THE APPLICATION OF NATURAL ELEMENTS GREEN APPLICATION (NEGA) STRATEGIES WITHIN INTERIOR ENVIRONMENT IN SHANGHAI, CHINA

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by

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LIST OF ABBREVIATIONS

AVE	Average Variance Extraction
CABEE	China Association of Building Energy Efficiency
C2C	Cradle to Cradle
CFA	Confirmatory Factor Analysis
CMB	Common Method Bias
CMV	Common Method Variance
CR	Composite Reliability
CITC	Corrected Item-Total Correlation
DCV	Dynamic Capabilities View
KMO	Kaiser-Meyer-Olkin
EFA	Exploratory Factor Analysis
GOF	Goodness-of-Fit
NEGA	Natural Elements Green Application
NRBV	Natural Resource-Based View
IDD	Integrated Digital Delivery
RBV	Resource Based View
OLS	Ordinary Least Squares
PLS-SEM	Partial Least Squares-Structural Equation Modelling
SRMR	Standardized Root Mean Square Residual
ULMC	Unmeasured Latent Methods Construct
USM	Universiti Sains Malaysia
VIF	Variance Inflation Factor

LIST OF APPENDICES

APLIKASI STRATEGI NATURAL ELEMENTS GREEN APPLICATION (NEGA) DALAM PERSEKITARAN DALAMAN DI SHANGHAI, CHINA

ABSTRAK

Dalam dunia pembangunan teknologi yang dinamik hari ini, menjalankan perniagaan berorientasikan hijau untuk kelangsungan hidup jangka panjang bukan lagi pilihan, terutamanya bagi syarikat pembinaan untuk mencapai kelangsungan hidup dan kemampanan jangka panjang. Mengenal pasti pemacu untuk penggunaan Aplikasi Hijau Elemen Semula Jadi (NEGA) dalam aktiviti reka bentuk dalaman menyumbang dengan ketara untuk memastikan prestasi firma yang mampan dalam seni bina. Walau bagaimanapun, kajian terdahulu mengenai topik ini lebih tertumpu kepada kajian di mana firma seni bina bergantung pada satu elemen semula jadi (ciri reka bentuk elemen seni bina) untuk meningkatkan amalan reka bentuk yang mampan. Sementara itu, bagaimana firma seni bina dirangsang untuk mengguna pakai NEGA melalui pemacu NEGA (elemen semula jadi, pemacu dalaman dan pemacu luaran) untuk menggalakkan prestasi korporat yang mampan masih menjadi bidang yang kurang diselidiki. Oleh itu, untuk menangani jurang ini, kajian ini membangunkan rangka kerja konsep berdasarkan pandangan berasaskan sumber asli (NRBV) dan pandangan keupayaan dinamik (DCV) untuk mengenal pasti faktor-faktor yang mempengaruhi penggunaan NEGA oleh firma pembinaan, serta untuk menerangkan bagaimana dalaman /pemandu luaran menjejaskan prestasi alam sekitar melalui NEGA. Responden untuk kajian ini diambil daripada senarai kontraktor bangunan dalaman yang berdaftar dengan Pentadbiran Industri dan Perdagangan di setiap daerah Shanghai, China, yang telah terlibat dalam projek reka bentuk bangunan dalaman yang mampan dan mempunyai kelayakan sama ada peringkat A atau B, yang layak. mereka

untuk populasi kajian ini. Empat ratus soal selidik yang ditadbir sendiri Likert telah diedarkan kepada responden dan 253 soal selidik yang sah telah dikembalikan. Bagi mencapai objektif kajian ini, analisis korelasi Pearson dan Partial Least Squares Structural Equation Modelling (PLE-SEM) telah digunakan untuk mengkaji korelasi antara elemen semula jadi, pemacu dalaman dan luaran, pelaksanaan amalan NEGA dan prestasi firma yang mampan. Selain itu, hasil daripada 13 temu bual telah digunakan dalam kajian ini untuk membuat susulan lagi dapatan tinjauan soal selidik. Selepas pendekatan kaedah campuran yang terdiri daripada soal selidik dan temu bual separa berstruktur, hasil kajian ini menunjukkan bahawa empat elemen semula jadi utama (bahan lestari, kehijauan, motif hiasan, dan kraf folklorik), penggerak dalaman (Tanggungjawab Sosial Korporat, Keupayaan Teknologi). . Keupayaan Organisasi) dan pemacu luaran (Kerajaan, Pasaran dan Faktor Sosial) menyediakan insentif yang paling penting untuk firma seni bina untuk mengguna pakai NEGA dalam aktiviti reka bentuk dalaman mereka. Di samping itu, pemacu dalaman, pemacu luaran dan NEGA mempunyai kesan yang ketara ke atas prestasi firma. Hasil kajian ini juga mencadangkan bahawa amalan NEGA menjadi pengantara antara pemacu dalaman dan luaran dan prestasi firma. Oleh itu, kajian ini menyumbang kepada merapatkan jurang kajian dari tiga perspektif. Dari perspektif produk dan komponen (peringkat mikro), kajian ini memperdalam pemahaman tentang bagaimana elemen semula jadi yang berbeza (ciri reka bentuk elemen bangunan) mempengaruhi keputusan dalam operasi perniagaan, dan memberikan pandangan dan panduan baru untuk pengurus dan syarikat pembinaan tentang cara untuk mempromosikan NEGA dan mengatasi halangan untuk pelaksanaannya yang berkesan. Dari perspektif operasi perniagaan (peringkat meso), penemuan kajian ini membuka "kotak hitam" dalaman yang wujud antara pemacu dalaman/luaran NEGA dan prestasi perniagaan yang mampan, dan

menyumbang kepada pengembangan teori NRBV dan DCV, serta teori NEGA. Dari perspektif persekitaran binaan dalaman (peringkat makro), kajian ini mengambil kira konteks institusi China yang unik dan memberi sumbangan penting kepada pencapaian matlamat pembangunan mampan di peringkat perusahaan dan negara.

THE APPLOCATION OF NATURAL ELEMENTS GREEN APPLICATION (NEGA) STRATEGIES WITHIN INTERIOR ENVIRONMENT IN SHANGHAI, CHINA

ABSTRACT

In today's dynamic world of technological development, running a green-oriented business for long-term survival is no longer an option, especially for construction companies to achieve long-term survival and sustainability. Identifying the drivers for the adoption of Natural Elements Green Application (NEGA) in interior design activities contributes significantly to ensuring sustainable firm performance in architecture. However, previous research on this topic has mainly focused on studies where architectural firms rely on a single natural element (architectural element design feature) to enhance sustainable design practices. Meanwhile, how architectural firms are stimulated to adopt NEGA through NEGA drivers (natural elements, internal drivers and external drivers) to promote sustainable corporate performance remains an under-researched area. Therefore, to address this gap, this study develops a conceptual framework based on natural resource-based view (NRBV) and dynamic capability view (DCV) to identify the factors influencing the adoption of NEGA by construction firms, as well as to explain how internal/external drivers affect environmental performance through NEGA. Respondents for this study were drawn from a list of interior architecture contractors registered with the Administration of Industry and Commerce in each district of Shanghai, China, who have been involved in sustainable interior architecture design projects and have either A or B level qualifications, which qualify them for this study population. Four hundred Likert self-administered questionnaires were distributed to the respondents and 253 valid questionnaires were

returned. In order to achieve the objectives of this study, Pearson correlation analysis and Partial Least Squares Structural Equation Modeling (PLE-SEM) were used to examine the correlation between natural elements, internal and external drivers, implementation of NEGA practices and sustainable firm performance. In addition, the results of 13 interviews were used in this study to further follow up the findings of the questionnaire survey. After a mixed-method approach consisting of questionnaires and semi-structured interviews, the results of this study indicate that the four main natural elements (sustainable materials, greenery, decorative motifs, and folkloric crafts), internal drivers (Corporate Social Responsibility, Technological Capabilities. Organizational Capabilities) and external drivers (Government, Market, and Social Factors) provide the most important incentives for architectural firms to adopt NEGA in their interior design activities. In addition, internal drivers, external drivers and NEGA have a significant effect on firm performance. The results of this study also suggest that NEGA practices mediate between internal and external drivers and firm performance. Therefore, this study contributes to bridging the research gap from three perspectives. From the perspective of products and components (micro level), this study deepens the understanding of how different natural elements (design features of building elements) affect the results in business operations, and provides novel insights and guidance for managers and construction companies on how to promote NEGA and overcome the barriers to its effective implementation. From the perspective of business operations (meso level), the findings of this study open up the internal "black box" that exists between the internal/external drivers of NEGA and sustainable business performance, and contribute to the expansion of NRBV and DCV theories, as well as NEGA theory. From the perspective of the indoor built environment (macro level), this study takes into account the unique institutional context of China and makes an

important contribution to the achievement of sustainable development goals at the enterprise and national levels.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The construction industry is crucial to the continued growth of the economy, but it also accelerates environmental imbalances and the depletion of natural resources (Chen et al., 2021). The construction industry's dependence on non-renewable resources poses a risk to the industry's sustainable development (Iqbal et al., 2023). Globally, the construction industry consumes more than 3 billion tons of raw materials annually (Guerra et al., 2021). Energy consumption and non-recyclable industrial waste are the main environmental challenges facing the construction industry (Ahmed, 2023). These challenges have accelerated this carbon footprint. The interior construction industry has been further explained to contribute approximately 20% of the total global construction industry emissions (Chen & Bi, 2022). Carbon emissions and environmental pressures require timely action by interior construction companies to manage their environmental impact (Kazancoglu et al., 2021). Environmental performance is a response to mitigating environmental risks (Kraus et al., 2020). Environmental performance represents "the conscious efforts of a business organization to safeguard the interests of environmental sustainability through pollution control and waste minimization" (Sahoo et al., 2023). Due to competitive globalization, business trends have changed. It is no longer enough to consider green resource management (Singh et al., 2020), green supply chain competition (Wiredu et al., 2024), and green bonds, etc. (Yeow & Ng, 2021) to make profits and gain a competitive advantage. It is also necessary to enhance the organization's understanding of potential environmental solutions and the technical configuration of

functional processes (Sahoo et al., 2023).

Currently, issues such as social sustainability, safety, health, and legality are brought about by energy and carbon emissions, prompting companies to consider these issues when promoting environmental performance. In order to save their bad reputation and improve environmental performance, construction companies urgently need to transform sustainably (Chen, 2024). The perspective of sustainable design in interior architecture points out that the shift in design strategies has a significant impact on global environmental, economic, social, and technological changes (Ashour et al., 2022). For organizations today that consider the impact of ecological challenges, designing and producing products that do not contain hazardous and toxic substances and that consider the experience and well-being of occupants is essential (Narain, 2023). Natural elements green application (NEGA) is defined as an applied approach to transform conventional design and production methods into sustainable operations, achieving higher functionality with fewer resources, new technological designs and overall systemic changes in the construction and renovation process (Hafez et al., 2023). NEGA as a radical systemic design process (e.g., through life cycle assessment, implementing best available techniques in design/production to achieve construction waste recycling) brings the necessity of solutions for sustainable transformation of businesses. Therefore, it is urgent to explore which drivers construction firms adopt and how to promote sustainable transformation of firms through NEGA to bring sustainable firm performance for sustainable development of construction industry. Specifically, this study aims to understand and address the complex management issues facing construction firms in transition by bridging the research gap between micro, meso and macro perspectives.

In terms of products and components (micro level), natural elements can help NEGA achieve better functionality (Dokter et al., 2021). However, the current literature suggests that natural elements are used as a single process rather than multiple peripheral processes (e.g., circular design process) (Zhong et al., 2023). While this emphasis is somewhat shortsighted, as many of the prior studies are qualitative analyses rather than robust empirical tests, the prior literature also suggests that the gap between the combinatorial processes of nature-based elements and NEGA and product design processes) is a potential killer of green applied innovation, as they are systematic knowledge (e.g., interior contractors have little knowledge of how this systematic knowledge and methods are actually used in design practice) (Chen et al., 2022; Dokter et al., 2021; Zhong et al., 2023). Therefore, it is crucial to explore the impact of construction companies' use of natural elements to improve their NEGA.

In terms of firm-level perspective (meso-level), the adoption of NEGA drivers is often related to firm-level and human capital individual attributes. On the one hand, previous studies have shown that internal factors (corporate social responsibility, technological capabilities, and organizational measures) have the potential to promote NEGA (Aguiar et al., 2022). Paradoxically, some studies have shown that limited corporate social responsibility, technological capabilities, and organizational capabilities are one of the obstacles to the implementation of NEGA by construction companies (Ashour et al., 2021). Therefore, it is unclear how construction companies can leverage internal factors to drive their adoption of NEGA. On the other hand, some researchers discuss the importance of governmental, market, and societal factors on sustainable interior architecture design from the perspective of external factors (Ashour et al., 2022). Paradoxically, they do not indicate how traditional design

thinking can appear powerless in a complex system involving governmental, market, and societal factors. Meanwhile, previous research has not emphasized the role of contractors as coordinators (Dokter et al., 2021). Given that interior contractors focusing on sustainable interior design projects need to generate these externalities to facilitate resource loop closure, this also raises the question of how construction companies can facilitate this in NEGA. However, to date, there is little knowledge about how construction companies can leverage externalities to achieve NEGA. Therefore, it is crucial to explore the strategies of construction companies to adopt both internal and external drivers to improve their NEGA impact.

In terms of the indoor built environment (macro level), this study is highly instructive in the context of developing economies, where environmental problems are more serious than in developed economies, and the construction sector is the least developed. Most previous studies on NEGA drivers and firm outcomes have been conducted in the context of Western developed countries (e.g., (Zhang et al., 2023; Zhong et al., 2022). Similarly, economists have argued that green applications in developing countries are significantly different (Kaplinsky & Kraemer-Mbula, 2022), which limits the generalizability of previous research results. China was chosen for this study because it is the world's largest developing economy and its innovation practices are not as developed as those in Western economies. Chinese firms are generally constrained by knowledge and resources, which may lead to differences in the strategies adopted by different companies for sustainable design of interior architecture. However, some patterns of key determinants can be observed.

Although the current transition of the Chinese construction industry towards sustainability is critical for the global achievement of sustainability goals, no study has

investigated the adoption of NEGA drivers by construction companies in the context of Shanghai. Shanghai is considered one of the financial capitals of the East, and there is a lack of research work dedicated to the built environment activities (Bao, 2023). Therefore, improving the sustainable business performance of construction companies in Shanghai is expected to make an important bottom-up contribution to sustainability goals at the national level as well as the global level. Previous research has shown that China has encouraged Shanghai to utilize the latest technology to address the production and utilization of building materials to convert waste into energy (Ma et al., 2020). However, at present, construction companies lack the capacity and skills to deal with the application of sustainable operations to transform traditional design/production methods(Chen & Haron, 2024). Therefore, it is crucial to explore how construction companies can influence NEGA strategies through NEGA to impact sustainable corporate performance.

Overall, the sustainable transformation of construction enterprises is a continuous process involving micro, meso and macro perspectives. In this study, the researcher explore how natural elements, internal drivers, and external drivers constitute an organization's NEGA strategy to help achieve sustainable business performance using NEGA in dynamic and complex project processes. The following sections highlight the research background and research questions, emphasizing the current problems in the Chinese construction industry. This chapter introduces the research questions, purpose, and objectives. It also explains the scope of the research, its significance, and a brief research method before providing general guidance on the outline of the chapters of the paper.

1.2 Background of Research

The construction industry's dependence on natural resources and vulnerability to the threat of climate change pose risks to its future industry development (Iqbal et al., 2023). Energy consumption and non-recyclable industrial waste are major environmental challenges facing the construction industry (Ahmed, 2023). For example, although building materials such as steel, glass and concrete only account for a small proportion of the total cost of construction, they consume a large amount of energy during manufacturing, transportation and installation. The construction sector is considered to be a major source of environmental problems, especially in developing economies.

The construction industry is a pillar industry in China and is crucial for sustained economic growth. Instead, it has led to the germination of environmental damage and the degradation of natural resources. China's construction industry is one of the manufacturing industries with the highest carbon emissions (Y. Sun et al., 2023). According to the China Association of Building Energy Efficiency (CABEE) 2021, carbon emissions from the construction industry reached 50% of the national total in 2019. It is further stated that the carbon emissions of the indoor construction industry account for about 20% of the total global construction industry emissions (Chen & Bi, 2022). Against the backdrop of today's dynamic world, the stakeholders of enterprises are increasingly concerned about the social and environmental economy, and they require them to take appropriate and timely actions to manage their impact on the economic environment and society. However, this is seen as a performance of the scientific community rather than the business community.

Despite the above, the substantial efforts made by construction companies in

recent years in terms of environmental management and green business strategies are worthy of respect. According to Chen (2024), construction companies are promoting sustainable corporate transformation by improving environmental management practices, gradually paying attention to their environmental performance in order to reduce the potential adverse effects of their operations on the natural environment. However, further efforts are needed, as environmental issues such as “climate change,” “energy consumption,” and “non-recyclable industrial waste” and “carbon emissions” have not yet been adequately addressed at the corporate level. However, this issue is neither a common topic discussed in any organizational level meetings, nor does the company have a formally designed process to communicate to employees and require them to follow throughout their work.

Environmental issues cannot be solved by organizations and individuals in the short term, and it requires a simultaneous transformation of individual or organizational awareness. In this sense, proactive measures are needed to drive sustainable transformation of the enterprise, but so far, the practice of Chinese construction companies is quite limited and seems to be in its early stages. Some researchers attribute the limited progress of sustainable transformation of construction enterprises to technical barriers such as incorrect product design, lack of government support and incentives, market conflicts (e.g., lack of customer interest and competitive relationships), and lack of knowledge among contractors (e.g., (Ashour et al., 2022), while other scholars have identified non-governmental organizations and media exposure (Zhao et al., 2022), implementation of environmental management systems such as ISO 4001 certification (Hazarika & Zhang, 2019), and lack of corporate social responsibility (Le, 2022). Furthermore, sustainable firm performance,

as the outcome of sustainable transformation of a business with a triple bottom line of environmental, social and economic performance, is interpreted differently by different actors and in different ways. These internal and external factors are crucial to drive construction companies to make sustainable production decisions, thus promoting sustainable firm performance. However, many scholars believe that sustainable firm performance requires a systematic understanding of resources and life cycles, and requires fundamental systemic changes, rather than "a little distortion of the status quo" (Gupta et al., 2021).

There is consensus among both academic institutions and politicians that design is important for the sustainable transformation of the construction industry. For example, Q. Li et al. (2021) point out that most of the environmental impacts of a building project are determined by design decisions during the project design process. Therefore, the environmental impacts of the design features of building elements are determined during the design phase. Therefore, the potential of building element design features to address environmental challenges is considered to be significant, especially in the design of products and indoor built environments. However, to realize the potential of sustainable transformation of the construction industry, Dokter et al. (2021) point out that design strategies for products, services, systems, and infrastructure also require systemic change.

For the design teams involved, this change brings a whole host of new challenges that require new approaches. In order to develop products, buildings and services that operate within closed-loop resource flows, the entire life cycle needs to be addressed in a coherent manner (Hazarika & Zhang, 2019), including the design, production, use and disposal phases. Natural elements green application (NEGA) in

the construction industry are therefore applied methods that transform traditional design and production practices into sustainable operations, achieving higher functionality with fewer resources, new technological designs and holistic systemic changes in the building and renovation process (Hafez et al., 2023). This requires designers and construction teams to adopt holistic and systemic approaches to problem solving, which need to combine “process and industrial product design methods” and be more predictive of how interior architecture or products will operate and change over time.

From the perspective of natural resource-based view (NRBV) and dynamic capability view (DCV), NEGA strategies provide solutions for sustainable transformation of enterprises, and are a bridge between the strategies of “sustainable design of interior architecture” and “sustainable transformation of enterprises”. According to NRBV, environmental protection is considered an important part of the organization’s decision-making and strategic design process. Building companies need to design products using natural elements to promote different strategies based on dynamic environments in order to survive in the business competition. For example, Khoshnava et al. (2020) showed that the potential applications of biocomposites in interior architecture include frames, walls, wall panels, window frames, doors, floors, decorative panelling, partition walls and ceilings. In addition, companies can also renovate old buildings using local bamboo as interior design materials (Dai & Hwang, 2021), or use different decorative patterns, such as decorative patterns to incorporate design features into local culture (ZhenKai, 2022). Therefore, it is crucial to explore NEGA as a strategy for business operations by integrating traditional design and production into the design process.

Although different methods, tools and frameworks have been developed to support sustainable design of interior architecture and sustainable transformation of construction companies. However, most studies focus on the adoption of any one particular practice. For example, Zhong et al. (2023) in a case study themed on the design of a nature company, attempts to analyse the utilisation of "natural elements" in architectural practice through a green plant design framework. Chen et al. (2022) in a study of modular product design models for manufacturing technologies, uses a case study to attempt to achieve sustainable design by combining traditional Taiwanese craft products with industrial product design methods. Mouton et al. (2023) in a review study of bio-based building material solutions showed that bio-based options have environmental benefits compared to traditional options. In the design process, the design characteristics of building elements should not be described as linear and simply predictable during their development. Therefore, research should comprehensively explore the needs of designers and construction teams for natural elements (design characteristics of building elements).

From a sustainability perspective, "sustainability" requires design to be a process that addresses environmental issues. Design is a non-linear process that requires appropriate design management to ensure that design objectives and project target values are achieved (Q. Li et al., 2021). Given that the design process of interior architecture is full of more complex requirements and diverse disciplines. The complex process is inherently dynamic because it faces a large number of internal and external relationships. Due to poor internal project communication, poor management of the design process, and a lack of constructive external stimuli (Ashour et al., 2022). This is often seen as the root cause of wasted resources in design projects (Ng et al., 2023).

This is often present in traditional design, as there is rarely a combination of internal relationships, external relationships and the design process. Therefore, it is crucial to explore the influence of internal and external factors on driving companies to adopt NEGA.

From the perspective of sustainable design in interior architecture, Ashour et al. (2022) showed that the concept of sustainable design in interior architecture has long been a major concern in the built environment, but designers/construction teams often do not make sustainable choices. Ng et al. (2023) further pointed out that early organizational integration (i.e., designers and construction teams integrated into the contractor) helps design management across processes, information, and organizations. In fact, the integration of designers and construction teams is even more important for companies to adopt natural elements (design strategies for building elements), internal factors, and external factors to drive NEGA. However, the current literature has not yet studied the role of interior construction contractors (including design teams and construction teams) as linkers.

The importance and characteristics of NEGA mentioned above imply that it is desirable to study the field of "sustainable interior design" by considering natural elements, internal drivers, and external drivers as the strategy of NEGA. The integration of the field of "sustainable transformation of enterprises" is encouraged by encouraging interior construction contractors to consider the relationship between the design characteristics of architectural elements, internal drivers and external drivers and sustainable enterprise performance, and to adopt effective analysis strategies to make optimal decisions in the design process. However, in the intersection of the fields of sustainable interior design and sustainable business transformation, no literature

reveals how construction companies can use NEGA strategies to influence sustainable firm performance. There is a lack of research that provides a holistic approach to sustainable interior design and sustainable business transformation. Furthermore, there is no framework that assesses an organization's performance in sustainable firm performance by adopting NEGA strategies. To fill these gaps, this research work focuses on developing a framework for sustainable business transformation and performance by identifying NEGA strategies.

Therefore, the main objective of this research is to develop a systematic NEGA framework to explore the NEGA strategies and its impact on sustainable firm performance in Shanghai, China, in order to help construction companies leverage these drivers and NEGA in green environmental and business strategies to achieve sustainable transformation. In addition, this research also aims to collect insights from interior construction contractors. To collect insights that capture complexity, this study began with a survey of middle and senior managers from interior fit-out contractors with Class A and B qualifications who have been involved in relevant sustainable interior fit-out projects, followed by a series of interviews. The interior fit-out contractors surveyed in this study included two types: design professionals and construction professionals, which helped to explore the insights of interior fit-out contractors on NEGA strategies in greater depth, as different building disciplines may differ significantly in terms of different NEGA strategies. Nevertheless, sustainable interior design and sustainable transformation of businesses are common goals for all disciplines. Studying the progress and focus of the intersection between the disciplines of interior design and sustainability can provide insight into the overall development of NEGA-related interior design and provide opportunities to share knowledge and

strategies.

1.3 Problem Statement

Since the official convening of the United Nations Conference on the Human Environment in Stockholm in 1972, global environmental issues have been discussed at the policy level, and sustainable development has become on the political agenda of most countries. The Rio Declaration and the Paris Agreement have promoted the need for environmental management. Subsequently, on September 22, 2020, the 75th session of the United Nations General Assembly announced that carbon emissions would peak by 2030 and carbon neutrality would be achieved by 2060. It is expected that a complete green revolution will take place in the next 40 years, which will be a milestone for the consolidation of the climate economy (Y. Wang et al., 2021). Today, environmental issues such as “climate change,” “pollution,” and “greenhouse gas emissions” have been well communicated to society, making people aware of environmental degradation. At the same time, environmental issues have brought up issues such as social sustainability, safety, and legitimacy, prompting companies to consider social issues when promoting environmental performance. In order to save their bad reputation and improve environmental performance, companies urgently need to transform sustainably (Chen, 2024).

Despite the above, corporate sustainability transformation practices remain rather limited and seem to be in their early stages for companies so far. Some researchers have attributed the limited progress of corporate sustainability transformation to technical barriers such as incorrect product design (He & Ortiz, 2021). Other scholars, however, believe that the main barriers to corporate

sustainability transformation are not technical in nature, but rather the lack of corporate social responsibility (de Oliveira et al., 2024), the reluctance of organizations to develop environmental management capabilities (Fitriani & Ajayi, 2023), the lack of support from government, lack of support from the government, market and society (Ashour et al., 2022), and the lack of use of natural elements in green building projects (i.e., a sustainable design strategy that improves recyclability and product efficiency by adopting design features in building elements) (Dokter et al., 2021).

NEGA refers to a shift away from the current adherence to traditional design and production principles (e.g., the linear principle of "take-make-use-dispose") towards sustainability, which is considered a solution that minimises environmental pressures. In this strategy, economic growth is decoupled from resource consumption, eliminating the notion of waste by keeping products, components, and materials in the most efficient use and value (Grafström & Aasma, 2021). Moreover, NEGA is still characterized by conceptual and terminological ambiguities and controversies, which do not contribute to its implementation. For example, it encompasses many different definitions and is interpreted in different ways by different actors. However, many scholars agree that NEGA requires a systemic understanding of resources and their life cycles (De Wolf et al., 2023) and that it requires fundamental system changes rather than "some tweaking of the status quo" (Dokter et al., 2021).

There is consensus in both academia and industry that design plays an important role in the uptake of NEGA in the construction industry (Mouton et al., 2023). For example, it has been claimed that 80% of a product's environmental impact is determined during the design phase (Fitriani & Ajayi, 2023). Therefore, the potential for the uptake of NEGA in the construction industry to address environmental

challenges is considered to be significant, particularly in the design of the indoor built environment. However, to realize the potential of NEGA, products, systems and interior design approaches also need to be systematically transformed (Ashour et al., 2022).

NEGA in the construction industry is such a systematic design process that uses new technologies to achieve higher functionality with fewer resources and overall systematic changes in the design and construction and renovation processes. For example, the negative environmental impacts of building products can be significantly reduced by applying life cycle assessment (De Wolf et al., 2023), implementing the best available technology in design/production and applying natural elements (design features of building elements) and substituting limited natural resources with waste from other production processes (Mouton et al., 2023). Basically, minimizing the environmental impact of construction can be attributed to these strategies (the use of natural elements), namely improving the efficiency of the construction process, conserving water, energy and other limited resources during the construction process, and reducing the amount of waste and emissions generated (Kraus et al., 2020). Therefore, it can be argued that the use of natural elements in design/production is considered an important factor affecting NEGA.

So far, in the construction industry, both scholars and practitioners have emphasized the potential benefits of natural elements (design features of building elements) for firms' NEGA adoption behavior (Dokter et al., 2021). Specifically, the concept of natural elements is a possible factor in the source of sustainable design features in interior architectural design (Dalay, 2020), such as the use of sustainable materials (Khoshnava et al., 2020), green plants (Qadir et al., 2023), decorative

patterns (Sun, 2022), and folk crafts (Knapik & Król, 2023), which are sustainable design features of architectural elements that open up opportunities for businesses to adopt NEGA. Some studies also report that NEGA drivers (sustainable design features of building elements) utilize new technologies (Huang et al., 2022).

Although many studies have investigated the role of natural elements in building companies' NEGA, knowledge gaps remain in the literature. Umoh et al. (2024) argue that natural elements are drivers of integrative and generative green applications (e.g., recycling demolished buildings into new products or components). To some extent, natural elements are considered to be the drivers of green application innovation because they shift the green application process from a single process to multiple peripheral processes (circular design process). For example, this process requires interdisciplinary cooperation and covers the life cycle of the project (Chen et al., 2022). In summary, the positive impact of natural elements on green application seems almost unquestionable so far. Moreover, many of the previous studies are qualitative analyses rather than robust empirical tests (Chen et al., 2022; Dokter et al., 2021; Zhong et al., 2023). This study believes that this emphasis is somewhat shortsighted and lacks an understanding of the whole phenomenon.

Specifically, previous literature suggests that the combinatorial nature of natural elements and NEGA (the gap between the process of folk craft and product design) is a potential killer of green applied innovation (Chen et al., 2022) because they are associated with systemic knowledge (e.g., interior contractors have little knowledge of how this systemic knowledge and methods are actually used in design practice) (Dokter et al., 2021). Therefore, this study explores what the impact of construction companies' use of natural elements to improve their NEGA is.

However, NEGA is an important part of the sustainable transformation of construction companies (Silva et al., 2020). If they do not clearly inhibit the ability to promote the competitive advantage of the enterprise, they may not promote the sustainable development of the enterprise. This is a form of path dependence (Moradi et al., 2021). In fact, the adoption of NEGA drivers is often related to firm-level and human capital individual attributes that enable firms to seize opportunities, such as experience and knowledge. One study found that firms with corporate social responsibility may increase the propensity of individuals to engage in certain creative activities (e.g., contractors proactively creating new products by processing raw materials with new technologies) (Aguiar et al., 2022). In design research, recent literature suggests that firms' capabilities to apply new technologies are important for the transformation from traditional design/production to innovative design/production (B. Ding et al., 2023). Firm characteristics, such as organizational measures, such as integrating an environmental management system into business strategy and implementing NEGA through life cycle analysis and cleaner production (Hazarika & Zhang, 2019). Although these internal factors that facilitate NEGA are important, previous studies have shown that corporate social responsibility, technical capacity, and limited organizational capacity are among the barriers to the implementation of NEGA by construction companies (Ashour et al., 2022). Therefore, it is unclear what the impact of construction companies using internal factors to drive their adoption of NEGA is.

On the other hand, some scholars have discussed the importance of government, market, and social factors in sustainable interior architecture design from the perspective of external factors. Paradoxically, Dokter et al. (2021) point out how

traditional design thinking appears to be inadequate in complex systems involving government, market and social factors. However, their research does not emphasise the role of contractors as "facilitators" who use NRBV strategies and prototypes as knowledge to promote the values of external stakeholders (e.g., government, competitors, customers, non-governmental organizations and the media) (Chen & Haron, 2023). In fact, companies need to establish new ways of working (information disclosure to build public trust) (Wang et al., 2020), new business partners (e.g., customers, competitors), and obtain environmental subsidies from the government (Z. Ding et al., 2023). Therefore, the success of interior contractors focusing on sustainable interior design projects relies heavily on the support of government, market, and social factors to promote the closing of the resource cycle (Ashour et al., 2022). This raises the question of how construction companies can achieve this in the NEGA. However, to date, there is little knowledge about how construction companies can leverage external factors to achieve the NEGA (Z. Ding et al., 2023).

Therefore, the transition to sustainability will not be successful if companies try to overcome barriers alone; instead, they need to adopt natural elements (design features of building elements), have corporate social responsibility, build technical and organizational capabilities, and government, market and social incentives. Therefore, the success of projects focused on sustainable design of interior architecture relies heavily on the adoption of natural elements, supported by internal and external factors to promote the closing of resource cycles (Ashour et al., 2021). This raises the question of the role of interior contractors in facilitating the connection and coordination of natural elements, internal drivers and external drivers with NEGA, and how building companies can achieve this in promoting NEGA. However, there has not been a clear

or detailed analysis of the natural elements and internal and external drivers of NEGA that motivate construction companies to adopt NEGA. This is one of the research gaps in this study. The first research question in this study aims to fill this gap: What is the impact of natural elements, internal drivers, and external drivers on sustainable firm performance in Shanghai, China?

The literature has extensively studied the benefits of implementing NEGA on energy and emissions (Gan et al., 2020). Specifically, the use of NEGA can minimize the environmental impact during construction by improving the efficiency of the construction process, conserving water, energy, and other limited resources during construction, and reducing the total amount of waste and emissions generated (Wang et al., 2022). However, the implementation of NEGA may require significant investments, which do not lead to improved environmental performance (Rattalino, 2018). Therefore, the understanding of the impact of NEGA on sustainable performance remains limited, and many companies have failed in their attempts to adopt such green applications (Weimin et al., 2021). That is, the impact of construction companies using NEGA to create new value to improve their sustainable firm performance is unclear (Rhaiem & Amara, 2021).

At the firm level, internal factors emphasize the necessary links between social responsibility, technology, and capabilities and organizational processes. Previous research on internal factors in firms has prompted the exploration of some important issues. First, recent studies have explored how corporate social responsibility (CSR) can change organizational processes at the level of environmental management, including the sustainable development of green buildings (e.g., (Avotra et al., 2021), accelerating internal sustainable transformation (e.g., (Le & Mohiuddin, 2024), and

redesigning customer relationship management processes (e.g., (Ghobakhloo et al., 2023). Second, some studies have used an ecosystem perspective to examine the characteristics of firms' technological capabilities, for example, green technology innovation accelerates firms' environmental performance (e.g., (Sahoo et al., 2023) and optimizes the energy performance of buildings throughout their life cycles (e.g., (Umoh et al., 2024). Third, some researchers have recently explored the interaction of organizational capabilities at the firm ecosystem level, including organizational measures such as the integration of environmental management systems into business strategies, which play an important role in improving the sustainable firm performance of firms (e.g., (Bravi et al., 2020).

On the other hand, external factors emphasize the necessary connection between government, market, and society and corporate sustainability. A large number of studies have attempted to identify the factors that drive sustainable development in construction firms (Hazarika & Zhang, 2019). First, government factors, such as government-imposed command and control or laws and regulations, can influence firms to achieve sustainable development. Government policies have been found to be the most important prerequisite for helping firms achieve sustainable firm performance, in the form of policy instruments such as regulation, fiscal instruments, and plans and programs (Chen, 2024). Second, market factors emphasize that contractors educate customers about sustainability, encourage and persuade customers, and seek to implement design processes without compromising customer budgets and aesthetic preferences, thereby ensuring that construction companies achieve their sustainability goals (Ashour et al., 2022). Third, social factors, for example, customers do not believe that the materials and components used in sustainable projects will lead to a decrease

in their willingness to purchase green products. Companies that disclose their environmental information to the mass media and environmental protection agencies in their corporate reports are more likely to obtain financial capital, thereby improving corporate financial performance (Wang et al., 2020).

Although many studies have investigated internal and external drivers as being so important for corporate sustainability, there are few studies in the current literature that assess the impact of internal and external drivers on sustainable corporate performance, and they do not take sustainable corporate performance as the desired outcome (e.g., (Hazarika & Zhang, 2019). Moreover, the current literature lacks a collective examination of the integration of corporate social responsibility, technological capabilities, organizational capabilities, government, market, social factors, and NEGA in promoting sustainable performance (environmental, social, and economic) in construction firms (e.g., (Ashour et al., 2022). Therefore, elucidating how internal drivers and external drivers and NEGA influence sustainable firm performance can reveal the potential outcomes of internal drivers, external drivers, NEGA initiatives, and sustainable firm performance. Given that this is an apparent research gap, the second research question aims to fill this gap: What is the impact of internal drivers, external drivers, and NEGA on sustainable firm performance in Shanghai, China?

In addition, few studies have identified the internal mechanisms of the relationship between internal and external drivers and sustainable firm performance in construction companies (Owusu-Manu et al., 2023). Construction firms adopting CSR, technology, capabilities, external incentives and sustainable firm performance all face the problem of cognitive inertia, which is defined as “resistance to change that deviates

from existing models or frameworks" (Faghih & Samadi, 2024). NEGA, which embodies the ability to deviate from existing structural and technological principles, exhibits different forms of cognitive inertia (Le & Mohiuddin, 2024). Some studies investigate the business impact of environmental factors by trying to understand dynamic capabilities and their role in value creation (Chen, 2024). However, the role of NEGA as an important component of dynamic capabilities in promoting sustainable firm performance through internal and external drivers has not been well explained in the literature (Alnaim et al., 2024; Farza et al., 2021). Driven by cognitive processes, NEGA utilizes the process of construction firms' dynamic capabilities when adopting internal and external drivers. Given that this is a clear research gap, the third research question is: How does NEGA impact the relationship between internal drivers, external drivers, and sustainable firm performance in Shanghai, China?

Previous studies on NEGA drivers and firm outcomes have mostly been conducted in the context of developed Western countries (e.g., (Zhang et al., 2023; Zhong et al., 2022), while China is an emerging economy with less developed innovation practices than Western economies. Similarly, economists have argued that green applications in developing countries are significantly different (Kaplinsky & Kraemer-Mbula, 2022), which limits the generalizability of previous research findings. China is a developing economy where firms are generally constrained by knowledge and resources, leading to the possibility that the factors driving the adoption of natural elements (design features of building elements) and the adoption of NEGA may differ across firms. However, some patterns of key determinants can be observed. Therefore, this study considers the institutional context unique to China, making an important contribution towards the achievement of sustainability goals at the firm and national

levels.

Although the current transition of the Chinese construction industry towards sustainability is crucial for the global achievement of the sustainable development goals, no study has investigated the drivers of NEGA adoption among construction companies in the Shanghai context. Shanghai is not only one of the world's largest cities in terms of population and land area, but also a representative emerging global city with extensive economic, cultural, and social influences both domestically and abroad. Meanwhile, Shanghai is one of China's major industrial centers, with a total industrial output value of 545.1 billion yuan in 2019 (Chen et al., 2023). According to Dai et al. (2022), the main sources of 65% of PM2.5 in Shanghai are transportation, industrial activities, and biomass burning. Although building materials such as glass, steel, and concrete only account for a small portion of the total construction cost, they consume a large amount of energy during manufacturing, transportation, and installation. Therefore, cleaner construction activities are crucial for Shanghai's economic development, environmental health, and human well-being.

According to Ma et al. (2020), China has encouraged Shanghai to utilize the latest technologies to address the production and utilization of building materials to convert waste into energy. In fact, with the latest technological design, every city can support contractors in implementing waste minimization and minimizing energy consumption in construction projects. There is no doubt that rapid technological change, the rise of emerging markets, rapid urbanization and population growth now pose serious challenges (Aslam et al., 2020). However, currently, construction companies have insufficient capacity and skills to deal with the application of sustainable practices to transform traditional design/production approaches (Chen,

2024). Research efforts dedicated to addressing the built environment in Shanghai are inadequate (Bao, 2023). Therefore, it is important to assess the capacity and incentives for sustainable transformation in Shanghai construction companies, not only for environmental performance, but also for economic and social performance. However, no systematic or theoretical studies have examined their overall interactions to date. That is, they have not been examined as part of a single model, and their degree of relevance has not been empirically measured. More importantly, there is a lack of rigorous empirical evidence and systematic research on the key components of the mediating variables (NEGAs) in the fields of "sustainable design of interior architecture" and "sustainable transformation of enterprises." Given this is a clear research gap, the fourth research question is: How to evaluate the impact of NEGA Strategy and NEGA on achieving sustainable firm performance in Shanghai, China?

In summary, this study is a step towards filling the gaps in previous research. First, it explores the relationships between drivers and existing NEGA and environmental performance. By adopting the perspective of sustainable design in interior architecture, it fills the research gap on the design characteristics of architectural elements and NEGA, and emphasizes the positive impact of design strategies on the adoption of NEGA by construction companies. Previous studies have mainly focused on the role of design strategies in enhancing sustainable design (e.g., Chen et al., 2022; Zhong et al., 2022). This study further points out that not only the design level, but also the firm level (internal drivers and external drivers) have a positive impact on stimulating architectural firms to adopt NEGA. Therefore, this study's research on the impact of NEGA drivers makes a valuable contribution to firms seeking to develop sustainable interior architectural design strategies and systematic