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Constructing A Case Study Framework on The Impact Of Green Supply Chain Practices on Carbon Reduction Performance Of China's Construction Company

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Abstract: *This conceptual paper is aimed at constructing a framework to explore the application of green supply chain practices (GSC) in construction enterprises and their potential impact on project management optimization and carbon reduction performance. Through literature review and theoretical analysis, this paper divides green supply chain practices into green procurement, green construction, green transportation, green warehousing and reverse logistics, and explores the embedding process of these practices in construction enterprises and their association with project management and carbon reduction performance. The paper analyzes the potential of green supply chain practices in improving resource efficiency, reducing operating costs, and reducing carbon emissions, and reveals the main challenges faced, such as high costs, insufficient technical support and limited policy incentives. In addition, this paper proposes a conceptual framework to explain how green supply chain practices are embedded in the project management of a construction enterprise, and thus affect the carbon reduction performance of enterprises. Simultaneously, the role mechanism of internal factors (such as corporate culture and employee capabilities) and external factors (such as market demand and policy support) in the implementation of green supply chain is clarified, providing theoretical guidance for future empirical research. This study provides a preliminary theoretical basis and direction for construction enterprises and policymakers to promote low-carbon supply chain transformation.*

Keywords: Green Supply Chain Practice, Carbon Reduction Performance, Construction Industry

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1. Introduction

As global climate change and energy crises become increasingly severe, the international community has put forward new requirements for environmental protection and energy efficiency. The concept of "low-carbon economy" first proposed in the British Energy White Paper in 2003 came into being, emphasizing the reduction of natural resource use and environmental pollution while increasing economic output. This concept quickly gained global consensus and became the common strategic direction for the international community to cope with resource and environmental challenges.

The 2022 Buildings-GSR report shows that despite significant global investment and achievements in reducing the energy intensity of buildings, the sector's overall energy

consumption and CO2 emissions increased in 2021, exceeding pre-pandemic levels. Specifically, building energy demand increased by about 4% from 2020 to 135 EJ, the largest annual increase in nearly a decade. CO2 emissions from building operations also hit a record high of about 10 GtCO2, about 5% higher than in 2020 and 2% higher than the previous peak in 2019 (Environment, 2022).

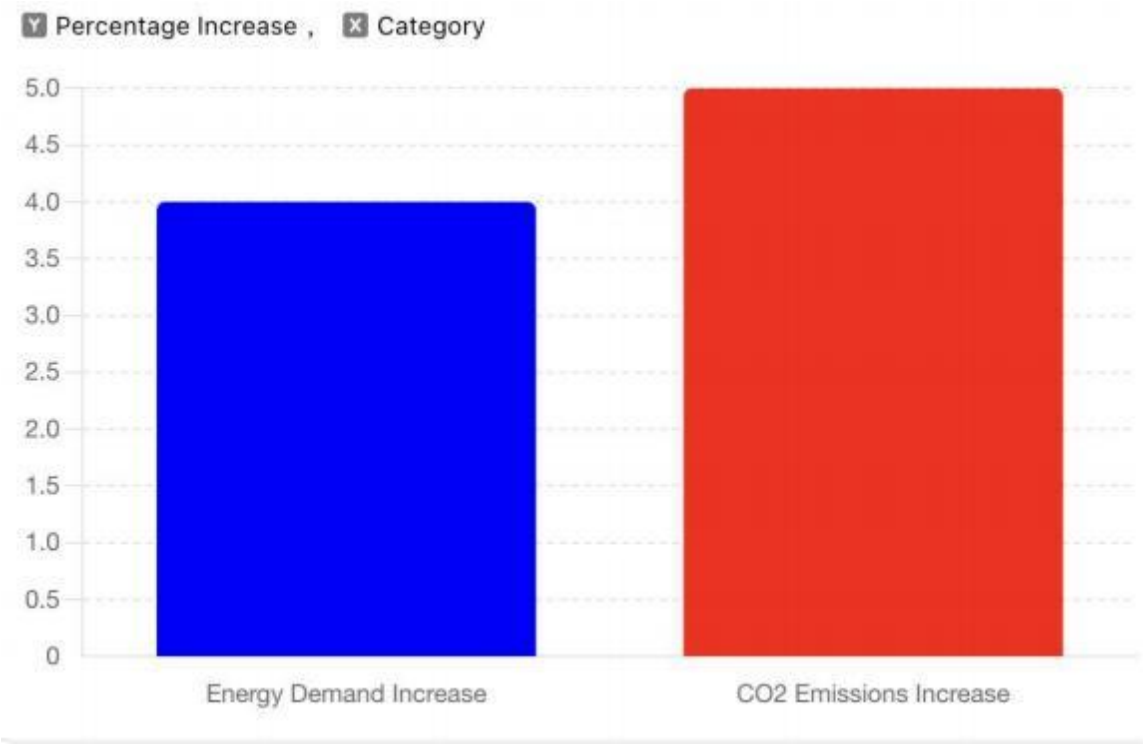

Figure 1: Energy demand and CO2 emissions growth in 2021
Source: Environment, 2022

In China, the construction industry, as a pillar industry for national economic development, has developed rapidly, reflecting the vitality of economic growth, but also bringing challenges to energy efficiency and resource utilization. Compared with the high efficiency of developed countries, China's construction industry shows relatively low efficiency and resource waste in energy and resource consumption patterns, which not only poses challenges to sustainable development, but also questions the effectiveness of existing energy and environmental impact management practices (Zhou,Y. 2023).

According to the "2022 China Urban and Rural Building Carbon Emissions Series Research Report" released online by the China Building Energy Conservation Association and Chongqing University, the total energy consumption of the entire construction process (including building materials production, construction and building operation) in 2020 was 2.27 billion tons of standard coal, accounting for 45.5% of the national total energy consumption; the total carbon dioxide emissions were 5.08 billion tons, accounting for 50.9% of the national carbon emissions (Engineering, Architecture and Construction Management,2023).

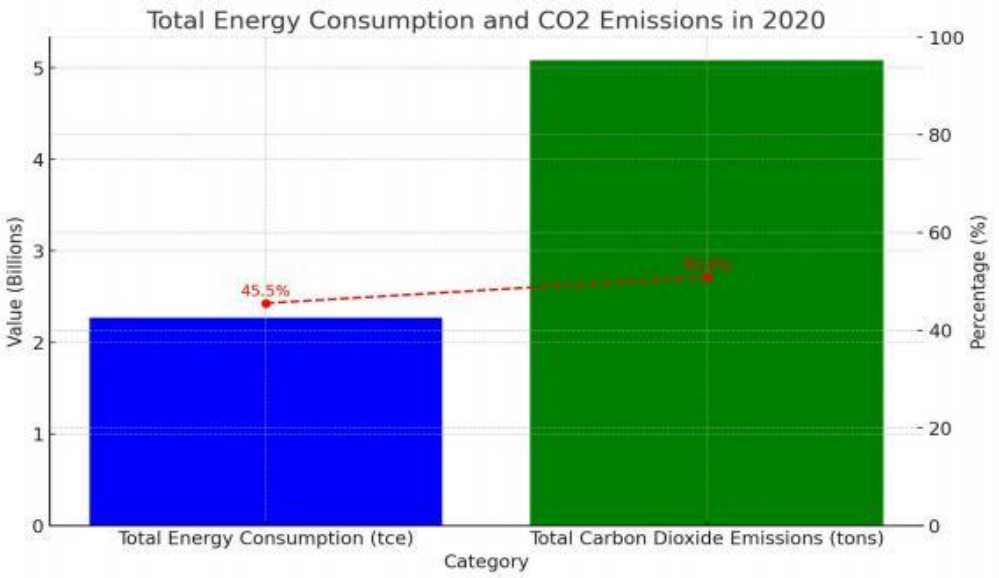

Figure 2: Total energy consumption and carbon dioxide emissions in 2020
Source: Construction Times, 2023

From 2017 to 2021, the national energy consumption of housing construction increased from 1.72 billion tons of standard coal to 1.91 billion tons of standard coal, an increase of 1.11 times, with an average annual growth rate of 2.6%. In 2021, the national energy consumption of housing construction increased by 5.0% year-on-year compared with 2020. From 2017 to 2021, the national carbon emissions of housing construction increased from 3.86 billion tons of CO2 to 4.07 billion tons of CO2, an increase of about 1.05 times, with an average annual growth rate of 1.3%. In 2021, the national carbon emissions of housing construction increased by 4.8% year-on-year compared with 2020.

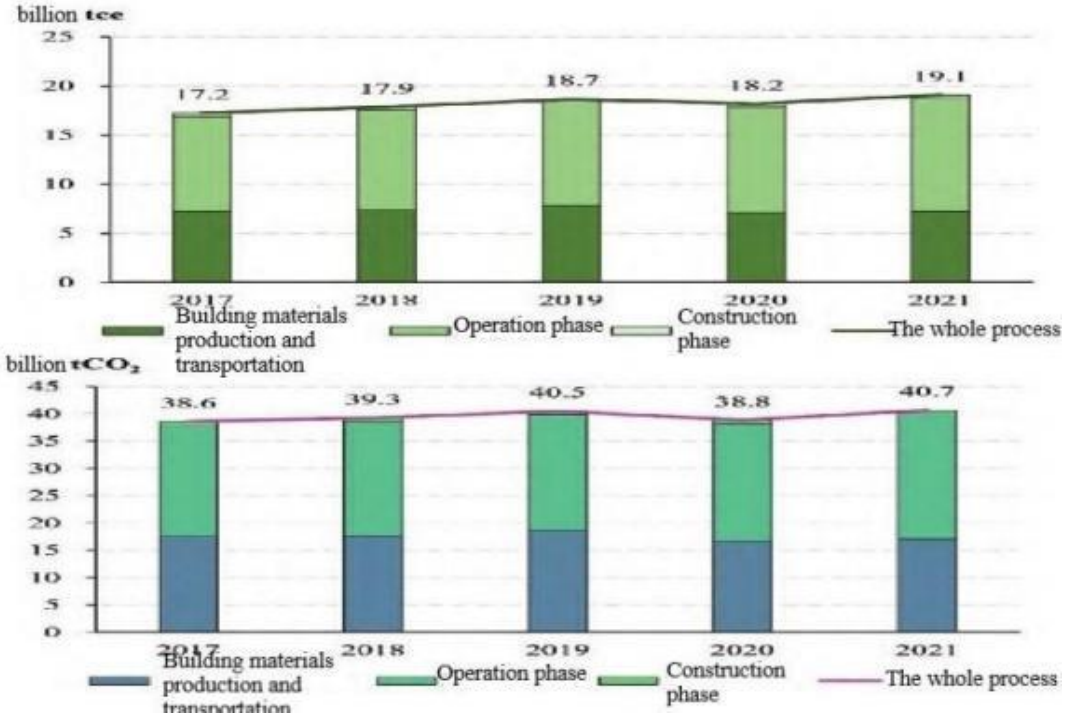

Figure 3: Trends in energy consumption and carbon emissions throughout the construction process across the country
Source: Construction Times, 2023

Based on the above-mentioned current situations, the Chinese government has regarded environmental pollution and energy shortage as important constraints on economic and social development, especially in the fields of construction and transportation and logistics, where energy conservation and environmental protection are still weak links (S. Ren et al., 2023). The rapid development of the construction industry has exacerbated the challenges of energy efficiency and resource utilization. Due to inefficient project management and technical limitations, overall carbon emissions continue to rise (Ahmed A, et al., 2020). Green supply chain practices are seen as a key strategy for carbon emission reduction, which can be addressed by improving efficiency, reducing costs, providing technical support and policy incentives. However, the industry still faces obstacles such as high costs, insufficient resources and lack of expertise in implementation (Gawusu et al., 2022). Therefore, a comprehensive approach of policy support, technological innovation and management improvement is needed.

Sichuan Province, China, has promoted green supply chain management (GSCM) through policies like the Green Building Action Plan and the 14th Five-Year Plan, achieving advancements in energy conservation, emission reduction, and circular economy. By 2022, green buildings accounted for 70% of new constructions, carbon emissions decreased by 15%, and over 50% of building materials were green-certified. Projects such as Chengdu Tianfu New District and Chengdu Metro demonstrated GSCM's impact on reducing carbon emissions and improving resource efficiency. Company A excelled in GSCM through the Hariliangbao Hydropower Station project, with over 60% green-certified materials, 80% waste recycling, and a 15% reduction in construction energy use. From 2019 to 2022, Sichuan's green material use increased from 30% to 55%, with 75% of companies reducing carbon emissions. Internally, factors like culture, management support, and training are vital for GSCM success, while externally, market demands, competition, and disruptions challenge Company A to adapt its strategies and maintain competitiveness.

2. Literature Review Discussion

2.1 Green supply chain practice in construction enterprises

Green supply chain practices integrate economic benefits with environmental protection, resource conservation, and ecological balance, optimizing processes to improve service levels and responsiveness (Letunovska et al., 2023). These practices balance corporate, social, and environmental benefits, creating closed-loop systems that recycle materials and energy for sustainable resource utilization (A. Zhang et al., 2021). Key objectives include enhancing competitiveness, supply chain performance, and sustainability while reducing costs, risks, and environmental impact (Pinto, 2020). Research defines green supply chains as encompassing green manufacturing, procurement, sustainable material management, and reverse logistics, focusing on environmental, economic, and operational performance (Upadhyay, 2020; Borella et al., 2021).

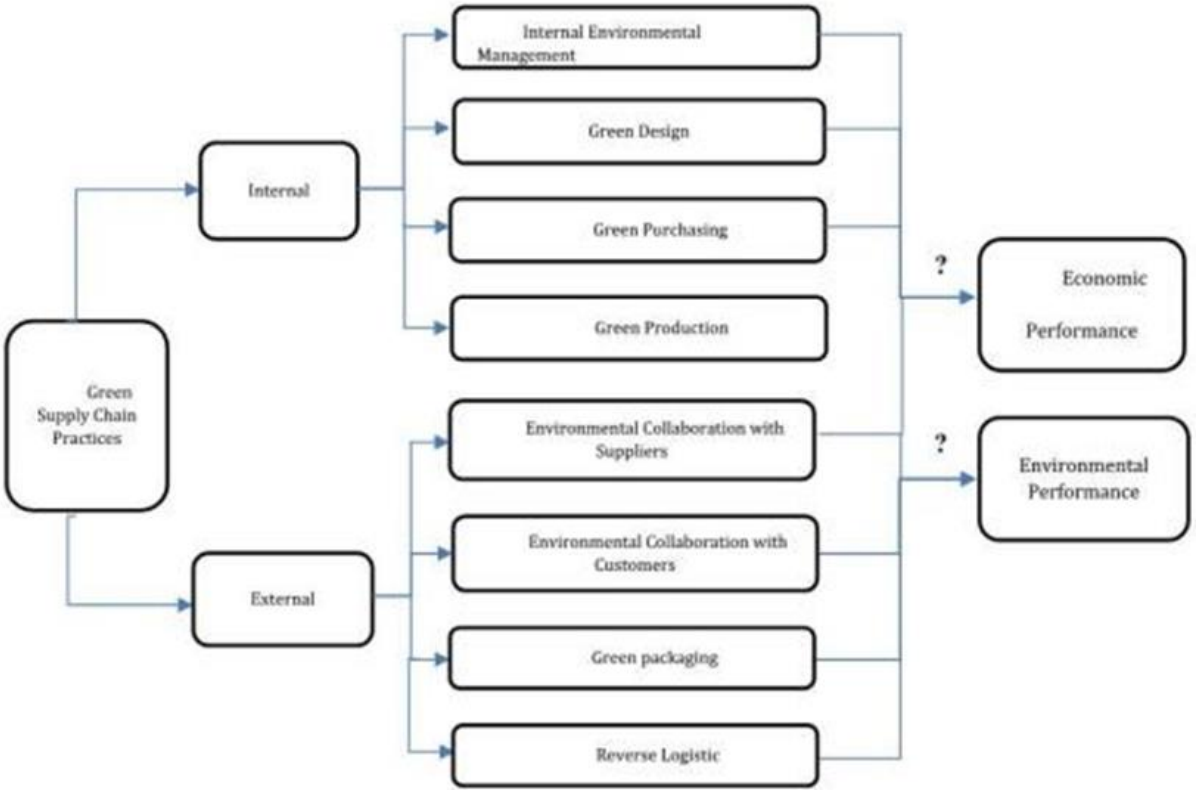

Figure 4: The green supply chain classification used in this study is from Luísa Pinto (2019)
Source: Cleaner Production , 2019

Green supply chain practices in construction include green procurement, construction, transportation, warehousing, and reverse logistics. Green procurement prioritizes low-carbon materials and optimizes the supply chain (Letunovska, 2023). Green construction reduces pollution and ensures low-carbon performance through technologies like low-emission equipment and energy-saving systems (Owusu-Manu et al., 2022; Hafez et al., 2023). Green transportation minimizes emissions by optimizing delivery routes and adopting energy-efficient vehicles. Green warehousing reduces greenhouse gases through efficient inventory management and energy-saving designs. Reverse logistics recycles materials like steel and concrete, reducing waste and resource dependence (C. Zhang et al., 2023). Effectiveness is assessed using economic, social, and environmental indicators (Plaza-Úbeda et al., 2021).

2.2 Carbon reduction performance

2.2.1 Carbon reduction performance overview

Carbon performance evolved from environmental performance and green performance. It was originally used in the macro field (such as carbon tax and carbon trading policy effects). It mainly evaluated green total factor productivity through the Malmquist index and DEA model, and compared and analyzed carbon performance (Wang et al., 2020). At the micro level, the measurement of corporate carbon performance varies depending on the research purpose, including carbon emissions, carbon efficiency, and emission reductions potential (Wang et al., 2020). Carbon footprint reduction has been used as a performance evaluation indicator to formulate corporate carbon efficiency strategies. In addition, eco-efficiency has been introduced to more realistically reflect carbon performance. The emission reduction performance of the power industry was analyzed through carbon intensity, and it was found that it was still difficult to achieve the goal (Prada et al., 2020). Studies have shown that low-carbon competitiveness can alleviate cost pressure in the carbon trading mechanism, expand market share and attract supplier preference (Zhou, 2022). At the same time, the carbon quota

allocation mechanism based on emission reduction potential effectively supports industry goal setting.

2.2.2 Carbon reduction performance classification

The following model is the relationship between green supply chain practices (GSCP) and sustainable performance. The following is an explanation of the components and connections in the model:

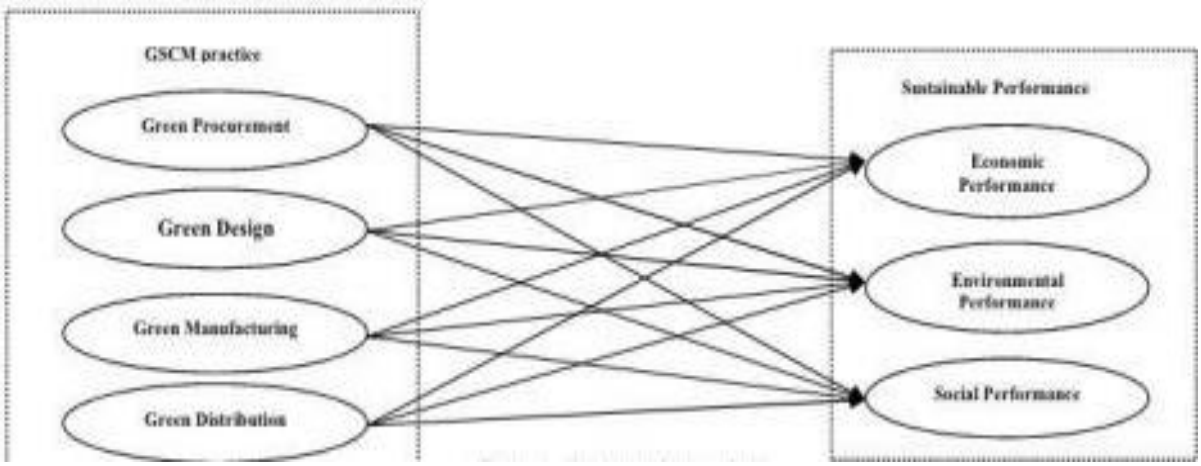

Figure 5: Luísa Pinto Thi Tam Li 's relationship model between GSCM practices and sustainable performance adoption
Source: Technology Management , 2020

From the perspective of scholars, carbon emission reduction performance is below sustainable performance. Carbon emission reduction performance focuses on the environmental field, while corporate carbon emission reduction performance also focuses on the economic field (Adesina, 2020). Therefore, the academic community usually divides carbon emission reduction performance into environmental performance and economic performance:

(a) Environmental performance

Construction companies contribute to emission reductions through energy-saving equipment, optimized designs, and low-carbon materials. For instance, passive design and insulation materials reduced CO2 emissions by 30% in new buildings (Adesina, 2020). Optimized processes and waste management cut methane and nitrogen oxide emissions (Prada et al., 2020). Improved energy efficiency, such as efficient lighting and HVAC systems, lowered a building's energy use by 25% (H. Zhou et al., 2022).

Resource efficiency is enhanced by water-saving measures and recycling. Water-saving equipment and rainwater systems conserve water and reduce waste (Geetha Varma, 2022). Low-emission diesel machinery improves air quality, reducing particulate matter pollution (Huang et al., 2021). Carbon reductions also protect ecosystems, with coastal projects minimizing habitat damage using low-carbon technologies.

(b) Economic performance

Carbon reduction measures in construction often require high initial investments in green materials, energy-efficient equipment, and better designs (Z. Liu et al., 2023). However, these measures lower long-term operating costs and boost efficiency. For instance, green certifications like LEED, despite upfront costs, save energy expenses (Hafez et al., 2023). Government incentives such as tax breaks and subsidies further alleviate financial pressure

while increasing carbon reduction effectiveness. Green buildings also enhance brand loyalty and competitiveness by attracting eco-conscious customers (Alam, 2021).

These measures drive innovation, positioning companies as industry leaders through advancements in energy-saving materials and smart systems (Jiang et al., 2020). They also attract investors and improve shareholder returns by boosting stock prices and market value (Lambrechts et al., 2021). Proactive adoption of environmental measures reduces compliance risks and costs, ensuring financial stability and avoiding penalties when regulations tighten (DeMenno, 2023).

3. Research gaps

This research focuses on green supply chain management (GSCM), a frontier field in supply chain research. While much existing research reviews GSCM theory and implementation frameworks, there is a lack of case studies on its practical applications, particularly in the construction industry (Bhatia, 2021). Construction supply chains contribute significantly to global carbon emissions, especially through transportation and warehousing, making GSCM crucial for reducing emissions. However, limited studies explore how specific factors like green procurement, warehousing, and construction affect the environmental and economic performance of construction companies. This study aims to provide a comprehensive qualitative evaluation of GSCM's impact on carbon reduction in construction, offering new insights and methods for future research.

4. Problem Statement

China's construction industry, a major contributor to global carbon emissions, accounts for 36% of global emissions, with total emissions projected to reach 12.88 billion tons by 2030. Despite government efforts to promote green buildings and energy-saving renovations, the economic and environmental benefits of green supply chain practices remain limited. High implementation costs in material procurement, logistics, and construction management hinder the potential for improved resource efficiency and reduced environmental impact (Mojumder, 2021). Moreover, insufficient technical support and a lack of policy incentives make it difficult for companies to achieve significant carbon reductions, with balancing economic costs and environmental benefits being a key challenge.

5. Research objectives

This study uses a qualitative research method to explore how green supply chain practices impact project management in construction companies and reduce carbon emissions. It considers the role of internal and external factors in shaping these impacts and proposes strategies for achieving low-carbon supply chain development (Nazir, 2024). The focus is on evaluating the implementation of green supply chains in Company A, analyzing challenges such as cost, technical support, and resource availability, and how these factors affect project management effectiveness. The study examines the impact of green practices in key areas such as material procurement, logistics, and construction management on carbon emissions. It also provides strategic recommendations for construction industry managers and policymakers to promote green supply chains, optimize project management, and drive sustainable, low-carbon transformation in the industry. Through empirical research, the study aims to offer practical solutions for the broader adoption of green supply chains in China’s construction industry (Lai et al., 2023).

6. Research Questions

In order to gain a comprehensive understanding of the impact of green supply chain practices on carbon reduction performance in the construction industry, this study focuses on the following research questions. These questions aim to explore the challenges and opportunities faced by Company A, as well as the factors that influence the adoption and integration of green supply chain practices into project management to achieve carbon reduction goals. By addressing these questions, this study aims to gain insight into the effectiveness of these practices in reducing the company's carbon footprint and improving overall sustainability.

RQ1: How can green supply chain management practices be integrated into project management of a project?

RQ2: What are the internal and external factors that influence the integration of green supply chain practices into project management?

RQ3: Is the integration of green supply chain practices into project project management implemented by Company A effective in reducing the company’s carbon emissions?

7. Research significance

Green supply chain practices in the construction industry play an important role in achieving carbon reduction and expand the theoretical basis for sustainable development. This study explores the mechanism by which supply chains promote low-carbon development in construction companies by focusing on key elements such as green procurement, warehousing, transportation, and reverse logistics. These practices fill critical gaps in current policies and systems, especially in resource-intensive industries such as construction (Fu et al., 2023). In addition, this study combines theoretical advances with practical strategies for implementing green supply chain management to enrich the understanding of sustainable practices in project management (H. Xin et al., 2023). From a practical perspective, green supply chain practices have a direct impact on project management, improving resource utilization, reducing waste, and enhancing market competitiveness. Internal factors such as organizational structure and employee quality, as well as external factors such as market demand and regulatory environment, determine the success of these green initiatives. The study companies with feasible strategies to fully integrate green practices, such as adopting advanced technologies and promoting collaboration among supply chain stakeholders, ultimately enhancing the company's ability to cope with environmental regulations and market challenges (Letunovska, 2023).

Incorporating the five key aspects of green supply chain management (GSCM) (procurement, warehousing, transportation, construction, and reverse logistics) into construction projects will directly affect project management and carbon reduction performance. These practices can not only reduce environmental impact, but also improve overall operational efficiency from material management to waste disposal. By utilizing green technologies and optimizing resource allocation, enterprises can improve environmental performance, comply with certification standards, and enhance market competitiveness, making significant contributions to social sustainable development (Jihu, 2022).

8. Concept model development

This paper proposes a conceptual framework to illustrate the impact of green supply chain practices on project management and carbon reduction performance and considers the role of internal and external factors. Figure 2.3 shows the SEQ Figure2. * ARABIC The conceptual framework of this study.

Figure 6: Conceptual framework
Source: Author, 2024

This conceptual framework illustrates how green supply chain practices impact project management and carbon emission reduction by optimizing processes. It also considers the influence of internal and external factors, such as corporate culture and market policies. This study seeks to understand how green supply chains enhance environmental performance and the role of these factors in this transformation. Through qualitative analysis, key elements that drive or hinder low-carbon development are identified, offering specific recommendations for carbon emission reduction strategies.

9. Methodology

Creswell et al. (2011) outlined the five main steps of case study research as follows:
a. Define the case
b. Select the case
c. Collect and analyze data
d. Interpret the data
e. Report research results

This study justifies using Company A as a single case study by formulating research questions, reviewing the literature, and understanding green supply chain theory and the construction industry. Informal interviews with Company A's senior executives highlighted challenges in addressing high energy consumption and carbon emissions, emphasizing the potential of green

supply chain practices. Qualitative data will be collected from middle and senior managers through literature review, observations, and semi-structured interviews to examine the economic and environmental impacts. Using coding and thematic analysis, the study identifies patterns in collected data and provides a case study report combining findings with secondary information. The results offer recommendations for improving economic and environmental performance, serving as a reference for other companies.

10. Research design

Given the constructivist stance of this study, the epistemological approach of Stake, Merriam, and Creswell aligns with the research objectives. Creswell's (2007) five-step case study process is chosen for its structured framework, which includes:
a. Identify case study as the method.
b. Confirm the case.
c. Collect field data.
d. Evaluate and analyze data. e. Prepare reports.

This framework ensures that the case is thoroughly explored and analyzed, is consistent with the constructivist paradigm, and provides a holistic understanding of the research context. Figure 7 illustrates the research design process, which is derived from Creswell's (2007) case study steps.

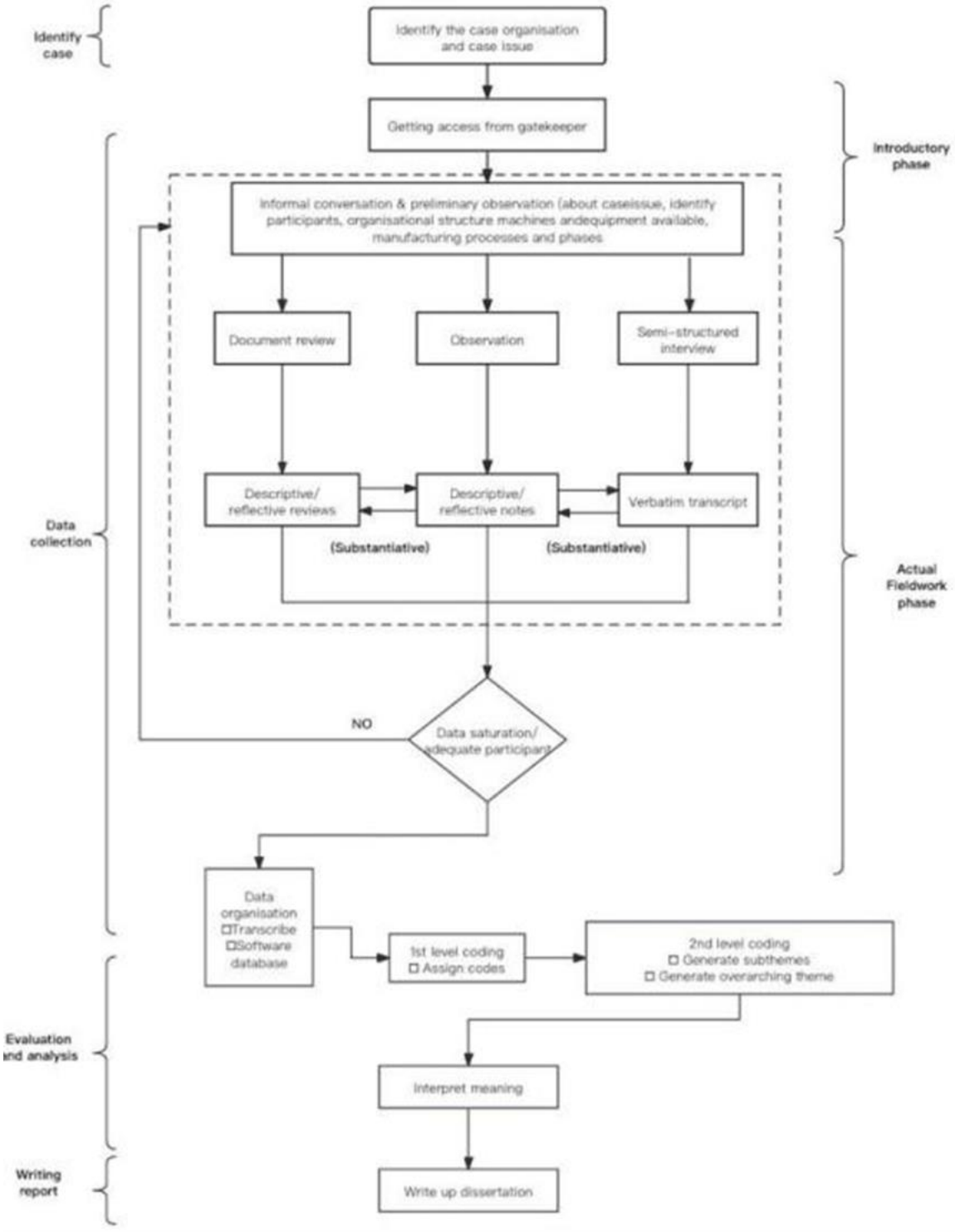

Figure 7: research design
Source: Cresswell, 2007

11. Conclusion

This paper explores the role of green supply chain practices in construction companies, focusing on their impact on project management and carbon reduction performance. It highlights that while these practices can improve resource utilization, reduce environmental burdens, and enhance market competitiveness, challenges such as high costs, limited technical

resources, and insufficient policy incentives hinder their implementation. The paper proposes a conceptual framework for understanding how green supply chain practices are integrated into project management and affect carbon reduction. It also clarifies the roles of internal factors (e.g., corporate culture, employee capabilities) and external factors (e.g., market demand, policy support) in this process. The framework lays the groundwork for future research and data collection.

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