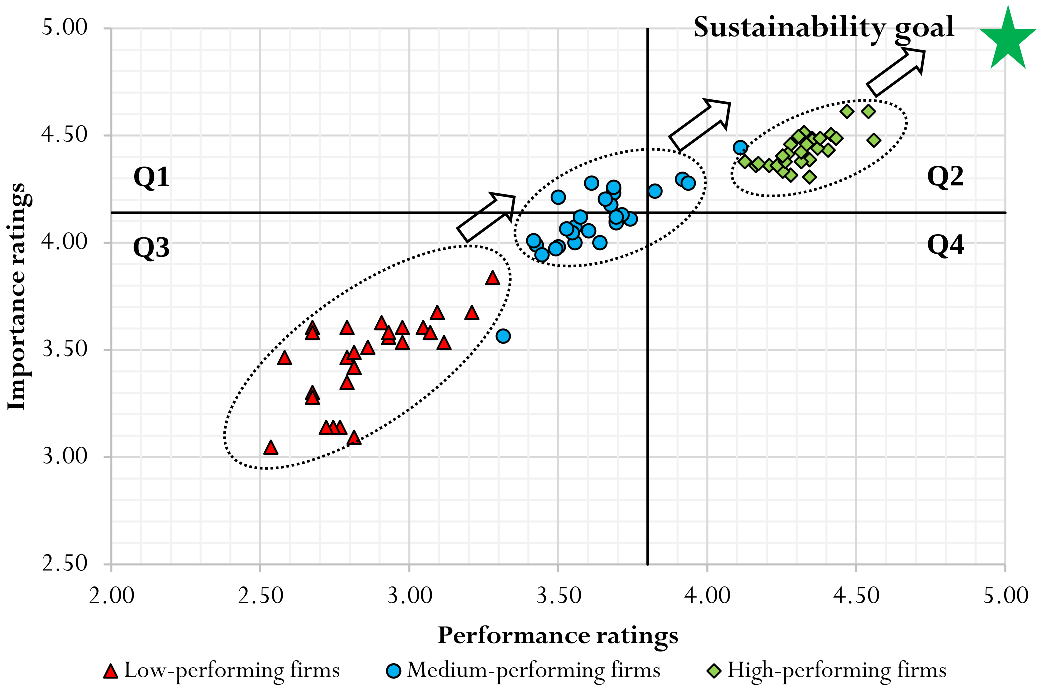

Figure 7.4 Three firm clusters on IPA grid

Table 7.6 Cross-table linking firm groups divided by size and firm groups divided by sustainability levels

	Low-performing firms	Medium-performing firms	High-performing firms
SEs	0.17	0.50	0.33
MEs	0.17	0.47	0.36
LEs	0.16	0.38	0.45
HEs	0.14	0.17	0.69

The previous section has statistically justified that firms of larger size tend to have better sustainability performance. By employing cluster analysis, this section has further grouped together the firms with similar sustainability performance, thereby identifying three different groups. Table 7.6 shows the percentage of the three groups in the firms of different sizes. It is apparent that the percentage of high-performing firms in SEs, MEs, LEs and HEs increases continuously, while the percentage of low-performing and medium-performing firms decreases. This again demonstrates that firms of larger sizes tend to have better sustainability performance, further justifying H1.

7.3.3.2 Performance gap analysis

Performance gap analysis has been utilized by previous IPA studies to identify the attributes that needed urgent managerial attention (Taplin, 2012). By calculating the performance gap (performance mean minus importance mean), the gap analysis was employed in the current study to investigate the urgency of performance improvement for each of the CSAs. For further comparison across the clusters, the performance gaps of the 29 CSAs were calculated for each of the firm clusters (see Fig. 7.5).

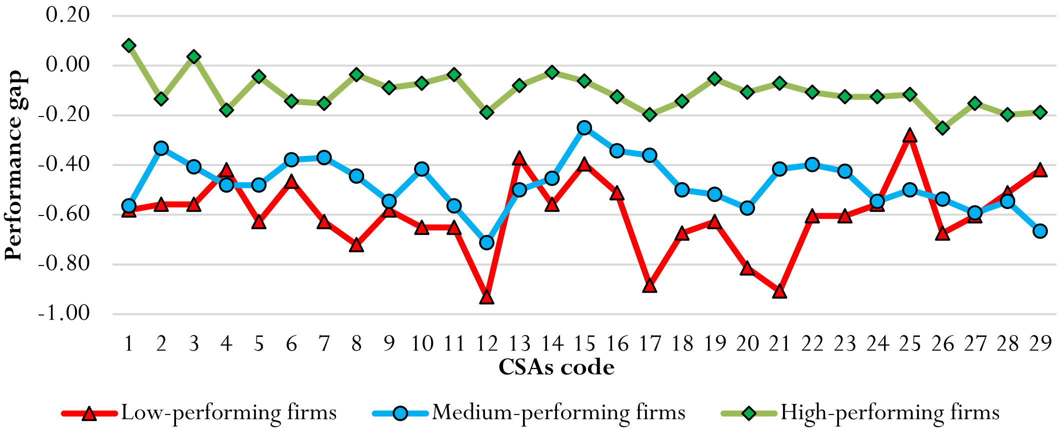

Figure 7.5 Performance gaps for three firm clusters

The average performance gaps within low-performing, medium-performing and high-performing firms were -0.6, -0.48 and -0.11, respectively. This indicates that, compared to high-performing firms, it is more urgent for low-performing and medium-performing firms to improve their sustainability performance. Among the three firm clusters, high-performing firms had the smallest performance gaps for all of the 29 CSAs, while low-performing firms had the largest performance gaps for most of the CSAs, except for several aspects where medium-performing firms had the largest performance gaps. These exceptions comprised *innovation system* (A4), *anti-corruption and fair competition* (A13), *managing impacts on biodiversity* (A25), *light pollution control* (A28) and *noise control* (A29). As shown on Fig. 7.5, the three groups presented very different patterns of performance gaps, except for *wages and welfare* (A12) where all the three groups had large performance gaps.

This indicates that, in general, respondents were not convinced with the wages and welfare provided.

Specifically, for high-performing firms, the aspects which firms had the least motivation to further improve (i.e. the lowest performance gaps) were *corporate strategy* (A1) and *supply chain management* (A3), while the most urgent aspects that called for improvement (i.e. the largest performance gaps) were *emission reduction* (A26) and *caring for all employees* (A17). For medium-performing firms, the aspects with the lowest performance gaps were *supporting community development* (A15) and *quality management* (A2), while the aspects with the largest performance gaps were *wages and welfare* (A12) and *noise control* (A29). For low-performing firms, the aspects with the lowest performance gaps were *managing impacts on biodiversity* (A25) and *anti-corruption and fair competition* (A13), while the aspects with the largest performance gaps were *wages and welfare* (A12) and *caring for all employees* (A17).

The aspects with large performance gaps suggested a high level of urgency for performance improvement. It is important to note that the aspects with small performance gaps did not mean that the firms did not need to improve on these aspects. Rather, it meant that the firms had similar levels of importance and performance on these aspects. For instance, as low-performing firms had similar low ratings on importance and performance for *managing impacts on biodiversity* (A25), this aspect had a small performance gap. However, with a performance rating of 2.81, this aspect clearly could be further improved within the low-performing firms.

7.3.3.3 IPA results of firm clusters

The grand mean values of importance and performance scores for the three firm clusters were calculated separately and the scores of each aspect were compared against the grand mean value. As a result, the IPA grid positions of the 29 CSAs for the three firm clusters were identified, as shown in Table 7.7.

Table 7.7 Comparison of IPA grid positions for the three firm clusters

Code	Critical sustainability aspects	Low-performing firms	Medium-performing firms	High-performing firms
A1	Corporate strategy	Keep up the good work	Keep up the good work	Keep up the good work
A2	Quality management	Keep up the good work	Keep up the good work	Keep up the good work
A3	Supply chain management	Keep up the good work	Possible overkill	Possible overkill
A4	Innovation system	Keep up the good work	Low priority	Concentrate here
A5	Corporate governance	Keep up the good work	Low priority	Possible overkill
A6	Customer service and satisfaction	Keep up the good work	Keep up the good work	Keep up the good work
A7	Communication management	Keep up the good work	Possible overkill	Low priority
A8	Network building	Keep up the good work	Low priority	Low priority
A9	Risk management	Keep up the good work	Keep up the good work	Keep up the good work
A10	Occupational health and safety	Keep up the good work	Keep up the good work	Keep up the good work
A11	Education and training	Concentrate here	Low priority	Low priority
A12	Wages and welfare	Concentrate here	Concentrate here	Concentrate here
A13	Anti-corruption and fair competition	Low priority	Low priority	Low priority
A14	Human rights	Keep up the good work	Low priority	Possible overkill
A15	Support community development	Low priority	Low priority	Low priority
A16	Obey laws and regulations	Keep up the good work	Keep up the good work	Keep up the good work
A17	Caring for all employees	Low priority	Low priority	Low priority
A18	Promoting the development of the industry	Low priority	Keep up the good work	Low priority
A19	Environmental management	Low priority	Low priority	Keep up the good work
A20	Construction waste management	Concentrate here	Keep up the good work	Low priority
A21	Land use efficiency	Concentrate here	Keep up the good work	Keep up the good work

A22	Water conservation and harvesting	Low priority	Possible overkill	Keep up the good work
A23	Materials conservation	Low priority	Keep up the good work	Keep up the good work
A24	Energy conservation	Low priority	Keep up the good work	Low priority
A25	Managing impacts on biodiversity	Low priority	Low priority	Low priority
A26	Emission reduction	Concentrate here	Low priority	Low priority
A27	Green innovation and products	Low priority	Low priority	Low priority
A28	Light pollution	Low priority	Concentrate here	Low priority
A29	Noise control	Low priority	Concentrate here	Concentrate here

Q1: Concentrate here. The aspects in this quadrant have higher importance scores but lower performance scores than the grand mean, suggesting that firms should concentrate on these aspects. For all three of the firm clusters, *wages and welfare* (A12) were deemed to be a managerial focus. For low-performing firms, more resources should also be allocated to promote *education and training* (A11), *construction waste management* (A20), *land use efficiency* (A21) and *emission reduction* (A26). For medium-performing firms, *light pollution control* (A28) and *noise control* (A29) should be paid more attention. For high-performing firms, *innovation system* (A4) and *noise control* (A29) should be further improved.

Q2: Keep up the good work. The aspects in this quadrant have both higher importance and performance scores than the grand mean, suggesting that these aspects are the strengths of the firms. *Corporate strategy* (A1), *quality management* (A2), c*ustomer service and satisfaction* (A6) and *risk management* (A9) were perceived to be the most important aspects by all three groups, and were also highly ranked on the performance evaluations, suggesting that, generally, economic aspects were the strength of construction enterprises. In particular, all economic aspects were placed in this quadrant for the low-performing firms, indicating a focus on economic competitiveness in this group. All three groups had two social aspects in this quadrant, namely, *occupational health and safety* (A10) and *obeying laws and regulations* (A16). No environmental aspects were in this quadrant for the low-performing firms, while both medium-performing and high-performing firms had four environmentally-related aspects, indicating a lack of consideration of environmental issues in low-performing companies.

Q3: Low priority. For low-performing firms, most of the social and environmental aspects were placed in this quadrant, indicating that these firms, in general, perceived social and environmental sustainability to be less important, and they performed worse in these aspects than in the economic aspects. Several aspects were placed in this quadrant for all three groups, including *anti-corruption and fair competition* (A13), *supporting community development* (A15), *caring for all employees* (A17), *managing impacts on biodiversity* (A25), and *green innovation and product* (A27). This suggested that, generally, these sustainability aspects were not considered to be a priority for the construction firms that were investigated.

Q4: Possible overkill. No aspects were placed in this quadrant for low-performing firms. *Supply chain management* (A3) was a possible overkill for both the medium-performing and high-performing firms. *Corporate governance* (A5), *communication management* (A7), *human right* (A14) and *water conservation and harvesting* (A22) were also deemed to be possible overkill by either medium-performing or high-performing firms. This indicated that too much effort had been placed on these aspects in contrast to their level of perceived significance.

7.3.3.4 Transition pathways towards sustainability (TPS) for construction enterprises

The previous section presented the IPA results for the three identified firm clusters. Based on the IPA results, the *Transition Pathways towards Sustainability* (TPS) could be proposed, providing managerial guidance for construction enterprises to facilitate their efficient transition towards higher sustainability levels, as shown in Fig. 7.6.

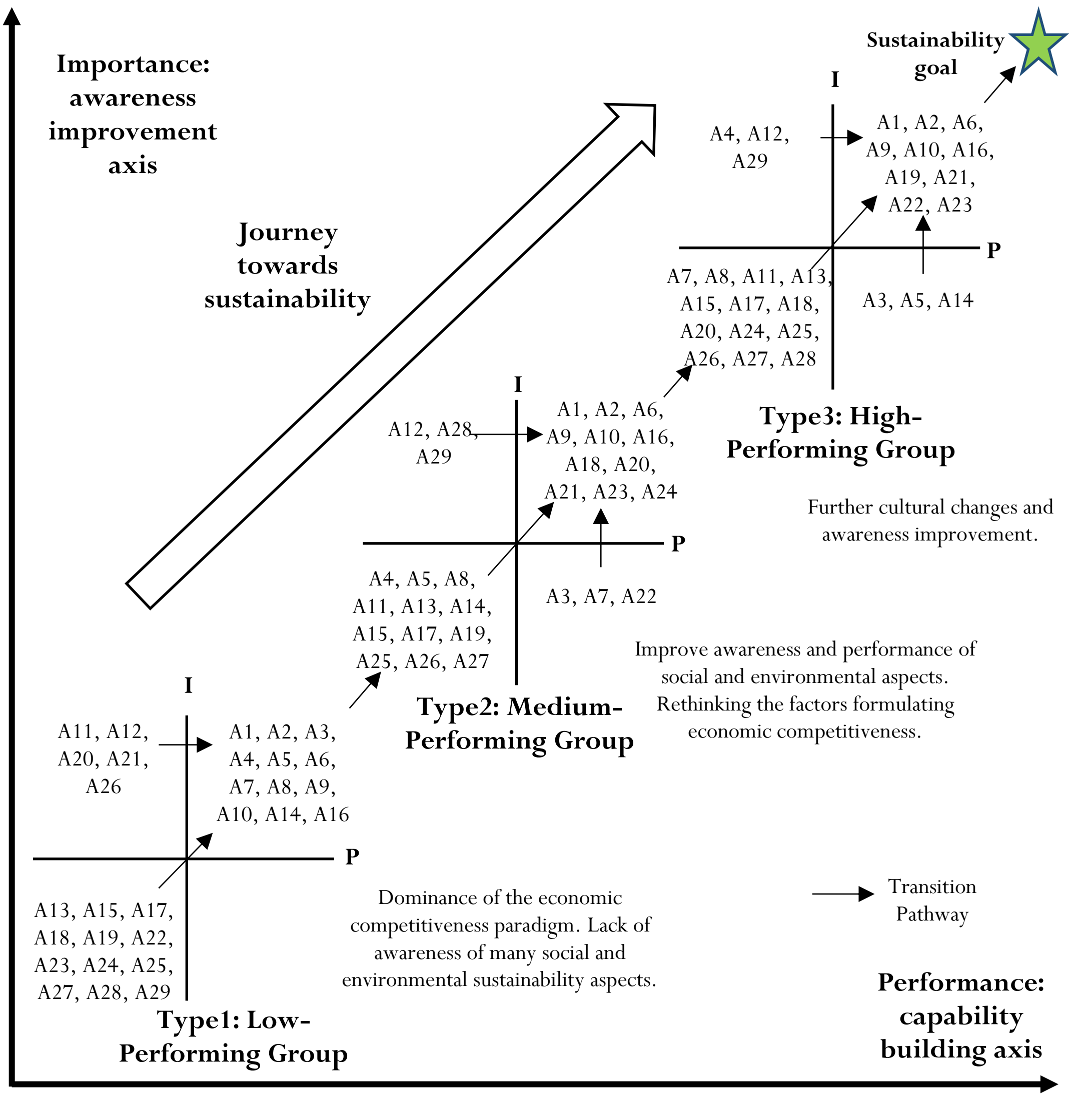

Figure 7.6 Transition pathways towards sustainability (TPS) for construction enterprises

Existing studies have suggested that firms' sustainability behaviours and performances vary significantly (Klewitz and Hansen, 2014; Serpell et al., 2013). Consistent with existing studies, the three firm clusters identified in this study have different ratings for the importance and performance of the CSAs, as is clearly shown in Fig. 7.4. Compared to high-performing enterprises, low-performing and medium-performing firms have lower sustainability performance scores for all of the CSAs. Meanwhile, it is more urgent for these firms to improve their sustainability performance, as indicated by the gap analysis. In line with Klewitz and Hansen (2014), this study suggests that the sustainability transition of the construction industry consists of a series of processes in which every cluster of firms experiences continuous sustainability improvements, that is, low-performing firms to medium-performing and high-performing firms; medium-performing firms to high-performing firms; and high-performing firms towards higher sustainability goals.

The IPA was conducted for the three firm clusters separately to investigate how the CSAs were perceived by the different firm clusters. The results showed that, for the low-performing groups, all economic aspects were placed in the "*keep up the good work"* quadrant while most of the social and environmental aspects were recognized as "*low priority"*. This does not mean that low-performing firms perform very well on the economic aspects, as Fig. 7.4 clearly shows that medium-performing and high-performing companies perform much better on the economic aspects than is the case with low-performing firms. Rather, it indicates that, in the low-performing firms, the economic aspects have higher importance and performance values than the grand mean. This suggests that the economic competitiveness paradigm is still dominant in this group of enterprises and that many social and environmental aspects are ignored.

In contrast, in medium-performing and high-performing firms, several social and environmental aspects were placed in the "*keep up the good work*" quadrant, indicating that the importance and performance ratings of some social and environmental aspects were beyond the grand mean in these groups, surpassing some economic aspects. This was further confirmed by the fact that some economic aspects were placed in the "*low priority*" quadrant in the medium-performing and high-performing firms, as shown in Table 7.7. Compared to low-performing firms, this indicated that, in medium-performing and high-performing firms, the dominance of the economic competitiveness paradigm was weakened, while social and environmental sustainability were starting to gain momentum and to experience both awareness and performance improvements. This indicates that the sustainability transition of the construction industry calls for cultural changes in which construction firms rethink the appropriateness of the sole dominance of the economic competitiveness paradigm and increasingly recognize the importance of social and environmental sustainability (Zhang, 2014).

The transition perspective, as illustrated by Fig. 7.6, also re-interprets the managerial implications from the four quadrants of the IPA grid. In the traditional IPA grid, if the attributes have lower importance and performance values than the grand mean, they will be placed in the "*low priority*" quadrant, indicating that these attributes are not organizational preferences (Martilla and James, 1977). However, are the attributes that firms perceive to be unimportant really insignificant? Due precisely to the lack of awareness about environmental protection, many environmental issues emerged in the 1960s which triggered the emergence of the "sustainable development" concept and its increasing popularity (Dresner, 2008). A firm's understanding of sustainability is constantly changing: having CSAs with a lower importance value than the grand mean indicates only that they are not priorities under the current mentality and culture of the firm. This does not neccesarily mean that these aspects are not important for the firm's long-term development.

Thus, from a transition perspective, the critical issue is to continuously improve firms' awareness and performance of sustainability, transitioning the aspects in the "*concentrate here*", "*low priority*" and "*possible overkill*" quadrants into the "*keep up the good work*" quadrant. Specifically, the following three areas warrant significant attention: (1) the performance level of aspects in the "*concentrate here*" quadrant needs to be improved; (2) the importance level of aspects in the "*possible overkill*" needs to be improved; and (3) both the importance and performance levels of aspects in the "*low priority*" need to be improved. Firms with limited resources could firstly focus on those aspects in the "*concentrate here*" quadrant, and then on those in the "*low priority*" and "*possible overkill*" quadrants. The arrows in Fig. 7.6 denote the improvement processes of these aspects in the quadrants. To improve the importance levels, the concept of sustainability should be popularized in construction enterprises. To improve the performance levels, capability building is the key so that firms have the ability to improve their performance. Each of the identified 29 CSAs is clearly plotted into the appropriate quadrants in the IPA grid for all three firm clusters, as shown in Fig. 7.6.

Construction enterprises could use this framework, together with Table 7.5 and Table 7.7, to understand the importance or performance levels of the sustainability aspects which need to be further improved with the aim of facilitating the firms' transition towards higher sustainability levels. For instance, for low-performing firms to efficiently transition towards sustainability, in the short term, they could firstly allocate their resources to improve the performance level of the "*concentrate here*" quadrant, and then seek to improve both the importance and performance levels of the "*low priority*" quadrant. When in the medium and long term they become medium-performing and high-performing firms, they should then allocate their resources according to the new distribution of the aspects in the four quadrants. Specifically, this study reveals that, for the low-performing firms, the five aspects allocated in the "*concentrate here*" quadrant include *construction waste management* (A20) and *emission reduction* (A26). This indicates that, although the surveyed low-performing firms recognized the importance of these aspects, they still performed poorly. Therefore, the low-performing firms, as well as the government, should assign priorities to improve performance on these aspects. The government could, for instance, provide more economic incentives specifically for the low-performing firms' efforts in improving their waste management strategies and emission reduction. A total of nine aspects were allocated in the "*low priority*" quadrant for the low-performing firms, including *water conservation and harvesting* (A22) and *materials conservation* (A23). This indicates that the firms not only had a poor performance level on these aspects, but they also did not recognize their importance. Therefore, unlike those aspects in the "*concentrate here*" quadrant which had already gained recognition in the firms, those aspects in the "*low priority*" quadrant needed to be improved by both propaganda and capability-building activities and, thus, may require more efforts. When those aspects in the "*concentrate here*" quadrant are improved, the firms could start to allocate resources, for example, conducting workshops, investing in relevant technologies and software tools, and recruiting experienced employees in sustainable construction, to improve the aspects in the "*low priority*" quadrant. The "*keep up the good work*" quadrant consists of 12 aspects including all the economic ones. This suggests that, to efficiently transition towards sustainability, the low-performing firms do not need to make additional investments on these economic aspects before they resolve their sustainability bottlenecks, namely, the social and environmental aspects in the "*concentrate here*" and "*low priority*" quadrants.

To sum up, for the low-performing firms, the following strategic plan could be initiated: (1) improving the performance level on the five aspects in the "*concentrate here*" quadrant (e.g. *construction waste management* and *emission reduction*) through capability-building activities; (2) improving both the awareness and performance levels on the nine aspects in the "*low priority*" quadrant (e.g. *water conservation and harvesting* and *materials conservation*) through both propaganda and capability-building activities; and (3) maintaining awareness and performance levels on the 12 aspects in the "*keep up the good work*" quadrant (e.g. *quality management* and *corporate governance*). Once this strategic plan is implemented, it is expected that the low-performing firms will improve their overall sustainability performance and transition towards becoming medium-performing and high-performing firms. Consequently, the firms could similarly propose the strategic plan according to the new distribution of the aspects in the IPA matrix. By classifying the various sustainability aspects into different types according to their managerial priorities, the proposed TPS assists the strategic planning of corporate sustainability (CS) in construction enterprises.

7.4 Summary

This chapter has adopted a holistic approach to investigate the sustainability attitude and performance of construction enterprises in China. A five-point Likert scale was utilized to measure both the attitude and performance levels of construction enterprises on 29 critical sustainability aspects (CSAs) covering the economic, social and environmental dimensions of sustainability. This holistic approach taken is different from most existing studies which have only investigated the environmental dimension of sustainability or have merely focused on a particular group of firms. This study suggests that, compared to social and environmental aspects, economic aspects have generally received higher ranking in both the attitude and performance evaluations. *Quality management* and *customer service* are perceived as the most important sustainability aspects while *supporting community development* and *anti-corruption and fair competition* are the least important aspects.

Three hypotheses were developed to reflect the relationships between sustainability attitude, sustainability performance and firm size. Most existing studies exploring similar issues have provided arguments without empirical evidence or have the evidence but have failed to illustrate the association between firm size and holistic sustainability performance. By employing statistical techniques to empirically test the hypotheses, this study has responded to this knowledge gap. Non-parametric correlation analysis has shown that the construction firms that perceive sustainability to be of higher importance have higher sustainability performance. The Kruskal–Wallis test and Mann–Whitney U test have shown that, overall, larger firms tend to have higher sustainability performance than smaller firms, but the association between firm size and sustainability attitude is weaker. In contrast to existing studies, this study suggests that larger construction enterprises do not necessarily perceive sustainability as being more important than is the case for smaller construction enterprises in China.

There is a lack of studies on classifying the various sustainability aspects according to their managerial priority which would provide strategic guidance for construction enterprises to transition towards sustainability. The IPA technique was applied in this study as a diagnostic instrument to identify perceived importance and performance of CSAs by construction enterprises. Three firm clusters, namely, low-performing firms, medium-performing firms and high-performing firms, were identified based on *k*-means cluster analysis, and the IPA was subsequently conducted for the three clusters. The study then proposed the *Transition Pathways towards Sustainability* (TPS). The findings show that among the three firm clusters, high-performing firms had the lowest performance gaps on all of the 29 CSAs, while low-performing firms had the highest performance gaps on most of the CSAs. This suggests that it is more urgent for low-performing firms to improve their sustainability performance. The IPA results of the three firm clusters reveal that, in low-performing firms, the dominance of the economic competitiveness paradigm is apparent with a lack of consideration given to social and environmental sustainability. In contrast, medium-performing and high-performing firms have placed more emphasis on social and environmental aspects. The proposed transition pathways clearly demonstrate which sustainability aspects need to be further improved to facilitate the firms' transition towards higher sustainability levels.

To summarize, the study reported in this chapter has adequately responded to ***Research Objective 5***, namely, holistically examining the sustainability perceptions and performance across construction enterprises of different scales and with different sustainability levels.

Chapter 8 Drivers for and barriers to sustainability transition of Chinese construction enterprises

8.1 Introduction

In the previous chapter, cluster analysis was employed to identify three firm groups: low-performing firms, medium-performing firms and high-performing firms according to the firms' sustainability performance. Importance–performance analysis (IPA) was also adopted to classify the various sustainability aspects according to their perceived importance and the performance levels of the three firm groups, thereby revealing the transition pathways for construction firms towards higher sustainability levels. However, sustainability transition does not come about easily. Various factors influence the transition efforts: managerial, technological, institutional, cultural, etc. How do the three identified firm groups perceive these various factors? Moreover, what are the most important drivers for and barriers to the sustainability transition of the three firm groups?

As was illustrated in Chapter 2, even though a few similar studies have investigated the drivers for and barriers to sustainable construction, these studies are far from holistic. Different scholars have designed different questionnaires to collect empirical information, but few scholars have explained the underlying theories supporting these questionnaires. As a result, this strand of research remains very unsystematic and fragmented. A lack of coherent theory in this field linking the various factors leads to poor conceptualization of the key mechanisms behind transformation towards sustainable construction. Chapter 3 specifically discussed the rationale for studying the factors that influence sustainability from a transition perspective to respond to the deficiencies of the existing studies. As a response to ***Research Objective 6*** (analysing the drivers for and barriers to sustainability transitions of construction enterprises with different sustainability levels), this chapter employs relevant approaches to sustainability transition to investigate the perceptions of the pre-identified three firm clusters on the various drivers for and barriers to sustainability transitions.

The previous chapter identified the sustainability aspects on which construction enterprises with different levels of sustainability should focus to further transition their firms towards sustainability. This chapter identifies what factors drive or prohibit these enterprises' transitions towards sustainability. Thus, this study provides a complete understanding of the sustainability transition of the Chinese construction industry.

8.2 Conceptual framework

The multi-level perspective (MLP) highlighted that the factors influencing transitions could be grouped into three levels: the niche, regime and landscape levels. Specifically, niches are the locus of sustainability practices and innovations, that is, the seeds for potential transitions such as renewable energy technologies and off-site construction. Regimes are the dominant rules and practices of socio-technical systems. These dominant rules stabilize the existing systems. The landscape level highlights the wider contexts, that is, the stable long-term trend that influences niche and regime levels. For the construction industry, a culture of mutual distrust and conservatism could be a landscape factor that is hardly to be changed in a short period. The MLP emphasizes that the transition is enabled by the dynamic interactions between the three levels. To transition the construction industry towards sustainability, innovative sustainability practices and technologies at the niche level need to be empowered to gradually replace the existing unsustainable way of construction at the regime level, and this process is influenced by the broader landscape level. The factors at each level could be further differentiated by their functions in transitions, in other words, the drivers for or barriers to transitions. For instance, regarding the niche level, many factors could prohibit the formation of a shared vision for a sustainable construction industry, for example, differences in subjective interpretations of values and responsibilities, few sustainability leaders, lack of political vision and strategic planning, and sectoral fragmentation of the construction industry (Faber and Hoppe, 2013). However, there are also positive factors, such as the effect of industry associations that could contribute to a shared vision for sustainability. Previous studies on the MLP have highlighted that the interactions between the drivers for and the barriers to sustainability at each level determine the potential of sustainability transitions.

However, even though the MLP conceptualizes the three levels for analysing transitions, it does not provide many insights into the inner structure of the three levels. For instance, regarding the regime, Geels (2004) explained that "as the different groups share different rules, we may distinguish different regimes, e.g. technological or design regimes, policy regimes, science regimes, financial regimes and societal or user regimes." Similarly, the niche and landscape levels could also be further differentiated into various components to provide a detailed understanding of the transition dynamics. This work was not fully explored until Geels (2014) proposed the triple embeddedness framework (TEF) that indicates the three main components in a transitioning system, namely, the industry, the economic environment and the socio-political environment. The industry is interacted (co-evolved) with the economic environment, which consists of suppliers and clients selecting firms through economic competitiveness, and the socio-political environment, which consists of the government, the media, NGOs and the public selecting firms through social fitness. The industry itself consists of various related firms and their technology, policy and values. To transition the industry towards sustainability, the firms with higher sustainability levels in the industry need to be selected by the economic and socio-political environments.

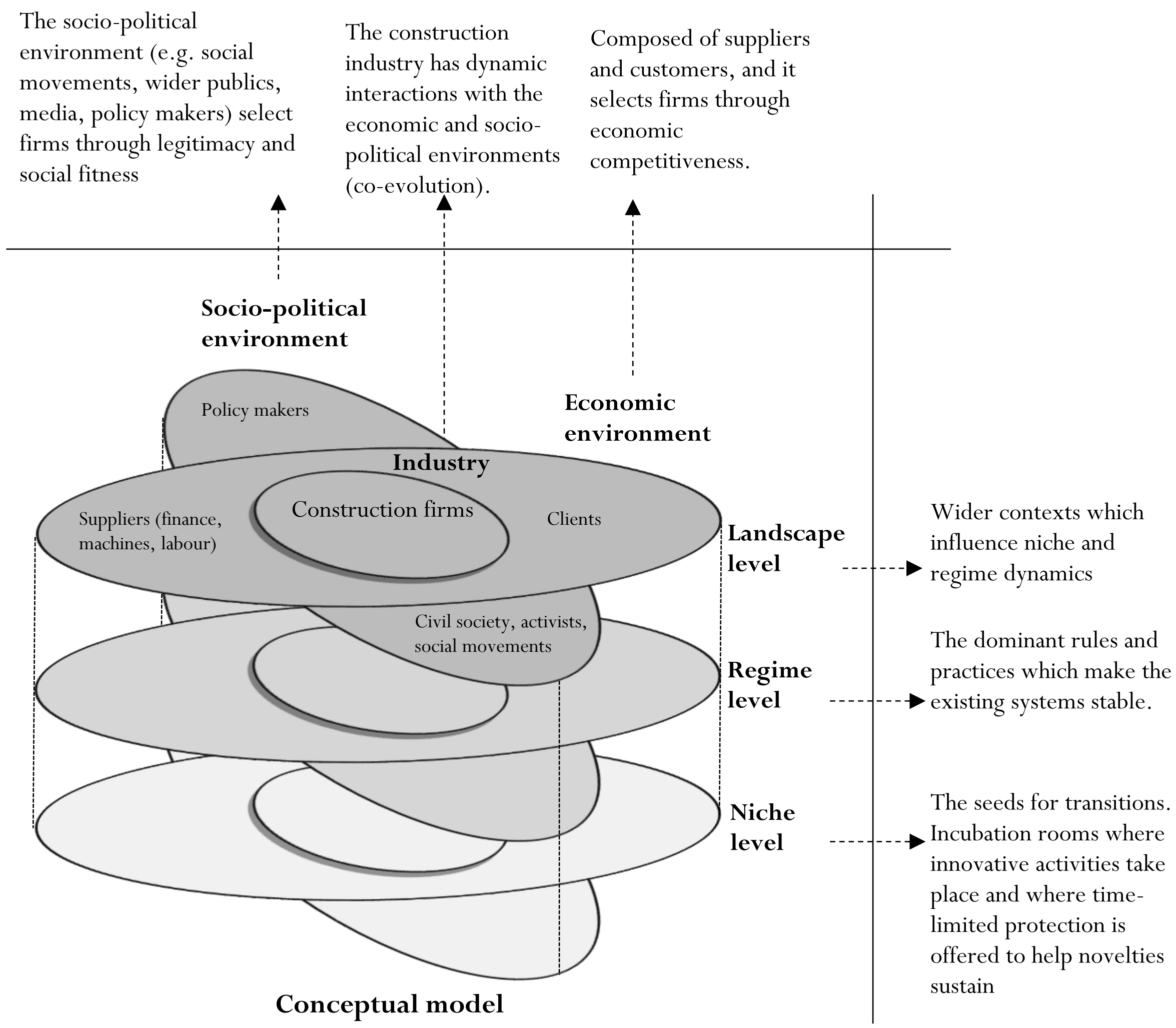

Figure 8.1 Key mechanisms of sustainability transitions for construction industry

Thus, the TEF further differentiates the niche, regime and landscape levels into various components. For instance, regarding the regime level, it has been argued that innovation in the construction industry is mainly incremental driven by short-term cost reduction. This factor is clearly related to the industry. Similarly, it has also been argued that market demand for the construction sector is homogeneous, with a focus on price tendering. As traditional projects with lower costs tend to have stable cash flow, the financial actors are also primarily geared to provide loans for traditional projects with a lower level of willingness to support innovative projects (Faber and Hoppe, 2013). These factors are clearly related to the economic environment. In terms of the socio-political environment, it has been discovered that policies for the construction industry around the world are usually focused on regulating laggards rather than on encouraging front runners. To be specific, policies are good at stipulating what firms should not do rather than encouraging firms to be visionary and leaders. Factors at the niche and landscape levels could be likewise differentiated according to their positions in the system, that is, the industry, the economic environment and the socio-political environment.

Thus, built on the MLP and the TEF, a conceptual framework is proposed for analysing factors that influence sustainability transitions, as shown in Fig. 8.1. According to this framework, the factors could be differentiated based on three features: levels, functions and positions. For instance, factors such as technical difficulties, high initial costs and lack of expertise and information associated with the sustainability practices are barriers (function) in the industry (position) at the niche level (level). Other factors could be similarly differentiated according to their level, function and position in the transitioning system. As the three levels (niche, regime and landscape) are the main conceptualization of transitions, and the functions and positions are useful conceptual additions to the three levels, the three levels will be used as the main feature to differentiate the factors.

8.3 Method

8.3.1 Identification and classification of factors influencing sustainability transitions

Based on the theoretical frameworks illustrated in Fig. 8.1, the factors impacting on sustainability transitions were appropriately grouped according to their levels, positions and functions. The factors were derived from the content analysis of the relevant literature and the researchers' personal perceptions and understandings of the Chinese construction industry. The main referred studies include Du et al. (2014), Trianni and Cagno (2012), Häkkinen and Belloni (2011), Heffernan (2015), Huang et al. (2016), Shi et al. (2008), Li and Shui (2015), Pan and Ning (2015) and Gan et al. (2015). The content analysis procedure used is similar to that adopted in Chapter 5 where it was explained in detail. The final list of the drivers and barriers consists of 38 factors (see Table 8.1).

Table 8.1 List of claims related to sustainability transitions of Chinese construction industry

Code	List of claims	Position			Function	
		I	E	S	D	B
	Niche					
F1	Stakeholders have different interpretations of construction firms' values	×				×
F2	There are few sustainability leaders from whom construction firms could learn	×				×
F3	The government does not have a clear political vision and strategic plan			×		×
F4	Industry conferences and associations can significantly contribute to the form of a shared vision	×			×	
F5	Technological innovations of sustainability generally are difficult to be learned	×				×
F6	Technological risks hamper construction firms' motivation to be sustainable	×				×
F7	It may take more time to complete the sustainable project	×				×
F8	Sustainable technologies induce additional responsibility for maintenance	×				×
F9	The adoption of new design, material and technologies induces incremental cost	×				×
F10	Assessment tools for sustainability in the industry are far from mature	×				×
F11	Through promoting sustainability, construction firms could reduce cost by reducing the consumption of energy, materials and water	×			×	
F12	Construction firms could gain a good corporate image	×			×	
F13	It is hard to access various resources and information on sustainability	×				×
F14	Economic incentives provided by the government are inadequate			×		×
F15	Supporting policies for sustainability lack coherence and stability			×		×
F16	Supporting policies for sustainability are too complex and lack efficiency			×		×
F17	The number of suppliers and manufacturers of sustainable products is too small		×			×
F18	Various sustainable demonstration projects effectively popularize sustainability			×	×	
F19	Industry associations or conferences effectively popularize sustainability	×			×	

	Regime					
F20	Financial actors have higher willingness to support traditional projects		×			×
F21	Market demand focuses on low price rather than sustainability		×			×
F22	Improved energy efficiency and lower operational cost attract customers		×		×	
F23	Uniqueness of sustainable projects attracts investors and customers		×		×	
F24	Due to the lack of knowledge, clients do not require sustainable projects		×			×
F25	Sustainable projects impact on the benefits of the vast number of construction firms which focus on traditional construction works	×				×
F26	Employees in the industry lack adequate understanding of sustainability	×				×
F27	Innovation in the industry is incremental, driven by short-term cost reduction	×				×
F28	Workers have specialised expertise on a limited range of technologies	×				×
F29	Fierce competition may encourage some firms to promote sustainability	×			×	
F30	Construction standards may restrict the possibility of sustainable innovations			×		×
F31	Long history of a planning-oriented economy can inhibit efficient decision making, flexibility and innovation			×		×
F32	Policy usually focuses on regulating laggards rather than encouraging front runners			×		×
F33	Relevant interest groups, the media and NGOs generate pressures			×	×	
	Landscape					
F34	Environmental problems raise the public's environmental awareness			×	×	
F35	Sectoral fragmentation locks in a culture of mutual distrust and conservatism	×				×
F36	It is hard to change the lack of social responsibility or environmental values	×				×
F37	Rising energy and resource prices trigger firms to promote sustainability		×		×	
F38	The CO_2 emission reduction goal proposed by the government determines that the industry has to transition towards sustainability			×	×	

Note: I=industry; E=economic environment; S=socio-political environment; D=drivers; B=barriers

8.3.2 Data analysis

Respondents were asked to evaluate, using a five-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”), whether they agreed with the factors that had been suggested as impacting on their firm’s transition towards sustainability. Details of the questionnaire distribution were explained in the Methodology section. To analyse the data, firstly, the mean value of each factor was calculated for the whole sample and the rank of each factor was determined by the mean value. As described in the previous chapter, cluster analysis was employed to identify three clusters of construction firms with regard to their sustainability performance: low-performing, medium-performing and high-performing firms. As described in this chapter, the mean of each factor was calculated for respondents from the three clusters of firms. To test whether there was consensus among the three groups of respondents on the ranking exercise, the Spearman rank correlation coefficient ‘r_s‘ was computed. The value of ‘r_s’ ranges between -1 and +1, with a value of +1 indicating a perfect positive linear correlation and -1 indicating a perfect negative linear correlation. Comparisons of the factors according to the three features across the three firm groups were then conducted, namely the comparison between drivers and barriers, the comparison between the niche, regime and landscape levels, and the comparison between the industry, the economic environment and the socio-political environment. The averaged mean of the factors within the different categories was calculated to enable the comparison. After comparing the factor groups, the Kruskal–Wallis test was conducted to identify the specific factors which received significantly different mean scores from the different groups of respondents. The Kruskal–Wallis test compares the scores on continuous variables for three or more groups and, if significant results are obtained for certain factors, the Mann–Whitney U test is conducted to identify the pairs of groups that have significantly different mean scores on the factors.

8.4 Results

8.4.1 General features of ranking exercise by the three firm groups

The means and ranks of the factors are shown in Table 8.2. Factors contributing to sustainability transitions were generally ranked higher in the whole sample than those prohibiting sustainability transitions. The top three ranked factors were F38, F34 and F37, all of which were landscape factors, suggesting these long-term development trends were highly recognized by the respondents. The positive impacts of sustainability practices on economic competitiveness were also highly recognized by the respondents, as F11, F22 and F23 were also highly ranked in the whole sample. However, when differentiating the respondents according to the sustainability levels of their firms, contrasts were revealed. For instance, F14 (*economic incentives provided by the government are inadequate*) was not ranked in the top 30 factors by respondents from high-performing firms, but this factor was ranked among the top three factors by respondents from low-performing and medium-performing firms.

Table 8.2 Ranking of claims

Category	Code	All Firms		Low-performing firms		Medium-performing firms		High-performing firms		*p*-values[a]
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	
Niche										
	F1	3.64	35	3.56	19	3.82	32	3.50	37	0.137
	F2	3.66	33	3.40	30	3.81	33	3.62	24	0.137
	F3	3.74	24	3.67	8	3.98	14	3.53	31	0.020[b]
	F4	4.02	8	3.56	19	3.99	11	4.23	6	0.000[b]
	F5	3.64	35	3.42	29	3.77	37	3.60	25	0.120
	F6	3.66	34	3.33	33	3.94	20	3.51	34	0.002[b]
	F7	3.59	37	3.12	38	3.80	34	3.58	28	0.002[b]
	F8	3.57	38	3.26	37	3.76	38	3.51	34	0.013[b]
	F9	3.71	29	3.65	10	3.90	27	3.55	29	0.096
	F10	3.88	13	3.65	10	4.09	4	3.77	14	0.011[b]
	F11	3.91	12	3.35	32	3.94	17	4.09	12	0.000[b]

	F12	4.05	4	3.49	26	4.06	6	4.26	5	0.000[b]
	F13	3.74	24	3.53	23	3.86	30	3.70	19	0.109
	F14	3.84	16	3.95	1	4.11	2	3.52	33	0.003[b]
	F15	3.83	17	3.30	36	4.01	8	3.86	13	0.000[b]
	F16	3.84	15	3.65	10	3.99	11	3.77	14	0.146
	F17	3.72	26	3.70	6	3.86	30	3.59	27	0.429
	F18	3.95	11	3.44	28	3.92	24	4.19	10	0.000[b]
	F19	4.03	7	3.33	33	4.01	8	4.32	4	0.000[b]
Regime										
	F20	3.74	23	3.72	4	3.99	11	3.51	34	0.036[b]
	F21	3.80	18	3.60	14	3.91	25	3.77	14	0.170
	F22	4.04	5	3.37	31	4.00	10	4.34	2	0.000[b]
	F23	4.04	5	3.53	23	3.94	17	4.33	3	0.000[b]
	F24	3.70	30	3.56	19	3.91	25	3.55	29	0.038[b]
	F25	3.71	28	3.58	16	3.95	16	3.53	31	0.023[b]
	F26	3.72	26	3.95	1	3.90	27	3.45	38	0.008[b]
	F27	3.79	20	3.70	6	3.94	20	3.68	21	0.313
	F28	3.69	31	3.67	8	3.78	36	3.60	25	0.904
	F29	3.99	9	3.58	16	3.94	20	4.21	9	0.000[b]
	F30	3.77	21	3.51	25	3.94	17	3.70	19	0.053
	F31	3.69	31	3.47	27	3.79	35	3.68	21	0.056
	F32	3.79	19	3.65	10	3.94	20	3.71	18	0.140
	F33	3.97	10	3.33	33	3.96	15	4.23	6	0.000[b]
Landscape										
	F34	4.10	2	3.74	3	4.19	1	4.16	11	0.005[b]
	F35	3.77	21	3.58	16	3.88	29	3.74	17	0.242
	F36	3.84	14	3.60	14	4.11	2	3.68	21	0.009[b]
	F37	4.06	3	3.72	4	4.05	7	4.22	8	0.004[b]
	F38	4.12	1	3.56	19	4.08	5	4.38	1	0.000[b]

[a]In this column, the value of 0.000 means the *p*-value is less than 0.0005.
[b]These values are less than 0.05, indicating the corresponding factors received significantly different ratings from the firm groups

To identify whether any similarity exists between the three groups of respondents on the ranking exercise, the Spearman rank correlation test was conducted with the results shown in Table 8.3. The computed r_s between respondents from medium-performing firms and high-performing firms was 0.481, suggesting that the ranking exercises of these two groups have a certain level of similarities. However, respondents from low-performing firms had different opinions on the factors to those expressed by respondents from medium-performing and high-performing firms, with this indicated by the insignificant correlation coefficients. This indicates the necessity of further comparing the ratings by the three groups of respondents on the factors.

Table 8.3 Spearman's rank correlation test between groups of respondents

Group	Low-performing firms	Medium-performing firms	High-performing firms
Low-performing firms	1	0.242(NS)	-0.240(NS)
Medium-performing firms		1	0.481[a]
High-performing firms			1

[a]p<0.01 (2-tailed); NS=not significant

8.4.2 Comparison of factor categories generated by the three attributes

8.4.2.1 Comparison of drivers and barriers

To identify whether a particular pattern exists regarding the ranking of the drivers and barriers, the averaged means of the drivers and barriers were calculated respectively for the three groups of respondents, as shown in Fig. 8.2. Drivers received higher recognition from respondents in the high-performing firms. In contrast, barriers were more recognized by medium-performing firms than by low-performing and high-performing firms, demonstrating a reverse U shape. This indicates that, with the perceived strongest drivers and weakest barriers, of the three groups of firms, those with the highest sustainability levels had the highest motivation to transition towards sustainability, while firms with a medium sustainability level perceived the strongest barriers to sustainability transition.

The previous chapter demonstrated that the sustainability performance of firms is positively correlated with firm size; that is, firms with higher sustainability performance tend to have larger firm size. Several studies (e.g. Serpell et al., 2013) have indicated that larger firms perceive significantly stronger influences from drivers for sustainability, which is in accordance with this study. However, some controversies exist in the literature in terms of whether larger or smaller firms perceive stronger barriers to sustainability practices. For instance, Du et al. (2014) studied the barriers to energy-saving technologies in the building sector and discovered that the averaged mean of the barriers in large firms was higher than that of small firms. They argued that due to the rich experience in working on various projects, large enterprises are more likely to encounter operational barriers in practice than smaller firms. This contrasts to Trianni and Cagno (2012) who studied the barriers to energy efficiency and discovered that large firms generally perceive weaker barriers than small firms, as small business generally had other priorities and faced considerable difficulty accessing capital for energy efficiency measures.

Few studies have explored the association between the sustainability performance of construction firms and the strength of their perceived barriers. The current study shows that the perceived barriers to sustainability firstly increase along with the growing sustainability levels of firms, and then decrease. Generally, firms with low sustainability levels have little experience in implementing sustainability practices and, thus, may not be aware of the barriers associated with them. When firms start to implement sustainability practices with which they are not familiar, they tend to perceive higher barriers. When firms become increasingly larger and have accumulated experience in sustainability practices, they have a realistic understanding of sustainability and start to perceive weaker barriers. Gan et al. (2015) discussed that, while many studies exploring sustainable construction in China discovered additional cost is a significant barrier, the Finnish study by Häkkinen and Belloni (2011) suggested that economic issues are not significant barriers to sustainability for Finnish construction firms that are generally more experienced in sustainability. This indicates that firms with more experience in sustainability could perceive lower barriers. This may explain the presented reverse U shape of the barriers discovered in this study.

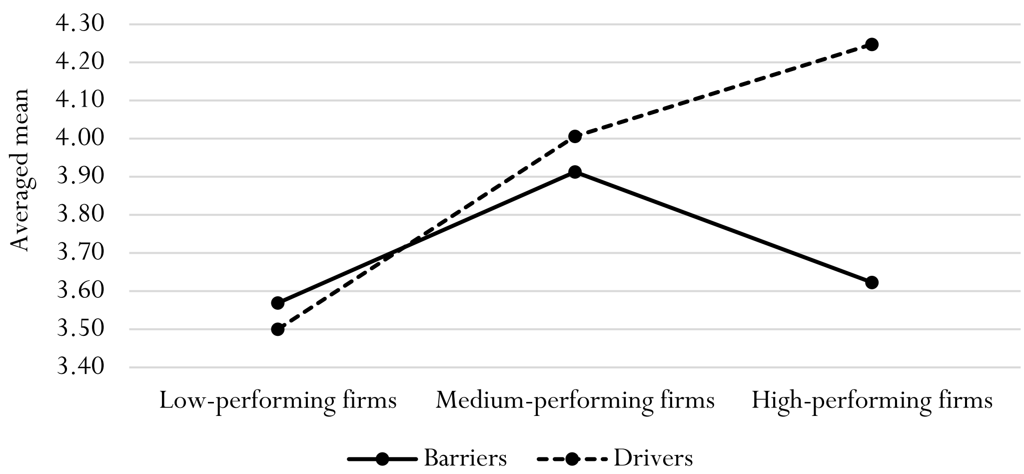

Figure 8.2 Averaged means of factors driving and prohibiting sustainability transitions

8.4.2.2 Comparison of niche, regime and landscape levels

To further explore the ratings of factors at different levels, the averaged means of the factors at the niche, regime and landscape levels were calculated, respectively, as shown in Table 8.4. Regarding the drivers, landscape factors received more recognition than niche and regime factors for low-performing and medium-performing firms, while regime factors received a higher score from high-performing firms. In contrast, regarding the barriers, landscape factors received more recognition than niche and regime factors for high-performing firms and medium-performing firms, while regime factors received a higher score from low-performing firms.

Table 8.4 Averaged scores of factors at the three levels

Level	Low-performing firms				Medium-performing firms				High-performing firms			
	D	R	B	R	D	R	B	R	D	R	B	R
Niche	3.43	3	3.51	3	3.98	2	3.91	2	4.22	3	3.61	3
Regime	3.45	2	3.64	1	3.96	3	3.90	3	4.28	1	3.62	2
Landscape	3.67	1	3.59	2	4.10	1	4.00	1	4.25	2	3.71	1

Note: D=driver; B=barrier; R=rank

The MLP implies that transition towards sustainability is facilitated by the interactions between the three levels. To be specific, the landscape level generates pressures on the niche and regime level, the regime level becomes destabilized providing opportunities for the niche level, and sustainability practices at the niche level become increasingly stronger to diffuse into the regime level. Based on these dynamics, Table 8.4 indicates that: 1) for low-performing and medium-performing firms, the strongest motivator for sustainability is the pressures from the landscape level (i.e. people's increasing environmental awareness, rising resource prices and the government's strong willingness), while the high-performing firms perceive the destabilized regime to be the strongest motivator (e.g. improved energy efficiency and lower operational cost from implementing sustainability practices); and 2) for low-performing firms, the biggest hindrance to sustainability is the stable regime (e.g. unwillingness of the financial actors to support sustainability), while the medium-performing and high-performing firms perceive the landscape to be the strongest hindrance (e.g. the culture of conservatism). This implies that high-performing firms have perceived the opportunities for sustainability transition generated by the regime, and that the task is to further destabilize the unsustainable regime and convey the positive influences to low-performing and medium-performing firms.

8.4.2.3 Comparison of industry, economic environment and socio-political environment

The averaged means of factors related to the industry, the economic environment and the socio-political environment were calculated respectively for the three groups of firms, as shown in Table 8.5. With regard to the factors driving sustainability transitions, low-performing and medium-performing firms rank the socio-political environment as the most important while, for high-performing firms, the economic environment is the main driving force. This indicates that the high-performing firms have a higher awareness of the business opportunity generated by sustainability practices, while the low-performing and medium-performing firms pursue sustainability mainly due to the governmental and social pressures. With regard to the barriers to sustainability transitions, low-performing and high-performing firms regard the economic environment as the main hindrance, while medium-performing firms believe the socio-political environment to be the main hindrance. Fig. 8.2 shows that the medium-performing firms perceive the strongest barriers among the three groups. Thus, hindrances to sustainability from the socio-political environment for medium-performing firms need to be a policy focus.

Table 8.5 Averaged scores of factors at the three dimensions

Dimension	Low-performing firms				Medium-performing firms				High-performing firms			
	D	R	B	R	D	R	B	R	D	R	B	R
Industry	3.46	2	3.53	3	3.99	2	3.89	3	4.22	3	3.6	3
Economic environment	3.45	3	3.66	1	3.97	3	3.94	2	4.34	1	3.73	1
Social-political environment	3.52	1	3.6	2	4.04	1	3.97	1	4.24	2	3.68	2

Note: D=driver; B=barrier; R=rank

Drivers or barriers related to the industry were not considered as the most significant in any of the three groups. The TEF indicates that the economic and socio-political environments select the firms in the industry. This echoes the results of this study which suggests that firms generally have higher agreement on the importance of the economic and socio-political environments in influencing the sustainability transition of the industry than does the industry itself. Heffernan (2015) examined the factors influencing the development of zero carbon homes in the UK and revealed results that were similar to those of the current study. The author argued that legislative and economic drivers are much more significant than drivers within the industry and that, without the appropriate external environment, firms alone may hardly embrace sustainability. Therefore, this study highlighted that when analysing transitions of the construction industry towards sustainability, the economic and socio-political environments surrounding the industry cannot be overlooked.

8.4.3 Comparison of each factor across the three firm groups

The above sections compared factors in different clusters as a whole. This section further elaborates by comparing the scoring of each factor across the three firm groups. Table 8.2 presents the results of the Kruskal–Wallis test. A p-value less than 0.05 is an indication that these factors receive significantly different scoring from the three firm groups. In all, 24 factors among the 38 factors had a p-value less than 0.05. In particular, all the drivers received significantly different scores from the three firm groups, indicating the divergent opinions on the drivers by the firms. To further identify which pairs of groups evaluated the 24 factors differently, a Mann–Whitney U test was conducted, as shown in Table 8.6. Changes in the scores for the factors assessed by the three groups are summarized in Fig. 8.3.

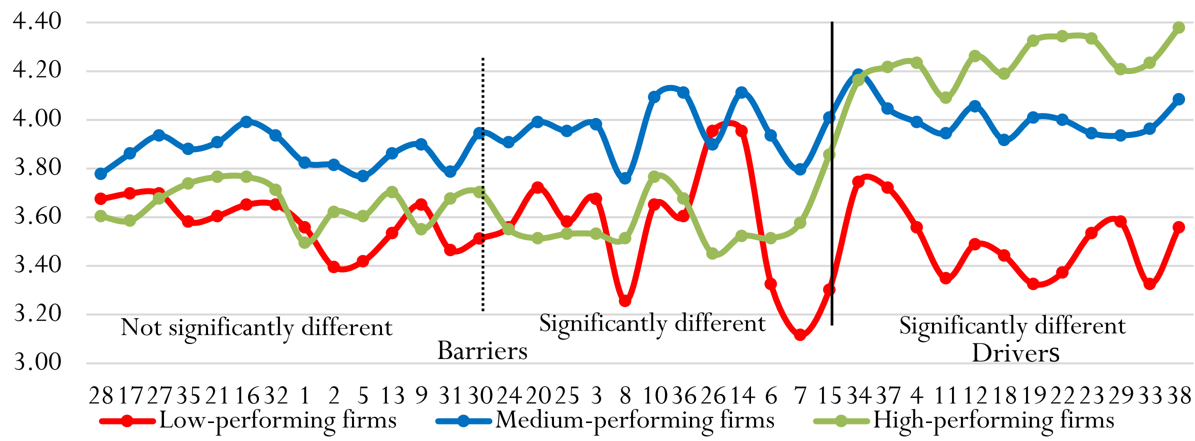

Figure 8.3 Changes in scores for factors assessed by the three groups

Table 8.6 Results of the Mann–Whitney U test

Code	Firm group pair		
	Low-performing firms/Medium-performing firms	Low-performing firms /High-performing firms	Medium-performing firms / High-performing firms
F3	0.024	0.970	0.015
F4	0.002	0.000	0.001
F6	0.000	0.140	0.071
F7	0.000	0.013	0.550
F8	0.001	0.066	0.403
F10	0.001	0.148	0.139
F11	0.000	0.000	0.102
F12	0.000	0.000	0.022
F14	0.176	0.162	0.001
F15	0.000	0.001	0.915
F18	0.002	0.000	0.003
F19	0.000	0.000	0.001
F20	0.080	0.767	0.015
F22	0.000	0.000	0.001
F23	0.007	0.000	0.000
F24	0.031	0.663	0.034
F25	0.011	0.710	0.030
F26	0.699	0.020	0.006
F29	0.014	0.000	0.008
F33	0.000	0.000	0.004
F34	0.004	0.002	0.813
F36	0.002	0.282	0.050
F37	0.050	0.001	0.067
F38	0.002	0.000	0.002

Fig. 8.3 clearly illustrates that, compared to the low-performing and medium-performing firms which have relatively consistent ratings for drivers and barriers, the high-performing firms give significantly higher ratings to the drivers than to the barriers. This is supported by Fig. 8.2 which shows that the averaged means of drivers and barriers are similar in the low-performing and medium-performing firms, but become very divergent for the high-performing groups. Fig. 8.3 reaffirms that with more experience in sustainability, high-performing firms are more optimistic about sustainability transition than other groups of firms.

8.4.3.1 Comparison of drivers

To be specific, all the drivers received significantly different ratings, with most of the ratings from high-performing firms in the 4.2–4.4 range, medium-performing firms in the 3.8–4.2 range, and low-performing firms in the 3.2–3.8 range. With regard to the pairs of groups that provided significantly different ratings, as indicated on Table 8.6, some drivers received low ratings from the low-performing group but similar ratings from the medium-performing and high-performing groups, including F34, F37 and F11. Except for these factors, other factors all received significantly different ratings from each pair of groups.

A detailed analysis reveals that low-performing and medium-performing firms present similar preferences for the top drivers. For instance, people's rising environmental awareness (F34) was regarded as the biggest driver for sustainability transition by both low-performing and medium-performing firms. In recent years, severe environmental problems have been witnessed in China, especially the issues of haze and polluted air. The increasing environmental awareness of the Chinese public has generated strong pressures on construction enterprises to promote sustainable construction practices. Similarly, rising energy and resource prices (F37) and the government's CO_2 reduction goal (F38) were also strongly acknowledged by these two groups of firms. It seems that low-performing and medium-performing firms strongly acknowledge external long-term developments in driving sustainability transition. However, medium-performing firms also rated some drivers much higher than was the case with the low-performing group, for example, the positive corporate image brought by sustainability (F12).

For high-performing firms, the government's CO_2 reduction goal (F38) presented the strongest impetus for sustainability. In addition, lower operational cost (F22), uniqueness of the green projects (F23) and popularization of sustainability from industry associations (F19) were among the strongest drivers for sustainability as rated by the high-performing groups. However, these factors did not receive high ranking from the low-performing group. For instance, F19 was only ranked 33rd by the low-performing firms, indicating that the role of industry associations in popularizing sustainability was more accepted in larger firms. An examination of the industry associations relevant to construction in China reveals that member enterprises are usually large firms. Few small firms are registered in these associations through which they would receive relevant training and education on sustainability. F22 and F23 were also ranked low by low-performing firms. This indicates that low-performing firms have inadequate awareness about the economic benefits brought by sustainability practices.

With regard to the drivers that receive low ranking, the low-performing group perceived F11, F19 and F33 to be the weakest drivers, while both medium-performing and high-performing groups perceived F11, F18 and F29 as the weakest drivers. To be specific, the reduced consumption of resources and the associated cost for firms (F11) was ranked as the weakest driver by all the groups. Previous studies (e.g. Zhang et al., 2015) have suggested that the clients could benefit more from the improved environmental performance of sustainable projects as the actual cost saving is reflected in the operational stage. Thus, constructing sustainable projects does not necessarily lead to the project client or builder experiencing the resource and cost savings as this benefit is enjoyed by the occupants. This may explain why the high-performing firms perceive more customers because of lower operational cost (F22) as a main driver while, at the same time, they do not regard lower cost for firms (F11) to be a main driver. In addition, large firms feel much stronger pressures from the society to promote sustainability than is the case for small firms; thus, low-performing firms do not perceive social pressures (F33) as a key driver. This is consistent with Zeng et al. (2011) who found that, in China, the impacts of environmental organizations and media attention are much stronger on large enterprises than they are on small and medium-sized enterprises. The effects of demonstration projects (F18) and market competition (F29) were also not perceived as key drivers for sustainability by the medium-performing and high-performing groups, but the low-performing group recognized the role of market competition (F29) in facilitating sustainability transition. The Chinese government has established various demonstration projects to popularize sustainable construction practices. However, previous studies have indicated that only weak effects are apparent in terms of demonstration projects contributing to popularizing sustainability. Similarly, Ye et al. (2015) examined the effect of market competition on construction firms' sustainability performance and discovered that, while market competition could positively contribute to the economic and social performance, the effect on environmental sustainability was negative. Ye et al. (2015) indicated that excessive competition could cause various issues, for example, unethical conducts, poor quality and environmental pollution, but that an appropriate level of competition could boost sustainability performance. This may explain why market competition (F29) was not considered as a main driver for medium-performing and high-performing firms, but was recognized by low-performing firms.

8.4.3.2 Comparison of barriers not significantly different across the groups

Fig. 8.3 clearly shows that medium-performing firms rated nearly all the barriers higher than they were rated by the low-performing and high-performing groups. In terms of the factors that were not rated significantly differently by the three groups, complexity of the supporting policy (F16) was considered as a strong barrier in all three groups. Several studies have highlighted the complexity and low efficiency of the policies in promoting sustainable construction in China.

Huang et al. (2016) specifically pointed out that the complicated policy system seriously hinders the effective enforcement of the designed policies for sustainable construction. They indicated that some subsidy policies for the developers and clients have a very complex application process and may even take more than a year to fulfil the application requirements (Huang et al., 2016). The complexity is fundamentally inherited from the design of the bureaucratic system. Huang et al. (2016) indicated that, compared to Japan which issues relevant codes and policy consistently at the national level, China has a rather complicated system for issuing and enforcing relevant policy, with construction laws mainly administered by the MHUD, national building codes and sustainability guidelines issued by various governmental departments and organizations, as well as regional building codes and sustainability policies developed by regional governments. Gan et al. (2015) argued that different regulations are imposed by different authorities, creating confusion in implementation, and existing policies fail to contain all of the principles of sustainability including the economic, social and environmental dimensions.

Other factors that were highly rated by all three groups included the policy focus on laggards rather than on front runners (F32) and low market demand (F21). The high-performing firms, in particular, regarded F21 as the second strongest barrier. The policy instruments for sustainability issues in the construction industry could be classified into three types: mandatory regulation instrument, economic incentive instrument and voluntary scheme instrument (Shen et al., 2016). Although the establishment of regulation and control is the traditional function of government (Spence and Mulligan, 1995), Shen et al. (2016) discovered that, compared to Western countries, Eastern countries, such as China, use regulation instruments more often. Especially in China, the control and regulatory instrument is considered as the most efficient type of policy owing to its long execution period (Huang et al., 2016). However, the main strength of regulation instruments is in controlling the behaviour of laggards rather than in encouraging front runners. Similarly, with regard to low market demand (F21), the current study is consistent with several studies which have suggested that low market demand is a serious barrier to sustainable construction. From the developers' perspective, Zhang et al. (2015) indicated that developers in China are often concerned with immediate results rather than with the potential benefits that may occur in the future. The long-term benefits of sustainability practices may not be realized by them, but by the end-users, and thus owners have little motivation to incur extra costs to develop sustainable projects. Furthermore, this view was supported by Gan et al. (2015) who discovered that only 11.5% of the surveyed Chinese owners in their study reported much implementation of sustainable construction. Gan et al. (2015) also discovered that the consideration of economic feasibility is the most important factor influencing the owner's decision to implement sustainable construction. From the end-users' perspective, Li and Shui (2015) suggested that, due to the lack of access to objective information on the sustainability level of projects, customers hesitate to purchase the so-called green projects propagated by the developers. The issue of low market demand for sustainable construction is not unique to China or other developing countries. Studies, for example, Faber and Hoppe (2013) and Persson and Grönkvist (2015), have highlighted that this is also an issue in developed countries, for example, the Netherlands and Sweden.

In contrast, few sustainability leaders (F2) and the technological difficulties of sustainability innovations (F5) were regarded as weak barriers by the three groups. Several studies have suggested that technological difficulties are no longer key hurdles for Chinese enterprises in implementing sustainability technologies. For instance, Shi et al. (2008) highlighted technological hurdles at the operational level as no longer being the most prominent barrier to cleaner production in Chinese firms as had been concluded in previous studies. Hoffman and Henn (2008) indicated that obstacles faced by the green building movement are no longer mainly technological, but social and psychological. Similarly, few sustainability leaders (F2) was not considered as a key barrier by the firms; as suggested in our previous study, China does have sustainability-rooted construction firms which provide learning models for other firms.

It is important to note that, even though these barriers received similar ratings from the three groups, these factors were ranked differently by the firm groups, considering that other factors received significantly different ratings. For instance, inadequate suppliers and manufacturers (F17) and cultural conservatism (F35) both received similar ratings from the firm groups, but have very different rankings with the high-performing firms ranking F35 as a key barrier while the low-performing firms ranked F17 as a key barrier.

8.4.3.3 Comparison of barriers significantly different across the groups

A number of barriers received significantly different ratings from the three groups, as shown in Fig. 8.3. The barriers which received the highest and lowest rating in the three groups appear in this cluster of barriers. Low-performing firms perceived F14 and F26 as the strongest barriers, while F8 and F7 were the weakest barriers. Similarly, medium-performing firms perceived F14, F36 and F10 as the strongest barriers, while F8 and F7 were the weakest barriers. High-performing firms perceived F10 and F15 as the strongest barriers, while F26 was the weakest barrier.

To be specific, both low-performing and medium-performing firms perceived inadequate economic incentives (F14) as the strongest barrier, and both medium-performing and high-performing firms perceived lack of assessment tools (F10) as the strongest barrier. It has been mentioned that China's policy system focuses on regulation and control. Previous studies, for example, Huang et al. (2016) and Gan et al. (2015), suggest that China lacks adequate economic incentives for sustainability practices in the construction industry. Gan et al. (2015), for instance, indicated that the subsidies provided by the government for green building projects accounts for only around 20% of the incremental costs. Kostka et al. (2013) discovered that it is almost impossible for small and medium-sized firms to apply for energy-saving subsidies owing to the high minimum investment thresholds. This may explain why high-performing firms did not rate inadequate economic incentives (F14) as a strong barrier. Similarly, several studies have highlighted the lack of assessment tools. Pan and Ning (2015) stated that, even though China issued its own green building evaluation standard, the standard mainly focuses on the design stage and there is a lack of evaluation tools for green building performance at completion or operation stage. The current green building evaluation standard also largely overlooks the social and economic aspects of buildings. Similarly, Li and Shui (2015) indicated that the lack of a comprehensive and reliable database hinders the benchmarking exercise of building energy efficiency in China. This is echoed by Huang et al. (2016) who indicated that the lack of applicable methods in the area of building energy efficiency in China, for example, the energy consumption baseline determination and the calculation of the amount of energy saved.

In addition, the low-performing firms regarded the inadequate understanding of sustainability (F26) as the strongest barrier, while the medium-performing firms and high-performing firms regarded inadequate social responsibility (F36) and lack of coherence of the policy (F15) as the key barriers. One strand of studies, for example, Gan et al. (2015) has implied that there is a general lack of awareness of sustainable construction within the industry due to the lack of relevant education and training. Furthermore, Li and Shui (2015) indicated that there is great difficulty in conducting education and training on sustainable construction for all employees, as the average level of education among construction workers in China is primary and middle school while that of designers and engineers is college/university level. In addition, the current study found that the high-performing firms rated F26 as the weakest barrier. This is consistent with another strand of literature (e.g. Shi et al., 2008) who suggested that the awareness of sustainability is not the most prominent barrier for China. The significantly different perceptions of low-performing and high-performing firms towards sustainability awareness may be attributed to the uneven distribution of educational backgrounds among employees in the industry. High-performing firms are often large firms with a good reputation; thus, they have a high entry threshold for their employees who tend to have better education than employees in low-performing firms.

With regard to inadequate social responsibility (F36), Zhang et al. (2015) highlighted that, as there is no powerful party in project management who represents the true interests of social and environmental issues, the passive culture towards social responsibility and environmental issues is deeply embedded in the Chinese construction industry. Regarding lack of coherence of the policy (F15), the complicated design of the policy system could face great difficulty in the coordination of the various policies. Li and Shui (2015), for instance, have argued that there is a lack of consistency between policies for building energy efficiency in China which provides obscure signals for private actors. Similarly, Shen and Zhou (2014) indicated that, even though the Chinese government is strongly promoting sustainable urbanization, the policy design for sustainable urbanization is very chaotic. Many indicator systems for sustainable urbanization have been issued by different organizations, including research institutions, governmental departments and corporations, with no government department coordinating the various established indicator systems. Many new sustainability issues (e.g. climate change, biodiversity, resource depletion) are neither directly visible nor tangible (Geels, 2010). The lack of a coherent and holistic policy system for sustainability hinders the encouragement of proactive practices towards intangible sustainability issues within the industry. Jiang et al. (2013), for instance, indicated that in China the focus in many policies is only on the elimination of tangible environmental issues, for example, air, water and waste pollution, rather than the reduction of greenhouse gas (GHG) emissions. Similarly, Li and Shui (2015) indicated that there is still a serious absence of a coherent national policy framework for building energy efficiency.

In terms of the perceived weakest barriers, both low-performing and high-performing firms suggested incremental time (F7) and additional responsibility for maintenance (F8), even though medium-performing firms had significantly higher ratings on these two barriers. Previous studies (e.g. Zhang et al., 2015) indicated that sustainability practices request extra works which need more time contribution and may generate additional responsibility for maintenance. The current study suggests that, compared with other more prominent barriers such as inadequate economic incentives, these barriers are perceived as weak barriers by construction enterprises.

8.5 Facilitating the transition towards sustainable construction

The previous section has focused on analysing the various drivers for and barriers to sustainability transition, as perceived by different firm groups, without exploring the linkages between the firm groups. To summarize the research results in a vivid manner, Fig. 8.4 has visualized the top five strongest drivers and barriers perceived by each firm group by mapping them onto the appropriate positions in the established conceptual framework for sustainability transition. By doing this, Fig. 8.4 illustrates the roadmap of sustainability transition for the Chinese construction industry. The factors in blue denote drivers while the factors in red denote barriers.

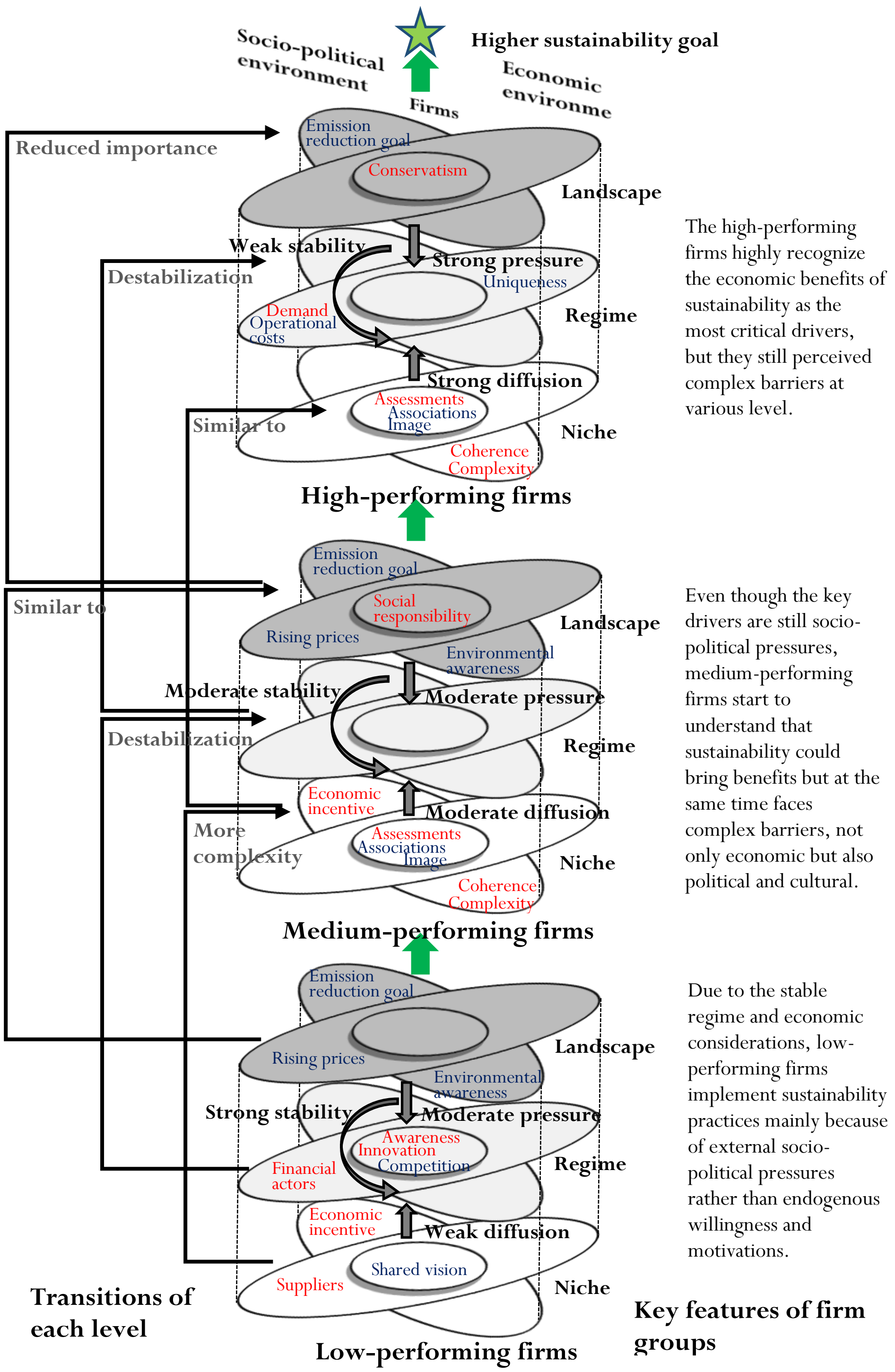

Figure 8.4 Roadmap of sustainability transition for the Chinese construction industry: the top five strongest drivers and barriers perceived by each firm group

8.5.1 Changes of perceived critical factors in the transition process

According to the multi-level perspective (MLP), sustainability transition is facilitated by the interactions between the niche, regime and landscape levels, with the landscape generating pressures for transitions, the niche trying to replace the dominant unsustainable practices in the regime, and the regime becoming destabilized to provide opportunities for the niche. The current study has revealed that, for low-performing firms, the barriers at the niche and landscape levels are stronger than the drivers, while the barriers at the landscape level are slightly weaker than the drivers. In contrast, for the medium-performing firms, the drivers at every level are slightly stronger than the barriers, and for the high-performing firms, the drivers at every level are significantly stronger than the barriers (see Table 8.4). Therefore, it could be concluded that for low-performing firms, the landscape generates moderate pressure for transitions, while the niche is weak and the regime is stable. Similarly, the key features of the other groups could be mapped onto Fig. 8.4. Consistent with different firm groups' sustainability performance, the low-performing firms are the most pessimistic about sustainability transition while the high-performing firms are the most optimistic among the three groups.

Built on the TEF, the established framework differentiates three conceptual components at each level: the industry (firms), the economic environment and the socio-political environment. The top five strongest drivers and barriers for each firm group have been mapped onto the appropriate position which shows that, for each firm group, all three components have the top rated factors, reflecting the complexity of the factors that influence sustainability transitions.

The mainly distributed levels and positions of the top rated drivers and barriers are summarized in Table 8.7. The current study has revealed that for low-performing firms, the key stimulus for sustainability comes from the external socio-political pressures at the landscape level, while the economic and industry issues, for example, inadequate incentives and low sustainability awareness at the niche and regime level, present the biggest hindrance. This reflects the fact that due to the stable regime and economic issues, low-performing firms lack endogenous motivation to actively implement sustainability practices. Even though the medium-performing firms also regard the external socio-political pressures at the landscape level as key drivers, they have started to recognize the benefits brought by sustainability, for example, improved corporate image as a key driver. They have also started to be aware of severe policy barriers, for example, the inconsistency and complexity of the supporting policies and the deep-rooted cultural issues, such as the lack of social responsibility. This reflects the view that, compared with low-performing firms, the medium-performing firms have more experience in sustainability and, thus, have a more holistic understanding of the various issues associated with it. They understand that sustainability could bring benefits but, at the same time, that it faces complex barriers, not only economic but also political and cultural. Of the three groups, the high-performing firms have the most experience in sustainability. They strongly acknowledge the economic benefits of sustainability, as they rated lower operational cost and uniqueness as the key drivers. However, similar to the medium-performing firms, they still perceived complex barriers to sustainability, for example, complexity and inconsistency of the policies, lack of assessment tools and the culture of conservatism. This reflects that China still has a long way to go to promote sustainability practices in the construction industry as both medium-performing and high-performing firms perceived the various barriers associated with its adoption.

Table 8.7 Mainly distributed levels and positions of top rated drivers and barriers

Factors	Firm groups	Main Levels	Main Position
Drivers	Low-performing firms	Landscape	Industry and socio-political environment
	Medium-performing firms	Niche and landscape	Industry and socio-political environment
	High-performing firms	Niche and regime	Industry and economic environment
Barriers	Low-performing firms	Niche and regime	Industry and economic environment
	Medium-performing firms	Niche and landscape	Industry and socio-political environment
	High-performing firms	All levels	Industry and socio-political environment

To facilitate the sustainability transition of the entire construction industry, low-performing firms in the industry need to transition towards medium-performing and high-performing firms; medium-performing firms need to transition towards high-performing firms, which then need to aim for higher sustainability goals. In accordance with the key features of the three firm groups discussed above, the changes of each level in the transition journey towards sustainability are highlighted in Fig. 8.4. With regard to the top rated factors at the niche level, medium-performing and high-performing firms have similar judgements, which are more holistic than those of the low-performing firms. With regard to the regime level, the firm groups at a higher sustainability level perceived stronger drivers and weaker barriers, reflecting the perceived increasing degree of destabilization of the regime. With regard to the landscape level, low-performing and medium-performing firms perceived many of the strongest drivers at this level, while the high-performing firms placed more drivers at the niche and regime levels, reflecting the reduced importance of the external landscape in stimulating sustainability transitions when firms become aware that sustainability could bring economic benefits.

8.5.2 Potential measures facilitating the transition process

According to the MLP, to facilitate the transition process, the two main sets of strategies are: 1) empowering sustainability innovations at the niche level, and 2) accelerating the destabilization of unsustainable practices at the regime level. As the landscape level comprises factors that cannot be influenced in the short term (Grin et al., 2010), the landscape level represents the greatest degree of structuration in the sense of being beyond the control of individual actors (Geels, 2012). The landscape level can only be gradually influenced by the changes at the niche and regime levels. Furthermore, the TEF indicates that the interactions among the industry, the economic environment and the socio-political environment influence the sustainability transition of the industry. Thus, to empower the niche and destabilize the regime, actions need to be taken by relevant stakeholders to nurture an appropriate economic and socio-political environment suitable for the growth of sustainability practices but not suitable for the further expansion of unsustainable practices in the industry.

With regard to the economic environment, the current study has identified that the economic environment in China has various issues that hinder firms' proactive actions towards sustainability transitions, especially for the low-performing firms. The strongest barriers in the economic environment have been identified as the lack of green suppliers and manufacturers, lack of support from financial actors, and the clients' focus on prices rather than on sustainability. Thus, measures should be taken to promote the development of the various green suppliers for the construction industry; to encourage financial actors to provide monetary support for sustainable construction projects; and to propagate the concepts and benefits of sustainability to the public. Previous studies (e.g. Berry et al., 2013), have indicated that the development of large green projects could gradually also nurture the development of green suppliers. This is consistent with the TEF which suggests co-evolutionary relationships between the industry and the economic and socio-political environments. More financial institutions, such as banks, could be allowed to be involved in the preparation of the policy-making process (Huang et al., 2016). The current study has also revealed that the low operational costs and uniqueness of sustainable projects are the strongest drivers for high-performing firms, but not for low-performing and medium-performing firms. Thus, the establishment of an efficient information channel on sustainability for low-performing and medium-performing firms is critical. The knowledge of the benefits of sustainability practices needs to be transferred to these firms. Typical information channels include regular workshops, newspapers, TV promotions, conferences and internet dissemination (Huang et al., 2016). For instance, a technology database, software tools and sustainability handbooks could be distributed to firms in industry forums (Kostka et al., 2013). Once they are fully aware of the associated benefits, they may implement these practices due to motivations from within rather than external socio-political pressures.

Regarding the socio-political environment, this study has identified that the inconsistency and complexity of the policy system and the lack of economic incentives are the strongest barriers to sustainability for both the medium-performing and high-performing firms. Thus, measures need to be taken to improve the current policy system. Wang and Chang (2014) specifically analysed the evolution of China's low-carbon development strategy, and discovered that compared with other areas, for example, developing the renewable energy sector, the energy efficiency in construction industry has received significantly less policy attention and resources. Previous studies, for example, Zhao et al. (2016), have suggested that under the government's strong and holistic incentive policies, the renewable energy industry in China has achieved tremendous growth during the past decade, such as the installed capacity of wind power increasing by 167 times from 2002 to 2012. This illustrates the power of economic incentives in encouraging Chinese firms. The economic incentive instruments could be improved by ensuring the continuity of the policies, seeking more funding channels and designing multiple subsidy schemes (Shen et al., 2016). For instance, a reformed taxation scheme could be introduced in favour of builders and buyers of sustainable construction projects. The central government should also shift from the current mode of supporting large firms to supporting small and medium-sized firms, as this study has revealed that low-performing and medium-performing firms perceived the lack of economic incentives as a critical barrier. In addition, the central government needs to play a more active role in coordinating all related authorities, strengthening collaboration with industry bodies and professional organizations to review the issued policies to ensure their consistency and operability. Standards and codes should be reviewed and updated to meet new challenges when new technologies are introduced (Shen et al., 2016). It has also been found that the increasing environmental awareness of the public and the national strategy for emission reduction are the strongest drivers for low-performing and medium-performing firms. Thus, the government could strengthen these aspects to further improve their power in facilitating the transition.

With regard to the industry, this study has identified the lack of assessment tools, the deep-rooted culture of conservatism and the economy-centred mindsets, and the tendency of incremental innovation as being the strongest barriers to sustainability. Governmental agencies should provide more research grants to support the development of the various assessment methods of the sustainable built environment, such as emission accounting of the energy saving of buildings. There is a need to develop various assessment tools, for example, sustainability assessments for construction enterprises, various types of construction projects and even technology and structures to facilitate the benchmarking of sustainability practices. Particular attention should also be paid to the alignment between the assessment tools and the principles of sustainability. It is a difficult task to enable the culture shift to change the deep-rooted values and cultural preferences. To gradually alter the economy-centred and conservative culture in the construction industry, a few scholars have proposed various suggestions. For instance, Zhang et al. (2015) proposed a bold vision that independent environmental representatives appointed by the government should be assigned to construction enterprises to truly represent the interests of the environment. The TEF suggests that, compared to technology and policy, core beliefs, culture and business models are fundamental regime elements that are more difficult to change (Turnheim and Geels, 2012). If the changes in the economic and socio-political environments discussed above are made, the deep-rooted cultures in the industry may gradually change. The current study also found that industry associations play a critical role in popularizing sustainability for medium-performing and high-performing firms but not for low-performing firms, and thus measures could be taken to lower the associations' entry threshold for low-performing firms, or even to establish new associations specifically targeting the low-performing firms.

8.5.3 Next step: towards a systematic model for facilitating transitions?

Due to the length constraints of this thesis, the above suggestions to facilitate sustainability transitions are inevitably brief and do not explore the details of each suggestion. Indeed, a whole range of measures and approaches have the potential to facilitate sustainability transitions. On the one hand, various approaches have been proposed with the aim of leading transitions, for example, strategic niche management (SNM) and transition management (TM) discussed in Chapter 3. Other approaches have been initially proposed for guiding transformation at the enterprise level, such as Kotter's change model which has also been applied to influence transitions at the industry level (Mousa, 2015). On the other hand, various studies, for example, Li and Shui (2015) have highlighted the necessity of developing a systematic approach to facilitate the sustainability transition of the construction industry. Zhang et al. (2011a) suggested that the application of green technologies for buildings in China is at the initial stage and that it is urgent to develop a unified strategy plan to encourage the active application of green technologies through engaging most of the key stakeholders in the process. Similarly, Shi et al. (2013) indicated that it is imperative to establish a collaborative system among the government, industry associations and enterprises to promote sustainable construction.

This study has taken the preliminary step of revealing the complexity of the drivers for and barriers to sustainability transitions in the construction industry, and has briefly discussed potential measures for facilitating transitions. Consistent with other studies, for example, Li and Shui (2015), this study concludes with a final proposal that emphasizes the urgency of developing a systematic and holistic approach to facilitate the sustainability transition of the construction industry. It is beyond the scope of this study to develop such an approach, but a critical discussion could shed light on future endeavours in this area. This study suggests that future endeavours for developing a systematic approach to leading transitions could focus on three key themes, as shown in Fig. 8.5.

The first theme is the transition processes for which various studies have proposed different conceptualizations. For instance, the multi-phase concept (MPC) has proposed that transition consists of four phases: predevelopment, take-off, acceleration and stabilization. Similarly, Chapter 3 has summarized that stabilization of the existing system, the transition of the existing system and the consolidation of the transitioned system as being the key processes of sustainability transitions indicated by the MLP and the TEF. In focusing on Chinese construction firms, this chapter has also developed a process, indicating that low-performing firms should transition towards medium-performing and high-performing firms. The holistic approach to leading transitions should provide insights on facilitating transitions at every key process. For instance, how should the government change its incentive policies for sustainable construction in accordance with the different transition stages of the industry? Future research endeavours should reveal the key features and dynamics at every main stage of transition, enabling the identification of strategies to influence each transition stage.

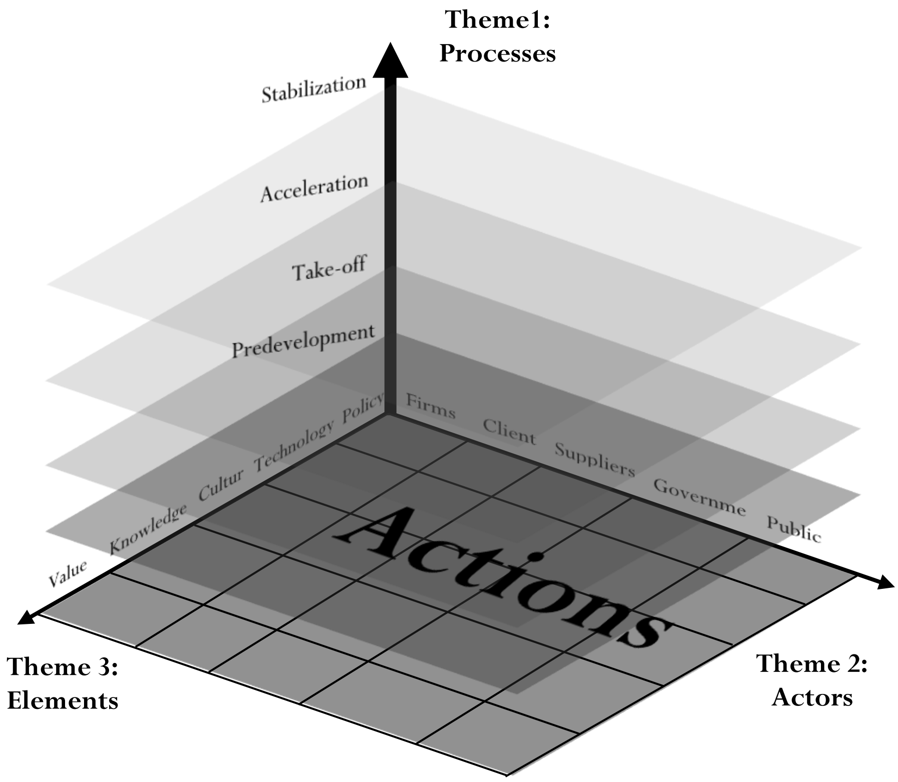

Figure 8.5 Conceptual model for development of a systematic approach to facilitate sustainability transitions

The second theme is the actors in transitions. This chapter has identified that various drivers for and barriers to transitions are associated with different actors, such as, the construction firms, suppliers, clients, the government, etc. Stakeholders to the construction industry could all impact on the sustainability transition of the industry; thus, the approach that is leading the transitions should engage most of the key stakeholders, offering guidelines on how these stakeholders should coordinate with each other to facilitate transitions. The TEF has provided a preliminary outline revealing that these key actors form three interacting components, that is, the industry, the economic environment and the socio-political environment. Future research should further explore the interactions between these actors in sustainability transitions. For instance, for the government, in order to empower sustainability niches in the most efficient way, how should limited resources be allocated? For example, should subsidies be provided to different kinds of actors involved in the sustainability networks? How do different kinds of actors in a sustainability network interact with each other at every key stage of transition?

The third theme is the changing elements in transitions. Transitions are sets of connected changes at various dimensions completed by different actors. This chapter has identified that the three firm groups have many divergent opinions on the sustainability technologies, policies and culture of the industry. To transition towards a sustainable construction industry, the policy, technology, knowledge, culture and many other elements linked to construction all need to be changed. Thus, the holistic approach to facilitate transitions needs to be capable of demonstrating how to facilitate the co-evolution among these elements towards sustainability. For instance, how does the development of sustainability technologies co-evolve with the value system of construction enterprises? What is the most efficient way to influence the deep-rooted regime and landscape elements, for example, the culture of conservatism?

The interactions between the processes, elements and actors form a space for analysing the various actions that facilitate transitions; that is, the actors need to take actions to change the elements while following a certain process to facilitate the sustainability transitions at the industry level. Each group of actors could take actions to influence the various elements, and the actions may need to be adjusted in different transition stages. Thus, the holistic approach to facilitate transitions should provide guidelines on what actions should be taken by the various groups of actors to influence the different elements along with the different stages of transitions.

However, by comparing the established SNM and transition management (TM) with this requirement, several deficiencies of SNM and transition management (TM) are revealed. For instance, with regard to the 'Element' axis, it has been widely accepted that SNM has a strong emphasis on technology (i.e. the technology-driven bias of transitions) but that it neglects other elements. Hegger et al. (2007) suggested that the learning process is often prevented in practice, despite been recognized by SNM. These authors argued that, in SNM research, more efforts should be made on developing concepts and guiding principles of sustainability rather than technological innovations (Hegger et al., 2007). Similarly, regarding the 'Actors' axis, it has been argued that transition management (TM) has been primarily implemented in social contexts initiated by the government, with limited application in a business environment (Loorbach and Wijsman, 2013). It is far from clear what transition management (TM) means for different types of firms in various sectors and to what extent the dominant culture within a business could influence the space for sustainability transitions (Loorbach and Wijsman, 2013). At a more fundamental level, with regard to the 'Process' axis, both SNM and transition management (TM) focus on nurturing sustainability niches to enable larger societal transitions. The MLP implies that niches are important, but niche developments are rarely able to bring about sustainability transitions without the help of other forces from the regime and landscape levels (Schot and Geels, 2008). Most scholars in the debate on sustainability transitions have focused on the emergence and empowerment of the niche at the predevelopment stage while how to facilitate the destabilization of existing regimes at the acceleration stage has been largely overlooked.

Thus, even though SNM and transition management (TM) are proposed as approaches to facilitate transitions, they are far from the ideal approach and have various inadequacies. Scholars have yet to develop a robust approach to facilitate sustainability transitions (Garud and Gehman, 2012). This study calls for future endeavours to contribute to this area of research.

8.6 Summary

There is a lack of studies on systematically analysing the drivers for and barriers to the sustainability transition of the construction industry based on solid theoretical underpinnings. Built on the multi-level perspective (MLP) on transitions and the triple embeddedness framework (TEF), this chapter has proposed a conceptual framework for analysing the factors that influence the sustainability transition of the construction industry. Based on the framework, the various factors were differentiated according to their features of level (niche, regime and landscape), function (driver and barrier) and position (the industry, the economic environment and the socio-political environment). Questionnaires were distributed to Chinese construction firms and various statistical techniques were employed to analyse perceptions on the factors.

The results show that, in general, the ranking exercises of the factors by the medium-and high-performing firms have similarities but are different from those of the low-performing firms. Detailed comparisons of the factors based on the three attributes were conducted. The Kruskal–Wallis test further compared the ratings on the factors from different firm groups, and revealed that all drivers and some of the barriers received significantly different ratings. Thus, the factors were classified into three groups: drivers, barriers that are not significantly differently rated, and barriers that are significantly differently rated. Detailed analysis was conducted of the factors that received the highest or lowest ratings in each of the three factor groups. This was followed by systematic discussions including changes of the perceived most important drivers and barriers in different firm groups, the potential measures to facilitate the transition and the future research opportunity to develop a holistic approach to facilitate the transition. Therefore, ***Research Objective 6*** is achieved.

Chapter 9 Conclusions

9.1 Summary of the research work

By investigating sustainability transition through the literature review, content analysis, case studies, cluster analysis, importance–performance analysis (IPA) and various statistical techniques, this research has provided a substantive contribution to understanding the transformation towards sustainability in the Chinese construction industry. The six research objectives proposed in Chapter 1 have been achieved, and the main research work conducted in this study to achieve the objectives is summarized as follows:

- *[Objective 1: To review the theories and existing studies on sustainability of enterprises, sustainability of construction enterprises and sustainability of the Chinese construction enterprises]*

This study has firstly reviewed: 1) the concept of sustainability; 2) the theories explaining sustainability in enterprises (CSR, stakeholder theory, corporate sustainability [CS] and the TBL, and green policies); 3) sustainability research in the construction industry in general (sustainable construction, corporate sustainability [CS] and CSR research, drivers for and barriers to sustainability); and 4) the development of the Chinese construction industry and the sustainability research on this industry (economic sustainability, social sustainability and environmental sustainability).

- *[Objective 2: To review the approaches to sustainability transition]*

After reviewing the literature on sustainability and construction enterprises, this study then reviewed the approaches to sustainability transition. The main research work included systematically reviewing: 1) the various approaches to sustainability and their limitations, such as ecological modernizers and green economists; 2) the concepts of sustainability transitions; and 3) the five approaches within the sustainability transition field, comprising the MPC, the MLP, SNM, transition management (TM) and the TEF. This study compared these various approaches to sustainability transition, and then proposed a detailed research plan by linking the sustainability transition perspective with the sustainability of the Chinese construction industry.

- *[Objective 3: To examine China's policy system for facilitating the transition towards sustainable construction]*

Government policy plays a critical role in promoting sustainability practices in the construction industry, as indicated by both the existing construction studies and the studies on sustainability transition. This study has holistically examined China's policy system for facilitating the transition to sustainable construction. Regulation and control, economic incentives and supporting activities have been identified as the main policy instruments to promote sustainable construction in China. This study also identified that the policy system places much emphasis on the environmental dimension of sustainability while largely neglecting the economic and social dimensions, while the effectiveness of some policies is questionable and needs further improvement.

- *[Objective 4: To investigate the evolution of the leading Chinese construction firms' sustainability behaviours and practices]*

After examining the macro policy environment, this study adopted a multiple-case study approach to examine the specific sustainability practices and behaviours of the leading Chinese construction firms. Through inductive category development, 24 critical sustainability aspects were identified from three sustainability reporting guidelines. Then, based on directed content analysis, it was identified that, from 2009 to 2013, the three leading construction firms (the cases in this study) have implemented various sustainability practices which could be summarized into 29 critical aspects and 92 sub-aspects. By comparing the firms' sustainability practices with the requirements of the guidelines, this research has identified the evolving strategic sustainability behaviours, and the strengths and weaknesses of the case firms. In particular, the case studies highlighted that even the studied leading construction firms cannot fulfil many requirements of the sustainability guidelines, indicating the urgency of a transition towards sustainability.

- *[Objective 5: To holistically examine the sustainability perceptions and performance across construction enterprises of different scales and with different sustainability levels]*

Based on the logic of purposeful sampling, case studies have a strong theory-building ability through a deep exploration of the process in the real-world context, but they also have the drawback of weak generalizability. To investigate how various construction firms in China perceive sustainability instead of only studying the perceptions of the leading firms, a questionnaire survey was conducted. This study investigated how the surveyed construction enterprises perceive the importance and performance levels of the identified 29 sustainability aspects explored in the case studies. Three main research tasks were fulfilled. First, the relative importance value (RIV) and relative performance value (RPV) of the sustainability aspects were calculated, to identify which sustainability aspects were perceived to be the most and least important, and the best and worst performed by the enterprises in general. The study compared the ratings provided by enterprises of different sizes, and statistically tested the associations between firm size, sustainability performance (performance ratings) and sustainability attitude (importance ratings). Finally, cluster analysis was employed to classify the firms, according to their sustainability performance, into three groups, namely, low-performing firms, medium-performing firms and high-performing firms, and then importance–performance analysis (IPA) was employed to investigate the managerial priorities of each sustainability aspect in the three firm groups, dividing the 29 sustainability aspects into four categories: "*keep up the good work*", "*concentrate here*", "*possible overkill*" and "*low priority*" for each of the three firm groups. By linking the IPA results of the three firm groups, this study proposed the *Transition Pathways towards Sustainability* (TPS), illustrating how low-performing and medium-performing firms should allocate their resources to improve their performance on the sustainability aspects, thereby transitioning towards becoming high-performing firms.

- *[Objective 6: To analyse the drivers for and barriers to sustainability transitions of construction enterprises with different sustainability levels]*

After discovering how the construction enterprises perceived the various sustainability aspects and the transition pathways towards a higher level of sustainability, this study then investigated the various factors driving and prohibiting the transitions, based on an integrated conceptual framework built on the multi-level perspective (MLP) on transitions and the triple embeddedness framework (TEF). Built on the three pre-identified firm groups, this study specifically highlighted how the various firm groups with different sustainability levels perceived the drivers and barriers differently, and what constituted the most important drivers and barriers for the three firm groups. These most influential factors were mapped onto the proposed conceptual framework to show the key mechanisms of sustainability transition for each firm group. The whole research study was concluded with discussions on the potential measures to facilitate the transitions, highlighting that this is an ongoing research area, and that more research needs to be conducted to develop a holistic approach to facilitate sustainability transitions.

In summary, this study has provided a relatively holistic examination of the sustainability transition of Chinese construction enterprises following a rational logic of inquiry, by firstly examining the macro policy environment for sustainability, conducting explorative case studies to identify the critical sustainability aspects on which the Chinese firms have implemented practices, then conducting a questionnaire survey to examine how various construction firms perceived the identified sustainability aspects. The firms were classified according to their sustainability performance. Finally, this study has investigated the drivers for and barriers to the sustainability transition of each firm cluster. This research has established a basis for future research studies to further explore how to systematically facilitate the transition processes.

9.2 Key findings

9.2.1 Policy system for sustainable construction

To promote sustainability in the construction industry, the Chinese government has developed and implemented a number of laws, regulations and policies. However, few existing studies specifically investigate how the Chinese government is responding to the sustainability issues of construction enterprises. This study has holistically examined the policy system that China has adopted to facilitate the transition towards sustainability construction.

The behaviours of various participants in the construction industry, including the government, developers, builders, suppliers and designers are regulated and controlled by a number of laws and regulations. These policies include the *Energy Conservation Law*, *Administrative Regulation on the Work Safety of Construction Projects* and *Environmental Impact Assessment Law*. ***A series of economic incentive policies are also introduced, including subsidy policies, award policies and financial innovation policies.*** Subsidy policies are mainly used to promote renewable energy applications in buildings while green buildings are mainly promoted by the award policies. Financial innovation policies are introduced to enhance the economic sustainability of infrastructure construction. ***The Chinese government has also conducted many supporting activities to enable the transition to sustainable construction.*** These include: (1) technology innovation which is strengthened and planned by the *12th Five-Year Plan for Technology Development of Green Buildings*; (2) standards and evaluation which are largely developed by the government; (3) demonstration projects which have experienced a significant increase during recent years, and (4) publicity which is strengthened by some policies to increase the awareness of sustainable construction among the public.

To further improve the current policy system for sustainable construction in China, it is recommended that more social factors should be considered in future policy making. It is also suggested that more research should be conducted to investigate the impact of implementing sustainability practices on the economic competitiveness of construction corporations in China. In addition, in the future policy revision process, policy makers should consider and respond to the critiques from the public about the lack of consideration of regional differences in the current green building evaluation system, as well as the low level of public participation in the environmental impact assessment of construction projects.

9.2.2 Sustainability perceptions and performance of construction enterprises in general

There is a lack of studies investigating various dimensions of sustainability (i.e. economic, social and environmental) in construction firms of various sizes, not only in the context of China but also in other countries. Previous studies have addressed similar issues, but they explored sustainability issues of the construction industry from different perspectives. Some studies have focused on a particular group of firms. For instance, Bevan and Yung (2015) investigated the implementation of CSR in Australian small and medium-sized construction firms. By contrast, Zuo et al. (2012) examined the sustainability policy of leading international contractors by analysing their sustainability reports. Most related studies have only investigated the environmental aspects of sustainability. For instance, Serpell et al. (2013) explored the awareness and actions of sustainable construction in the construction industry of Chile, under a narrow definition of sustainable construction which only contained the environmental aspects. The current study has enriched the existing body of knowledge by holistically diagnosing the Chinese construction firms' attitudes towards and performance on various economic, social and environmental sustainability aspects, and testing the association between firm size and the sustainability attitudes and performance.

Specifically, ***the findings show that while 27 out of 29 CSAs were deemed to be important, construction enterprises had good performance on only two CSAs, revealing a gap between the importance and performance levels.*** Existing studies have argued that concerns related to high costs are the main barriers to the implementation of environmental sustainability practices (Shi et al., 2013; Zhang et al., 2011a). ***By simultaneously investigating construction***

firms' attitudes towards economic, social and environmental sustainability in China, this study has revealed that generally the economic aspects were perceived as more important and better performed compared to social and environmental aspects. In particular, the top four most important aspects perceived by the enterprises are all economic-related. As economic aspects are considered a priority, the judgement of whether and how social and environmental sustainability will affect economic competitiveness could be a crucial factor in determining construction firms' strategies for sustainability. ***This study has also revealed that compared to those aspects (e.g. managing impacts on biodiversity) which are not directly related to economic performance, the environmental aspects which can directly influence the economic gains of construction enterprises are more acknowledged, such as, land use efficiency and construction waste management.*** This reaffirmed that the conflict between short-term economic gains and long-term benefit of sustainable development presents a significant challenge for the proliferation of sustainable construction practices (Häkkinen and Belloni, 2011).

9.2.3 Sustainability perceptions and performance of construction enterprises of different sizes

Few studies have statistically explored the association between firm size and the sustainability attitudes and performance of construction firms. Some studies, for example, Zainul Abidin (2010) have argued that larger construction enterprises are more aware of environmental sustainability, but without empirical evidence. Other studies, for example, Serpell et al. (2013) and Du et al. (2014), have provided this evidence but have not illustrated the association between firm size and the various dimensions of sustainability performance. ***Based on empirical evidence, this study reveals that larger construction enterprises in China tend to have better sustainability performance.*** Thus, to facilitate the transition of the entire Chinese construction industry towards sustainability, the government may have to alter the current approach of focusing on regulating large firms. Relevant policies could be introduced to address the sustainability issues of small and medium-sized construction enterprises. As sustainability attitude is found to be positively correlated with sustainability performance, a potential approach to improve firms' sustainability performance is to enhance their sustainability awareness. ***However, this study revealed that there is a weak association between firm size and sustainability attitude; that is, larger construction enterprises do not necessarily perceive sustainability as more important than how it is viewed by smaller firms in China.*** Even though larger firms receive higher pressures from the government, the media and the public (Zeng et al., 2011), they do not necessarily believe that sustainability is more important, as this study found that large enterprises (LEs) have a significantly lower, rather than a higher sustainability attitude level (SAL) than medium enterprises (MEs). This contrasts to existing studies, for example, Zainul Abidin (2010) and Serpell et al. (2013), who implicitly indicated that larger firms have a more proactive attitude towards sustainability. This means it could be a challenge to develop a holistic and efficient approach to improve the sustainability attitude of all sizes of construction firms, particularly in China. Future research could be conducted using a more intricate technique, for example, structural equation modelling (SEM) to further explore the underlying factors explaining why larger construction enterprises in China do not necessarily believe sustainability is more important.

9.2.4 Transitions from low-performing to high-performing firms

There is a lack of studies on classifying the various sustainability aspects according to their managerial priority thereby providing strategic guidance for construction enterprises to transition towards sustainability. The cluster analysis conducted in this study captured the firm groups' divergent opinions on the importance and performance levels for various aspects of sustainability. This is different from previous studies, for example, Zhao et al. (2016) and Bevan and Yung (2015), in which all respondents were treated as a homogeneous group without segmentation. Therefore, this study reveals a more granular picture of the sustainability perceptions of construction firms on the various sustainability aspects. Three firm clusters, namely, low-performing firms, medium-performing firms and high-performing firms were identified based on k-means cluster analysis, and the IPA was subsequently conducted for the three clusters. Then, the *Transition Pathways towards Sustainability* (TPS) were proposed. Gap analysis further showed that among the three firm clusters, high-performing firms had the lowest performance gaps on all of the 29 CSAs, while low-performing firms had the highest performance gaps on most of the CSAs. This suggests it is more urgent for low-performing firms to improve their sustainability performance. ***The IPA results of the three firm clusters reveal that, in low-performing firms, the dominance of the economic competitiveness paradigm is apparent while consideration of social and environmental sustainability is lacking. In contrast, medium-performing and high-performing firms place more emphasis on social and environmental aspects.*** The proposed transition pathways clearly demonstrate which sustainability aspects need to be further improved to facilitate the firms' transition towards higher sustainability levels.

9.2.5 Drivers for and barriers to sustainability transition of construction enterprises

Few existing studies that have examined the drivers of or barriers to sustainability in the construction industry are underpinned by solid academic theories. The conceptualization of the mechanisms behind transitioning the industry towards sustainability remains very unsystematic and fragmented. Most existing studies only investigate the drivers or barriers, without simultaneously examining both. Other studies have examined both drivers and barriers, but have produced only the overall perceptions of all of the respondents without any differentiation between them. Some studies have differentiated the respondents, but are based only on demographical information, thus losing the opportunity to compare the perceptions of firms with different levels of sustainability performance.

By examining the drivers for and barriers to the sustainability transition of construction enterprises with different sustainability levels based on a solid theoretical framework, this study has responded to the above gaps of knowledge. ***It was found that, generally, with the perceived strongest drivers and weak barriers, firms with the highest sustainability levels have the highest motivation to transition towards sustainability in the three groups of firms, while firms at the medium sustainability level perceive the strongest barriers to sustainability transition.***

Specifically, this study reveals that low-performing firms lack endogenous motivations to implement sustainability practices actively. For these firms, the key stimulus for sustainability comes from the external socio-political pressures, while the economic and

industry issues, for example, inadequate incentives and low sustainability awareness present the biggest hindrance. Even though the medium-performing firms also regard the external socio-political pressures as key drivers, they start to recognize the benefits brought by sustainability, for example, improved corporate image as key drivers. They also start to be aware that there are severe policy barriers, for example, the inconsistency and complexity of the supporting policies and the deep-rooted cultural issues, such as the lack of social responsibility. ***This reflects that, compared with low-performing firms, the medium-performing firms have a more holistic understanding of the various issues around sustainability. They understand that sustainability could bring benefits but, at the same time, they face complex barriers, not only economic but also political and cultural.*** The high-performing firms have the most experience in sustainability in the three groups. ***The high-performing firms highly acknowledge the economic benefits of sustainability, but they still perceive complex barriers to sustainability, for example, complexity and inconsistency of the policies, lack of assessment tools and the culture of conservatism. This reflects that China still has a long way to go to promote sustainability practices in the construction industry as both medium-performing and high-performing firms perceive various barriers to the adoption of sustainability practices.***

9.2.6 Potential measures to facilitate sustainability transitions

The TEF indicates that the interactions between the industry, the economic environment and the socio-political environment influence the sustainability transition of the industry. With regard to the economic environment, this study has identified that the strongest barriers in the economic environment are the lack of green suppliers and manufacturers, lack of support from financial actors, and the clients' focus on prices rather than sustainability. ***Measures should be taken to promote the development of the various green suppliers for the construction industry; to encourage financial actors to provide monetary support for sustainable construction projects; and to propagate the concepts and benefits of sustainability to the public.*** With regard to the socio-political environment, this study has identified that the inconsistency and complexity of the policy system and the lack of economic incentives are the strongest barriers to sustainability for both the medium-performing and high-performing firms. ***Measures need to be taken to improve the current policy system, such as introducing a reformed taxation scheme in favour of builders and buyers of sustainable construction projects, and shifting from the current mode of predominantly supporting large firms to small and medium-sized firms.*** With regard to the industry, this study has identified the lack of assessment tools, the deep-rooted culture of conservatism and economy-centred mindsets as the strongest barriers to sustainability. ***Governmental agencies and private funding bodies should provide more research grants to support the development of the various assessment methods of the sustainable built environment, and facilitate a cultural change towards sustainability.***

Moreover, this study suggests that currently there is the lack of a systematic and holistic approach to facilitate the sustainability transition of the construction industry. Both SNM and transition management (TM) have drawbacks which need to be further explored by future studies. ***This study suggests that future studies could focus on three key components of transitions, namely, the transition processes (e.g. predevelopment, take-off, acceleration and stabilization); elements (policy, technology, knowledge and culture); and actors (construction firms, suppliers, clients and government) which form a space for analysing the various actions facilitating transitions***. Each group of actors could take actions to influence the various elements, with the actions needing to be adjusted in different transition stages. Thus, the holistic approach to facilitate transitions should provide guidelines on what actions should be taken by the various groups of actors to influence the different elements along with the different stages of transitions.

9.3 Contributions of this research

This study has delivered important implications for understanding the transitioning of the construction industry towards sustainability. Theoretically, it contributes to both the research fields of sustainability transitions and the sustainability of construction industries. Empirically, it has enriched the empirical knowledge of sustainability policy, sustainability practices, perceptions and performance, and factors influencing the transformation towards sustainability in the Chinese construction industry. It also has practical implications for construction enterprises and the government's policy-making effort to promote sustainability in construction industries. The main contributions in the three dimensions, namely, the theoretical, empirical and practical contributions, are summarized in Table 9.1.

Table 9.1 Contributions of this project to the body of knowledge

Dimension	Aspects	Implications
Theoretical contributions	For research on sustainability transitions	• Most existing transition studies adopt a qualitative case study approach to investigate the dynamics of transitions. By employing the various statistical techniques to differentiate three firm clusters and investigate the differences and commonalities of the firm groups' perceptions towards sustainability transitions, this study enriches the methodological toolbox of transition studies (Chapters 7 and 8) • Most transition studies investigate the energy sector. This study provides a transition study of the construction industry which enriches the empirical settings of transition research (the whole study)
	For sustainability research of construction industries	• Statistically explores the associations between firm size and the sustainability attitudes and performance of construction firms (Chapter 7) • Offers an example of how IPA could be employed in construction-related studies. IPA and the associated research procedure proposed in this study have the potential to be widely used by other construction studies to investigate factor-related issues (e.g. risk factors, competitiveness factors, sustainability factors, factors causing cost overruns, etc.) (Chapter 7). • Integrates the various factors influencing the transition towards sustainability, e.g. technological, cultural and political, into one overarching framework, enhancing the conceptualization of the key mechanisms behind the transition towards sustainability in construction industries (Chapter 8)
Empirical contributions	For sustainability policy	• Holistically examines the policy system to facilitate the transition to sustainable construction in China (Chapter 5) • Identifies and discusses several key deficiencies of the policy system (Chapters 5, 7 and 8)
	For sustainability practices, perceptions and performance	• Contributes to the understanding of sustainability practices implemented by Chinese construction enterprises by identifying 29 critical sustainability aspects (CSAs) and 92 sub-aspects implemented by the leading firms (Chapter 6) • The proposed TPS is one of the earliest of its kind in terms of demonstrating both the importance and performance levels of the sustainability concept in a holistic manner perceived by construction firms at different sustainability levels (Chapter 7)
	For factors influencing sustainability	• Contribute to the empirical knowledge of how construction firms of different sustainability levels perceive the various drivers for and barriers to sustainability (Chapter 8)

Practical contributions	For enterprises	• The identified 92 sub-aspects of sustainability practices implemented by the leading Chinese construction firms provide other firms with a realistic model from which to learn to improve sustainability performance (Chapter 6) • The proposed TPS provides a lens through which the construction firms could view the sustainability perceptions and performance of their peers with similar, lower or higher sustainability performance, thereby informing the decision-making process of choosing an appropriate sustainability strategy (Chapter 7) • Construction enterprises could understand how their peers with similar, higher or lower sustainability performance perceive the various drivers for and barriers to sustainability, thereby facilitating the decision making on their own transition to sustainability (Chapter 8)
	For policy making	• This study provides a reference for the government to understand which sustainability aspects were best or worst performed by the construction enterprises, thereby informing the government to allocate the limited resources (e.g. subsidies) to support the worst performed aspects (Chapters 6 and 7) • The government should further improve the completeness, effectiveness, consistency and efficiency of the policy system supporting the transition to sustainable construction (Chapters 5, 7 and 8)

9.3.1 Theoretical contributions

Firstly, regarding the theoretical contribution, the various approaches of sustainability transition have been predominantly employed in analysing the energy sector, while this study offers an example of how the theory of sustainability transition could be employed in the context of the construction industry. From a transition perspective, the MLP and TEF have been proposed to specifically examine the key mechanisms of transformation towards sustainability. Based on the MLP and TEF, this study has integrated the various factors influencing transformation towards sustainability into one overarching framework according to the functions, positions and levels of the factors. This integrated conceptual framework provides a lens through which researchers could gain a holistic view of the factors influencing transition towards sustainability in the construction industry. Furthermore, this study also has methodological innovations in studying transitions. Chapter 3 has indicated that most existing transition studies adopt a qualitative case study approach to investigate the dynamics of transitions. Few studies have attempted to adopt quantitative data to analyse sustainability transitions. This study has innovatively employed a questionnaire survey and the associated statistical analysis to investigate the complex sustainability transitions which were normally studied by qualitative case studies. Built on the results of the cluster analysis in Chapter 7, Chapter 8 analysed and compared the perceptions of the pre-identified low-, medium- and high-performing firm groups, thereby identifying the key differences and similarities of the perceptions and revealing the transition processes. This research approach enriches the methodological toolbox of transition studies.

Apart from the innovative transition approach adopted, this study also statistically explored the associations between firm size, sustainability attitudes and sustainability performance of construction firms, as well as employing IPA to propose transition pathways for construction enterprises, which to the best of the author's knowledge, has never been done by previous construction-related studies. In particular, this study offers an example of how IPA could be employed in construction-related studies. Very few existing studies have employed IPA in the context of construction industries. Chapter 7 has demonstrated that IPA could be used in the context of construction industries as an effective approach to simultaneously investigate the perceived importance and performance levels of critical attributes, and to provide managerial suggestions for each attribute. Chapter 7 has shown that IPA is an effective method to identify the gap between perceived most important versus most unimportant as well as best-performed versus worst-performed sustainability aspects. In particular, IPA provides a streamlined approach to identify the most crucial sustainability aspects that warrant more attention, that is, those areas perceived to be the most important but which are the worst performed (i.e. aspects in the "*concentrate here*" quadrant). This provides useful input for making strategic decisions and for determining the most appropriate way to allocate scarce resources. The IPA and the associated research procedure proposed in this study have the potential to be widely used by other construction studies to investigate factor-related issues (e.g. risk factors, competitiveness factors, sustainability factors, factors causing cost overruns, etc.).

9.3.2 Empirical contributions

Apart from the theoretical contributions, this study also provides empirical knowledge and data relevant to the sustainability transition of the Chinese construction industry. Chapter 5 has systematically analysed China's policy system for sustainable construction and has identified the key strategies and policy instruments, and deficiencies of the policy system that have been discussed in Chapters 5, 7 and 8. This contributes to a better understanding of government policy in facilitating sustainability transition.

Similarly, through examining the sustainability practices of three leading Chinese construction enterprises and sustainability reporting guidelines, Chapter 6 has identified 29 critical sustainability aspects (CSAs) and 92 sub-aspects, which could be used as an indicator system for future studies. By investigating how the different economic, social and environmental sustainability aspects are perceived and performed by various construction enterprises, Chapter 7 contributes to the empirical knowledge in the area of corporate sustainability (CS) of construction enterprises. Based on empirical evidence, the proposed TPS is one of the earliest of its kind in terms of demonstrating both the importance and performance levels of the sustainability concept in a holistic manner perceived by construction firms at different sustainability levels.

Furthermore, Chapter 8 contributes to the empirical knowledge of how construction firms with different sustainability levels perceive the various drivers for and barriers to sustainability. It shows that segmentation of the respondents is necessary since significant differences exist in their perceptions. Cluster analysis produces the groups with greatest possible internal homogeneity (within groups) and external heterogeneity (between groups), and thus is appropriate for differentiating the respondents. To the best of the author's knowledge, this study is the earliest of its kind in terms of holistically investigating both the perceived drivers for and barriers to sustainability in various firm groups with different sustainability levels (i.e. low-performing, medium-performing and high-performing firms) in the construction industry, providing important data and insights for understanding the sustainability transition of construction enterprises.

9.3.3 Practical contributions

As China faces a practical challenge to transition its construction industry towards sustainability, this study is expected to also have practical implications for construction enterprises and the government.

For instance, as the 92 sub-aspects of sustainability practices were identified based on an examination of the leading Chinese construction firms in Chapter 6, they provide other Chinese construction firms with a realistic model to understand how the industry leaders implement practices to embrace sustainability, and learn from the best sustainability practices. Similar studies could also be conducted in construction industries of other countries to facilitate the international benchmarking exercise. Similarly, Chapter 7 assists Chinese construction enterprises of various scales to have a better understanding of how their peers of similar, smaller or larger sizes in the industry perceive and perform on sustainability, thereby informing the decision making of sustainability strategies. For instance, regarding economic sustainability, this study revealed that HEs pay much attention to stakeholder relations and innovations. Therefore, small and medium-sized enterprises could re-think their strategies whether to stick to project quality and customer satisfaction (i.e. their current priorities), or to invest more on stakeholder relations and innovations. Chapter 7 also supports sustainability decision making of construction enterprises with different sustainability levels. Due to resource constraints, construction enterprises could experience significant difficulties of determining how to allocate the limited resources to the various sustainability aspects. Based on cluster analysis, three firm groups, namely, low-performing, medium-performing and high-performing firms, were identified in Chapter 7. Then, based on IPA of 29 critical sustainability aspects (CSAs), the proposed TPS classified the various aspects into four quadrants for each of the three firm groups, and revealed that aspects in the "*concentrate here*", "*low priority*" and "*possible overkill*" quadrants should be transitioned towards the "*keep up the good work*" quadrant. The proposed TPS therefore informs the decision-making process of construction enterprises to choose an appropriate sustainability strategy.

Furthermore, Chapter 8 has identified the most and least important drivers for and barriers to sustainability transition of low-, medium- and high-performing firm groups.

Thus, construction enterprises could understand how their peers with similar, higher or lower sustainability performance perceive the various factors influencing sustainability, thereby facilitating the decision making on sustainability of their own. For instance, this study has identified that for low-performing firms, the key stimulus for sustainability comes from the external socio-political pressures at the landscape level. In contrast, the high-performing firms strongly acknowledge the economic benefits of sustainability as the key stimulus, such as the lower operational cost and uniqueness of the sustainable projects. However they still perceive complex barriers to sustainability, for example, complexity and inconsistency of the policies, lack of assessment tools, and the culture of conservatism. Thus, the low-performing firms could invest in sustainability as it could bring economic benefits which have already been experienced by high-performing firms, but the low-performing firms need to holistically assess the various risks to their transitions towards high-performing firms, as when they become more sustainable, they may experience the similar complex barriers to further sustainability improvements experienced by the current high-performing firms, if the situations of the economic and socio-political environments and the industry have not been significantly changed.

Similarly, this study also has significant implications for policy making. Chapter 8 has highlighted that the inconsistency and complexity of the policy system is a strong barrier perceived by both the medium- and high-performing firms. Chapter 8 has also discussed several suggestions to improve the policy making. These suggestions could be further researched by the policy makers to improve the policy system for facilitating the sustainability transition of the construction industry. Chapter 7 also provides a valuable reference for the government to understand how various sustainability aspects are perceived and performed by the construction industry, thereby facilitating the design of efficient policies to tackle the weakness of the industry. For instance, Chapter 7 revealed that anti-corruption and green innovation received low ranks in both the attitude and performance evaluations. Thus, the government could further strengthen the legislation to reinforce anti-corruption within construction professionals. Similarly, strong incentives could be introduced to encourage construction firms' research and development in green technologies.

9.3.4 Global implications

Even though this research investigates the sustainability transition of the Chinese construction industry, it has the potential to apply to the construction industry of other nations. Firstly, regarding the theoretical implications, this research provides an example of how the theory of sustainability transition could be applied to the construction industry. Scholars could apply the various approaches of sustainability transition to study construction industries in various geographical backgrounds. As general research tools, the IPA methods in Chapter 7 and the conceptual framework of sustainability transitions proposed in Chapter 8 could also be applied to study construction industries in other countries.

Secondly, regarding the empirical implications, the research findings of China's policy system and the Chinese construction firms' perceptions about the critical sustainability aspects (CSAs) and the factors influencing transitions are very likely to be applicable to other nations that have similar economic and social conditions. For instance, regarding the policy system, various studies have shown that regardless of the country's background, policy instruments for sustainability issues in the construction industry could be classified into three types, namely, mandatory regulation instrument, economic incentive instrument and voluntary scheme instrument (Shen et al., 2016; Al-Saleh and Mahroum, 2015). The identified categories of measures implemented by the Chinese government, that is, regulation and control, economic incentives and supporting activities in Chapter 5, correspond to the three main types of instruments. Compared to Western countries, Eastern countries, for example, China, Japan, India and Singapore use regulation instruments more often and tend to face similar challenges (Shen et al., 2016). Thus, China's policy system for the transition towards sustainable construction and the associated issues, for example, the lack of financial incentives discussed in Chapters 5 and 8 provide references and lessons for policy makers in other Asian countries, especially the developing Asian countries, for example, India and Vietnam. Similarly, the construction firms in countries with similar economic and social conditions share many similar perceptions towards sustainability. For instance, while Häkkinen and Belloni (2011) found in Finland that cost-related issues were not considered to be significant barriers to sustainable buildings and that clients had a realistic understanding of the cost, studies, for example, Shi et al. (2013), Hwang and Ng (2013), Serpell et al. (2013) and Zainul Abidin, 2010) suggest that in many other countries, for example, China, Singapore, Chile and Indonesia, construction enterprises perceive monetary issues as significant barriers. This is consistent with the current study which found the low-performing and medium-performing firms rank monetary issues, for example, the lack of economic incentives and financial actors' unwillingness as significant barriers. The conclusions regarding the Chinese construction enterprise are likely to be applicable to construction firms in many other developing countries, for example, Chile and Indonesia.

Thirdly, regarding the practical implications, this research provides several tools that could be adapted to be applied in the construction industry in other countries, regardless of whether a developing or developed country. Construction industries in many other countries face sustainability challenges similar to those faced by China. The identified 92 sub-aspects of sustainability in this study could be used as a basis for categorizing or comparing sustainability practices implemented by construction firms in other countries. Researchers could also adopt the IPA to study the managerial priorities of the sustainability aspects in other countries, thereby proposing the TPS for their construction enterprises. Similarly, researchers could adopt the framework proposed in Chapter 8 and cluster analysis to investigate how construction enterprises in other countries perceive the drivers for and barriers to sustainability.

9.4 Suggestions for future research

The data collection method for this research is documentation, for example, existing literature, policy documents and corporate reports (Chapters 5 and 6), as well as a questionnaire survey (Chapters 7 and 8). Although originally it was attempted to include other data collection methods in this research, for example, semi-structured interviews and direct observation, these methods were excluded in this study due to time constraints. Future studies with more resources and more relaxed time constraints than in this study could employ other means of data collection, for example, interviews.

To capture the attitude and performance levels of Chinese construction enterprises, a five-point Likert scale was employed in the questionnaire. The inherent subjective nature of this approach suggested that this evaluation is influenced by personal perceptions. The use of subjective ratings in sustainability or performance assessments is widely documented in previous construction-related studies, for example, Bevan and Yung (2015) and Shen et al. (2010b). Subjective evaluation of performance is also widely used in other areas, such as, multi-criteria assessment. The objective approach is not feasible in this study as currently there is no database available about the sustainability performance of construction enterprises in China. Therefore, this study adopted a subjective evaluation approach with this based on a five-point Likert scale. Objective evaluations of construction firms' sustainability performance are complex and difficult in nature as it not only involves the quantification of the firms' environmental impacts, but also involves the assessment of social issues that are largely subjective in nature. Future research opportunities exist to explore how the sustainability performance of construction firms can be better evaluated, for example, through the combination of a Likert scale and a Life Cycle Assessment.

Another main limitation is that this study does not propose systematic measures to facilitate the sustainability transition. At the end of Chapter 8, it was discussed that more studies need to be done before a systematic approach to facilitate sustainability transitions can be developed. However, this study has important implications for both the construction enterprises and the government, which have been summarized in Table 9.1. More research needs to be done to explore how to facilitate sustainability transitions considering the different transition stages, the various actors involved in transitions and the various elements that need to be changed in the transition process.

Furthermore, it was discussed in Chapter 3 that the economic and socio-political environments interact with the firms in the industry, thereby influencing the sustainability transition of the industry. As an exploratory study, this study mainly focuses on the practices of two actors involved in the sustainability transition of the industry, namely, the government (Chapters 5 and 8), and the construction firms (Chapters 6, 7 and 8), with other actors, such as, clients, NGOs and suppliers that have only had preliminary investigations (Chapter 8). Future studies could specifically investigate the practices and behaviours of these actors and how they influence the sustainability transition of the construction industry. For instance, Chapter 8 has identified that the low-performing firms have perceived the lack of green suppliers as one of the most serious barrier hindering their sustainability transitions, while the medium-performing and high-performing firms do not. Future studies could specifically focus on the green manufacturing industry of construction materials and components, to explore the evolution of the industry, the perceptions of green suppliers, the barriers they are facing etc.

More fundamentally, as sustainability transitions are multi-dimensional phenomena, they could be examined through various lenses underpinned by different ontology, that is, the foundational assumptions about the nature of the world and its causal relationships (Geels, 2010). Chapter 8 mainly builds on the MLP and the TEF to propose the conceptual framework. Therefore, this study inevitably shares the same ontology (i.e. "foundational assumptions about the nature of the world and its causal relationships") with the MLP and the TEF (Geels, 2010). By viewing firms as selected by and influencing the economic and socio-political environments, the proposed conceptual framework implicitly adopts an evolutionary perspective to view the construction industry. Another key feature of the MLP is that it interprets transition processes in a hierarchical way, with the niche, regime and landscape being the micro-, meso- and macro-level descriptions of societal processes (Markard et al., 2012). It has been explained in Chapter 3 that sustainability transition is an emerging research field in which new approaches constantly appear. Even though the MLP and the associated evolutionary perspective dominate the current discussions on sustainability transitions, there are other approaches that adopt a fundamentally different perspective to view transitions from the MLP. Jørgensen (2012), for instance, proposed an alternative arena of development (AoD) approach as a framework to study transitions based on the relationism ontology which conceptualizes the world as "flat" and refuting the notion of structural levels (Geels, 2010). It challenges the idea of selection environments implied by the MLP and the TEF by flattening distinctions between agency and structure, based on the notion that actors involved in transitions are simply part of ongoing entanglements (Garud and Gehman, 2012). Under the flat ontology, sustainability transitions are no longer a matter of shifting from one equilibrium state to another, but a far more fluid transformation process where the old and new become entangled (Garud and Gehman, 2012). The actor network theory (ANT) is developed based on the flat ontology (Latour, 1987), and Genus and Coles (2008) argued that ANT could provide a useful approach to examine sustainability transitions. However, considering that the approaches based on the flat ontology are still in the stage of theoretical development and have not been widely utilized in empirical studies, the dominant hierarchical interpretation, namely, the MLP was adopted in this study. Future studies could explore how transitions could be explained by the ANT or other methods based on the flat ontology, and how these approaches based on the flat ontology could be adopted to study the sustainability transition of the construction industry.

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Appendix A: Online questionnaire (in Chinese)

中国建筑业可持续转型问卷调研

尊敬的问卷调研参与者，

您好！

我是澳大利亚阿德莱德大学建筑与建设环境学院的在读博士生。很高兴将我的研究工作与阁下交流，并希望得到您的支持。

我的研究题目是推动中国建筑业的可持续发展：一个转型视角。可持续发展强调一个社会经济系统在经济，社会与环境三大维度上的协调发展。本研究旨在系统的分析中国建筑业的可持续性问题，包括中国建筑企业的关键可持续因素，在中国建筑业推进可持续性的驱动因素和障碍等。由于目前政府强烈推动建筑业向可持续方向发展，本研究旨在对未来的政策制定以及企业决策提供参考。

为了推动可持续性在中国建筑业的发展，获得建筑企业对可持续转型的理解的实证信息十分必要。 因此我邀请您参与这次问卷调查，完成本问卷大约用时20分钟。您被邀请的原因是我们认为您在建筑行业有相关工作经验。如您填写本问卷，则默认您同意我们将您填写的信息用于科学研究。本次问卷调研获得的数据将会被我们匿名编码，您不需要填写您的名字。本调研已经被阿德莱德大学人类研究与伦理委员会批准 (批准号 H-2014-255)。如您需要联系我们，请发送邮件至以下联系人。

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第一部分: 基本信息

本部分旨在调查您以及您工作企业的基本信息。请选择符合您情况的选项。

1.1. 请问您所在的企业去年（2014）的营业收入是多少？ *

- ○ 营业收入≤2千万
- ○ 2千万 < 营业收入≤2亿
- ○ 2亿 < 营业收入≤15亿
- ○ 15亿 < 营业收入

1.2. 您在建筑工程类企业的工作经验是(年)？ *

- ○ 1-5年
- ○ 6-10年
- ○ 11-15年
- ○ 16-20年
- ○ 大于20年

1.3. 您在企业的工作岗位是？ *

○ 造价与监理人员　○ 项目管理人员　○ 设计人员
○ 工程技术人员　○ 企业管理人员　○ 其他 ________ *

1.4. 您所在企业的业务范围是什么？ * [多选题]

☐ 施工
☐ 设计与规划
☐ 项目管理、造价、监理、咨询
☐ 工程投资开发
☐ 其他 ________ *

下一页

第二部分: 中国建筑企业可持续发展关键因素调查

本研究已识别出29项影响建筑企业可持续发展的关键因素。请您根据自己的理解，对这些因素的1）您认为的重要程度；2）您所在企业在这些方面的表现，进行评估打分。请按下面说明选择您认为合适的分数。

• 重要程度打分
1-极不重要；2-不重要；3-中等重要；4-重要；5-极重要

• 企业表现评估
1-差；2-较差；3-中等；4-较好；5-好 *

	您认为的重要程度打分	您所在企业在这些方面的表现打分
经济		
企业战略	请选择	请选择
质量管理	请选择	请选择
供应链管理	请选择	请选择
创新系统	请选择	请选择
公司治理	请选择	请选择
客户服务	请选择	请选择
沟通管理	请选择	请选择
战略联盟	请选择	请选择
风险管理	请选择	请选择
	您认为的重要程度打分	您所在企业在这些方面的表现打分

社会		
职业健康与安全	请选择	请选择
员工教育培训	请选择	请选择
薪酬福利	请选择	请选择
反腐败与公平竞争	请选择	请选择
注重人权	请选择	请选择
促进社区发展	请选择	请选择
遵纪守法	请选择	请选择
关怀员工	请选择	请选择
促进行业发展	请选择	请选择
	您认为的重要程度打分	您所在企业在这些方面的表现打分
环境		
环境管理制度	请选择	请选择
施工废料管理	请选择	请选择
土地利用效率	请选择	请选择
节约水资源	请选择	请选择
节约建材	请选择	请选择
节约能源	请选择	请选择
保护生态多样性	请选择	请选择
减少灰尘废气排放	请选择	请选择
绿色技术创新	请选择	请选择
控制施工光污染	请选择	请选择
控制施工噪音	请选择	请选择

您认为还存在哪些上述表格里没有提到的因素会影响企业的可持续发展？ *

第三部分：中国建筑业可持续转型动力与阻力评估

推动中国建筑业可持续发展势必面临一系列动力与阻力。本部分列出关于建筑业可持续发展动力与阻力的代表性观点。请您按下列说明选择您认为合适的分数。

• **认同度打分**
1-很不认同；2-不认同；3-较认同；4-认同；5-非常认同

3.1) 中国建筑业可持续发展转型首先需要明确发展规划与愿景，请对下列关于可持续发展规划与愿景的说法进行评估。 *

	1	2	3	4	5
1. 建筑业利益相关者对建筑业的社会责任及企业价值主观理解不同。	○	○	○	○	○
2. 建筑业内缺少关于可持续发展的标杆企业。	○	○	○	○	○
3. 政府缺少对建筑业可持续发展的政治目标及战略规划。	○	○	○	○	○
4. 建筑业的行业协会聚集众多企业，对形成可持续发展的共识具有重要作用。	○	○	○	○	○

3.2) 推动中国建筑业可持续发展需要破旧立新，学习并采用新技术，新模式。请对下列关于学习创新的说法进行评估。 *

	1	2	3	4	5
1. 可持续发展的技术创新很难被学习。	○	○	○	○	○
2. 采用新技术带来的技术风险削弱了建筑企业可持续转型的积极性。	○	○	○	○	○
3. 开发可持续项目可能需要更长工期。	○	○	○	○	○
4. 采用新技术增加建筑企业对项目后期的维护责任。	○	○	○	○	○
5. 采用新设计，材料与技术增大建筑企业投资。	○	○	○	○	○
6. 有关可持续发展的评价工具仍不够完善。	○	○	○	○	○
7. 实施可持续发展的建筑企业由于注重节能节水节材等措施，降低了资源费用，因此建筑业会积极推动可持续性。	○	○	○	○	○
8. 通过实施可持续发展战略可以提高企业形象及获得经济利益。	○	○	○	○	○
9. 推动可持续发展的技术创新需要各种资源与信息，而目前缺少获得这些资源的渠道。	○	○	○	○	○

下一页

3.3) 推动建筑业可持续转型需要政府、企业等形成合力推动创新的应用。请对下列关于行业合作的说法进行评估。 *

	1	2	3	4	5
1. 政府为推动建筑业可持续转型的经济激励措施仍然力度不够。	○	○	○	○	○
2. 政府为推动建筑业可持续转型的各种支持政策变化过快，缺乏连贯性与稳定性。	○	○	○	○	○
3. 政府为推动建筑业可持续转型的各种支持措施过于复杂，实施效率低。	○	○	○	○	○
4. 缺少为建筑业可持续转型提供资源的配套企业，如新型建材制造商与供应商等。	○	○	○	○	○
5. 各种可持续示范项目推广了可持续发展理念在建筑业的应用。	○	○	○	○	○
6. 行业协会或关于可持续发展的行业会议推广了可持续发展理念在建筑业的应用。	○	○	○	○	○

下一页

3.4) 建筑业的可持续发展转型势必会挑战传统模式，触及保守势力。请对下列关于传统模式的说法进行评估。 *

	1	2	3	4	5
1. 金融企业规避风险的特征决定了他们在项目投资上倾向于支持技术成熟的传统项目。	○	○	○	○	○
2. 建筑业的市场需求偏于单一，主要倾向于价格竞争而不是可持续发展。	○	○	○	○	○
3. 可持续项目具有较高的能源利用效率与较低的运营费用，会为客户带来长期收益，因此这些项目更能吸引客户。	○	○	○	○	○
4. 与其他项目不同的可持续项目具有独特性，会吸引特定投资者和客户。	○	○	○	○	○
5. 由于缺少对可持续性的有关知识，客户很少主动要求提供可持续产品。	○	○	○	○	○
6. 要推动可持续建设，势必会影响专注于传统建设模式的建筑企业的经济利益，因此可持续转型阻力很大。	○	○	○	○	○
7. 建筑业从业人员缺少关于可持续性的知识与理解。	○	○	○	○	○
8. 由于关注于短期的经济效益与成本降低，中国建筑业的创新成果主要都是渐进性的，难以产生突破性创新。	○	○	○	○	○
9. 由于建筑工人专业性较强，往往专注于有限的几种相关操作，因此创新的技术操作难以在项目中推广应用。	○	○	○	○	○
10. 中国建筑业激烈的产业竞争迫使某些企业关注可持续发展战略。	○	○	○	○	○
11. 行业标准尽管规范了建设活动，但全行业实施一个标准也阻碍了创新活动。	○	○	○	○	○
12. 中国过去长期的计划经济体制降低了决策效率与柔性，影响创新政策的实施。	○	○	○	○	○
13. 大多数政策关注于管理违规违法建设企业，而不是鼓励推动行业领先企业。	○	○	○	○	○
14. 社会中存在一些非政府组织，媒体及民众监督推动建筑业的可持续转型。	○	○	○	○	○

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3.5) 建筑业的可持续转型受深层次的文化、环境、经济等宏观趋势影响。请对下列关于宏观趋势的说法进行评估。 *

	1	2	3	4	5
1. 严重的环境问题使公众的环境意识越来越强。	○	○	○	○	○
2. 产业分散使建筑行业形成了保守主义，相互间缺乏信任合作，对行业的可持续转型十分不利。	○	○	○	○	○
3. 建筑行业内企业普遍缺少社会责任的企业文化难以短时间改变。	○	○	○	○	○
4. 越来越高的能源与资源价格会促使建筑企业进行可持续转型。	○	○	○	○	○
5. 中国提出的温室气体排放目标迫使建筑业必须进行可持续转型。	○	○	○	○	○

3.6) 您认为还有哪些没有提到的动力或阻力影响中国建筑业可持续转型？ *

Appendix B: English version of the online questionnaire

Sustainability transition of the Chinese construction industry

Dear participants,

Hello.

I am a PhD student at the School of Architecture & Built Environment, University of Adelaide, Australia. I would like to introduce my research to you, and hopefully obtain your support.

My research topic is "Towards sustainability in the Chinese construction industry: a transition approach". Sustainability calls for the balanced development among the economy, society and environment. My research aims to systematically study the sustainability issues of the Chinese construction industry, including the critical sustainability factors for Chinese construction firms, the drivers for and barriers to promoting sustainability in the Chinese construction industry, etc. Since currently the Chinese government strongly promotes sustainability in the construction industry, this research aims to offer references for policy making and provides guidance for the Chinese construction firms.

To promote sustainability in the Chinese construction industry, it is essential to obtain the empirical information about Chinese construction firms' understanding and strategies to sustainability. Thus, I would like to invite you to participate in this questionnaire survey, which will take approximately 20 minutes to complete. The reason why you are invited is that you have relevant experience in the construction industry. By filling the questionnaire, you give your consent to us to conduct scientific research based on the questionnaire data. The data obtained from this questionnaire survey will be anonymously code-recorded by the researcher. You do not need to give your name when completing the survey. The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2014-255).

For any further information, please feel free to contact:

Ruidong Chang (PhD candidate)
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The University of Adelaide
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Ph. 61 8 83134587; Fax 61 8 83134377
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Part 1: Background Information

This section aims to obtain your general information and the firm that you are working in. Please mark the check box in front of the option you want to choose.

1.1 What is the annual revenue of your firm last year (2014)?

☐ no more than 20 million CNY; ☐ more than 20 million and no more than 200 million CNY; ☐ more than 200 million and no more than 1.5 billion CNY; ☐ more than 1.5 billion CNY

1.2 How long have you been working in the construction industry (years)?

☐ 1-5; ☐ 6-10; ☐ 11-15; ☐ 16-20; ☐ more than 20

1.3 What is your occupation?

☐ quantity surveyors or supervisors; ☐ project managers; ☐ designers; ☐ engineers; ☐ corporate managers; ☐ other (please specify) ____________________

1.4 What is the business type of your firm? (multiple choice)

☐ Construction; ☐ design and planning; ☐ project management, quantity survey, supervision, consultancy; ☐ development and investment; ☐ other (please specify)____________________

Part 2: Critical sustainability aspects for Chinese construction enterprises

This research has identified 29 critical sustainability aspects that impact construction enterprises' sustainability performance. Please according to the following instructions to evaluate 1) the importance degree of; and 2) the performance of your enterprises on these aspects. Please give the score that you think is appropriate.

- **Importance evaluation**

1-very unimportant; 2-unimportant; 3-neutral; 4-important; 5-very important

- **Performance evaluation**

1-very bad; 2-bad; 3-neutral; 4-good; 5-very good

Sustainability dimension	**Critical sustainability aspects**	**Importance evaluation**					**Performance evaluation**				
		1	2	3	4	5	1	2	3	4	5
Economic	Corporate strategy										
	Quality management										
	Supply chain management										
	Innovation system										
	Corporate governance										
	Customer service										
	Communication management										
	Network building										
	Risk management										
Social	Occupational health and safety										
	Education and training										
	Wages and welfare										
	Anti-corruption and fair competition										
	Human rights										
	Supporting community development										
	Obeying laws and regulations										
	Caring for all employees										
	Promoting the development of the industry										
Environmental	Environmental management										
	Construction waste management										
	Land use efficiency										
	Water conservation and harvesting										
	Materials conservation										
	Energy conservation										
	Managing impacts on biodiversity										
	Emission reduction										
	Green innovation and products										
	Light pollution control										
	Noise control										

Besides the factors listed above, are there any other aspects impacting construction enterprises' sustainability ?

Part 3: Drivers for and barriers to sustainability transition of the Chinese construction enterprises

There are various drivers for and barriers to sustainability transition of the Chinese construction enterprises. Please indicate the extent of your agreement with these statements according to the following instructions.

- **Acceptance degree**

1-strongly disagree; 2-disagree; 3-neutral; 4-agree; 5-strongly agree

3.1) Please evaluate the following claims associated with visions and expectations of sustainability innovations.

	Acceptance				
	1	2	3	4	5
1. Stakeholders have different interpretations of construction firms' values					
2. There are few sustainability leaders from whom construction firms could learn					
3. The government does not have a clear political vision and strategic plan					
4. Industry conferences and associations can significantly contribute to form a shared vision					

3.2) Please evaluate the following claims associated with the learning of sustainability innovations

	Acceptance				
	1	2	3	4	5
1. Technological innovations of sustainability generally are difficult to be learned					
2. Technological risks hamper construction firms' motivation to be sustainable					
3. It may take more time to complete the sustainable project					
4. Sustainable technologies induce additional responsibility for maintenance					
5. The adoption of new design, material and technologies induces incremental cost					

6. Assessment tools for sustainability in the industry are far from mature					
7. Through promoting sustainability, construction firms could reduce cost by reducing the consumption of energy, materials and water					
8. Construction firms could gain a good corporate image					
9. It is hard to access various resources and information on sustainability					

3.3) Please evaluate the following claims associated with the networking for sustainability innovations

	Acceptance				
	1	2	3	4	5
1. Economic incentives provided by the government are inadequate					
2. Supporting policies for sustainability lack coherence and stability					
3. Supporting policies for sustainability are too complex and lack efficiency					
4. The number of suppliers and manufacturers of sustainable products is too small					
5. Various sustainable demonstration projects effectively popularize sustainability					
6. Industry associations or conferences effectively popularize sustainability					

3.4) Please evaluate the following claims associated with the established rules and practices

	Acceptance				
	1	2	3	4	5
1. Financial actors have higher willingness to support traditional projects					
2. Market demand focuses on low price rather than sustainability					
3. Improved energy efficiency and lower operational cost attract customers					
4. Uniqueness of sustainable projects attracts investors and customers					
5. Due to the lack of knowledge, clients do not require sustainable projects					

6. Sustainable projects impact on the benefits of the vast number of construction firms which focus on traditional construction works					
7. Employees in the industry lack adequate understanding of sustainability					
8. Innovation in the industry is incremental, driven by short-term cost reduction					
9. Workers have specialised expertise on a limited range of technologies					
10. Fierce competition may encourage some firms to promote sustainability					
11. Construction standards may restrict the possibility of sustainable innovations					
12. Long history of a planning-oriented economy can inhibit efficient decision making, flexibility and innovation					
13. Policy usually focuses on regulating laggards rather than encouraging front runners					
14. Relevant interest groups, the media and NGOs generate pressures					

3.5) Please evaluate the following claims associated with the long-term trends impacting sustainability transitions

	Acceptance				
	1	2	3	4	5
1. Environmental problems raise the public's environmental awareness					
2. Sectoral fragmentation locks in a culture of mutual distrust and conservatism					
3. It is hard to change the lack of social responsibility or environmental values					
4. Rising energy and resource prices trigger firms to promote sustainability					
5. The CO2 emission reduction goal proposed by the government determines that the industry has to transition towards sustainability					

Besides the factors listed above, are there any other drivers or barriers impacting construction enterprises' sustainability transitions?

Appendix C: Ethics approval

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Applicant:	**Professor G Zillante**
School:	**School of Architecture and Built Environment**
Project Title:	**Towards sustainability in the Chinese construction industry: a socio-technical transition approach**

The University of Adelaide Human Research Ethics Committee
Low Risk Human Research Ethics Review Group (Faculty of Humanities and Social Sciences and Faculty of the Professions)

ETHICS APPROVAL No: **H-2014-255** **App. No.: 0000019375**

APPROVED for the period: **18 Nov 2014 to 30 Nov 2017**

Thank you for your responses dated 3.11.2014 and 14.11.2014 to the matters raised.

This study is to be conducted by Ruidong Chang, PhD Student.

PROFESSOR RACHEL A. ANKENY
Co-Convenor
Low Risk Human Research Ethics Review Group (Faculty of Humanities and Social Sciences and Faculty of the Professions)

ASSOCIATE PROFESSOR PAUL BABIE
Co-Convenor
Low Risk Human Research Ethics Review Group (Faculty of Humanities and Social Sciences and Faculty of the Professions)

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Facilitating the transition to sustainable construction: China's policies

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A B S T R A C T

China faces a challenge to balance its future urbanization process with resource conservation and environmental protection. Promoting sustainable construction is identified by the Chinese government as an important strategy to tackle such challenges. To promote sustainable construction, the Chinese government has released a large number of laws, policies and regulations. This paper investigates the policy system in China which aims to facilitate the transition to sustainable construction. The related laws, policies and regulations are analyzed and three main functions are identified, namely regulation and control, economic incentives and supporting activities. The results show that the behaviours of various participants in the construction industry, including the government, developers, builders, suppliers, and designers, are regulated and controlled by these laws and regulations. Subsidy policies, award policies and economic innovation policies are adopted by the government to promote renewable energy applications in buildings and infrastructure construction. The key supporting activities for sustainable construction include strengthening technology innovation, improving standards and evaluation, establishing demonstration projects, and publicity. Two emerging challenges of the current policy system are also identified. They are: a lack of considering social and economic dimensions of sustainable construction, and the ineffectiveness of some key policies such as the environmental impact assessment policy. This paper provides a useful reference for construction corporations and policy makers in China to facilitate sustainable construction in future urbanization process. Similarly, policy makers in other emerging economies can understand how sustainable construction is promoted in China.

1. Introduction

Since the implementation of the opening-up policy in 1979, China's economy has gained a rapid development, with an average annual growth rate of the gross domestic product (GDP) consistently being around 10% in the past three decades (NBS, 2013a). Along with this huge economic expansion also comes rapid urbanization. China's urbanization rate increased dramatically in the past three decades, from only 19% in 1979 to 53.73% in 2013 (Chen et al., 2013; NDRC, 2014). Compared to an average of 78% for high-income countries, China's current urbanization rate is still low (NBS, 2013b). In March 2014, the Chinese central government released the *China's New-style Urbanization Plan (2014–2020)*, revealing an ambitious goal that by 2020 the urbanization rate needs to achieve 60% (NDRC, 2014). The rapid economic development and urbanization process in the past, however, brought about high amount of emissions, tremendous energy consumption and severe environmental problems. Back to 2006, China has surpassed America to become the world's largest CO_2 emitter (IEA, 2013a). Similarly in 2009, China became the world's largest energy consumer, accounting for approximately one fifth of the world's total energy consumption (IEA, 2013b). The environmental pollution in China is also severe, evidenced by the fact that less than 1% of the 500 largest cities in China met the air quality standards recommended by the World Health Organization (Asian Development Bank, 2012). Therefore, it presents a significant challenge to China to balance its future urbanization process with resource conservation and environmental protection.

The Chinese government has recognized this challenge and as a result, many new concepts of sustainable urban development, such as eco-city, low-carbon city and low-carbon eco-city, have been researched and implemented in several regions (Liu et al., 2014). To

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realize these concepts of sustainable urban development, sustainable construction needs to be promoted in the urban development process. The Chinese government has recognized the critical role of sustainable construction in China's future urbanization process, strengthening it in various strategic plans. The *China's New-style Urbanization Plan (2014–2020)* aims to "incorporate the concept of ecological civilization into the construction of cities to conserve land, water and energy, and promote green buildings" (NDRC, 2014). Similarly, the *12th Five-year Plan for Green Building and Low-carbon Urban Development* states that "the basis of promoting green buildings and sustainable urban development is the sustainability transition of the construction industry" (MHUD, 2013a). The *12th Five-year Plan for the Construction Industry* even specified that "energy conservation and emission reduction could become the new growth point of the construction industry" (MHUD, 2011a). Clearly, the Chinese construction industry needs to be transitioned towards sustainability, to support China's future urban development.

To facilitate such a transition, however, is a very complex issue. Some scholars have examined the driving forces and barriers of sustainable construction and a large number of factors have been identified for the adoption of sustainable construction practices. One of the key factors is the government policy. From a driving force perspective, Son et al. (2011) surveyed the constructors from the U.S. and Korea, and discovered that government policies have significant impacts on the sustainability knowledge of constructors. Similarly, Circo (2007) argued that "meaningful progress toward sustainability in the U.S. building industry requires state-level legislation that promotes, and sometimes even mandates, green building standards at the regional and local levels." In the UK, Elmualim et al. (2012) found that legislation is the most important driver for the implementation of sustainable practices. In the context of China, Qi et al. (2010) demonstrated that government regulatory pressures and managerial concerns are the two most important driving forces of green construction. Similarly, Zhang and Zhou (2016) argued that carbon reduction regulations positively correlate with Chinese construction contractors' carbon reduction awareness and behaviours. The important role of policy in providing financial incentives and promoting green procurement was also illustrated by Shi et al. (2013) and Gan et al. (2015). From a barrier perspective, the lack of financial incentives from the government is found to be a prominent barrier of sustainable construction in Chile (Serpell et al., 2013). Similarly, Zhang et al. (2012) found that in China, the lack of promotion and incentives from governments is one of the most crucial barriers to the implementation of extensive green roof features in buildings.

To promote sustainability in the construction industry, the Chinese government has developed and implemented a number of laws, regulations and policies, such as *Environmental Impact Assessment Law* (NPC, 2002), *Regulation on Energy Conservation in Civil Buildings* (SCC, 2008a) and *Action Plan for Promoting Green Buildings* (NDRC and MHUD, 2013). In spite of this, little work has been undertaken to investigate the actual laws, regulations and policies used by governments to promote sustainable construction. This paper is intended to systematically explore and evaluate the policy system, including relevant laws, regulations and policies, developed to promote sustainable construction in China. Since China has one of the largest construction industries in the world, a study of the policy system to facilitate the transition to sustainable construction in China will offer a valuable lesson for other emerging economies. To begin, recent attempts to achieve sustainable construction will be discussed in Section 2, followed by the introduction of methods employed in this study in Section 3. Detailed discussions on China's policy system for sustainable construction will be provided in Section 4. Emerging challenges facing the policy system will then be explored in Section 5, with Section 6 concluding this article.

2. The transition to sustainable construction in China

Following the commitment to move towards "sustainable development", historically marked by the release of the Brundtland Report (1987), the concept of "sustainable construction" emerged. Similar to "sustainable development", "sustainable construction" also covers three main domains: environmental protection, social well-being and economic prosperity (Tan et al., 2011). More specifically, it focuses on the application of sustainable development principles to the comprehensive construction cycle, from the extraction of raw materials, through the planning, design and construction of buildings and infrastructure, until their final deconstruction and management of the resultant waste (Tan et al., 2011; Zainul Abidin, 2010).

The sustainability performance of the Chinese construction industry needs to be largely improved, illustrated by various studies. For instance, Xue et al. (2014) measured the changing energy consumption efficiency of the Chinese construction industry from 2004 to 2009, and found that only the industry in one province, i.e. Guangdong, demonstrated effective energy improving in the whole reference period. It has also been discovered that the sustainability awareness of most Chinese construction corporations is low. For instance, Qi et al. (2010) identified eleven green construction practices and discovered that only 2.44% of the surveyed Chinese contractors undertook all the mentioned sustainability practices. Similarly, Zuo et al. (2012) pointed out that among the world's top 50 international contractors, most Chinese contractors do not have dedicated websites on sustainability, while all Japanese contractors have websites addressing sustainability issues.

To promote sustainable construction, the Chinese government has introduced various policies and regulations. Under the stimulus provided by these policies, the industry is experiencing a transition towards sustainability. Recent years have seen the dramatic growth of green buildings built in China, as shown in Fig. 1. Since 2006, China has introduced a Three Star evaluation system to assess the sustainability levels of green buildings (MHUD and AQSIQ, 2006). This system evaluates and rates building designs in six categories, namely land savings and outdoor environment, energy savings, water savings, material savings, indoor environment quality, and operation management (MHUD and AQSIQ, 2006). Based on the score received in each category, a building design can be rated as

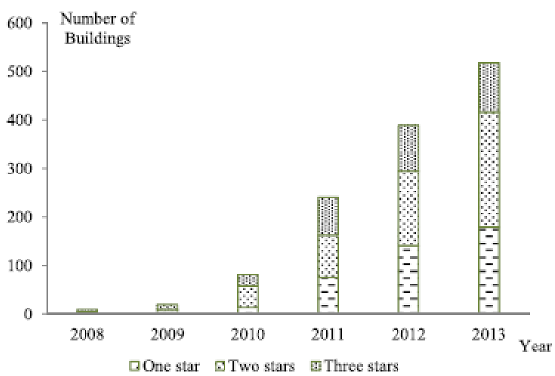

Fig. 1. Newly constructed 'green' buildings per year in China.

Table 1
China's policy system for sustainable construction.

Types	Items	Issued by department/year of publication
Framework policies	1. 12th five-year plan for energy conservation and emission reductions	SCC/2012
	2. 12th five-year plan for the construction industry	MHUD/2011
	3. Environmental protection law	NPC/2007
	4. Energy conservation law	NPC/2007
	5. Renewable energy law	NPC/2005
	6. Law on prevention and control of environmental pollution by solid waste	NPC/2004
	7. Environmental impact assessment law	NPC/2002
Supporting regulations	8. Regulation on the construction of barrier-free environments	SCC/2012
	9. Regulation on energy conservation in civil buildings	SCC/2008
	10. Regulation on energy conservation in state-funded institutions	SCC/2008
	11. The administrative regulation on the work safety of construction projects	SCC/2003
	12. The administrative regulation on the environmental protection of construction projects	SCC/1998
Specific instructions	13. Circular of the State Council on strengthening urban infrastructure	SCC/2013
	14. Notice on the implementation of green affordable housing	MHUD/2013
	15. Circular of the State Council on accelerating the development of the environmental production industry	SCC/2013
	16. 12th five-year plan for green building and low-carbon urban development	MHUD/2013
	17. Action plan for promoting green buildings	NDRC, MHUD/2013
	18. Opinions on accelerating green building development	MOF, MHUD/2012
	19. 12th five-year plan for technology development of green buildings	MOST/2012
	20. Notice on organizing the demonstration of photovoltaic applications in buildings in 2012	MOF, MHUD/2011
	21. Notice on organizing the demonstration of renewable energy applications in buildings in 2012	MOF, MHUD/2011
	22. Notice on further promoting renewable energy applications in buildings	MOF, MHUD/2011
	23. Notice on the organization and implementation of the demonstration of photovoltaic applications in buildings	MOF, MHUD/2011
	24. Opinions on accelerating the implementation of photovoltaic applications in buildings	MOF, MHUD/2009
	25. Interim measures on the management of the subsidies for photovoltaic applications in buildings	MOF/2009
	26. Bulletin of promoted, restricted and prohibited technologies in the construction industry	MHUD/2007
	27. Interim measures on the management of the special funds for renewable energy applications in buildings	MOF, MHUD/2006

Abbreviations: SCC – State Council of China; MHUD – Ministry of Housing and Urban–Rural Development; NPC – National People's Congress of China; NDRC – National Development and Reform Commission; MOF – Ministry of Finance; MOST – Ministry of Science and Technology.

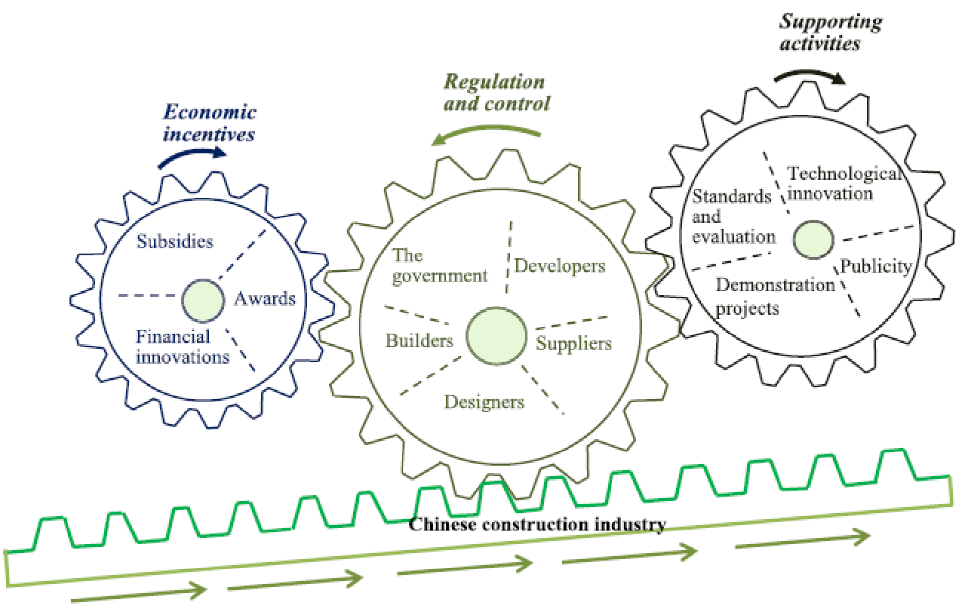

Fig. 2. A policy gear model of sustainable construction in China.

Since the central and local governments have the right to approve construction projects, the approval practices must be regulated and controlled. *Energy Conservation Law* stipulates that if the design documents of the construction projects do not comply with mandatory energy standards, the government cannot issue the construction permits (NPC, 2007). Before issuing construction permits, the government also needs to examine whether safety measures are planned for the construction. If the construction permits are issued to unprepared builders, the corresponding officers in the government will be punished (SCC, 2003).

Table 2
Key policies of regulation and control for sustainable construction.

Participants	Key policies of regulation and control	Policy source
The governments	• Must not approve project plans which are not in accordance with the compulsory energy standards.	Energy Conservation Law
	• Need to examine whether safety measures are planned by builders for the construction.	Administrative Regulation on the Work Safety of Construction Projects
	• The construction of unrealistic "image projects" and "achievement projects" should be forbidden and the actual economic and social conditions of cities must be considered in urban planning.	Circular of the State Council on Strengthening Urban Infrastructure
	• The governments above the county level are responsible for preparing and implementing a development plan of barrier-free environment for disabled people.	Regulation on the Construction of Barrier-free Environments
Developers	• Need to prepare an environmental impact assessment document for the proposed project.	Environmental Impact Assessment Law
	• Must arrange solid waste management facilities, which must be designed, constructed and put into place along with the main project.	Law on Prevention and Control of Environmental Pollution by Solid Waste
	• If the project has the potential to produce huge negative impacts on the environment and the public, the developers must arrange hearings or other forms of meetings to acquire expert and public opinions about the proposed project.	Environmental Impact Assessment Law
Builders	• Must effectively remove the construction waste they generate.	Law on Prevention and Control of Environmental Pollution by Solid Waste
	• The materials and equipment delivered to the construction site need to be checked to see whether they comply with the energy conservation requirements indicated by the design documents.	Regulation on Energy Conservation in Civil Buildings
	• Safety accountability systems and safety education systems should be established, and safety management personnel should regularly conduct safety checks and make safety inspection records.	Administrative Regulation on the Work Safety of Construction Projects
Designers	• Should obey relevant compulsory energy standards.	Energy Conservation Law
Suppliers	• The Ministry of Housing and Urban–Rural Development (MHUD) regularly publishes technology catalogues, showing which technologies in the construction industry are promoted, restricted or prohibited by the government.	Bulletin of Promoted, Restricted and Prohibited Technologies in the Construction Industry

Apart from project approval, the government is also responsible for urban planning. Recent years have seen the continuous emergence of luxurious public buildings and government office buildings in China. In 2013, the State Council of China (SCC) issued *Circular of the State Council on Strengthening Urban Infrastructure*, which forbids the construction of unrealistic "image projects" and "achievement projects" (SCC, 2013b). Similarly, the rights of vulnerable groups, such as the disabled people, are also given some attention in urban planning, indicated by some policies such as *Regulation on the Construction of Barrier-free Environments* (SCC, 2012b). This regulation stipulates that if the public buildings, public transport facilities and residential areas, which are already built, do not meet relevant accessibility standards, the governments shall be responsible for organizing the renovation of these facilities, which can be incorporated into the local social and economic development plan (SCC, 2012b).

Developers are crucial actors in the construction industry since their project requirements usually have to be met. However, developers' needs must not be harmful to the public and the environment. Therefore, the government issued some polices to clarify the obligations of developers, mainly concerned with the environmental dimension of sustainable construction, such as preparing environmental impact assessment document (NPC, 2002); arranging solid waste management facilities (NPC, 2004); and organizing meetings to acquire expert and public opinions about the proposed project (NPC, 2002). Similarly, the importance of Builders in contributing to sustainable construction is emphasized by the policies, since good design and plans of projects need to be correctly implemented in the construction process. Besides removing construction waste, builders also need to check the materials and equipment delivered to the construction site (SCC, 2008a), and establish safety management systems (SCC, 2003).

Compared to developers and builders, designers and suppliers receive much less attention. For designers, fulfilling the requirements of compulsory energy standard is important, since according to *Energy Conservation Law*, if they seriously violate the building energy standards, their level of qualification maybe lowered and their qualification certificates may even be revoked (NPC, 2007). For suppliers, one important policy is the "technology promotion, restriction and prohibition policy". According to the latest technology catalogue published by the MHUD, there are: 1) 326 promoted technologies, such as mineral wool insulation technology and planted roof technology; 2) 37 restricted technologies, such as slurry wall insulation material and spiral plate heat exchanger, and 3) 32 prohibited technologies, such as grey cast iron long wing radiator and slate knife switch (MHUD, 2007). Suppliers should therefore pay attention to these policies and adjust their production direction accordingly.

4.2. Economic incentives

Besides regulation and control, which prevent the misbehaviour of the participants in the construction industry, the central government also tries to encourage the construction corporations to actively transition themselves to more sustainable corporations, mainly through a series of economic incentive policies, providing subsidies, awards and innovative financing solutions (MOF, 2009; MHUD and MOF, 2012; SCC, 2013b).

4.2.1. Subsidies

In 2006, the Ministry of Finance (MOF) and the MHUD jointly released the *Interim Measures on the Management of the Special Funds for Renewable Energy Applications in Buildings*, which is the first policy on subsidy for sustainable construction issued by the central government. This policy indicates that the two ministries determine the subsidy values for different kinds of renewable energy applications in buildings each year, considering various factors such as the incremental cost, market price fluctuation and technical sophistication of the applications (MOF and MHUD, 2006). Subsidies are also provided to support research and development of key technologies, energy efficiency testing and improving technical standards around renewable energy applications in buildings (MOF and MHUD, 2006).

Since 2006, the government further released many regulations strengthening the subsidies for renewable energy applications in buildings. In 2011, *Notice on the Organization and Implementation of the Demonstration of Photovoltaic Applications in Buildings* was issued. According to this document, 50% of the bid price of the key components, such as the crystalline silicon components, grid inverters and energy storage lead-acid batteries, will be paid directly by the local finance department to the suppliers (MHUD and MOF, 2011d). Also issued in 2011, *Notice on Organizing the Demonstration of Photovoltaic Applications in Buildings in 2012* indicates that to support the large-scale application of photovoltaic systems in buildings, the central government encourages the local governments to develop green urban areas, where the photovoltaic systems need to be extensively adopted (MHUD and MOF, 2011b).

4.2.2. Awards

The government subsidies mainly provide financial support for renewable energy applications in buildings, while a broader concept of "green building" seems to be neglected by subsidy policies. In order to provide monetary support to green buildings, the MOF and the MHUD jointly released *Opinions on Accelerating Green Building Development* in 2012. This document indicates that the central government will establish a monetary award system for high-rated green buildings. According to this policy, in 2012 developers of Two Stars buildings received an award of 45 Yuan/m^2 and developers of Three Stars buildings received an award of 80 Yuan/m^2 (MHUD and MOF, 2012). The amount of the award will be adjusted based on the cost fluctuation and the situation of technology improvement annually (MHUD and MOF, 2012). Apart from the awards provided by the central government, some local governments also offer awards to green building developments. For instance, in Shandong province, One Star green buildings can receive an award, which is 15 Yuan/m^2 (The Public Daily, 2013).

4.2.3. Financial innovations

The construction of infrastructure often needs large investment, which traditionally comes from the government. Driven by the rapid urbanization process in China, the amount of infrastructure projects that need to be built are increasing dramatically and it is unsustainable that the government continues to be the sole investor. In order to alleviate the monetary pressure the government was facing, in 2013 the SCC issued *the Circular of the State Council on Strengthening Urban Infrastructure*, which indicates that the government will establish a sustainable investment and financing system for urban infrastructures by attracting private capital (SCC, 2013b). Modern project financing approaches, such as build-operate-transfer, build-own-operate-transfer, and build-own-operate, will be strongly promoted to increase the economic sustainability of infrastructure projects (SCC, 2013b). In addition, other financial innovations will also be examined to further support sustainable construction. For instance, it will be explored whether a private company's concessions from the government can be regarded as collateral for business loans (SCC, 2013a).

4.3. Supporting activities

While economic incentives may encourage corporations to start a sustainability transition, other obstacles still remain, such as lack of core technologies, lack of relevant standards, low awareness of green buildings among the public and lack of evaluation methods of sustainable construction. The Chinese government has recognized the existence of these obstacles and has issued a number of policies and regulations trying to reduce and eventually eliminate them.

4.3.1. Technological innovation

Issued in 2012 by the Ministry of Science and Technology, the *12th Five-year Plan for Technology Development of Green Buildings* offers comprehensive technology development strategies for green buildings. According to this document, three major areas of technologies are considered to be important and the research relating to these areas will be strongly supported by the government (MOST, 2012). These technologies are summarized in Fig. 3. Various aspects of sustainable construction, such as planning and design, construction, assessment, and information systems, are supported by the technology development plan.

The objective of innovative technology development in China is to improve the sustainability level of the Chinese construction industry. Among the technologies listed in Fig. 3, the research of the "technical information service system for green buildings" is very important and strongly supported by the government. Since there are many green technologies available, the holistic sustainability assessment of the technologies plays a crucial role in informing developers to choose the appropriate technology for their projects (Huang et al., 2012). Similar to the function of the BAT (Best Available Techniques) Reference Document (BREF) in guiding the technology development in European construction industries, this information service system in China will summarize and compare different materials and technologies for various kinds of construction projects, helping developers to choose appropriate technologies for their projects.

The *12th Five-year Plan for Technology Development of Green Buildings* indicates that in order to implement the technology development plan, six measures needs to be taken, namely 1) strengthening the sectoral coordination among relevant governmental departments; 2) establishing state key laboratories and research centres of green buildings; 3) supporting enterprises to increase research & development in green buildings; 4) improving the awareness of corporate social responsibility in construction corporations; 5) promoting international exchanges and cooperation; and 6) gradually establishing long-term mechanisms supporting the technology development of green buildings (MOST, 2012).

4.3.2. Standards and evaluation

The standards for sustainable construction in China have undergone a significant improvement during recent years. Table 3 summarizes the main sustainable construction standards which respond to the sustainability issues in various phases of construction projects. Among the listed standards, two standards are related to the design phase, i.e. *Design Standard for Energy Efficiency of Public Buildings*, and *Green Design Standard of Civil Buildings* (MHUD, 2010a; MHUD and AQSIQ, 2005). The other 4 standards regulate the construction and operation phases. Many articles in these standards are compulsory which help to provide the impetus for sustainable construction in China. For instance, the *Technical Code for Construction & Demolition Waste Treatment* has four compulsory articles, such as the requirement to cover construction waste during transportation, and the requirement to not deliver domestic garbage and hazardous waste to construction waste landfill and

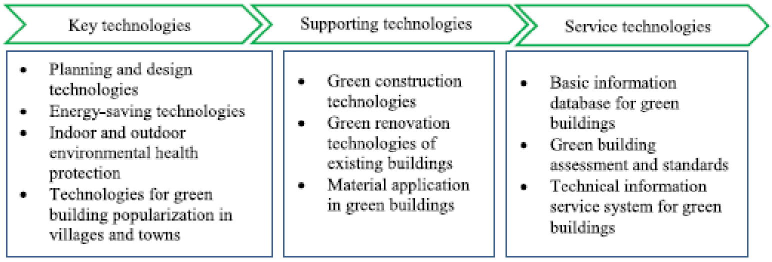

Fig. 3. China's technology development plan for green buildings.

Table 3
The main sustainable construction standards in China.

Serial number	Standard	Effective date
JGJ59-2011	Standard of construction safety inspection	1st July 2012
JGJ/T264-2012	Code for operation and maintenance of building mounted photovoltaic system	1st May 2012
GB/T 50640-2010	Evaluation standard for green construction of buildings	1st October 2011
JGJ/T229-2010	Green design standard of civil buildings	1st October 2011
CJJ134-2009	Technical code for construction & demolition waste treatment	1st July 2010
GB 50189-2005	Design standard for energy efficiency of public buildings	1st July 2005

recycling sites (MHUD, 2009b). The *Standard of Construction Safety Inspection* stipulates that construction corporations which do not meet safety inspections must take measures to rectify the problems within the specified time (MHUD, 2011b).

The evaluation system of green buildings in China has also experienced a significant improvement as shown in Fig. 4. The development of China's green building evaluation system can be divided into three stages. Firstly in 2006, the MHUD and the General Administration of Quality Supervision, Inspection and Quarantine released the *Evaluation Standard for Green Building*, which has been used to evaluate normal residential and business buildings. According to this document, a Three Star system is used to assess the greenness degree of buildings and six categories of indicators are used to evaluate the buildings, namely: (1) land conservation and outdoor environment, (2) energy conservation and application, (3) water conservation and application, (4) material conservation and application, (5) indoor environmental quality and (6) operation management (MHUD and AQSIQ, 2006). Then from 2007 to 2009, several supplementary documents were issued to refine the evaluation standard, and two kinds of assessment were differentiated, i.e. green building planning and design evaluation, which is for the projects in the design phase, and green building operation evaluation, which is for completed projects (MHUD, 2008, 2009a). The third stage begins with the issue of the *Guidelines for Green Industrial Building Evaluation*, which enriches the building types that can be evaluated (MHUD, 2010b). Besides industrial buildings, high-rise buildings and affordable housing are specifically given attention by the government (MHUD, 2012, 2013c).

Compared to other evaluation tools, the Three Star system in China is more controllable by the government. Mao et al. (2009) argue that the cultural and political diversities between the East and the West lead to the difference in the organizations providing the rating tools for green buildings. The Leadership in Energy & Environmental Design (LEED) and Building Research Establishment Environmental Assessment Methodology (BREEAM) rating tools, originated in the U.S. and UK respectively, were established by organizations independent from the government (Mao et al., 2009). By contrast, the Three Star system in China and the Green Mark in Singapore were both developed by relevant governmental departments. The Three Star system in China is even formalized as a national standard by the Chinese government. As a result, the rating system forms an integral part of China's supporting policies for sustainable construction.

4.3.3. Demonstration projects

The Chinese government also made efforts to popularize sustainable construction through the use of demonstration projects. In 2012, two important documents were issued concerning demonstration projects, namely *Notice on Organizing the Demonstration of Photovoltaic Applications in Buildings in 2012* and *Notice on*

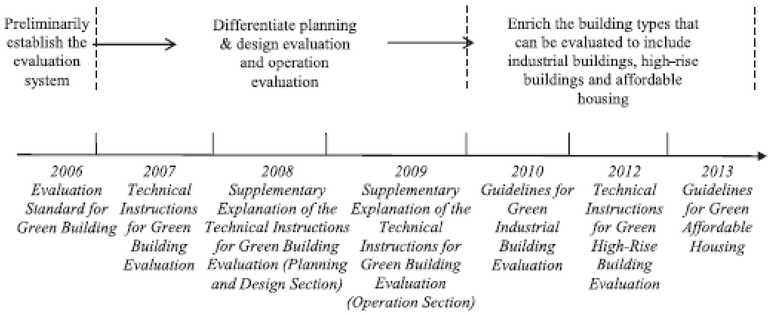

Fig. 4. The major governmental documents for green building evaluation.

Organizing the Demonstration of Renewable Energy Applications in Buildings in 2012 (MHUD and MOF, 2011b, c). Under the impetus of these policies, a few provinces, cities, counties and urban areas became concentrated areas of demonstration projects. For instance, in 2012, eight provinces, such as Jiangsu, Qinghai and Xinjiang, became photovoltaic building demonstration provinces, and a total of 21 cities and 52 counties were determined to be renewable energy building demonstration cities and counties respectively (MHUD, 2013b). Eight urban areas were selected as green urban areas, such as Zhongxin district in Tianjin and Guangming district in Shenzhen (MHUD, 2013b).

Demonstration projects in China include not only renewable energy applications in buildings and green buildings, but also the projects which are built through green construction methods. Under the guidance of the MHUD, China Construction Industry Association has selected three batches of green construction demonstration projects, including 11 projects in the first batch, 81 projects in the second batch and 278 projects in the third batch, distributed in 21 provinces (CCIA, 2011, 2013). By illustrating new building and construction techniques based on sustainability principles, these demonstration projects largely improve the awareness of sustainable construction in the industry.

4.3.4. Publicity

Strengthening the publicity campaign has been covered by many policies. The *Circular of the State Council on Accelerating the Development of Environmental Production Industry* stipulates that the local governments need to publicize the concept of ecological civilization and spread the knowledge of energy saving and low-carbon lifestyle to gradually trigger the formation of low-carbon production and consumption in the public (SCC, 2013a). The *Action Plan for Promoting Green Buildings* mentions that the concept of green buildings needs to be strongly propagated in the National Energy Conservation Week, Science and Technology Week, World Water Day and World Environment Day (NDRC and MHUD, 2013). This action plan suggests that various aspects around green buildings should be propagated, such as green building regulations, economic incentive policies of green buildings, and the advantages of green buildings (NDRC and MHUD, 2013). The *12th Five-year Plan for Green Building and Low-carbon Town Development* indicates that the government needs to take full advantage of various media, such as television, newspapers and the internet, to publicize the advantages and urgency of promoting green buildings (MHUD, 2013a).

5. Discussion: emerging challenges

The current policies provide strong stimulus for the Chinese construction industry to transition towards sustainability. However, challenges of these policies still exist. This paper identifies two prominent challenges, concerning the economic and social dimensions of sustainable construction, and effectiveness of the current policies.

5.1. Economic and social dimensions of sustainable construction

Sustainable construction practices pursue a balance among economic, social, and environmental performance in implementing construction projects (Shen et al., 2010). Thus, a well-developed policy system for promoting sustainable construction should balance various dimensions such as economic, social and environmental. However, this study revealed that the current policies related to sustainable construction in China heavily focus on the environmental aspects of sustainable construction, such as popularizing green buildings, promoting renewable energy applications in buildings, requiring energy conservation, and regulating solid waste management practices of construction corporations. By contrast, economic and social dimensions of sustainable construction receive much less attention from the policies. It has been argued that there is lack of a coherent national policy framework that integrates multiple objectives of sustainability underlying the development of the building sector in China (Li and Shui, 2015). Specifically, even though safety management and modern project financing approaches are paid attention by the policies, a large number of other social and economic factors are ignored, such as cultural and heritage conservation, local community engagement, financial affordability and economic impacts for the public.

It is well recognized that more social factors should be considered in future policy making. According to Hill and Bowen (1997), there are some main social principals of sustainable construction, such as improving human health through a healthy and safe working environment, implementing skills training and capacity enhancement of disadvantaged people, and seeking equitable distribution of the social benefits of construction. These important social principals should be highlighted in future policies. Similarly, more research should be conducted to examine the impacts of implementing sustainability practices on the economic competitiveness of construction corporations in China, since traditionally profit-driven culture is dominant in the industry and cost, quality and schedule have been the determinants ensuring maximum benefits to the construction business (Shen et al., 2010). Tan et al. (2015) did a preliminary study which revealed the complex interrelationships exist between sustainability performance and business competitiveness of international construction contractors. The issue of how sustainability practices affect cost, quality and schedule of construction projects, especially in the China context, could be further explored to inform future policy making targeting on the economic dimension of sustainable construction in China.

5.2. Effectiveness of the current policies

During the implementation of the current policies, some doubts gradually emerged among the public questioning the effectiveness of some policies. For instance, because little attention is given to regional differences of economic development by the current green building evaluation standards, it has been reported that for advanced cities in China such as Beijing and Shanghai, the requirements of the evaluation standards are too low and many developers can easily meet the standards, while for regions where economic development is lagging behind such as Guizhou and Gansu, the requirements in the standards are too high and few developers can meet the standards (EID, 2010). Similarly, China is a vast country with various climate zones, leading to the needs of setting up different energy saving standards for construction projects in different regions as well (Huang et al., 2016). Furthermore, *Environmental Impact Assessment Law* stipulates that the developers must arrange hearings or other forms of meetings to acquire expert and public opinions about the proposed project (NPC, 2002). However, the public's access to environmental information of large construction projects is still restricted and developers usually take the form of only consulting experts to fulfil the requirements of the law (Li et al., 2012).

In the future policy revision and making process, these negative feedbacks from the public should be given enough attention. To support the future revision work of the current green building evaluation standards, a multi-dimensional post occupancy evaluation of existing green buildings should be conducted to investigate and research the geographical distribution of the buildings, the users' feedbacks, the actual environmental performances of the buildings, the economic performance of the buildings and the developers' experience and attitudes about developing green buildings. Similarly, detailed polices are required to improve the public participation in the environmental impact assessment process of construction projects. The legal obligations of the government and developers for organizing public participation should be researched and determined (Li et al., 2012). The supervision of the participatory process and the penalty for inappropriate activities during the process, such as bribing the representatives of the public, should be reflected in future policies.

6. Conclusions

To respond to severe environmental problems, the Chinese government needs to promote sustainable construction in its future urbanization process. This paper identifies a total of 27 important policies in enabling the transition to sustainable construction in China. They are further divided into three categories, namely framework policies, supporting regulations and specific instructions. In order to show how these different policies join together to generate effective driving forces for sustainable construction, a policy gear model (see Fig. 2) is proposed which illustrate three important measures of the policy system, i.e. regulation and control, economic incentives and supporting activities.

The behaviours of various participants in the construction industry, including the government, developers, builders, suppliers, and designers, are regulated and controlled by a number of laws and regulations, such as *Energy Conservation Law*, *Administrative Regulation on the Work Safety of Construction Projects*, and *Environmental Impact Assessment Law*. A series of economic incentive policies are also introduced, including subsidy policies, award policies and financial innovation policies. Subsidy policies are mainly used to promote renewable energy applications in buildings while green buildings are mainly promoted by the award policies. Financial innovation policies are introduced to enhance the economic sustainability of infrastructure construction. The government has also conducted many supporting activities to enable the transition to sustainable construction, including (1) technology innovation, which is strengthened and planned by *12th Five-year Plan for Technology Development of Green Buildings*; (2) standards and evaluation, which are largely developed by the government; (3) demonstration projects, which experience a significance increase during recent years, and (4) publicity, which is strengthened by some polices to increase the awareness of sustainable construction among the public.

To further improve the current policy system for sustainable construction in China, it is recommended that more social factors should be considered in future policy making. It is also suggested that more research should be conducted to investigate the impact of implementing sustainability practices on the economic competitiveness of construction corporations in China. In addition, in the future policy revision process policy makers should consider and respond to the critiques from the public about lack of consideration of the regional differences in the current green building evaluation system, as well as the low level of public participation in the environmental impact assessment of construction projects.

This paper has systematically examined the policy system the Chinese government has developed to promote sustainable construction. It is expected that the research will help the participants in the Chinese construction industry to understand the policy environment of sustainable construction they are facing, and help policy makers in China to better promote sustainable construction in the future urbanization process. More importantly, since sustainable development is extensively regarded as the direction of development worldwide, the policy system including laws, regulations, plans and provisions examined in this paper can provide useful references for policy makers in other emerging economies.

Acknowledgement

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Appendix E: Published article in Journal of Management in Engineering

Chang, R., Zuo, J., Soebarto, V., Zhao, Z-Y, Zillante, G. & Gan, X-L. (2016).
Sustainability Transition of the Chinese Construction Industry: Practices and Behaviors of the Leading Construction Firms.
Journal of Management in Engineering, *32*(4), pp. 05016009-1 – 05016009-13

NOTE:
This publication is included on pages 316 - 328 in the print copy of the thesis held in the University of Adelaide Library.

It is also available online to authorised users at:

http://dx.doi.org/10.1061/(ASCE)ME.1943-5479.0000439

Appendix F: Acceptance letters for journal articles in press

The article accepted by *Journal of Construction Engineeering and Management*

Ruidong Chang

From:	em.jrncoeng.0.4f0f0d.219abb36@editorialmanager.com on behalf of Journal of Construction Engr. & Management <em@editorialmanager.com>
Sent:	Tuesday, 8 November 2016 2:17 AM
To:	Ruidong Chang
Subject:	Decision on Manuscript MS COENG-5183R2 - [EMID:b0cf2a405beab08a]

CC: jian.zuo@adelaide.edu.au, veronica.soebarto@adelaide.edu.au, zhaozhenyuxm@263.net, george.zillante@adelaide.edu.au, songanxl@126.com

ACCEPT FINAL

Ref.: Ms. No. COENG-5183R2
Discovering the transition pathways towards sustainability for construction enterprises: an importance-performance analysis Rui-dong Chang; Jian Zuo; Veronica Soebarto; Zhen-yu Zhao; George Zillante; Xiao-long Gan

Dear Mr. Chang,

Your Technical Paper, listed above, has been accepted for publication in ASCE's Journal of Construction Engineering and Management.

Thank you for your contribution to the journal of Journal of Construction Engineering and Management. You will now be listed as a reviewer in the journals database. We ask that you review two papers within a year within your field of studies.

Your manuscript will now be forwarded to a Production Editor who will prepare it for publication. You will be notified of a publication date once your paper has been schedule for an issue.

Thank you for submitting your work to ASCE's Journal of Construction Engineering and Management.

Sincerely,

Taryn Dollings
Editorial Coordinator

The article accepted by *Sustainable Development*

Ruidong Chang

From:	onbehalfof+scottlam+erpenvironment.com@manuscriptcentral.com on behalf of Sustainable Development <onbehalfof+scottlam+erpenvironment.com@manuscriptcentral.com>
Sent:	Monday, 5 September 2016 2:27 PM
To:	Ruidong Chang
Subject:	SD-16-0078.R2 - Decision
Attachments:	Attached file: Kudos-SD-Factsheet.pdf

Dear Rui-Dong Chang,

"Approaches for Transitions towards Sustainable Development: Status Quo and Challenges"

Thank you for further resubmitting your paper to Sustainable Development.

Further to your 2nd resubmission of the above-titled paper, to 'Sustainable Development', this has now been reassessed, and the editor has asked me to write to you with his decision.

He is now satisfied that you have addressed the concerns of the reviewers, and he is therefore now happy to accept the paper for publication in due course.

The proofs would be sent to you by the publisher via email. Please kindly get back to the publisher with your corrected proofs at your earliest convenience so we could try to publish your paper as soon as possible. In the meantime, could you please keep us informed if your email address changes, as the author's proofs will be sent to you for checking by email when the paper has been typeset.

Your article cannot be published until you have signed the appropriate license agreement. Within the next few days you will receive an email from Wiley's Author Services system which will ask you to log in and will present you with the appropriate licence for completion.

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For your information, we have recently participated in a trial of Kudos, a web-based service that provides authors with a free set of tools to explain and share their published work for greater usage and impact. Authors who have registered with Wiley Author Services and opted into the mailing list will receive the most streamlined experience, such as having their articles linked directly to their Kudos account and receiving personalized email invitations. Nonregistered authors can manually link articles in Kudos by searching by DOI, article title or author name. I have attached a factsheet to provide more detail on how Kudos works.

Thank you for your contribution.

Sincerely,

Scott Lam
Sustainable Development
scottlam@erpenvironment.com

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The article accepted by *Engineering, Construction and Architectural Management*

Ruidong Chang

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19-Sep-2016

Dear Mr. Chang:

It is a pleasure to accept your manuscript entitled "Dynamic interactions between sustainability and competitiveness in construction firms: a transition perspective" in its current form for publication in Engineering, Construction and Architectural Management. The comments of the reviewer(s) who reviewed your manuscript are included at the foot of this letter.

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Thank you for your contribution. On behalf of the Editors of Engineering, Construction and Architectural Management, we look forward to your continued contributions to the Journal.

Yours sincerely,
Dr. Chimay Anumba
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