ANALYSIS ON THE INFLUENCE OF SUPPLY CHAIN OPTIMIZATION AND IT DEVELOPMENT ON CHINESE REAL ESTATE

By

Mr. Li ZHENG

A Thesis Submitted in Partial Fulfillment of the Requirements

for Master of Engineering ENGINEERING MANAGEMENT

Department of INDUSTRIAL ENGINEERING AND MANAGEMENT

Silpakorn University

Academic Year 2024

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โดย

Mr.Li Zheng

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต

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By	Mr. Li ZHENG
Field of Study	ENGINEERING MANAGEMENT
Advisor	Associate Professor Choosak Pornsing, Ph.D.

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This paper seeks to conduct an in-depth analysis of the Chinese real estate sector, focusing on its key characteristics, projected development trends, and the application of engineering management principles to seize emerging opportunities. The study employs structural equation modeling (SEM) and hierarchical regression analysis to assess survey data from 144 Chinese firms, aiming to explore the influence of supply chain collaborative innovation on the long-term development of supply networks. Confirmatory factor analysis (CFA) and SEM are used to validate the findings, providing robust support for the results. Technological advancements in IT and supply chain management have reshaped the Chinese real estate market, leading to improved project efficiency, cost reductions, and higher customer satisfaction.

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Li ZHENG

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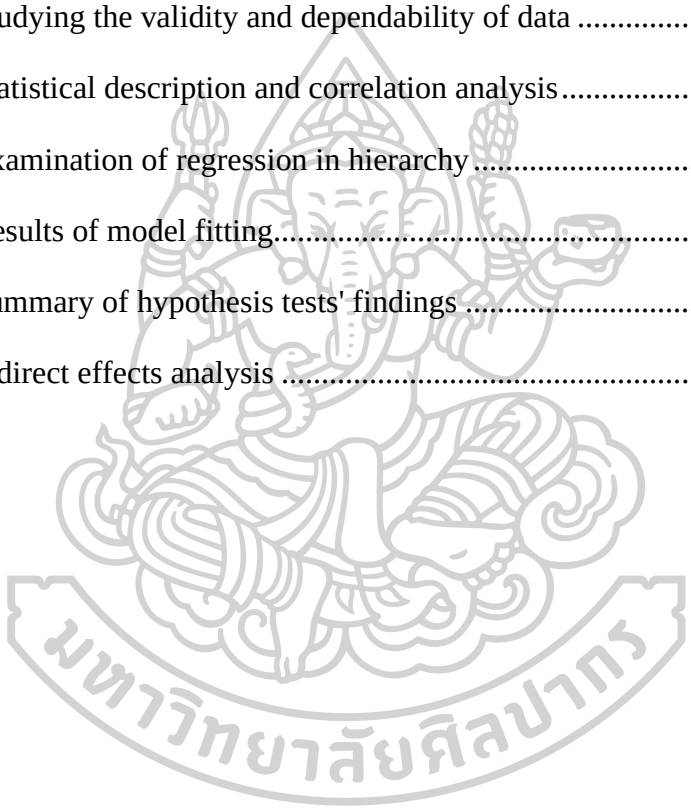

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CHAPTER 1
INTRODUCTION

1.1 Background of the Research

The Chinese government owned and controlled all property before to 1988 due to the country's communist central-planning economic system. Typically, many government bodies share the responsibility of enforcing land ownership. On April 12, 1998, the right to utilise land was included into the Constitution alongside the right to own property. The amendments to the Constitution in 1988 made it possible for land use rights to be valued independently of property ownership and traded freely. These legislative bodies are responsible for the allocation of property rights and land use responsibilities. Land ownership is not a tradable commodity, but land use rights certainly are. The major distinction between real estate in China and the West is that ownership in China is not tied to the land itself but rather to the improvements made to it and the rights to use it. Forty to seventy years is typical for these land use rights, with extensions possible (Yang et al., 2019). In 1990, real estate only accounted for 0.5 percent of Shanghai's GDP; by 2003, that number had risen to almost 1 percent, a

reflection of the booming nature of Chinese real estate sector. Chinese membership in the World Trade Organisation (WTO) in 2001 and Beijing's successful bid to host the 2008 Olympics have both contributed to this expansion.

The Chinese real estate market has experienced rapid development over the years. With the rise of Chinese construction enterprises in the international market, Chinese state-owned enterprises have actively constructed the "One Belt and One Road" initiative, delivering satisfactory results. In recent years, Chinese construction enterprises have gained market share in over 180 countries and regions, with 69 of the world's 250 largest engineering contractors coming from China. The "One Belt and One Road" initiative has created new opportunities for Chinese construction enterprises to enter the international construction market on a large scale (Chen et al., 2020).

However, Chinese construction companies have faced a crucial problem in the internationalization process, which could be better profitability. Although their turnover has increased tremendously, only a few can profit in overseas markets. The cost of quality has been overlooked by many companies, resulting in overspending on projects. Tracking quality costs is critical to the success of globalized companies. It has been estimated that the total cost of quality can be as high as 20-35% of sales for manufacturing and service companies in the USA. Chinese construction enterprises must learn from international companies with a global vision to improve their core competitiveness and sustain their internationalization (Cai et al., 2020). From the above, it is clear that the real estate industry in China has experienced rapid growth over the past few decades, and it has become one of the most critical sectors in the country's economy. The industry faces challenges, such as the government's shift toward controlling the housing market, high property prices, and oversupply in some regions. Therefore, it is crucial to explore the industry's characteristics and future development trends and how engineering management knowledge can be applied to seize opportunities in the future.

The real estate business has grown significantly crucial for the Chinese national economy since the start of the twenty-first century and has produced enormous riches. As a result, the real estate sector has grown to be one of the most essential foundations of economic growth in many parts of China. The real estate

industry's extraordinary growth has severely impacted Chinese politics and economy. The main problems impeding the Chinese economy's sustainable development are the high land cost, substantial waste of land resources, environmental devastation, and ongoing escalation of social conflicts. Therefore, it is essential to look at ways to encourage the real estate economy's sustainable growth (Jiang et al., 2019).

Despite a recent slowdown, the real estate market is continuously rising in value and now bears enormous potential threats after many years of tremendous booms. China has seen a rapid increase in urbanization since 2000, and urban dwellers' living standards have improved over time. The growth of the domestic real estate business has also been accelerating due to this favorable economic environment, and it now plays a significant role in the national economy. The real estate business has been significantly impacted by several industry rules and control measures that the central government introduced after 2005 to support the real estate sector's healthy and orderly growth. Figure 1 depicts the development of the real estate sector's total gross production value during the last ten years. The real estate sector had spectacular growth regarding investment and gross production values. The performance of the real estate business has changed recently, and this has caused a lot of public anxiety.

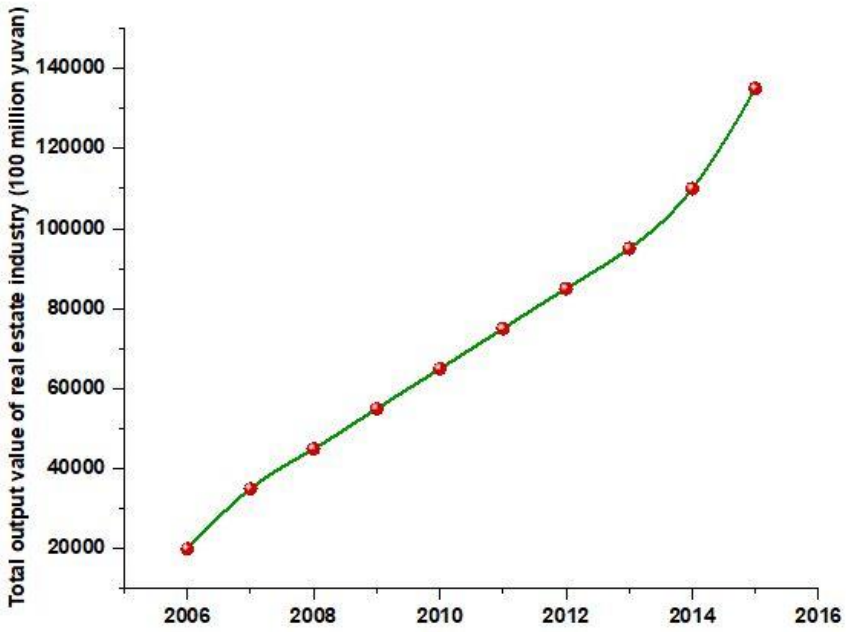

Figure 1.1 Total output value of the real estate industry

Source: Yang et al., 2019

1.2 Aim of Research

This article aims to thoroughly study the Chinese real estate industry, emphasizing its essential features, anticipated development patterns, and the use of engineering management concepts to grab potential possibilities. The real estate market in China will be precisely examined in this paper, along with best practices and case studies of noteworthy real estate developments. The impact of demography, technological innovation, and policy will be highlighted.

1.3 Research Contribution

This research utilizes structural equation modeling and hierarchical regression analysis to examine survey data from 144 Chinese companies, aiming to determine the impact of supply chain collaborative innovation on the long-term growth of supply networks. Structural equation modeling (SEM) and confirmatory factor analysis (CFA) are conducted to validate the findings, providing strong corroboration of the results .IT and supply chain advancements have transformed the Chinese real estate industry, enhancing project efficiency, reducing costs, and improving customer satisfaction.

CHAPTER 2
LITERATURE REVIEW

2.1 Supply chain definition

A product's "supply chain" consists of the many people, organisations, and technologies involved in its production and delivery (Lutkevich et al., 2021). The supply chain encompasses the whole of the production process, from the procurement of raw materials through their ultimate dissemination to the end consumer. The distribution channel is the section of the supply chain that actually delivers the goods to the customer. Supply chains and value chains may be compared and contrasted since they both contribute to a final product, but in different ways. Meeting client demands is the primary focus of every successful supply chain. The purpose of a value chain is to increase the selling price of a product. The establishment of the value chain proved beneficial to business. While both SCM and VCM focus on satisfying customer needs, they use somewhat different approaches (Bui et al., 2020).

Management of the flow of goods, data, and money from a supplier to a manufacturer to a wholesaler to a retailer to a consumer is the job of supply chain managers. Product, information, and money are the three main flows in the supply chain (Lutkevich et al., 2021). There are three basic phases in which these occur: strategy, planning, and operation. Within and between organisations, supply chain managaement (SCM) coordinates and integrates these processes.

2.2 Supply chain and IT in real estate

For real estate firms, supply chain management is coordinating all of the steps taken to get a product or service from the point of origin to the customer. The SCM entails controlling all aspects of the acquisition, disposition, and maintenance of real estate assets. Technology allows for efficient Supply Chain Management. The software products have powerful analytics tools that can examine information from any aspect of the company. With SCM, real estate investors can speed up decision-making and boost productivity across the company (Ullah et al., 2021).

1. Managing Properties &Assets :

The SCM solution can be used by the real estate industry to manage its properties, plants, equipment, land, buildings, and so on. The SCM Solution can keep tabs on all of investments, whether they are buildings or funds. An automated system

can classify real estate as either commercial, residential, industrial, agricultural, for sale or for rent, and so on.

2. Forecasting &Planning :

Supply and demand analysis is essential in the real estate industry. Real estate agencies can use the programme to keep track of all the properties they list for rent, sale, and other purposes. A SCM system can keep track of anything from listings and inquiries to ownership and lease information. Property demand, pricing, investment data, and more may all be analysed with the help of this programme.

3. Documentation & File Management :

The SCM System allows for the management of all property-related documentation. Title and lease deeds, tenant contact information, and information about the property's owner or investor can all be stored in the system alongside listings for the respective properties. A SCM system is an excellent tool for managing property-related documents. In particular for larger properties, it significantly shortens the time needed to create agreements and manage leases. Organizations and businesses working in real estate can streamline their compliance processes by digitising and managing their documents (Ullah et al., 2018).

2.3 Supply chain development in Chinese real estate

These have significant negative effects on the global economy and Chinese economy, which runs counter to the consensus of mainstream economists. The real estate industry accounts for 29 percent of Chinese gross domestic product, so it is easy to see why. In addition, its expansion during the past decade has been crucial to the expansion of the global economy (Polk, 2022).

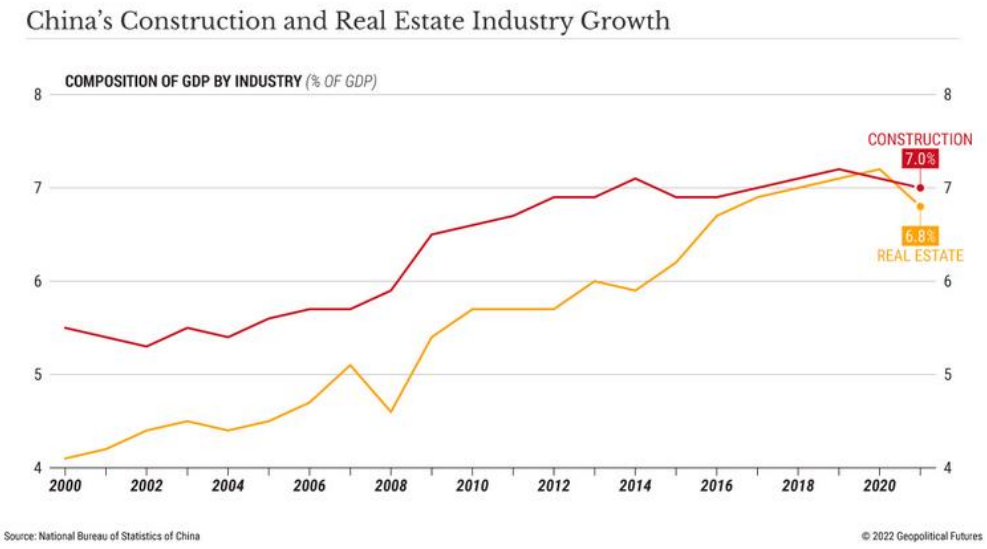

Figure 2.1 Real estate Industry growth in China
Source: Herczegh (2022)

About 1.5 million of Chinese annual apartment completions may be completely speculative, if the data is to be believed. Those who have been making speculative purchases in Chinese real estate market over the previous decade will be severely impacted by the subsequent huge drop in orders and valuation. The loss of speculative property gains has led to a 15 percent decline in car sales in China last month and a general slowdown in consumer spending (Cheng, 2022). Figure 2.1 illustrate the real estate industry growth in China.

The real estate industry's growth has had a domino effect on worldwide supply chains. For example, the price of iron ore has dropped from $223 per tonne in the middle of July to a low of $94 per tonne just last week, a drop of more than 50 percent (Cheng, 2022). Chinese supply chains face at least three distinct types of danger. An immediate threat is posed by geopolitical developments. This threat is increasingly recognised and is on the rise. However, it is preventable, or at least manageable. In addition to never having been much of a selling point for customers, "Made in China" is now seen as a negative descriptor. Not only do upstream suppliers of B2B clients with near-shored alternatives threaten consumer brands with Made in China labels,

but also so do B2C clients with overseas competitors. Figure 2.2 represents the price increase for new residential buildings in China.

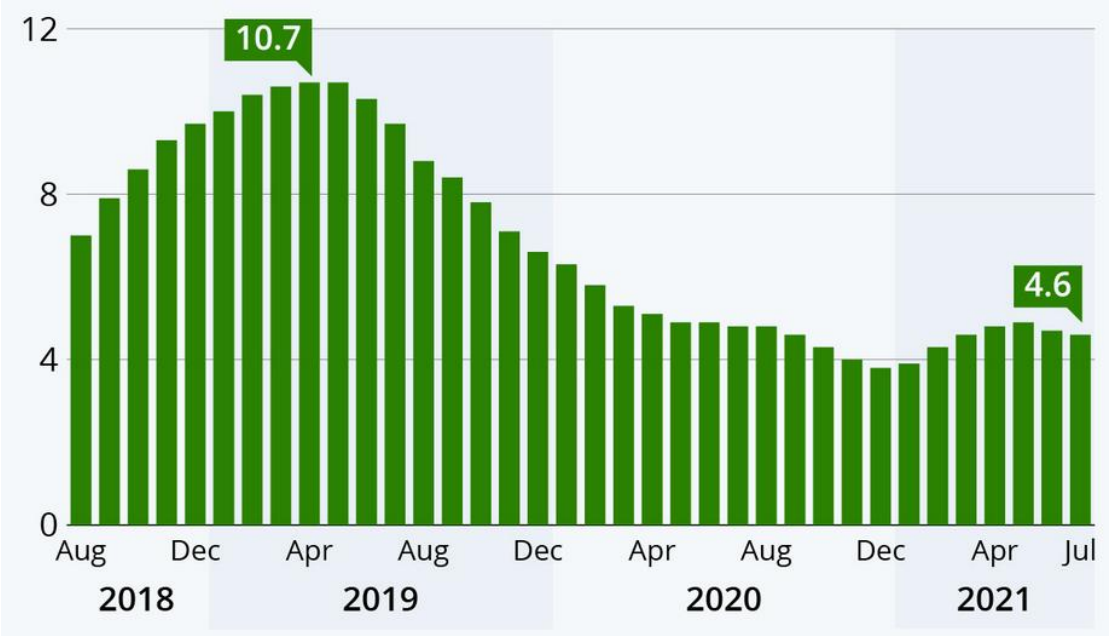

Figure 2.2 Price increase for new residential buildings in China
Source: Buchcholz (2021)

The China end of the supply chain also presents hazards. A fresh surge of anti-American sentiment threatens the safety of employees, infrastructure, and output. If the trade war escalates into the streets, the "spontaneous" anti-Japan riots of 2012 will look like a dance-off. In those days, rioters routinely smashed Toyotas on city streets (Nguyen et al., 2021). There is a chance that the Beijing Embassy will issue a similar statement this year if balloon tensions do not ease.

2.4 The trend of IT in real estate

Businesses now follow the lead of their most tech-savvy customers. They make up a sizable percentage of consumers because of their reliance on technology to meet virtually all of their demands. While the Pandemic may have harmed certain industries, the property market and property technology are both booming. According to Forbes, the real estate business had a banner year in 2021, with the number of

proptech companies jumping to over 8,000 from only 2,000 10 years earlier (Polk, 2022).

The Real Estate Software Industry is expected to be worth $12.89 billion by 2025 And 53% of real estate firms, according to analysts, are now investing in technology.About 85 percent of real estate agencies utilise MLS.About 90% of firms in the real estate industry use a web app.Up to 43% of prospective purchasers do initial research online.

In 2021, house sales increased by 21.9%, reaching an all-time peak not seen since the 1980s.By 2021, the markets in every region had grown, with North America accounting for $1.59 trillion, Asia Pacific for $1.50 trillion, Europe, Africa, and the Middle East for $797 billion, and Latin America for $51.5 billion. Figure 2.3 represents the technological innovation in real estate market by region.

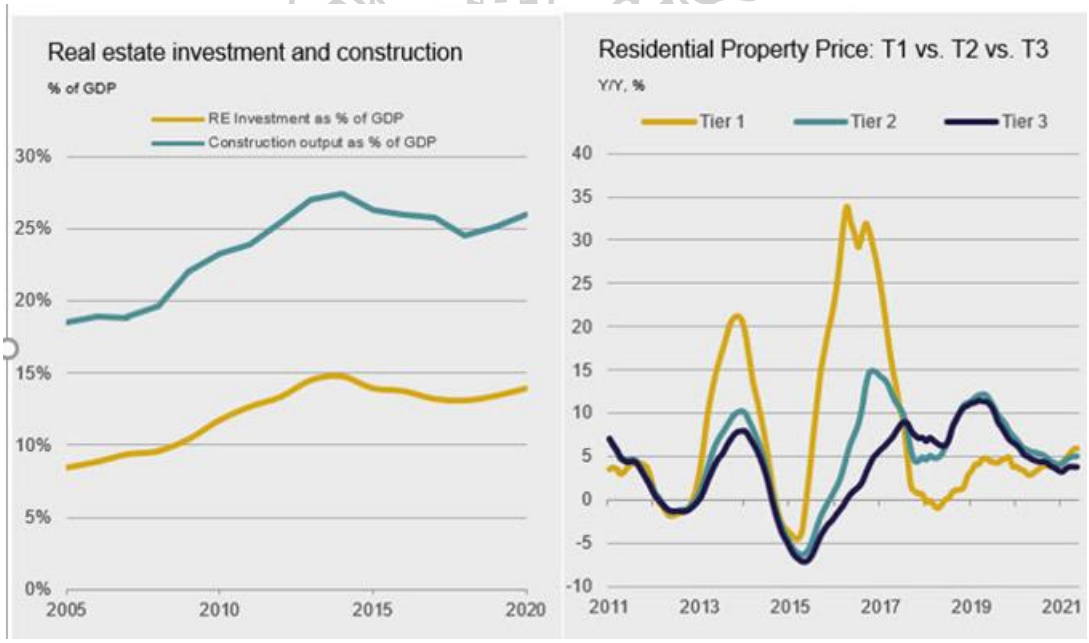

Figure 2.3 Technological innovation in real estate market by region

Source: Hao and Tucket (2021)

The years saw a rise in technology's influence on the sector. Since real estatefirms understood the benefits that technological solutions may bring to their operations.

2.5 Summary

This chapter presents the literary works of the supply chain and IT development of real estate market in China. The ongoing trade battle with the US, the epidemic, and geopolitical turmoil all heightened risk in Chinese supply chain. Increasing numbers of businesses are outsourcing production to developing nations like India, Mexico, and Vietnam. China is in the midst of a catastrophic economic crisis, yet its real estate market is among the biggest in the world. The real estate market in China has seen a 60 percent decline this year, making it the worst year on record. The growth of information technology has facilitated the real estate industry.

CHAPTER 3
RESEARCH METHODOLOGY

The Chinese real estate market has undergone a radical change because of supply chain (SC) optimization and IT growth. These factors aid in saving money, saving time, ensuring quality, protecting the environment, making informed decisions based on data, promoting businesses online, advancing construction techniques, and implementing smart home technologies. Those businesses in the real estate sector who embrace these advances will gain a competitive edge in the dynamic marketplace.Increasing supply chain dynamic capabilities and achieving sustainable supply chain growth are both facilitated by SC collaborative innovation, which has become the principal method by which enterprises in a number of countries cope with unexpected occurrences. Using a structural equation model and a hierarchical regression analysis, this research examines survey data from 144 Chinese companies to ascertain the effect of supply chain collaborative innovation on the long-term growth of supply networks.

3.1 Analyze the supply chain and IT development in real estate using Temporal and Regression method (TR)

Following the "behavior-capability-performance" methodology, this paper introduces supply chain dynamic capabilities (SCDC) as a mediating variable for the relationship model to examine the effect of SC collaborative innovation on the long-term viability of SCs (see Figure 3.1). “Supply chain management collaborative innovation (SCMNCI), supply chain market collaborative innovation (SCMKCI), and supply chain technology collaborative innovation (SCTCI) are the three obvious components of supply chain collaborative innovation (SCCI)”. An empirical research is undertaken to verify the impact of supply chain collaborative innovation (SCCI) on SCDC and sustainable supply chain performance (SSCP) by using a sizable sample of survey data obtained from mainland China.

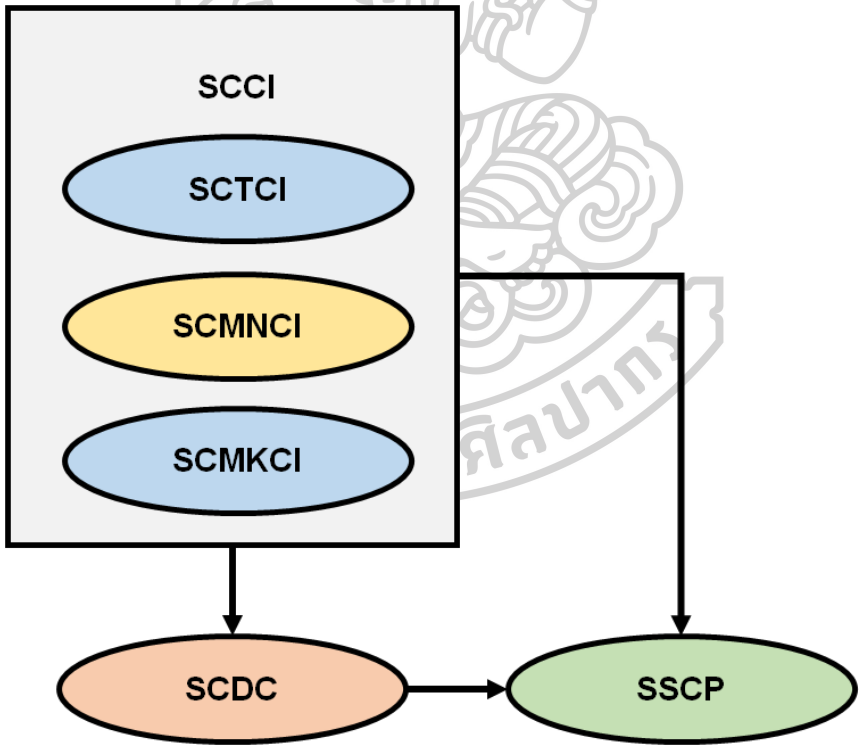

Figure 3.1 Relationships among SCCI, SCDC and SSCP

Source: Shan (2020)

3.2 Relationship between SC Collaborative Innovation and Performance

In this complex and ever-changing external setting, the supply and demand markets are competing fiercely. Today's successful businesses rely less on employee creativity and more on cooperation inside the SC. Organisations should swiftly find means of overcoming the bottleneck parts that limit individual growth and advancing cooperative development with SC component organisations in order to support efficiency, association, and effortlessness throughout the whole creation to utilisation chain.

This will aid the SC and its member companies in accomplishing their long-term, attainable goals for progress. Goldman Sachs found that the efficiency of SCs was significantly impacted by the core enterprise's collaborative innovation during the Sino-American trade war. The SC integration, sustained competitiveness, and overall performance are all benefited by the collaborative innovation perspective. Higher economic and environmental performance may result from collaborative innovation in the SC's lean production. Lean manufacturing and collaborative SC innovation may minimize waste, improve quality, lower prices, and boost SC flexibility. A SC's member companies' sporadic technological synergy has little bearing on the degree to which innovations succeed.

The familiar collaboration that binds technical innovation together, on the other hand, is better suited to enhancing the performance of a sustainable SC. Through the improvement of cross-border SC linkages and improved overall performance, as a useful supplier governance method, the fusion of virtual companies powered by technology could be used. Product innovation projects that incorporate suppliers early on have been shown to reduce the need for costly redesigns later in the process, save development time, and increase efficiency. For businesses, using information technology to manage the SC process and boost performance has remained a major focus. Performance is greatly enhanced by SC collaboration in management innovation. Retailers' attempts to recycle items may be encouraged by a simple management coordination method, improving the SC's environmental performance overall. By jointly managing the social responsibilities of upstream and downstream companies, leadership companies may enhance the social sustainability of long-term SC growth by lowering supply-side interruptions risk, social danger, and

demand-side unpredictability. While there is a U-shaped relationship between marketing collaborative innovation and the success of innovative companies and a positive connection between it with the success of mature businesses, there is a positive correlation between management collaborative innovation and the success of innovative businesses. Additionally, the combination between management innovations with marketing innovation enhances the performance of established businesses. Due to this, the performance of the whole SC may be impacted by cooperative innovation rather than individual invention in a sustainable SC. For the purposes of our discussion, let's define "SC innovation" as the collaborative development of technological advances, administration, and market between SC a member companies based on mutual confidence, which may raise the level of environmentally friendly SC efficiency by realizing the accurate corresponding to the effective operation of supply and demand across the management team, from the acquisition of raw materials to the final phases of their sales. In conclusion, the following theories are advanced by this investigation:

Hypothesis 1: SSCP is positively impacted by SCTCI.

Hypothesis 2: The performance of the SC is improved via SCMNCI.

Hypothesis 3: The performance of the SC is improved via SCMKCI.

3.3 SC Collaborative Innovation and Dynamic Capability

If member companies of a SC are to see an improvement in the performance of the SC as a whole, they must commit to continuous collaborative innovation as a community of interests to develop their keen awareness of ecological changes and their capacity to react to market changes. As a result, SC innovation has a important impact on competitive advantage by favorably influencing all elements of risk management proficiency. By limiting the exchange of commodities among member companies, information technology, for instance, may speed up information transfer. This lowers the complexity of the SC network and increases SC flexibility. Partners in sustainable SCs may achieve the breakthrough and innovation of essential technologies and increase product and service innovation by integrating, integrating, and co-evolving their technological expertise. An empirical research finds that SSDC is positively impacted by collaborative innovation of SC quality management. The

main factors influencing a SC's capacity to adapt dynamically include learning organizations, information/knowledge exchange, cooperative innovation, collaborative knowledge production, information technology, and knowledge storage. SC reconstruction and environmental adaptability are improved by knowledge exchange among SC collaborative innovation participants.

SC enterprises, to put it simply, constantly progress the inner operations of a SC through realizing the efficiency of internal processes via technical innovation, organizational innovation of the production process and lean manufacturing, and ultimately improving the coordinated internal operations. Businesses in the SC also efficiently combine internal and external resources, work together to develop supply plans to satisfy market demand, timely execution of market collaboration innovation in line with the changing marketplace conditions, and enhance the SC's adaptability to market changes and customer needs. In light of its findings, this study makes the following assumption:

Hypothesis 4: SCDC benefits from SCTCI.

Hypothesis 5: SCDC is positively impacted by SCMNCI.

Hypothesis 6: SCDC is positively impacted by SCMKCI.

3.4 Implementing root cause analysis to evaluate trends of IT in real estate

Because SCs are cross-departmental while cross-organizational as well and their outside setting is unpredictable, it is crucial that participating enterprises have the capacity to adapt, self-regulate, and learn from their mistakes. They also need to be able to respond quickly to changes in the outside surroundings and customers' needs. This might reduce the likelihood of subpar SC performance and help prevent losing a competitive edge. Research using data from 144 Chinese manufacturing enterprises demonstrates empirically the connection between sustainable corporate governance practises and company success, including economic, environmental, and social outcomes. The association among institution-organization and organization-organization creative innovation and innovation effectiveness is also significantly mediated by absorptive ability. Most organizations involved in sustainable SCs have excellent innovation capacities. They refer to this high degree of dynamic capacity as "enhanced entrepreneurship," which may deliver efficient stability and adaptable

variability for the long-term sustainability of a SC. SC firms must continually modify their internal production, planning, forecasting, and relationship systems as well as their network structure to discover a strategy and environment that operate together. That is, to encourage the development of SC performance, the SC network should be regularly modified and reorganized. The dynamic capability is simply the ability to integrate and reorganize resources to speed up an enterprise's environment adaptation and create a new competitive advantage to boost performance. Companies may adjust organizational resources and SC procedures due to the dynamic nature of SC capabilities, which might help them, adapt more effectively to environmental changes and boost performance in general. Dynamic capacity may, in a timely manner, allow businesses to modify their internal operational procedures and company resources in response to changes in the external competitive environment, which may have an indirect impact on businesses' overall performance. Achieving a competitive edge and performance that is sustainable may need dynamic capacity. Evidence suggests that redistributing assets may improve both an organization's responsiveness to external changes and its ability to function over the long run. Businesses that use the SC coordination mechanism may boost their output efficiency by building capacities that are more adaptable. This might reduce manufacturing costs and increase productivity while also increasing a company's adaptability and potential for growth. Because of this, SC collaborative innovation has the potential to greatly increase the SC's adaptability, provide a lasting competitive enhancement that competitors would find difficult to imitate, and, ultimately, maximise the SC's capacity for sustainable performance in real estate companies. When taking into account the studies that have lately been cited, the ensuing prospects are discouraging:

Hypothesis 7: SSCP, which is influenced by SCDC, is favorable.

Hypothesis 8: SCTCI and SSCP are mediated by SCDC.

Hypothesis 9: SSCP and SCMNCI are mediated by SCDC.

Hypothesis 10: Between SSCP and SCMKCI, SCDC acts as a mediator.

3.5 Methodology

3.5.1 Research Framework

Figure 3.2 depicts the four steps that make up the framework for this study. Clearly, this first phase entails posing research questions, developing hypotheses, selecting evaluable variables, and collecting relevant data. The interaction's second part entails digging into the information's reliability and its origins and connections. In the last stage, an approximation of the purported connection described here is made using a hierarchical regression analysis. Finally, we do structural equation modelling analysis (SEM) and confirmatory factor analysis (CFA), both of which strongly corroborate these findings.

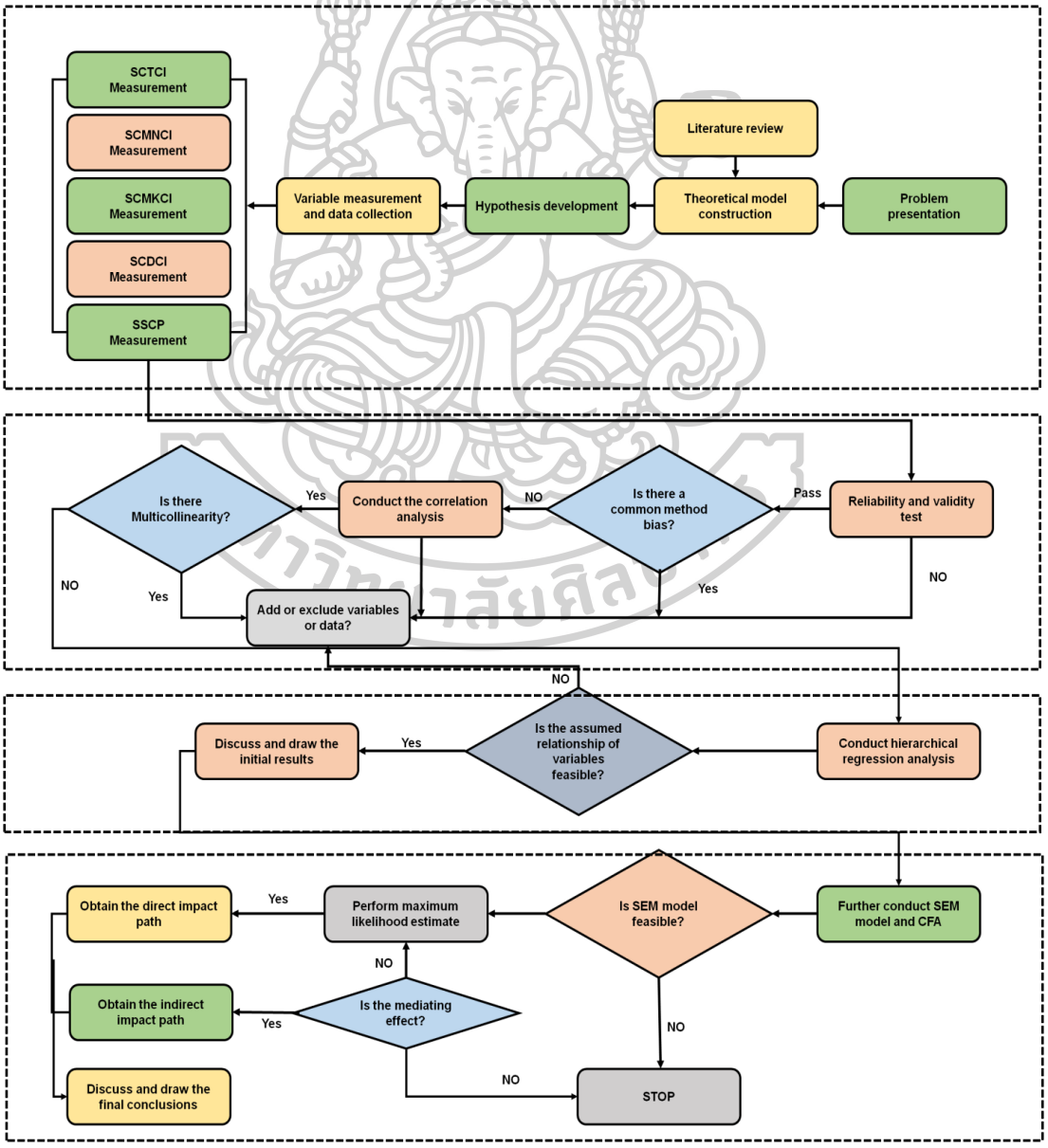

Figure 3.2 Detailed research framework of this study

Source: Author

3.5.2 Variable Measurement

This study employs SSCP as an outcome variable, SCDC as an intermediary variable, SCMKCI, SCMNCI, and SCTCI as explanatory variables based on the analysis of the research stated above. According to Table 3, the precise measurement indicators for the aforementioned variables in this study were completely developed based on the findings of research in pertinent literature. Be aware that the parameter symbols SCTCI 1-4, SCMNCI 1-4, SCMKCI 1-3, SSCP 1-4, and SCDC 1-3, as well, correspond to the first four items of the SCTCI questionnaire, the first four items of the SCMNI questionnaire, the first three items of the SCMKCI questionnaire, and the first three items of the SCDC questionnaire. Additionally, they are chosen as the control variables because to the clear distinctions between enterprise size (ES) and enterprise nature (EN).

Table 3.1 Variable selection

Ref	**Item**	
	SCTCI	
(Sezen, 2013) (Mangun, 2002) (Yuan, L., 2010) (Zhongfeng, 2010)	1.	We are devoted to increasing the usage of information technology, together with our partners;
	2.	The technological substance of our goods will always be improved by us and our partners;
	3.	To accelerate the development of new products, we collaborate with partners.
	4.	To increase the creation of new products, we collaborate with partners;
	SCMNCI	

(Ryoo, 2013) (Vachon, 2008) (Yawar, 2017)	1.	We regularly develop new organizational structures for cooperation with our partners;
	2.	With partners, we create new supply chain management techniques.
	3.	Supply chain management continues to be innovated and enhanced by us and our partners;
	4.	We continue to develop and enhance our internal management systems for cooperation with our partners;

Table 3.1 Variable selection (continued)

Ref	**Item**	
	SCMKCI	
(Zhao, 2017) (Swami, 2013) (Hong, 2019)	1.	Our successful partnerships with other companies enable us to consistently meet possible client requests.
	2.	We expand the market with the help of our clients;
	3.	Together with our partners, we develop new marketing channels;
	SSCP	
(Nyaga, 2010) (Lim, 2017) (Huo, 2014)	1.	Our supply network consistently delivers products on schedule;
	2.	We have a low rate of supply chain complaints from customers;
	3.	In the supply chain, we exchange information between businesses and their workers.
	4.	Our company's supply chain's operational procedures are appropriate;
	SCDC	
(Pagell, 2009) (Cui, 2022) (Wu, 2010)	1.	Our company's supply chain's resource allocation and usage are adequate.
	2.	Our supply network might vary with the times;
	3.	The level of qualification of our staff is acceptable;

Source: Author

3.5.3 Data Collection

Utilising the China Securities Regulatory Commission's (CSRC) sector classification from 2012 industry guideline documents, I analysed the relationship between corporate governance and capital structure of listed real estate enterprises in Mainland China. According to this definition, 144 real estate firms are publicly traded in China. Twenty-five groups were disqualified due to insufficient data, temporary postings (less than five years), or poor performance. Therefore, 119 active land financiers exist. The bulk of the information in this article came from the China Securities Market and Accounting Research Database (CSMAR), the most popular Chinese financial database. Financial statements, stock prices, and details on who runs publicly traded Chinese companies are only the beginning of what's available. We compile 595 observations over a five-year period using the most up-to-date information available from 15 CSMAR for 119 listed real estate businesses (Feng, 2020). Information about the groups is provided in Table 4. Table 5 also includes some descriptive statistics from the survey data.

Table 3.2 Additional details about the surveyed businesses

Annual sales, RMB	**Percentage (%)**	**Number of samples**
1–5 million	26.16	134
1–5 billions	25.74	132
Under 1 million	13.08	68
5 million–1 billion	20.68	106
More than 5 billion	14.35	75
Total	100	515
Private enterprise	43.46	223
State-owned enterprises	12.22	63
Foreign capital enterprise	24.47	126
Joint venture enterprise	10.97	57
Others	8.86	46
Total	100	515

Source: Author

Table 3.3 Descriptive statistics of survey data

	Variance	Skewness	Mean	Variable
SCTCI 1	1.463	-0.900	3.81	SCTCI
SCTCI 2	1.625	0.885	3.79	
SCTCI 3	1.684	-0.930	3.79	
SCTCI 4	1.587	-0.853	3.80	
SCMNCI 1	1.581	-0.836	3.74	SCMNCI
SCMNCI 2	1.650	-0.870	3.79	
SCMNCI 3	1.513	-0.894	3.79	
SCMNCI 4	1.553	-0.901	3.82	
SCMKCI 1	1.663	-0.854	3.77	SCMKCI
SCMKCI 2	1.799	-0.919	3.78	
SCMKCI 3	1.602	-0.898	3.81	
SCDC 1	1.212	-0.888	3.73	SCDC
SCDC 2	1.201	-0.828	3.85	
SCDC 3	1.105	-0.803	3.78	
SSCP 1	1.276	-0.885	3.72	SSCP
SSCP 2	1.151	-0.922	3.38	
SSCP 3	1.216	-0.935	3.39	
SSCP 4	1.261	-0.928	3.38	

Source: Author

3.6 Improving the standards of supply chain in real estate

Utilizing collaborative innovation with SC technology efficiently enhances sustained SC performance while also enhancing dynamic flexibility to changes in the external environment. “Therefore, in order to improve enterprise digitalization, speed up processes, and reduce pollution with the ultimate goal of enhancing the economic, social, and environmental performance, businesses should make full use of

new technology tools such as renewable technology, information technology, Internet of Things, and green technology”. The development of technological collaboration with SCs' upstream and downstream businesses is also crucial since it may significantly boost the performance of sustainable SCs. The research's findings show that collaborative innovation in SC management has a big influence on long-term SC performance. Organisations may better support SCM cooperative development via improved communication with upstream and downstream partners on administration alternatives, the development of hierarchical nimbleness and adaptation, and the cultivation of SCs' unique central seriousness. Additionally, it has been discovered that via the SCDC, SC market collaborative innovation indirectly influences SC performance. Therefore, businesses need to understand how the market's demand is dynamically changing and strengthen their capacity to innovate along with their customers and SC partners. Businesses can improve their SC performance by analysing potential customers' wants and needs, jointly filling in market gaps, and adjusting their primary marketing channels. This will allow them to save money on advertising, create more room for growth, gain a competitive edge, make more loyal customers, and stimulate the economy overall.

Additionally, businesses need to enhance their self-organizational capacity, become more agile and adaptable to shifts both internal and external, and guarantee that member businesses benefit from the SC's collaborative innovation in real estate given the significant mediating role that SCDC plays in determining SC outcomes.

3.7 Summary

Even while SCCI, SCDC, and SSCP have all been the subject of research, the connection between SCDC and SSCP is where most academics put their attention. Many academics emphasise on technical cooperation innovation in sustainable SC practise, while the literature on SCCI has paid less attention to management and marketing collaboration. Using the concept of "Innovation Behavior-Dynamic Capability-Sustainable Performance," this study offers fresh perspectives on SSCI, SCDC, and SSCP. This study has three main contributions. First, the research examines the influence of collaborative innovation in SC from three perspectives (as opposed to just one) on long-term SC success. This improves the link hypothesis

between sustainable SC management and collaborative SC innovation. Confirming that SCDC mediates the relationship between SCCI and SSCP is the focus of the paper's second part, which employs a structural equation model and hierarchical regression analysis. The results provide greater credence to DC theory's importance in real-world SSCM practise. Third, the influence mechanism is studied via empirical study. As a result, it validates and extends the preexisting framework for theoretical SCM use. The outcomes support the advancement of SCDC, encourage SC collaborative innovation, and enhance overall sustainable SC performance for businesses.

CHAPTER 4
RESULTS ANALYSIS

4.1 Correlation and Temporal analysis

SPSS(Statistical Package for the Social Sciences) 17.0 and Amos 21.0 were used to rigorously examine the quality and credibility of the polling data. Cronbach's alpha values for the factors and research items in Table 4.1 are above 0.8, indicating internal consistency. Also, the CR value is greater than 0.80, which indicates strong dependability overall. The reliability of the selected variables in this research may therefore be assumed to be excellent. The legitimacy test takes into account both individual and shared claims to validity. The combination system's precision may be evaluated in terms of the component load, the average separated variance (AVE), and the union proportion (CR). These three numbers should generally total greater than 0.5. Table 4.1 shows that the model has strong convergence validity since all factor loads, CR values, and AVE values are more than 0.5. To be valid, AVE's quadratic root must be more than 0.7, and AVE's quadratic foundation must be greater than the

connection between the estimate variable and other variables. We look at how reliable the unique trait is under these conditions. Factually depicting and evaluating the link between SCTCI, SCMNCI, SCMKCI, SCDC, and SSCP has real-world repercussions, as seen in Table 4.2. Values of the correlation coefficient lower than 0.8 disprove the presence of multicollinearity among the variables. Each of the latent variables has a stronger correlation coefficient than the others and quadratic roots larger than 0.7. This means the model is sufficiently discriminating. The presence of a CMB needs more investigation. In this case, we used the Harman one-factor test. The results reveal that a common component may account for 33.63 percent of the variation, which is less than the recommended criterion of 40 percent. This indicates that the data is not significantly biassed due to the use of a standard research approach.

Table 4.1 Studying the validity and dependability of data

Variable	**Number of Items**	**Factor Load**	**CR**	**Cronbach's α**	**AVE**
SCMNCI	5	0.76	0.8436	0.873	0.8744
		0.74			
		0.77			
		0.80			
SSCP	5	0.79	0.8375	0.868	0.5631
		0.73			
		0.75			
		0.77			
SCTCI	5	0.79	0.8636	0.860	0.6129
		0.80			
		0.82			
		0.76			
SCMKCI	4	0.82	0.8268	0.872	0.6141
		0.79			
		0.77			

SCDC	4	0.77	0.8497	0.884	0.5859
		0.79			
		0.74			
		0.79			

Source: Author

Table 4.2 Statistical description and correlation analysis

Variable	**Average Value**	**Standard Deviation**	**SCTCI**	**SCMCI**	**SCMKCI**	**SCDC**	**SSCP**
SSCP	7.487	0.077	0.650***	0.714**	0.682*	0.716***	0.7504
SCDC	7.385	0.080	0.633**	0.640**	0.704***	0.7654	
SCMKCI	6.997	0.082	0.597*	0.602*	0.7837		
SCMCI	7.694	0.087	0.618*	0.7579			
SCTCI	7.5149	0.084	0.7829				

Source: Author

4.2 Hierarchical Regression Analysis

The causal link between the variables is not clear from the aforementioned correlation study; it just reveals that they are highly correlated. The link between independent factors, dependent variables, and intermediate variables is thus examined using a hierarchical regression analysis before the structural equation model (SEM) is used. The findings of such an investigation are shown in Table VI. As can be shown from Models 1 and 10, EN significantly improves SSCP and SCDC but ES significantly improves SSCP and SCDC. Models 2 and 3 show a substantial beneficial influence of "SCTCI (beta = 0.34, $p < 0.001$) and SCMNCI (beta = 0.325, $p < 0.001$) on SSCP", suggesting that H1 and H2 are validated.

The performance of the sustainable SC is not significantly improved by SCMKCI (beta = 0.170) in Model 4, hence H3 is not supported. Model 5 shows that SCDC has a considerable beneficial influence on SSCP (beta = 0.33, $p < 0.001$), proving that H7 is supported. Additionally, it can be shown from "Models 8–10 that SCTCI (beta = 0.294, $p < 0.01$), SCMNCI (beta = 0.286, $p < 0.05$), and SCMKCI

(beta = 0.325, $p < 0.001$) all significantly improve the SCDC, supporting H4, H5, and H6".

Finally, when include all independent and intermediate factors, Model 6 has the greatest R2 value, suggesting a favourable influence on interpretation. When comparing Models 2 and 6, Models 3 and 6, Models 4 and 6, and Models 2 and 6, the inclusion of intermediate variables reduces the regression coefficient of independent variables to dependent variables.

Table 4.3 Examination of regression in hierarchy

Variable	SSCP					SCDC				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**	**Model 0**
SCMKCI				0.170		0.115				0.325**
ES	0.246**	0.229*	0.220*	0.210*	0.202**	0.197**	0.211**	0.228**	0.217**	0.199**
EN	0.230**	0.213**	0.200**	0.196**	0.193**	0.190**	0.199**	0.177*	0.169*	0.162*
F value	21.59**	22.66***	24.77**	25.18**	26.35**	31.70**	7.52**	8.27**	8.55**	8.77**
SCMNCI			0.325*			0.277*			0.286**	
Adjust R^2	0.188	0.206	0.236	0.245	0.263	0.277	0.051	0.056	0.060	0.064
SCDC					0.33***	0.31***				
R^2	0.195	0.232	0.255	0.268	0.282	0.297	0.050	0.052	0.063	0.070
SCTCI		0.34***				0.290**		0.294**		

Source: Author

[Note: *** represents $p < 0.001$, ** represents $p < 0.01$, * represents $p < 0.05$]

4.3 Structural Equation Modeling and Path Analysis

This study use the "structural equation modelling (SEM) method and confirmatory factor analysis (CFA)" inside the Amos21.0 programme to assess the soundness and consistency of the proposed theoretical framework and research hypotheses. When there is a link between the error components e2, e4, e6, and e9 and larger MI values, the Chi-square value of the model lowers and the matching degree increases. Figure 4.1 shows how the SEM method intuitively demonstrates the effect of SC innovation on performance. Table 4.4 demonstrates that when the Chi-square statistic is divided by the number of possible outcomes, the resulting value is 1.214, which is less than 3. The "Root Mean Square Error of Approximation (RMSEA)" is less than 0.1, as is required. The values of "decency of fit (GFI)," "normed fit (NFI)," "gradual fit (IFI)," and "near fit" (CFI)" are all more than 0.9. This results in a very high grade model fit.

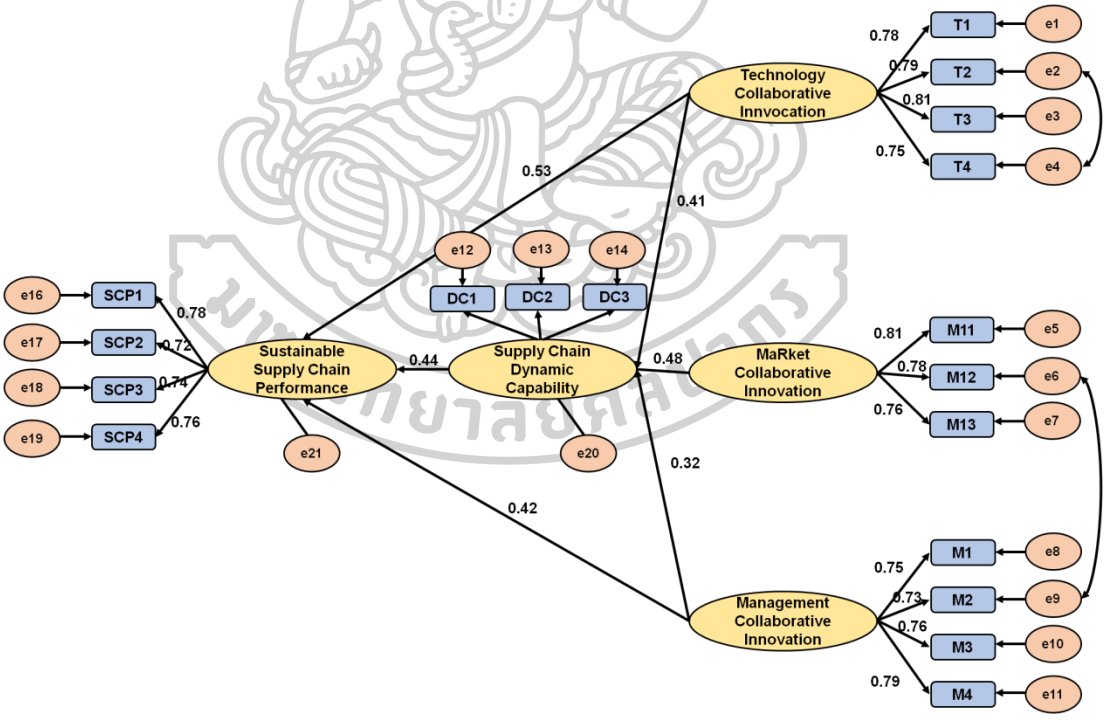

Figure 4.1 Standardized estimate outcomes from the structural equations model. Error words are represented by e1 through e21

Source: Shan, 2020

Table 4.4 Results of model fitting

Index	Model Fit Results	Judgement Criteria	Fit Index
Simple fit index	0.873	>0.51	PNFI
	0.822	>0.51	PGFI
Value added fit index	0.918	>0.91	NFI
	0.952	>0.91	IFI
	0.960	>0.91	CFI
Absolute fit index	1.214	<4	$\chi 2$/df
	0.032	<0.11	RMSEA
	0.919	<0.91	GFI

Source: Author

In this study, we use maximum likelihood estimation (MLE) to calculate route coefficients and determine the importance of relationships between variables. Table 4.5 shows that the route coefficient from SCTCI to SSCP is 0.54, and that this value corresponds to a ρ value of 0.001. Therefore, it is safe to conclude that (H1) is right, and that SCTCI has a major effect on SSCP. The correlation between SCMNCI and SSCP is 0.43, and the ρ value is less than 0.05. This provides good support for H2, demonstrating a correlation between SCMNCI and SSCP. The route coefficient from SCMKCI to SSCP is just 0.04, well below the threshold for statistical significance. Therefore, H3 is false. The indirect effect test in this research is performed using Bootstrap. Among these, SCTCISCDCSSCP has an indirect influence of 0.19, and its ρ value reaches a significant level of 0.01. Therefore, H7 is approved.

An indirect effect size of 0.22 for SCMNCI+SCDC+SSCP at a significance level of ρ 0.01 is statistically significant. We may recognise H8 in this way. Together, SCMKCI, SCDC, and SSCP have an influence of 0.15, and the ρ value drops to 0.01. As a result, we may conclude that H9 is true. The results are shown in Table 4.6. As a result of SCDC, SCMKCI has a more significant effect on SSCP than

any other factor. To a lesser extent, the SCTCI and SCMNCI also have an indirect effect. SCDC has substantial secondary effects on SC performance and creativity.

Table 4.5 Summary of hypothesis tests' findings

Hypothesis	**Standard Error**	**Assumption Results**	**Path Coefficient**	**Path**	***ρ* Value**
H1	0.079	Established	0.43	SCMNCI→SSCP	**
H2	0.076	Established	0.54	SCTCI→SSCP	***
H3	0.063	Established	0.42	SCTCI→SCDC	**
H4	0.055	Not established	0.04	SCMKCI→SSCP	0.62
H5	0.073	Established	0.49	SCMKCI→SCDC	***
H6	0.065	Established	0.45	SCDC→SSCP	***
H7	0.058	Established	0.33	SCMNCI→SCDC	*

Source: Author

Table 4.6 Indirect effects analysis

Hypothesis	**p Value**	**Assumption Results**	**Mediating Effect**	**Path**
H8	**	Established	0.15	SCMKCI→SCDC→SSCP
H9	**	Established	0.19	SCTCI→SCDC→SSCP
H10	***	Established	0.22	SCMNCI→SCDC→SSCP

Source: Author

4.4 Discussion

In this study, the association between SCCI and SSCP is empirically investigated, and the SCDC is looked at as a potential mediating factor. The important findings, which are based on thorough survey data for Chinese enterprises, are summarized below. (1) SCDC gains a lot from the SC collaborative innovation, namely SCTCI, SCMNCI, and SCMKCI. Recent studies that have zeroed down on one facet of innovation find this to be mainly in accord with their findings. Lim (2017) argues that the use of IT and the preservation and exchange of knowledge in SCCI are the two most crucial components in improving the adaptability of SCs. In

addition, Kwak (2018) demonstrates the positive effects of SC advancement on the efficacy and adaptability of chance limit. According to Shan's research in 2020, coordinating efforts to improve SC quality administration is beneficial to SCDC. (2) According to Kim (2018) SCCI has some beneficial effects on SSCP. This agrees with the conclusions of previous research that only looked at one facet of innovation (Lindgreen, 2018). The benefit of technical innovation to sustainable development performance, such as information technology synergism innovation or environmentally friendly and green technology (Hong, 2018). (3) In contrast to the results of (Hong, 2019), which indicated only a partial involvement for such an intermediate, SCDC performs a considerable intermediary role between SCCI and SSCP.

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

The Information technology (IT) and supply chain (SC)) elements have been essential in changing the market and propelling its development in recent years. To begin with, supply chain optimization has completely changed how real estate projects are conceived, created, and managed. Across the whole real estate value chain, the use of modern logistics and supply chain management strategies has increased productivity, decreased costs, and simplified operations. The improvement of construction procedures, reduction of material waste, and timely project delivery have all been made possible by this optimization. By using technology and data-driven methodologies, developers have improved project results and customer satisfaction by gaining greater insight into and control over their supply chains. Second, the Chinese real estate market has been significantly impacted by the information technology sector's explosive rise. Various parts of the sector have

changed as a result of the adoption of digital technologies including artificial intelligence (AI), big data analytics, and the Internet of Things (IoT). These technologies have been used by the real estate industry to better understand market trends, make data-driven investment choices, and improve client experiences. Additionally, the expansion of IT has aided in the development of cutting-edge business models including online property portals, virtual property tours, and electronic property management programs. These digital platforms have completely changed how real estate is marketed, sold, and managed, making it more effective, easy, and open to a larger variety of customers. In general, the Chinese real estate industry has changed due to the convergence of supply chain optimization and IT development, which has encouraged operational efficiency, improved decision-making, and improved consumer experiences. With a more open and digitally driven real estate sector, these developments have empowered renters and purchasers as well as developers and investors. These trends are anticipated to continue in the years to come as technology develops and the emphasis on optimization and customer-centric solutions remains a top concern.

Improving the opportunities of using supply chain and IT in real estate.The real estate business has a number of potential for improvement due to the integration of supply chain and information technology (IT). The following are some crucial areas where these developments may expand possibilities:

- Efficient Project Planning and Development: Better project planning, resource allocation, and scheduling are made possible by supply chain optimization combined with IT technologies. To make wise choices about site selection, material sourcing, and building schedules, real estate developers may use data analytics and predictive modeling. This enhances the efficiency of the project as a whole, lowers expenses, and simplifies the development process.
- Enhanced Inventory Management: Techniques for supply chain optimization, such as just-in-time inventory management and real-time tracking, aid in the optimization of inventory levels and the reduction of waste. Developers may precisely manage inventory movement, automate reordering procedures, and closely check the availability of building supplies by integrating IT systems. This guarantees

the timely delivery of goods, lowers storage expenses, and avoids delays brought on by inventory shortages.

● Improved Collaboration and Communication: Developers, architects, contractors, and suppliers can all work together easily on real estate projects due to IT tools and platforms. Real-time information sharing, document management, and coordination are made possible by cloud-based project management systems, digital communication tools, and virtual collaboration platforms. This improves communication, lowers mistake rates, and increases productivity.

● Data-Driven Decision Making: Access to enormous volumes of data that can be processed to get useful insights is made possible by the combination of supply chain and IT. Real estate businesses may learn more about consumer preferences, market trends, and investment prospects by using sophisticated analytics. This data-driven strategy enhances investment results, allows for more informed decision-making, and reduces risks.

● Enhanced Customer Experience: Real estate organizations can now provide better client experiences across the whole lifecycle, from property search to after-sales services, due to IT improvements. Virtual tours, 3D visualization tools, and online real estate websites enable prospective buyers to see houses remotely, saving them time and travel. Personalized interactions, effective grievance processing, and quick service delivery are all made possible by customer relationship management (CRM) systems, which promotes long-term client pleasure and loyalty.

● Sustainable Practices: IT solutions and supply chain optimization assist in the adoption of sustainable real estate practices. Developers may lessen their influence on the environment by choosing energy-efficient transportation options, using eco-friendly building materials, and minimizing their energy use. Energy efficiency is further improved by IoT sensors and smart building technologies, which also allow for efficient resource monitoring and management.

Innovative Business Models: Innovative business models for the real estate industry are now possible because to the confluence of IT and supply chain optimization. Supply chain and IT solutions are used by shared economy platforms, such co-working spaces and co-living ideas, to promote flexible and effective space

usage. Additionally, blockchain technology has the ability to expedite contractual procedures and make real estate transactions transparent. In conclusion, real estate has a considerable opportunity to benefit from the combination of supply chain optimization and IT in terms of project efficiency, inventory management, collaboration, decision-making, customer experience, sustainability, and business model innovation. Real estate firms may remain ahead in a competitive industry and provide value to stakeholders by adopting these developments.

5.2 Future work

In future real estate sector possibilities to use supply chain optimization and information technology (IT) include the following: By offering a safe, open, and unchangeable record, blockchain technology has the potential to completely transform real estate transactions. Blockchain-based smart contracts may speed up real estate deals, automate verification procedures, and lessen the need for middlemen. By reducing fraud and conflicts, this technology may improve real estate transactions' trustworthiness, effectiveness, and speed. Real-time monitoring and management of several systems, including energy use, temperature, security, and maintenance, may be made possible through the integration of IoT devices and sensors in buildings. IoT-powered smart buildings have the potential to improve resource efficiency, lower energy use, and occupant comfort. Building design, operation, and maintenance choices may be made with the use of IoT data by real estate developers. AI algorithms to provide insights and forecasts about consumer patterns, investment possibilities, and real estate market movements may analyze large volumes of data. Predictive analytics enabled by AI may help real estate organizations make data-driven choices, pinpoint possible hazards, and improve investment plans. Additionally, AI can improve real estate appraisal models and automate tedious operations, increasing accuracy and efficiency. The way real estate is advertised and experienced has the potential to change due to virtual and augmented reality (VR/AR) technology. Without physically seeing houses, prospective buyers may have realistic and engaging experiences with virtual property tours, immersive 3D visualizations, and virtual staging. These innovations may improve client interaction, broaden market reach, and speed up decision-making. Real estate organizations will be able to obtain greater

insights into market dynamics, customer preferences, and investment patterns as big data and advanced analytics continue to expand. Businesses may find patterns and correlations that inform investment choices, marketing plans, and portfolio management by integrating a variety of data sources, including social media, demographic information, and property records. Automating repetitive and rule-based processes in real estate operations, such lease administration, property management, and tenant onboarding, is possible using robotic process automation (RPA). Real estate organizations may increase operational effectiveness, decrease mistakes, and free up personnel to concentrate on higher-value tasks by using software robots. Prefabricated building techniques are becoming more and more common because of their efficacy, affordability, and sustainability. Prefabrication may be improved even further by integrating supply chain optimization and IT solutions by improving the sourcing, transportation, and assembly of component parts. This might result in shorter building schedules, lower costs, and better quality control. We conclude that the real estate sector has a lot of potential for transforming in the future using supply chain optimization and IT. Among the important technologies that may open up new possibilities for enhanced productivity, customer experiences, sustainability, and operational excellence in real estate are blockchain, IoT, AI, VR/AR, big data analytics, RPA, and supply chain integration. To remain competitive and satisfy the changing demands of the industry, real estate businesses must embrace these innovations.

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