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How to Complete Supply Chain Integration and Improve Supply Chain Performance Through Relationship Governance in the Digital Age

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ABSTRACT

In the process of manufacturing supply chain development, because appropriate governance mechanisms are lacking, manufacturing supply chain stability, integration and other aspects face many challenges. Such as opportunism, "free riding" and data leakage affect supply chain development. Thus, many manufacturing firms are adopting supply chain relationship governance (SCRG) as a strategic to enhance performance. Using data collected from a survey of 295 manufacturing firms, this paper confirms the influence of SCRG on supply chain performance (SCP). The mediating effect of supply chain integration (SCI) and the moderating effect of digital capabilities (DCs) are explored. The results show that SCRG has a beneficial effect on SCP. SCI plays a partial mediating role in SCRG and SCP. DCs positively moderate the relationship between SCRG and SCI. This study is one of the first to explore the role of DCs in the relationship between supply chain partners and the impact on performance. It provides fresh perspectives and real-world evidence for determining the importance of SCRG strategies.

KEYWORDS

Digital Capabilities, Industry 4.0, Supply Chain Integration, Supply Chain Performance, Supply Chain Relationship Governance

INTRODUCTION

As the competitive environment has become more complex, enterprises have come to rely on the supply chain as a primary driver of their competitive advantage (Feizabadi et al., 2019; Walker et al., 2000). Within the supply chain, various partners, such as suppliers, manufacturers, distributors, retailers, and customers, assume distinct roles to collectively contribute to its functioning. To effectively

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and efficiently maintain normal supply chain operations, it is imperative to establish several stable relationships and sustainable cooperation patterns among supply chain enterprises (Govindan et al., 2016) to increase the competitive advantage of the supply chain. Therefore, to manage such relationships and collaborations, organizations need to develop numerous effective governance mechanisms (Gimenez & Tachizawa, 2012; Formentini & Taticchi, 2016). Sound governance mechanisms can reduce the risk of opportunistic behavior, eliminate the uncertainty associated with conflict (Dolci et al., 2017; Govindan et al., 2016), help gain competitive advantages, and improve organizational performance (Dolci et al., 2017; Lee & Choi, 2021). Different from supply chain management, which focuses on direct activities, supply chain governance places a stronger emphasis on implementing mechanisms and rules to minimize uncertainty and guarantee the smooth operation of supply chain activities (Dolci et al., 2017).

Embedded within corporate structures and processes, governance is a multidimensional phenomenon, and it is a fundamental approach to analyzing interorganizational relationships. In recent years, scholars have focused on how to enhance the competitive edge within supply chains, and a wide range of definitions and concepts have been proposed (Ahola et al., 2014; Bonatto et al., 2020; Poppo & Zenger, 2002; Roehrich et al., 2020). Governance is mainly categorized into contractual governance and relational governance (Poppo & Zenger, 2002). Contractual governance essentially consists of written contractual terms that set out the roles, obligations and responsibilities between the parties involved in a collaborative relationship (Roehrich et al., 2020; Schepker et al., 2014). Relationship governance pertains to less formal and spontaneous mechanisms that rely on trust and collaborative arrangements derived from social interactions. This approach emphasizes the establishment and maintenance of trust, cooperation, and long-term relationships between partners to enable collective action and effectively respond to unexpected circumstances (Poppo & Zenger, 2002; Bonatto et al., 2020). Unlike contractual governance, relationship governance focuses more on building cooperative relationships based on mutual trust and synergy rather than just relying on explicit contractual terms to regulate cooperation. The two are complementary, not mutually exclusive (Cao & Lumineau, 2015).

Another important means of improving the competitive advantage of an organization is supply chain integration (SCI) because competition is transferred to the supply chain network of competitors; without establishing a stable cooperative relationship and coordinating and synchronizing information flow, logistics flow, and capital flow, profitable competition will be difficult to achieve (Eltantawy et al., 2009; Stock et al., 2010). Achieving efficient and effective collaboration in the supply chain necessitates the seamless integration of processes, people, knowledge, and information; considering the interconnectedness and synergies among the different links in the chain, the various partners, and the related processes, each enterprise can succeed in competition only in close cooperation with its partners. Thus, SCI involves strategically aligning functions and processes within an organization and among supply chain members (Kumar et al., 2017; Tiwari, 2021). Integration, collaboration, and trust among chain members have become the main forces for gaining competitive advantages (Manik, 2022; Garcia et al., 2023), and they have emerged as central concerns in the realm of supply chain management (Huang et al., 2014).

Notably, although the consensus among most managers and scholars is that SCI is helpful in improving enterprise performance, the effect of SCI is also inconsistent across firms, or there are mixed results (Van der Vaart & Van Donk, 2008; Khanuja & Jain, 2019), mainly because of the large variations that occur in practice. At the same time, given the extensive involvement of numerous businesses and stakeholders in the supply chain, the lack of a set of perfect mechanisms to ensure smooth cooperation and communication has also become one of the main reasons for differences in the effectiveness of SCI. According to the interpretation of "integration" in the New International Dictionary (William, 1966), the core essence of integration is governance (Shou et al., 2017). Therefore, we believe that supply chain governance is an effective means of achieving

SCI. In particular, through relationship governance, the establishment of good partnerships, effective communication mechanisms, and transparent information sharing can help achieve closer integration throughout the supply chain and ultimately achieve the goals of improving corporate performance and gaining competitive advantage. However, there has been limited research dedicated to examining the correlation between relationship governance and SCI. The primary focus of supply chain governance studies has predominantly revolved around conceptual frameworks, contextual factors impacting the adoption of governance mechanisms, influential factors, and their impact on performance (Bonatto et al., 2020; Roehrich et al., 2020), and research on SCI has focused on its drivers, dimensions, and effects on performance (Khanuja & Jain, 2019). Therefore, we propose the first question (Q1) of this research: What is the relationship among supply chain relationship governance (SCRG), SCI, and supply chain performance (SCP) and is there a significant direct or indirect effect?

Early on, supply chain governance became the primary means for organizations to address and cope with supply chain disruptions and changes (Lin et al., 2023). However, as digital technologies have been implemented by supply chain participants and are progressively changing the supply chain landscape, they have made the sharing of abundant and complex information a reality. Digital technologies have become a major tool for maintaining different activity allocations in the supply chain; carrying out demand forecasting, process optimization, and real-time monitoring; and providing new forms of governance at a lower cost. The contribution of digital technologies in facilitating supply chain process integration to improve performance has been widely discussed by scholars (Cui et al., 2023; De Vass et al., 2018). While digital technology can help organizations reduce risk, it can also introduce new instabilities, such as an overreliance on digital technology solutions, overly burdensome requirements for digitalization processes, and a lack of digital talent on the team. Despite the significance of enterprise digital capabilities (DCs), how these capabilities contribute to supply chain governance and SCI is still unknown, and there is a lack of comprehensive understanding and real-world evidence. Therefore, we pose the second question (Q2) of this study: How do DCs mediate the relationship between SCRG and SCI?

To answer these research questions, we investigated 295 manufacturing supply chain firms in Zhejiang Province, China, collected relevant data, constructed a structural model of SCRG, SCI, DCs and SCP based on resource orchestration theory, and tested the hypotheses. Our research is novel and highly valuable. First, our study provides the opportunity to take a fresh look at the role of SCRG and the impact of performance relationships in the digital environment of the Industry 4.0 era. Furthermore, it validates the theoretical framework through empirical evidence and bridges a research gap in the domain of relational governance and integration. Second, this study represents one of the pioneering investigations into the influence of DC on the relationships and performance of supply chain partners. Digital technology tools will provide a new driving force for supply chain governance and integration. Finally, our findings offer important guidance and insights for business practitioners in this area. The development of a comprehensive and robust relationship governance structure will significantly contribute to integration and performance, and relationship governance will become an effective and crucial method for attaining the strategic objectives of manufacturing supply chains.

The remainder of this study is organized as follows. The second section comprises a literature review, establishing the theoretical foundation. The third section develops our research hypotheses based on the theoretical foundation and proposes a theoretical structural framework. The fourth section provides a description of the data collection and variable measurement procedures. In the fifth section, the results of the data analysis are presented to determine the validity of the hypotheses. The sixth section delves into the analysis results, emphasizing the importance of the research and providing insights into the study's limitations and prospects for future research. The final section presents a comprehensive overview of this study.

THEORETICAL FOUNDATION

Resource Orchestration Theory

Resource orchestration theory emphasizes the need for firms not only to have resources but also to organize and coordinate these resources to respond to changing markets and competitive environments (Chirico et al., 2011; Liu et al., 2016; Sirmon et al., 2011). The resource-based view is expanded upon by resource orchestration theory. The core issue of the resource-based view is the accumulation, control, and utilization of the internal and external resources of enterprises (Taher, 2012). However, this perspective fails to consider that in today's intricate and constantly evolving business landscape, it is not possible to achieve success with resources, nor does it address how enterprises can effectively organize and coordinate these resources to achieve strategic goals. Therefore, resource orchestration theory extends and deepens the resource-based view by emphasizing the integration and coordination of resources, the flexibility and adaptability of resources, and the practical utilization of resources. (Hughes et al., 2018; Sirmon et al., 2011).

In resource management and utilization, the effectiveness of resources depends not only on the utility of individual resources themselves but also on the synergistic effects and interactions between different resources (Zaefarian et al., 2013); in addition, the effective management and orchestration of resources become a priority. The resource orchestration process consists of three subprocesses: structuring of resources, bundling of resources, and leveraging of resources (Cui et al., 2017; Sirmon et al., 2011; Sirmon et al., 2007). Structuring involves the acquisition, accumulation, and divestment of resources to shape a company's resource portfolio, while bundling entails the integration of resources to develop capabilities; leveraging encompasses a series of processes aimed at cultivating a firm's capabilities and capitalizing on specific market opportunities (Sirmon et al., 2011). Firms orchestrate their resources by acquiring, updating, structuring, and bundling and by taking other resource-centric actions as a way to gain new dynamic capabilities (Sirmon et al., 2011; Teece et al., 1997; Cui & Pan, 2015). Orchestration acts as a bridge between an uncertain environment and the capabilities of an enterprise.

Resources represent the foundation that supports supply chain operations and the achievement of supply chain objectives, and they are the main element in supply chain management. To access resources, enterprises need to collaborate with value cocreators (such as suppliers, partners, or other stakeholders) (Chen & Tian, 2022). Supply chain governance establishes the essential prerequisites for companies to obtain valuable resources from their partners in the supply chain through the implementation of resource-oriented actions, such as procuring, updating, and organizing, and it is employed to harmonize the activities of supply chain management. Therefore, supply chain governance sets the limits for the structure of enterprise resources. (Lin et al., 2023). Considering the aspect of value cocreation, the participants in each link in the supply chain become a resource synergy community through information sharing, professional knowledge, technology, and other aspects of synergistic cooperation to achieve common goals. Therefore, we believe that SCI is the process of realizing resource bundling. DCs are the ability to mobilize, coordinate, and leverage resources. They are reflected in improving the supply chain's transparency, visibility, and responsiveness (Ali & Govindan, 2023) and in enabling enterprises to better improve the efficiency of resource utilization through data analysis and an intelligent decision support system, which determines the effectiveness of the resource leveraging of an organization.

SCRG

With the far-reaching impact of globalization, technological advances, and increased market competition on supply chains, companies are placing growing emphasis on optimizing their supply chain structure and adopting the model of organizational relationship governance to improve economic performance. In contrast to supply chain management, supply chain governance places greater emphasis on maintaining balance through long-term self-interested decision-making and

fostering interdependence among upstream and downstream enterprises in the supply chain (Dolci et al., 2017). Supply chain governance is seen as an effective approach for organizations to address environmental changes and market pressures, and it has stimulated extensive research and discussion in the academic community. The different forms of governance can be categorized into contractual governance and relational governance (Senge et al., 1999; Poppo & Zenger, 2002; Cao & Lumineau, 2015; Dolci et al., 2017; Bonatto et al., 2020). A contract is a basic relationship management tool that establishes the rights, obligations, responsibilities and expectations of parties through a written agreement to ensure that the parties are treated fairly and lawfully in their dealings and cooperation. Although contract/contractual governance plays a crucial role in business and organizations, it cannot control emergencies in the transaction process or the boundary rationality of people (Lu et al., 2015). Humans are unable to act independently of society, and contractual governance fails to take this social factor into account. Thus, relying on contractual governance alone is insufficient (Heide & John, 1992; Macneil, 1980).

Exchanges between people or organizations are largely based on social relationships; thus, exchange behavior is influenced by social rules and value systems. In a social relationship, there is a way to manage the relationship through shared values and common commitments. On this basis, Macneil first proposed "relationship governance" in 1980. Based on social exchange theory (Emerson, 1976), the relational view (Dyer & Singh, 1998), and the network perspective (Cook & Emerson, 1978), SCRG relies on trust and relational norms; it includes a structural aspect, which refers to the hierarchical or market structure within the relationship, and a process aspect, which encompasses the anticipated and actual interfirm activities related to information sharing and collaborative problem solving (Zaheer & Venkatraman, 1995).

As a form of informal governance, SCRG places significant emphasis on the anticipation of sustained relationships among supply chain partners and is dependent on mechanisms such as relational norms and cooperative behaviors to ensure the continued achievement of shared development goals. Relational norms establish acceptable limits of appropriate conduct and act as a crucial measure to prevent deviant behavior (Heide & John, 1992; Macneil, 1980). Relationship governance establishes a common set of norms and values among partners involved in an exchange (Macneil, 1980); promoting collaboration between buyers and suppliers for mutual benefits is achieved through the utilization of relational tools, such as information sharing, solidarity, and flexibility (Heide & John, 1992; Lusch & Brown, 1996). It performs a function akin to contractual governance by controlling opportunistic behavior and facilitating the achievement of goals (Heide & John, 1992; Bonatto et al., 2020). Therefore, SCRG becomes crucial in establishing and maintaining the stability of buyers' relationships with stakeholders both upstream and downstream in the supply chain (Liu et al., 2009; Awan, 2019), providing a viable and effective approach to successfully manage and maintain interorganizational relationships (Poppo & Zenger, 2002).

SCI

Integration is regarded as a competitive strategy for coping with the current uncertain business environment (Li & Chen, 2018). SCI has been widely discussed by scholars as a key practice activity (Stadtler, 2005), and the degree to which something is defined is referred to as the degree to which a company strategically engages in collaboration with its supply chain partners and collectively manages processes within and across organizations (Flynn et al., 2010; Mofokeng & Chinomona, 2019). It is generally accepted that SCI can be further segmented from three perspectives into the following categories: supplier integration (SI), internal integration (II), and customer integration (CI) (Flynn et al., 2010; Piprani et al., 2020; Ganbold et al., 2021).

SI is the degree of coordination between manufacturers and suppliers in making decisions about capacity planning, demand forecasting, inventory management, replenishment, and material flow. SI helps reduce uncertainty in the supply chain and improve delivery reliability. II refers to the coordination and collaboration between departments and functions within an organization. It includes

information sharing, process optimization, and goal coordination among different departments, such as sales, production, procurement, and logistics (Frohlich & Westbrook, 2001). The objective of II is to guarantee that all segments within an organization make an active contribution to achieving the overarching objectives of the supply chain and fulfilling customer requirements. CI involves cooperation and coordination between a business and its customers. It includes communication with customers, order management, demand planning, and coordinating services to ensure that products or services are delivered in accordance with customer needs and expectations (Wong et al., 2011). The ultimate goal of SCI is to achieve collaborative optimization of the entire supply chain by establishing smooth business processes throughout the supply chain network to enhance operational efficiency and flexible and sustainable supply chain operations to meet customer needs and improve competitiveness (Huo et al., 2016).

SCP

For organizations to effectively manage, optimize, and improve supply chain operations, SCP evaluation is essential and serves as the cornerstone of effective supply chain management (Balfaqih et al., 2016). Therefore, scholars have been studying SCP for many years, and much work has been performed. SCP is defined as a supply chain that reduces costs while being cost effective to meet the demands of the end customer (Mofokeng & Chinomona, 2019). Based on a review of 364 articles on SCP management published between 1998 and 2015, Balfaqih et al. (2016) concluded that scholars assess SCP through perspective-based, process-based, and hierarchical-based approaches. The majority of scholars employ the perspective-based approach as their primary method, followed by the process-based approach and the hierarchical-based approach.

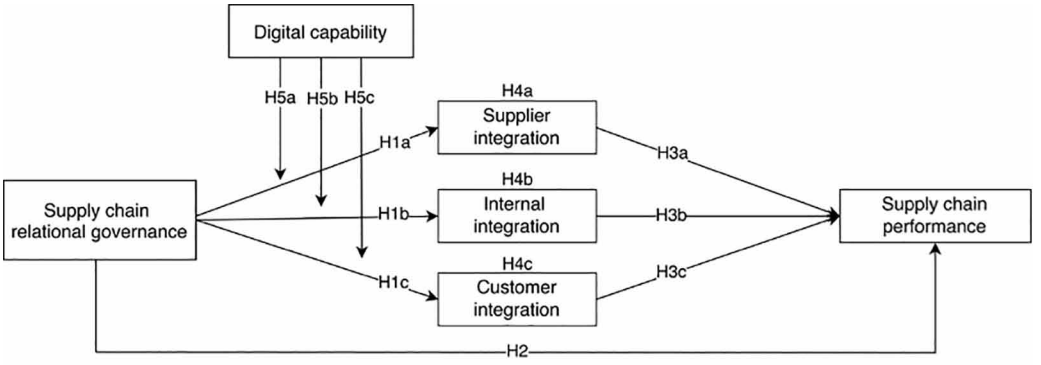
Financial performance or return on investment receives the most attention, and other important factors needed for supply chain success, such as resilience, flexibility, or delivery performance, tend to be disregarded or given less attention (Cadden et al., 2021). Therefore, Piprani et al. (2020) proposed dividing performance measurement standards based on cost and noncost types. Cost types include financial aspects and asset management, while noncost types include customers, internal processes, learning and innovation, flexibility, reliability, responsiveness, quality, resources, output, information, time, efficiency, and integration (Bai & Sarkis, 2012; Angerhofer & Angelides, 2006; Bhagwat & Sharma, 2009; Hamid Abu Bakar et al., 2009; Balfaqih & Yunus, 2014; Banomyong & Supatn, 2011; Tyagi et al., 2015; Balfaqih et al., 2016; Bhattacharya et al., 2014; Chan & Qi, 2003).

SCP is influenced by an array of internal and external factors. The primary factors that exert influence include the structure of the supply chain, the inventory control policy, information sharing, customer demand, the method of forecasting, delivery time, and the review cycle (George & Pillai, 2019). When enterprises or organizations try to improve SCP, they may face multiple risks and challenges, such as unstable market demand, a shorter product life, and inventory cost pressure. Therefore, enterprises need to make use of SCI (Rajaguru & Matanda, 2019; Wu & Chiu, 2018), supplier relationships, customer relationship management (Ziggers & Henseler, 2016), information technology (Han et al., 2017), information flow (Akcay et al., 2017), top management commitment (Lam & Rahma, 2014; Shrivastav, 2021) and other strategic means to improve SCP.

RESEARCH HYPOTHESES

The aim of this study is to examine the relationships between SCRG and SCI (internal and external) and between SCRG and SCP. Considering the backdrop of the digital age and the moderating influence of supply chain enterprises' DCs on the relationship between SCRG and SCI, Figure 1 shows our research framework. Next, we discuss the logic of each relationship and present our hypotheses.

Figure 1. Research Framework



Relationship Between SCRG and SCI

From the economic perspective, when organizations manage relationships, cost minimization is the basic standard from the perspective of transaction cost theory (TCT) (Williamson, 1975), and cooperation is essential for upstream and downstream firms in the supply chain to maintain low transaction costs. As a structure, SCI provides an environment in which low transaction costs are realized, and both suppliers and buyers can benefit from such an environment (Lo et al., 2018). However, the effectiveness of this environment needs to be maintained through the contractual or relationship governance of supplier relationships (Heide & Stump, 1995). Due to the involvement of numerous partners in the supply chain, including manufacturers, suppliers, distributors, retailers, and customers, all stakeholders must engage in relationship governance within the supply chain to effectively manage and sustain various relationships, thereby establishing a positive, strong, and cooperative partnership, which is an important prerequisite for ensuring a continuous and stable exchange.

According to resource dependence theory (RDT), firms have limited resources that they own and that are available. Thus, they form interorganizational relationships. The external relationship of an enterprise is a response to these resource constraints (Lo et al., 2018), and the value brought to the organization by the different qualities of the partnership will also be different. The factors that determine the quality of external organizational relationships include commitment, benevolence, trust, business understanding, and conflict (Lo et al., 2018; Park et al., 2017). Through SCRG, common norms and values are embedded among partners, which is conducive to improving trust, reducing conflict, and improving business understanding, and suppliers and CI play a pivotal role in achieving this objective.

From the perspective of organizational ability, a company that possesses strong internal communication and coordination capabilities can attain a high degree of external integration (Zhao et al., 2011). II primarily encompasses the integration of data and information systems, as well as fostering cross-functional collaboration. SCRG aids in identifying shared objectives within the supply chain, which are then manifested throughout its operations, leading to better collaboration across departments to achieve these goals. Moreover, the theory of smooth, uninterrupted flow suggests that increased productivity is generally correlated with faster and more consistent movement of materials and information within a process, while variability within the process reduces productivity (Schmenner & Swink, 1998; Schmenner, 2001). SCRG will foster information sharing and collaboration among diverse partners in the supply chain. This means that closer connections between partners and more information flow will enhance the understanding of the external environment and requirements among the different departments within the supply chain. Consequently, SCRG establishes an environment that is conducive to information sharing, collaboration, trust, and collaborative working, which are also critical for supply chain II. Drawing from the analysis provided, the following hypotheses are proposed:

H1a. There is a positive correlation between SCRG and SI.
H1b. There is a positive correlation between SCRG and II.
H1c. There is a positive correlation between SCRG and CI.

The Relationship Between SCRG and SCP

The success of a business or project means that the organization and stakeholders have achieved the goals set; however, performance reflects the effectiveness of the different approaches (e.g., governance, controls) adopted in achieving those goals (Ika & Pinto, 2022). The essence of SCRG is to use trust, commitment, collaboration, and other mechanisms to maintain the achievement of common goals between partners. Therefore, trust requires both parties to believe that the other is trustworthy, while commitment is the mutual expectation that both parties will maintain a worthwhile and sustainable relationship. Trust and commitment will make them willing to relinquish speculation and, instead, strengthen their own learning and increase their investment in new technologies, with both parties beginning to rely on relationship norms as the guarantee of cooperation (Zaheer & Venkatraman, 1995; Wang & Wei, 2007).

On the one hand, under efficient information interaction and sharing, solidarity among members is stimulated, enhanced adaptability to environmental or market changes is accompanied by strengthened ability, and a high level of relationship quality results in improved synergistic effects within the supply chain. Scholars have confirmed that synergistic effects in supply chains are a major factor affecting SCP (Mofokeng & Chinomona, 2019; Um & Oh, 2020). On the other hand, SCP is closely tied to the level of trust, collaboration, and information sharing among the members of the supply chain (Hou et al., 2014; Swain & Cao, 2019), and one of the main purposes of SCRG is to enhance the trust and collaboration among members to reduce potential risks, optimize the supply chain's efficiency, and enhance its competitiveness, all of which can improve SCP. Therefore, building upon the preceding content, the following hypothesis is formulated:

H2. SCRG and SCP are positively correlated.

The Relationship Between SCI and SCP

SCI is divided into II and external integration (SI and CI). The goal of integration is to improve the overall efficiency of the chain using different methods, thereby increasing competitive advantage and ultimately improving performance. Dynamic capabilities theory suggests that by integrating business processes, firms can better adapt and reconfigure their resources to changing business dynamics (Teece et al., 1997), making supply chain II particularly important. Through effective II, the transmission of information can be promoted, and the ability to collaborate between departments can be improved more effectively. An enterprise with excellent internal information processing capabilities can not only eliminate cross-functional barriers within the enterprise and realize smooth cross-functional collaboration (Yu et al., 2021), but also better exchange information with customers and suppliers, disseminate and develop external knowledge gained from customers and suppliers, and enhance the closeness of cooperation (Lee, 2021). Supply chain II is considered the most important part of improving enterprise performance (Piprani et al., 2020).

TCT suggests that organizations aim to minimize the combined costs of vertical integration and market transactions in their pursuit of efficiency (Huang et al., 2014; Williamson, 1975). Opportunistic behavior is a type of behavior that can seriously threaten efficiency because it can lead to a waste of resources, the instability of contracts, and a lack of trust between organizations. External SCI (SI and CI) enhances the structure of the supply chain to facilitate elevated levels of SCP by guiding behavior and improving interorganizational trust, responsiveness, stability, and overall efficiency (Eisenhardt et al., 2010). At the same time, efficient external integration necessitates managing the exchange of information visually between supply chain partners to seamlessly integrate customer and supplier

information (Lee, 2021; Ada et al., 2021), improve communication efficiency, and deliver high-quality information, thus reducing information asymmetry, further reducing opportunistic behaviors, lowering transaction costs, and improving cooperation efficiency (Li et al., 2023). The advantages of SI also compensate for problems in the production process through, for example, improved product quality, product portfolio flexibility, improved delivery speed, and controlled production costs and inventory levels (Ganbold et al., 2021). Innovation based on customer needs and participation has become one of the main trends; through CI, it is possible to understand customers' products, cultures, markets, and needs more quickly, and enterprises can further enhance their flexibility and responsiveness to market needs (Siagian et al., 2021), which is conducive to achieving the goal of SCP enhancement. Therefore, based on the analysis above, we propose the following hypotheses:

H3a. SI is positively correlated with SCP.
H3b. II is positively correlated with SCP.
H3c. CI is positively correlated with SCP.

The Mediating Role of SCI

Based on the above theories and hypotheses, we contend that SCI (SI, II, and CI) acts as a mediator in the impact of SCRG on SCP. SCRG facilitates the integration of internal functions and external (supplier and customer) collaboration in the form of more integrated management that improves interenterprise relationships, enhances trust, and facilitates the transfer of information and reliance. SCI involves collaborative work between partners, such as information sharing, coordinated production, and optimized inventory, and the efficiency and effectiveness of the supply chain are enhanced by all of these factors, leading to better SCP, including reduced costs, shorter delivery times, increased customer satisfaction, and improved product quality. Therefore, we propose the following hypotheses:

H4a. The relationship between SCRG and SCP is mediated by SI.
H4b: The relationship between SCRG and SCP is mediated by II.
H4c: The relationship between SCRG and SCP is mediated by CI.

The Moderating Role of DCs

With the arrival of the digital era, unlike capacity building in the traditional industrial period, enterprises and supply chains are increasingly aware of the developmental advantages brought about by cutting-edge information technologies like cloud computing and the Internet of Things, among others, as well as artificial intelligence and blockchain. Additionally, they are gradually gaining awareness of the application of digital technologies to enterprise strategy development, the organizational structure, business processes, the operation mode, and upstream and downstream cooperation (Li et al., 2019) to accelerate the construction of DCs and improve organizational management. According to dynamic management capability theory, as a type of dynamic capability, DCs refer to an organization's capacity to leverage digital technology for creating innovative products and processes and adapting to corresponding market changes (Rupeika-Apoga et al., 2022), which entails proficiency, aptitude, and expertise in digital technology (Khin & Ho, 2018). Well-developed information management capabilities and a flexible IT infrastructure are two of the most important components of DCs (Levallet & Chan, 2018).

In the process of SCRG and SCI, the DCs possessed by firms play a major role in coordinating and controlling transaction costs, mainly because digital technology is the key to efficiency (Paolucci et al., 2021; Chen et al., 2023). The use of digital technology by suppliers allows for continuous tracking and analysis of every step in design and production. It simplifies the transparency and traceability of real-time information, improves product quality assurance, incentivizes supplier empowerment and competitiveness (Huang et al., 2020; Liu et al., 2022), and fosters the cultivation of trust and

commitment among all involved parties, prioritizing these aspects over production concerns and conflict resolution. Digital technologies influence the governance of buyer-supplier relationships in various ways (Paolucci et al., 2021), which is more conducive to the acceleration of SI.

A customer demand-oriented supply chain places greater emphasis on real-time responses to customers. DCs facilitate the digital integration of supply- and demand-centered business processes, such as real-time order tracking (Varriale et al., 2021), demand forecasting, real-time inventory monitoring (El Jaouhari et al., 2022), and digital contracting and payment security (Raj et al., 2022); this maintains a more open and higher quality relationship in governing, enables the smooth exchange of information within the organization and its customers, and promotes CI to achieve a better customer experience and customer value.

For any organization, the level of competitiveness in a competitive landscape relies on the extent to which an organization's internal capabilities are integrated with the external environment. The relationship between SCRG and II is also affected by DCs. The reason is that II is how organizations structure their organizational practices, procedures, and behaviors into collaborative, synchronous, and manageable processes that primarily rely on the integration of data and information systems (Zhao et al., 2011; Williams et al., 2013). Therefore, with the application of high-level digital technology and the cultivation of DCs, information exchange can be faster and more effective within the organization, improve the efficiency of information processing, help all members of the organization form a common understanding of the ultimate goal, and ultimately form internal cohesion. Therefore, based on the analysis conducted, we propose the following hypotheses:

H5a. DCs positively moderate the relationship between SCRG and SI.
H5b. DCs positively moderate the relationship between SCRG and II.
H5c. DCs positively moderate the relationship between SCRG and CI.

RESEARCH METHOD

We adopt a quantitative research approach to test our research hypotheses. We conducted a questionnaire survey and analyzed survey data from manufacturing supply chain companies in Zhejiang Province, China. In this section, we will present the specific processes for data collection and analysis.

Sample and Data Collection

The first step is to identify the study sample. China's manufacturing industry has experienced ongoing development and growth. In this regard, Zhejiang Province ranks first among China's manufacturing provinces, and its strength cannot be underestimated. Zhejiang Province has a rich manufacturing base, covering light industry, heavy industry, high-tech manufacturing, and other fields, and it is the province with the most developed private economy. Simultaneously, Zhejiang Province, as a pivotal node in the manufacturing industry, holds a significant position in the global supply chain and establishes strong supply chain collaborations with both domestic and international enterprises. For these reasons, this province was chosen as the main research object.

The second step is to collect the data. We identified nearly 7,000 manufacturing companies through China's National Enterprise Credit Information Publicity System. After excluding some enterprises that had been established for less than 3 years, were small in scale, or were no longer operating but had not yet been written off, 1,300 manufacturing enterprises were finally selected. We then sent the questionnaire to the official email addresses of these companies and specified that we would like the general manager, the CEO or senior managers to complete our questionnaire. The research period lasted from January 2023 to June 2023. Of the 1,185 questionnaires distributed, 350 were returned. Invalid and incomplete questionnaires were excluded from the analysis, and a total of 295 questionnaires that could be used were collected, resulting in an effective response rate of 24.89%.

Measurement

This study adopted mature scales from existing studies in China and elsewhere. The scales were developed in compliance with the actual progress of the manufacturing supply chain, and the questionnaire was improved by incorporating expert opinions. All variables were measured by using a 5-point Likert scale, with 1 representing *very much disagree*, 3 representing *uncertain*, and 5 representing *very much agree*. The *SCRG* variable, which adopted six items from Lo et al. (2018) regarding relying on trust, commitment, communication, information sharing, and other measures, is implemented to prevent opportunistic behaviors, protect the interests of all supply chain stakeholders, and maintain relationships among members. The *SCP* variable utilized six items from Kankam et al. (2023), measured in terms of cost, product quality, customer satisfaction, information, and efficiency. The *SCI* variable was categorized as SI, II, or CI and was measured using nine items from Oubrahim et al. (2023). Finally, the *DC* variable referred to seven items from Lenka et al. (2017) and was measured based on the aspects of digital resources, digital technology, interdepartmental coordination and communication, and information sharing. At the same time, considering other factors that affect SCP, the time of establishment of the enterprise, the nature of equity, the size of the enterprise, and the position and the industry category were added to the model test as control variables. Table 1 presents the specifics outlined in the questionnaire.

ANALYSIS RESULTS

Descriptive Statistical Analysis

The 295 questionnaires collected were analyzed using the statistical package for the social sciences (SPSS) 27.0, and Table 2 displays the results of the descriptive statistical analysis for the enterprises. A total of 43.3% (128 companies) had been established for 10 years or less, and 11.5% (34 companies) had been established for more than 20 years. In terms of the ownership nature of enterprises, 53.6% (158 companies) were private enterprises. Companies with 301-1,000 employees accounted for 38% (112 companies) of the sample, and large manufacturing companies with more than 5,000 employees accounted for 5.8% (17 companies). The surveyed enterprises mainly covered most of the industries in the field of manufacturing enterprises and could basically reflect the situation of China's manufacturing industry. Finally, middle managers accounted for 42.03% (124 companies) of the respondents, and senior managers accounted for the lowest percentage, 15.25% of respondents (45 companies).

Reliability and Validity Testing

First, unrotated exploratory factor analysis (EFA) was conducted to analyze all the items in the questionnaire. The Kaiser–Meyer–Olkin (KMO) value was determined to be 0.930, and Bartlett's test of sphericity yielded a significance level of $p<0.001$. Subsequently, principal component analysis was carried out using the maximum variance rotation method, and there were six eigen roots with values greater than 1 in the analysis results before rotation. These six factors were able to explain 65.104% of the variance, reflecting the information of the sample well. That is, all of the variables above were verified by one-way validation, and the first factor accounted for 36.85% of the explained variance, which is less than 40%. The results suggest that this study does not exhibit significant common method bias. The reliability and validity of the variables were assessed using the analysis of moment structures (Amos) 24.0 and SPSS 26.0 analysis tools. According to the findings presented in Table 3, both the α coefficient and the composite reliability (CR) value exceed 0.798, suggesting a high level of internal consistency for each variable item and indicating good reliability of the scale. The factor loading of each measurement item exceeds 0.7, and all of them are statistically significant at the 0.001 level. With the exception of the average variance extracted (AVE) value of SCP, which is less than 0.5, it is possible that if the questionnaire items are not perfect, the subjective answers of the respondents will have an impact on the results, but the values of the other variables are greater than

Table 1. Measurement Scale Items

Variables and measurements	Source
SCRG	Lo et al. (2018)
1. The company believes that our major suppliers or customers will abide by their commitment and have a good social reputation.	
2. The company and supply chain partners carry out close communication and contact and have a harmonious relationship.	
3. The company has established a formal channel of information exchange with suppliers or customers, and supply chain members have a high degree of information sharing.	
4. When the company and suppliers or customers encounter major situations, both sides will mobilize their own resources to jointly solve most of the problems and difficulties together.	
5. In the process of cooperation, the suppliers or customers of the enterprise never use opportunism to harm the interests of the company or the collective to achieve an increase in profit.	
6. The company shares its goals and plans with suppliers or customers, and it regularly checks and coordinates the plans based on the actual situation.	
SCP	Kankam et al. (2023)
1. Our supply chain helps us achieve lower production costs than those of our competitors.	
2. Our supply chain helps us achieve superior product quality and stability over our competitors.	
3. Our supply chain helps us deliver on time.	
4. Our supply chain possesses the capability to promptly adapt products in order to fulfill the unique requirements of customers.	
5. There is good information sharing among members of our supply chain.	
6. We are content with the effectiveness of the supply chain process.	
SCI	Oubrahim et al. (2023)
SI	
1. The company and our suppliers trust and rely on each other and consider each other's interests.	
2. The company shares effective information such as requirements, forecast information, and operation plans with suppliers.	
3. The company shares information resources with suppliers through digital tools and components.	
II	
1. There is collaboration among various departments within the company.	
2. The company employs cross-functional teams to enhance process optimization and engage in research and development of new products.	
3. The company integrates the operational data and decision-making of various functional departments to understand the inventory level and operation situation in real time.	
CI	
1. The company has established a rapid order processing system with customers.	
2. The company utilizes formal practices and standard operating procedures to effectively communicate information with customers, enabling the identification of their desired products or services.	
3. The company will engage in customer follow-up to enhance the quality of products or services.	

continued on following page

Table 1. Continued

Variables and measurements	Source
DCs	Lenka et al. (2017)
1. The company can access our suppliers' or customers' technology research and development and the latest information on product production in a timely manner.	
2. The enterprise is able to select data resources that have commercial value and are conducive to its own development.	
3. Based on big data analysis, the company has the ability to anticipate the future business requirements of suppliers or customers.	
4. The company is improving the efficiency of supply chain decision-making through digital tools and components.	
5. The company has the capability to employ digital technology for automating and visualizing the production process.	
6. The company can leverage digital technology to coordinate the relationship with suppliers or customers.	
7. The company can utilize digital technology with suppliers or customers to achieve product life-cycle information tracking and feedback.	

Table 2. Descriptive Statistical Analysis (N=295)

Index	Frequency	Percentage	Index	Frequency	Percentage
Establishment time			**Profession**		
3-5 years	55	18.60%	Pharmaceutical manufacturing industry	20	6.80%
6-10 years	73	24.70%	Computer, communications and other electronic equipment manufacturing	41	13.90%
11-15 years	81	27.50%	Food manufacturing	30	10.20%
16-20 years	52	17.60%	General equipment manufacturing	36	12.20%
>20 years	34	11.50%	Specialized equipment manufacturing	31	10.50%
Equity nature			Automobile manufacturing	17	5.80%
State-owned or state-controlled	31	10.50%	Wholesale and retail trade	18	6.10%
private enterprise	158	53.60%	Transportation, warehousing and postal services	24	8.10%
Sino-foreign joint venture	56	19.00%	Information transmission, software and information technology services	24	8.10%
Foreign-funded enterprise	27	9.20%	Textile and clothing manufacturing	35	11.90%
Other enterprises	23	7.80%	Other manufacturing	19	6.40%
Number of employees			**Job position**		
<300	90	30.50%			
301-1000	112	38.00%	Senior management	45	15.25%
1001-2000	51	17.30%	Junior senior management	72	24.41%
2001-5000	25	8.50%	Middle management	124	42.03%
>5000	17	5.80%	Grassroots management	54	18.31%
Total	295	100%	Total	295	100%

Table 3. Reliability and Validity Analysis (N=295)

Variables		EFA			CFA		
		Item	Loadings	Cronbach's alpha	Loadings	CR	AVE
SCRG		RG1	0.758	0.869	0.834	0.871	0.531
		RG5	0.747		0.755		
		RG3	0.742		0.746		
		RG6	0.730		0.716		
		RG2	0.688		0.623		
		RG4	0.667		0.680		
SCI	II	II2	0.732	0.805	0.741	0.805	0.579
		II3	0.729		0.737		
		II1	0.718		0.803		
	CI	CI2	0.768	0.798	0.693	0.798	0.570
		CI3	0.735		0.778		
		CI1	0.666		0.790		
	SI	SI2	0.761	0.821	0.716	0.820	0.605
		SI1	0.715		0.886		
		SI3	0.696		0.720		
DC		A5	0.791	0.893	0.799	0.893	0.546
		A1	0.750		0.789		
		A3	0.711		0.772		
		A4	0.672		0.725		
		A2	0.669		0.713		
		A6	0.639		0.697		
		A7	0.612		0.667		
SCP		SCP5	0.711	0.833	0.718	0.834	0.457
		SCP1	0.704		0.713		
		SCP2	0.699		0.672		
		SCP4	0.690		0.609		
		SCP6	0.646		0.650		
		SCP3	0.632		0.677		
IFA		$\chi 2/df=1.694$,RMA=0.046,RMSEA=0.049,IFI=0.942,TLI=0.935,CFI=0.942					

0.5. Furthermore, the square root of the AVE for each variable exceeds the correlation coefficient between that variable and other variables. The results of the item factor analysis (IFA) for the model, as determined through confirmatory factor analysis (CFA), are as follows: $\chi 2/df=1.694<3$, SRMR $=0.046<0.08$, RMSEA$=0.049<0.08$, IFI$=0.942>0.9$, TLI$=0.935>0.9$, and CFI$=0.942>0.9$. That is, it is presumed that there exists a strong alignment between the theoretical model and the empirical data, and that the outcomes of the model are persuasive.

Correlation Analysis

To test the relationships between the variables, we also carried out Pearson correlation analysis. Table 4 displays the findings of the analysis. The variables exhibit a significant positive correlation, with

Table 4. Correlation Coefficients and Descriptive Statistics for Each Variable (N=295)

	Mean	Std. deviation	SCRG	SI	II	CI	DC	SCP
SCRG	4.062	0.728	1					
SI	3.935	0.859	0.416**	1				
II	3.947	0.913	0.429**	0.558**	1			
CI	3.920	0.880	0.362**	0.523**	0.559**	1		
DC	3.958	0.813	0.549**	0.585**	0.489**	0.506**	1	
SCP	3.993	0.726	0.434**	0.455**	0.460**	0.420**	0.525**	1

Note. ** p < 0.01

Pearson correlation coefficients reaching a level of significance of 0.01. There is a correlation, with the highest correlation coefficient value between the main variables of this study being 0.585, which is less than 0.075. Thus, there is no strong correlation between the variables. With an average variance inflation factor (VIF) = 1.26 for each variable, there is no serious problem of multicollinearity, and structural equation modeling can be performed.

Results of the Model Test and Path Analysis

To assess the fit of the sample data to the structural equation model depicted in Figure 2, Amos 24.0 was utilized. The primary fit indicators, including $\chi 2/df=2.518<3$, RMSEA=0.072<0.08, IFI=0.900, CFI=0.898, and TLI=0.882, are all within the acceptable range. Table 5 displays the results of the path analysis conducted on the structural equation model, revealing that all standardized path coefficients between the variables are statistically significant at p<0.01 and higher.

The standardized path coefficient from SCRG to SI is 0.567, indicating a significant relationship (p<0.001). Similarly, the standardized path coefficient from SCRG to II is 0.589, with a significance level of p<0.001. Additionally, the path coefficient from SCRG to CI is 0.508, which is also significant

Figure 2. Structural Equation Model

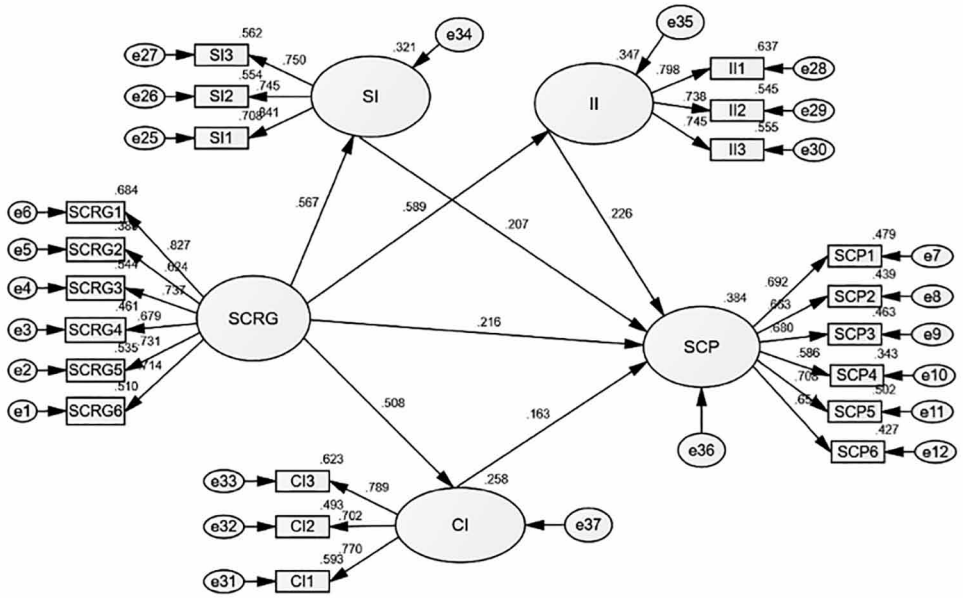


Table 5. Hypothesis Test Results (N=295)

Hypothesis	Path	Path Coef.	S.E.	C.R.	Decision
H1a	SCRG→SI	0.567***	0.076	8.536	Supported
H1b	SCRG→II	0.589***	0.080	8.531	Supported
H1c	SCRG→CI	0.508***	0.079	7.215	Supported
H2	SCRG→SCP	0.216**	0.095	2.089	Supported
H3a	SI→SCP	0.207**	0.063	2.651	Supported
H3b	II→SCP	0.226***	0.066	2.755	Supported
H3c	CI→SCP	0.163**	0.062	2.178	Supported

Note. * p < 0.05; ** p < 0.01; *** p < 0.001

at p<0.001. The standardized path coefficient from SCRG to SCP is determined to be 0.216, with a significance level of p<0.01. Therefore, H1a, H1b, H1c, and H2 are established.

The standardized path coefficient from SI to SCP is 0.207, p<0.01. The standardized path coefficient from II to SCP is 0.226, which is statistically significant at p<0.001. Similarly, the standardized path coefficient from CI to SCP is 0.163, indicating statistical significance at p<0.01. The path tests are all positive and significant, and H3a, H3b, and H3c are valid.

Bootstrap Mediating Effect Test

In this paper, we refer to the bootstrap method proposed by Hayes et al. (2017) to conduct the mediating effect test, and Table 5 presents the results of the regression analysis. In Model 1, SCRG has a significant positive effect on SCP, with a β coefficient of 0.425 (p<0.001). Model 2 (β=0.485, p<0.001), Model 3 (β=0.551, p<0.001) and Model 4 (β=0.404, p<0.001) show that SCRG has a significant positive effect on all three dimensions of SCI, and the explanatory power of SCRG regarding SCP increases from 21.0% to 29.4%, 29.7%, and 28.8%, respectively, and is significant

Table 6. Results of the Mediation Effect Analysis (N=295)

Construct	Model 1	Model 2		Model 3		Model 4	
	SCP	SI	SCP	II	SCP	CI	SCP
Establishment time	0.082*	0.090*	0.058	0.072	0.063*	0.008	0.080*
Equity nature	-0.038	-0.027	-0.03	0.032	-0.046	-0.086	-0.016
Number of employees	-0.0004	-0.015	0.004	-0.028	0.007	-0.074	0.018
Job position	0.036	0.143**	-0.003	-0.048	0.049	-0.092	0.059
Profession	-0.002	0.017	-0.006	-0.011	0.001	-0.018	0.003
SCRG	0.425***	0.485***	0.293***	0.551***	0.281***	0.404***	0.324***
SI			0.273***				
II					0.261***		
CI							0.251***
R^2	0.21	0.202	0.294	0.202	0.297	0.162	0.288
F	12.768***	12.182***	17.040***	12.120***	17.280***	9.268***	16.566***

Note. * p < 0.05; ** p < 0.01; *** p < 0.001

at p<0.001. The findings suggest that the influence of SCRG on SCP can be mediated by the three variables above; therefore, H4a, H4b, and H4c are verified.

The test results of the bootstrap method are presented in Table 7, indicating a 95% confidence interval. The confidence intervals of the three paths of the direct effect, the mediating effect, and the total effect do not include 0, indicating that the direct effect, the mediating effect, and the total effect are statistically significant. The mediating effect of SI accounts for 31.29% of the relationship, the mediating effect of II accounts for 33.88% of it, and the mediating effect of CI explains 23.76% of it. To summarize, the findings indicate that SI, II, and CI partially mediate the relationship between SCRG and SCP, and H4a, H4b and H4c are supported.

DC Moderating Effect Test

The moderating effect test refers to the bootstrap method of Hayes et al. (2017), and the test results, along with their 95% confidence intervals, are presented in Table 8. The interaction term of DCs' moderating effects on the relationship between SCRG and SCI is characterized by three-dimensional regression coefficients: SI (β=0.195, p<0.01), II (β=0.144, p<0.05), and CI (β=0.147, p<0.05). Regarding the effects of SCRG on SI, II, and CI, H5a, H5b, and H5c, respectively, are validated.

Table 7. Mediated Effect Values (N=295)

Construct	Effect	Effect size	standard error	LLCI	ULCI	Percentage
	Total effect	**0.425**	**0.054**	**0.320**	**0.531**	**100%**
SI	Direct effect	0.293	0.056	0.1831	0.4021	68.94%
	Indirect effect	0.133	0.036	0.071	0.204	31.29%
II	Direct effect	0.281	0.056	0.171	0.392	66.12%
	Indirect effect	0.144	0.034	0.084	0.215	33.88%
CI	Direct effect	0.324	0.054	0.218	0.430	76.24%
	Indirect effect	0.101	0.032	0.047	0.171	23.76%

Note. * p < 0.05; ** p < 0.01; *** p < 0.001

Table 8. Moderating Effect Values (N=295)

Construct	SI		II		CI	
	β	t	β	t	β	t
Establishment time	0.064	1.855	0.051	1.323	-0.015	-0.391
Equity nature	0.007	0.185	0.062	1.386	-0.052	-1.216
Number of employees	-0.050	-1.31	-0.055	-1.321	-0.103**	-2.588
Job position	0.052	1.062	-0.125*	-2.254	-0.177***	-3.313
Profession	0.025	1.967	-0.004	-0.241	-0.010	-0.700
SCRG	0.225**	3.282	0.329***	4.249	0.149*	1.996
DC	0.622***	9.522	0.509***	6.889	0.568***	7.986
SCRGxDC	0.195**	3.066	0.144*	2.000	0.147*	2.116
R^2	0.395		0.317		0.317	
F	23.368***		16.551***		16.599***	

Note. * p < 0.05; ** p < 0.01; *** p < 0.001

Table 9. Results of the Bootstrap Test for Moderating Effects (N=295)

	Index	Effect	Se	LLCI	ULCI
SI	eff1(M-1SD)	0.066	0.074	-0.079	0.211
	eff2(M)	0.225	0.068	0.090	0.359
	eff3(M+1SD)	0.383	0.096	0.194	0.573
II	eff1(M-1SD)	0.212	0.083	0.048	0.376
	eff2(M)	0.329	0.077	0.177	0.481
	eff3(M+1SD)	0.446	0.109	0.231	0.661
CI	eff1(M-1SD)	0.029	0.080	-0.129	0.187
	eff2(M)	0.149	0.075	0.002	0.296
	eff3(M+1SD)	0.268	0.105	0.061	0.475

Note. * p < 0.05; ** p < 0.01; *** p < 0.001

Based on the DC value, the high and low levels are divided based on the mean (M) plus or minus one standard deviation (SD). As shown in Table 9, when the DC level is low (M-1 SD), the confidence intervals of the SI and CI are 0, indicating that SCRG has no significant effect on the SI and CI. In contrast, the confidence interval of II does not include the value 0, indicating that SCRG also has an impact on II at a low DC level. When the DC level is high (M+1 SD), the 95% confidence interval does not include the value 0, which means that SCRG has a major impact on the three dependent variables; that is, DCs play a positive regulating role.

This paper utilizes the simple slope method to graphically represent the moderating effects of DCs on various relationships, as shown in Figures 3, 4 and 5. When the DC level of manufacturing supply chain enterprises is low, the impact of SCRG on SI and CI is relatively smooth, and the impact on II shows a gradual upward trend. When the enterprise DC level is high, the impacts of SCRG on SI, II and CI are steeper, and the curve of SI is more significant. When the SCRG is the same, the impact of a high level of DCs on the three dependent variables is greater than that of a low level of DCs. A high DC promotes the effect of SCRG on SI, II and CI; that is, it enhances the original positive effect. H5a, H5b and H5c are further verified.

Figure 3. Moderating Effect of DCs on the SCRG and SI

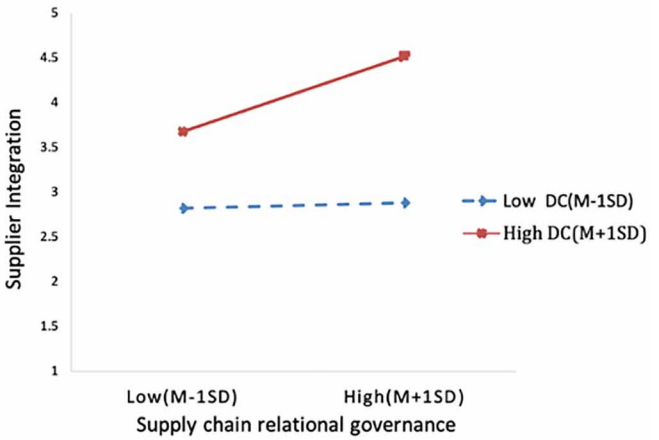


Figure 4. Moderating Effect of DCs on SCRG and II

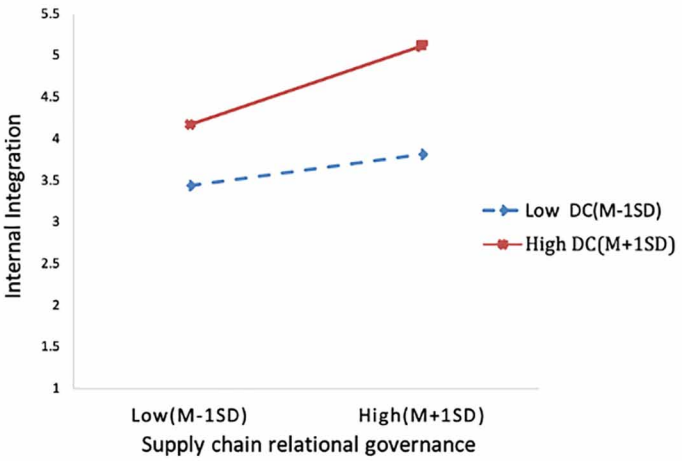
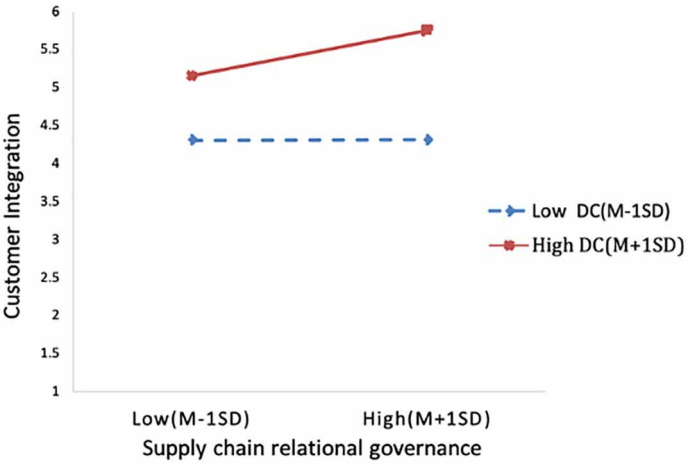


Figure 5. Moderating Effect of DCs on SCRG and CI



DISCUSSION

Conclusions and Discussion of the Results

In this study, within the context of the digital era, we constructed a structural model of the influence of SCRG, SCI, and DC on SCP from the perspective of SCRG in the manufacturing industry based on resource orchestration theory. An empirical analysis was conducted using survey data obtained from 295 manufacturing enterprises located in Zhejiang Province, China. Below, we discuss the results of the analysis.

SCI plays a partial mediating role in the process through which SCRG affects manufacturing SCP. SCRG has a positive effect on manufacturing SCP, which is partially achieved through the mediating effects of SI, II and CI. The findings answer Q1, and our results reconfirm and contribute to refining the idea that relational mechanisms exert an important influence on SCP (Liu et al., 2009; Dolci et al., 2017). The manufacturing supply chain contains many communities of interest, which form a functional network chain structure. Every enterprise node has the capability to engage in high-quality

information sharing, which can serve as a prerequisite for achieving synergistic operations within the supply chain. However, in reality, managers have limited rationality, which is likely to cause conflicts and opportunistic behaviors among supply chain partners; this, in turn, will have a detrimental effect on the relationships between supply chain members, thus reducing information transmission and affecting SCP. As an auxiliary means of contract governance, SCRG facilitates interaction and collaboration among supply chain stakeholders through trust and commitment. Additionally, the communication, collaboration and information sharing among various partners will increase, providing favorable conditions for the smooth realization of resource bundling in SCI.

Our results provide an observational perspective on research in a new SCI field. Although research in the field of SCI has been very fruitful (Khanuja & Jain, 2019), scholars continue to overlook the crucial aspect of the success and effectiveness of SCI heavily relying on the quality of relationships and the level of cooperation among members within the supply chain. Good relationships and positive collaboration can facilitate information sharing, resource optimization, risk management, and customer satisfaction for successful integration, and SCRG concerns establishing, maintaining, and improving collaborative relationships between parties in the supply chain. Therefore, it is imperative for scholars and enterprises to emphasize SCRG as an antecedent step in SCI implementation.

DCs excel in improving supply chain transparency, visibility, and responsiveness (Ali & Govindan, 2023), and through data analytics and intelligent decision support systems, DCs significantly enhance the efficiency of utilizing enterprise resources and the effectiveness of organizing resources. With the ability to mobilize, coordinate, and leverage resources, DCs provide technology and channels for the processes of SCRG and SCI and play a positive moderating role, clearly addressing Q2. The greater a firm's DCs are, the greater its ability to utilize and transfer information, the more capable it is of sharing information, the greater the level of supply chain visualization, and the greater the facilitation of SI, II, and CI through SCRG. Our results reinforce and expand the view of Paolucci et al. (2021) that the role of digital technologies and DCs is key to improving the efficiency of information delivery inside and outside organizations. In the digital era, the new SCRG uses data-driven intelligence as the carrier, focusing on collaboration, visualization, flexibility, and innovative tool development, which will greatly change the paradigm of traditional SCRG, more effectively improve supply chain efficiency and reduce costs.

Theoretical and Practical Implications

Our study has significant implications for both theoretical advancements and practical applications. In terms of theoretical implications, first, the majority of prior studies have concentrated on examining the influence of a single factor on SCP (Mofokeng & Chinomona, 2019; Dolci et al., 2017), ignoring the importance of addressing the multiple relationships among the resources required for SCP growth and the importance of mobilizing and allocating constituent resources. Our research goes beyond the effects approach of examining the direct relationship between governance strategies or integration strategies and performance. We use resource orchestration theory as the main theoretical basis of this study to theoretically elaborate and validate how SCRG (determining resource structural boundaries), SCI (realizing resource bundling), and DCs (the ability to mobilize and stimulate the application of resources) affect SCP. This study represents a novel endeavor to apply resource orchestration theory to the realms of SCP and supply chain management research, pushing the boundaries of the theory's research scope. Simultaneously, this study broadens the scope of research on social relations to the supply chain perspective and introduces new insights into the combination of various relational resources to improve SCP.

Second, digital technology, which is a crucial tool and core concept in the era of Industry 4.0, has been extensively applied in the manufacturing and supply chain sectors. Prior research on digital transformation, digital technology, and DCs has primarily concentrated on examining the direct influence of digitalization on performance. (Wielgos et al., 2021; Wang et al., 2022; Belhadi et al.,

2022). However, we know very little about the role companies' new tools (digitalization) play in supply chain management and the indirect additional effects they have. This study identifies the role of these new tools in "social relations in supply chains" by using DCs as a moderating variable, and the relationship between SCRG and SCI is examined. From this perspective, we compensate for the emphasis of existing research on the original role of DCs and provide theoretical implications for further understanding enterprise DCs.

Regarding practical implications, first, enterprises can focus on two types of SCRG strategies, namely, cooperative governance strategies (Kyazze et al., 2017) and relational governance strategies (Griffith & Myers, 2005), to achieve a strategic match with SCI goals and ultimately achieve SCP. If SCI is a key means to improve SCP, then relationship governance is accompanied by the whole integration process and represents an important strategy. The absence of a robust and comprehensive governance framework can result in significant issues during the strategic decision-making process or can give rise to dysfunctional conflicts among multiple management entities, which will have a significant impact on the overall performance and efficiency of an organization (Jamaluddin et al., 2023; Villavicencio & Solares, 2019). One of the challenges in supply chain governance is that managers must comprehend the distinct demands of each relationship and the shifts in demand as multiple relationships interact. Therefore, in relationship governance dominated by cooperation based on social exchange elements, informal or implicit rules and expectations that regulate and guide the behavior of all parties are adopted to achieve strategic goals based on SCI.

Second, our findings suggest that digital technology is the "lubricant" and "accelerant" between new types of SCRG and SCI in the era of Industry 4.0. They also propose that during the mobilization of DCs, different types of SCI should assume distinct roles. Therefore, when formulating digital development strategies, enterprises should pay attention not only to the direct influence of digital technology on production but also to bolstering their digital-driven business management capabilities and relationship management capabilities. Additionally, they should strategize the deployment of approaches to cater to the diverse demands within supply chain relationships. We also recommend that organizations focus on the development of a digital talent strategy. In the future, digital talent will provide an important management mechanism under the framework of building digital supply chain capabilities (Queiroz et al., 2021). Queiroz et al. (2021) proposed that critical digital SCI represents the convergence of information and communication technology (ICT) capabilities, worker capabilities, and stakeholder capabilities. Therefore, a digital supply chain based on the ability to process massive amounts of data will inevitably require that digital talent will be the operating basis for other related strategies.

Research Limitations and Future Research Directions

Although our study is novel, as in other studies, there are some unavoidable limitations. First, we wanted to expand the study sample as much as possible, but for various reasons, the sample size of the data that we collected was somewhat insufficient. Additionally, the questionnaire was composed of a static survey. However, the governance and integration of supply chain relationships show a dynamic process with changes in the environment and the market. Therefore, in future research, it will be necessary to conduct periodic dynamic research on supply chain enterprises to test the effectiveness of our research model. Furthermore, this study specifically examined the influence of a single SCRG model on integration and performance. This presents a potential avenue for future researchers to delve deeper into the realm of supply chain governance, exploring various impacts that emerge within the governance model, including supply chain resilience and supply chain innovation. In future research, we suggest adding more types of supply chain governance, examining the impact of governance models under digital supply chains, and considering the effect on other supply chain characteristics.

CONCLUSION

Understanding the role of relationship governance and its impact on performance is crucial for supply chain enterprises. This is due to the intricate nature of the supply chain, which encompasses a complex network of relationships involving multiple organizations, diverse links, resources, information, and activities. Although relationship governance is not as clear and explicit as the management objectives of production, delivery, logistics and other links, it serves as an imperceptible mechanism for ensuring the smooth and regular functioning of the entire supply chain, making it an essential and highly influential factor in enhancing both supply chain efficiency and SCP. Hence, the primary focus of this study is on the relationship between SCI and SCP through relationship governance and whether enterprise DC can serve as a new "booster" to enhance the relationships and integration among supply chain partners in the era of Industry 4.0. Our hypotheses were verified through empirical analysis, which further promoted the application of resource orchestration theory as a factor influencing SCP in the digital era. Additionally, through this study, we hope to draw the attention of academics and practitioners in the realm of supply chain governance or digital transformation because there are certain relevant questions to be answered. For instance, in the age of AI, will the advent of ChatGPT reshape the relationships between supply chain stakeholders and the way they are integrated? Will the current SCRG become simpler or more complex with new tools? These issues need to be addressed and discussed.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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