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**How intellectual capital builds supply chain resilience?**
**Exploring mediation and interaction effects from an intellectual capital-based view**

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## Abstract

**Purpose** – This study examines the relationship between the three dimensions of intellectual capital (IC), i.e., human, social, and organizational, and supply chain resilience (SCR) through testing a primary (mediation) and competing (moderation) model.

**Design/methodology/approach** – Structural equation modelling and regression analysis were used to test the mediation and moderation models using survey data from Chinese manufacturers.

**Findings** – Dual processes in which human, social and organisational capitals build SCR are revealed: (i) all the three IC components act as knowledge stocks for informing each other and (ii) both organizational and social capitals act as intervention mechanisms that draw knowledge resided within individuals and collectively deploy/enrich such knowledge for responding to supply chain disruptions.

**Practical implications** – The empirical results provide useful and timely guidance to managers on how to leverage knowledge resources to develop resilience, which is particularly valuable in the current volatile environment.

**Original/value** – By empirically testing both the mediation and moderation models, this study provides crucial evidence for advancing the understanding of how the three IC components may be managed to achieve SCR, which is of critical importance for addressing the many unprecedented disruptions facing global supply chains and economies.



**Keywords**: Human capital; Social capital; Organisational capital; Supply chain resilience

**Paper type**: Research paper

## 1. Introduction

Unforeseeable events such as the US-China trade wars and the COVID-19 outbreak (Alvarenga et al., 2023; Yu et al., 2019a, 2022) have seriously disrupted the global supply chain and economy. In January of 2020, the contours of the COVID-19 pandemic were beginning to emerge. Before long, supplies of key items such as N95 masks and other personal protective equipment became dreadfully short. This has elevated the importance of supply chain resilience (SCR), which is understood as the ability of a supply chain to return to a stable condition once it is disrupted (Alvarenga et al., 2023; Nakandala et al., 2023; Tukamuhabwa et al., 2015; Yu et al., 2022), to that of a "new boardroom imperative" (Birkinshaw, 2020). When both supply and demand are suddenly disrupted, firms use employees' knowledge and IT investments to rapidly innovate. For example, to cope with the dramatic increase in demand, firms such as Jabil leveraged their intellectual capital which included employees' knowledge, relationships with over 27,000 suppliers, and intelligent digital supply chain solutions to produce many ventilators. Therefore, we pose the research question: how does a firm renew its knowledge capital to achieve SCR?

Research investigating the underlying mechanisms leading to resilience is nascent (Ali et al., 2021), especially in terms of knowledge or intellectual capital. Using a single case study, Daghar et al. (2023) find that cognitive capital, a fundamental element of intellectual capital, is related to SCR. To extend these earlier works, this study aims to clarify the roles of the different dimensions of intellectual capital. A firm's intellectual capital (IC) is defined as "the sum of all knowledge firms utilize for competitive advantage" (Subramaniam and Youndt, 2005, p. 451). The intellectual capital-based view of the firm (ICV) suggests that knowledge created by and stored in a firm's capital components helps produce sustainable competitive advantage (Martín-de-Castro et al., 2011; Reed et al., 2006; Su et al., 2013). Following the ICV literature, we divide IC into three dimensions: human, social (relational), and organizational (structural) capital. *Human capital* refers to knowledge residing within and used by individuals; *social capital* includes knowledge embedded within interpersonal relationships; and *organizational capital* refers to knowledge codified in processes, systems, and structures (Subramaniam and Youndt, 2005).

While anecdotal evidence suggests the three ICs are linked to community resilience to climate change (Newman and Dale, 2005; Tompkins and Adger, 2004) and extreme events (Gölgeci and Kuivalainen, 2020; Johnson et al., 2013), the literature is unsettled about the impact of IC dimensions on SCR. Prior studies have investigated the effects of the single dimensions of IC.

However, there are competing perspectives about how the IC dimensions together creates SCR. Past models posit IC dimensions affect SCR through the mediation of constructs such as learning (Mubarik et al., 2022) and network capabilities such as flexibility, velocity, visibility, and collaboration (Ali et al., 2021; Johnson et al., 2013). This implies IC dimensions do not directly affect SCR. Others argue the effects are moderated by alignment between marketing and supply chain management (Gölgeci and Kuivalainen, 2020). IC dimensions may also moderate each other's effects on other performance outcomes (Atavesen et al., 2018; Gonzalez-Loureiro and Dorrego, 2012; Jardon and Martos, 2009; Subramanian and Youndt, 2005). It is important to clarify the opposing mediation versus moderation models theoretically because they involve dissimilar underlying mechanisms and roles of IC dimensions that have distinct practical implications.

Here is our theoretical explanation. The mediation model argues that when a firm hires or trains employees, it increases human capital, but human capital can also create SCR through relational and organizational capital. This potential increase in the amount and variety of knowledge could surface ideas that could be leveraged to address new disruptions. Human capital allows a firm to adopt/adapt structured routines (organizational capital) to address disruptions. Ericsson provides an example of this through its development of risk management structures, processes, and procedures after its supply chain was disrupted by a fire (Normann and Jansson, 2004). In addition, socialization through network ties (social capital) facilitates critical social learning to attain community and supply chain resilience (Johnson et al., 2013; Newman and Dale, 2005; van den Adel et al., 2022). Social capital can facilitate information sharing, knowledge exchange, and learning about SCR (Gölgeci and Kuivalainen, 2020).

Alternatively, the moderation model suggests that interactions among IC dimensions affect SCR, meaning that the effect of one IC component is contingent on others (Subramanian and Youndt, 2005). For example, human and organizational capital are thought to become effective when social capital is built up (Atavesen et al., 2018; Jardon and Martos, 2009; Gonzalez-Loureiro and Dorrego, 2012). Supply chain learning (Mubarik et al., 2022) and increased absorptive capacity (Gölgeci and Kuivalainen, 2020) is enhanced when social capital and organizational capital draw upon knowledge residing within and used by individuals, e.g., human capital (Cohen and Levinthal, 1990). As such, these knowledge utilization and creation processes occur when IC dimensions interact with one another. It is important to clarify whether the mediation or moderation perspective applies to the IC – SCR relationship and as such in the present study we test both moderation and mediation models.

From a theoretical perspective, the results of the study will bring greater understanding of the underlying processes in which hiring/developing employees (human capital) help enhancing the social and organizational capital necessary to influence SCR (mediation process) or the underlying processes in which social capital amplify the effects of human and organizational capital (moderation process). From a practical perspective, the results of the study will provide useful and timely guidance to managers on how to leverage human/knowledge or social resources to develop resilience, which is particularly valuable in the current volatile business environment. Knowing how to use and develop the three IC dimensions to build SCR could moreover prove to be a rare and inherently difficult to imitate resource (Martín-de-Castro et al., 2011; Reed et al., 2006; Wiklund and Shepherd, 2003), and thus lead to competitive advantage. Such insights can advance the management of resiliency competencies among employees (Lengnick-Hall et al., 2011) and studying them will reveal whether any of the three dimensions are more important than others for developing SCR.

## 2. Theoretical background

### 2.1. IC

Knowledge creates competitive advantage (Reed et al., 2006; Wiklund and Shepherd, 2003; Su et al., 2013). How effectively a firm uses knowledge depends on its knowledge generating mechanisms (Leonard-Barton, 1992). The question of how to manage and direct the stocks and flows of knowledge capital embedded in an organization (Youndt et al., 2004) can be addressed by the concept of IC, which refers to the total stock of intangible assets, knowledge, information, and team communication systems that could create value or performance for a firm (Ataseven et al., 2018; Hayton, 2005; Nahapiet and Ghoshal, 1998; Su et al., 2013). In this paper, IC is regarded as the sum of all knowledge that firms utilized to build SCR. IC has three fundamentally different dimensions: human, social, and organisational capital (Kang and Snell, 2009; Youndt and Snell, 2004; Subramaniam and Youndt, 2005). Each IC dimension has a unique role in the acquiring, sharing, and integrating of new knowledge (Crossan et al., 1999; Kang and Snell, 2009).

*Human capital* is defined as "the knowledge, skills, and abilities residing with and utilized by individuals" (Subramaniam and Youndt, 2005, p. 451). Human capital enables individuals to act in new ways, and in turn contributes to performance (Carpenter et al., 2001; Hitt et al., 2001; Kang and Snell, 2009; Reed et al., 2006).

*Social capital* is comprised of "the knowledge embedded within, available through, and utilized by interactions among individuals and their networks of interrelationships" (Subramaniam and Youndt, 2005, p. 451). Networks of relationships possessed by individuals or groups may create norms for collaboration, communication and sharing of ideas (Nahapiet and Ghoshal, 1998; Putnam, 1995).

*Organizational capital* is defined as "the institutionalized knowledge and codified experience residing within and utilized through databases, patents, manuals, structures, systems, and processes" (Subramaniam and Youndt, 2005, p. 451). Organizational capital is codified, and its creation, preservation, and enrichment occur through structured, repetitive activities (Ataseven et al., 2018). As a repository of knowledge accessible through different sources, organizational capital facilitates knowledge sharing and creation among employees and external parties (Reed et al., 2006).

Collectively these three forms of IC can become a resource (Grant, 1995), the effectiveness of which is dependent upon the effectiveness and efficiency of the knowledge associated or embedded within them. Standardized processes represent institutional knowledge and as such are captured as intellectual capital. The reconfiguration of processes and the exploitation of the knowledge associated with them may allow a firm to respond to changes in its environment that translate to greater supply chain resilience.

### 2.2. SCR

Adverse events that disrupt the flow of goods and services results in supply chain disruptions (Craighead 2007). Such events are unpredictable and span a diverse range. The tsunami of 2004, the great recession of 2008 and the COVID-19 pandemic are some examples that led to worldwide disruption to supply chains. In addition to the impact on human lives, the aftermath of supply chain disruptions brings about lower sales growth, increasing operating costs and inventories for the affected firms (Hendricks and Singhal 2005). To survive such turbulent and competitive environments, firms build resilience throughout the supply chain to address unexpected and unquantifiable disruptions (Ali et al., 2017; Nakandala et al., 2023; Yu et al., 2019a, 2022). While there is considerable extant work focused on resilience of supply chains to disruptions, there is also a lack of a unified definition of resilience (Ponomarov and Holcomb 2009). Ambulkar et. al. (2015) and Namdar et.al. (2017) summarize the varied definitions from extant work. A consistent

notion across all these definitions is the reference to the capability to restore or recover normal operations after a disruptive event. In more recent work, Wieland and Durach (2021) propose that an understanding of supply chain resilience should include not only stability in the face of disruptions but also the capability to adapt and transform in accordance with the larger ecosystem in which it resides.

In the current study we focus on the collective capability of the supply chain to be resilient and define supply chain resilience (SCR) in alignment with the work of Ponomarov and Holcomb (2009, p.131), as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function". A resilient supply chain can absorb or mitigate the impact of unexpected disruptions (Ali et al., 2017; Kamalahmadi and Parast, 2016; Pettit et al., 2013). SCR as an organisational capability enables the supply chain to quickly respond to unforeseen disruptions and restore operations (Alvarenga et al., 2023; Tukamuhabwa et al., 2015; Yu et al., 2019a).

### 2.3. Antecedents of SCR

Previous research has examined the antecedents for developing SCR (summarized in Table 1), including learning mechanisms (Scholten et al., 2019), managerial and organizational antecedents (Nikookar and Yanadori, 2022), and cooperation and trust (Dubey et al., 2017, Yu et al., 2022). More recently, several empirical research has examined the roles of digital technologies in building SCR (Alvarenga et al., 2023; Dubey et al., 2023; Nakandala et al., 2023). However, none of those studies have investigated the role of IC in developing SCR. A few notable works have examined the effects of specific dimensions of IC on SCR. For instance, using a single case study, Johnson et al. (2013) examine social capital act as facilitators or enablers of SCR and Daghar et al. (2023) investigate the significance of cognitive capital in developing SCR. Mubarik et al. (2022) examine the effects of three dimensions of IC (human capital, structural capital, and relational capital) on SC learning and SCR. However, none of the research has explored the interrelationship between the various dimensions of IC and their impacts on SCR. As such, our study significantly extends previous research by empirically testing both the mediation and moderation models, which provides crucial evidence for advancing the understanding of how the three IC components (i.e., human capital, social capital, and organizational capital) can be managed to build SCR.

---------- Insert Table 1 ----------

## 3. Theoretical models and hypotheses

We develop two models shown in Figure 1. Figure 1a suggests that the effect of human capital on SCR is mediated by both organizational and social capitals. Figure 1b assumes the three IC dimensions interact to affect SCR. In the following sections, we develop our research hypotheses.

---------- Insert Figures 1a, b ----------

### 3.1. Hypotheses for the mediation model

*Human capital* includes stores of knowledge about relational ties and organizational routines. Given this, the literature suggests that an improvement in human capital can improve structural (organizational) capital and socialization routines (Ataseven et al., 2018; Gonzalez-Loureiro and Dorrego, 2012; Jardon and Martos, 2012). If there is such an antecedent role for human capital, then arguably it may be the source of other dimensions of IC (Jardon and Martos, 2009; Gonzalez-Loureiro and Dorrego, 2012).

Ultimately, we contend that knowledge an organization uses to create value ultimately comes from individuals (Felin and Hesterly, 2007). For example, training, education, and motivation of employees spark new ideas. The sharing of these ideas creates opportunities to collaborate through interactions with other employees and their networks (Ataseven et al., 2018; Subramaniam and Youndt, 2005). Such ideas can lead to process improvements, new products, and the like. In fact, there is some evidence that human capital is positively associated with organizational (structural) capital and social (relational) capital (Huang and Hsueh, 2007; Jardon and Martos, 2012). Responding to supply chain disruptions involves harnessing employee knowledge to implement new or modified processes and strategies. These ultimately can become organization knowledge (Ataseven et al., 2018; Yu et al., 2019a). Thus, individual knowledge (human capital) about operations and supply chain disruption responses can inform organizational routines (e.g., risk management plan) and social interactions can be managed to build SCR. Thus, we posit:

*H1a: The greater the human capital in organizations, the greater their social capital.*

Employees use their knowledge to develop organizational capital such as databases, patents,

structures, standardized procedures, formalization of rules and routines (Ataseven et al., 2018; Subramaniam and Youndt, 2005; Kang and Snell, 2009). Thus, organisational capital derives its capabilities from employees (Reed et al., 2006). As individuals learn (i.e., increase their human capital), they create knowledge for improving organizational routines (Youndt and Snell, 2004). High levels of knowledge and skills may lead to generating novel ideas and practises that can be transformed into standardized processes, structures, and systems. Within a firm, it is employees' knowledge that forms an institutionalized, consistent, and legitimate codebook, and helps in organizational learning processes (Ataseven et al., 2018). Structures and processes for improving risk management are essentially developed by employees learning from their experience (Normann and Janssson, 2004) and learning from improving existing organizational routines (Normann and Wieland, 2020). Thus, we posit:

*H1b: The greater the human capital in organizations, the greater their organisational capital.*

*Human capital* provides a variety of knowledge that stimulates new ideas (Kang and Snell, 2009; Youndt et al., 2004), and Grant (1995) states that competitive advantage depends on knowledge. Competitive advantage in the context of the present study refers to being resilient to disruptions in the flow of materials. Since knowledge is embedded within people (Mubarik et al., 2022), this suggests that human capital is important to the management of supply chain disruptions (Tompkins and Adger, 2004). Human capital is important to the discovery processes, comprehension, combination, and application of knowledge when developing and testing various scenarios a firm may encounter and how to manage through them (Kang and Snell, 2009; Wright and Snell, 1998). It is particularly important for managers to acquire new knowledge for addressing different types of disruptions and crises (Tompkins and Adger, 2004; Daghar et al., 2023). Given such, we content that SCR may ensue from leveraging employee knowledge. This comports with the notion that experience with managing disruptions matters (Gölgeci and Ponomarov, 2013; Tukamuhabwa et al., 2015). Thus, we posit:

*H2a: The greater the human capital in organizations, the greater their SCR.*

Nonaka and Takeuchi (1995) indicate that organizations should be deliberate about knowledge sharing. Through knowledge sharing the organization's capabilities to compete can be enhanced. *Social capital* may be a conduit for such knowledge exchange (Nahapiet and Ghoshal,

1998; Gölgeci and Kuivalainen, 2020; Kang and Snell, 2009). Social capital may boost collaboration within and across organizations thereby enabling the sharing and dissemination of knowledge (Ali and Golgeci, 2020; Nahapiet and Ghoshal, 1998; Subramaniam and Youndt, 2005). These network ties help exploit existing and indigenous knowledge and technologies to address extreme events (Tompkins and Adger, 2004; Daghar et al., 2021, 2023). For example, Johnson et al. (2013) show that social capital builds relational ties, shared codes and language, shared narratives, trust, norms and responsibilities. Collectively these events could be actions of organizational learning; organizational learning being critical to building SCR (Hult et al., 2003). As such we posit:

*H2b: The greater the social capital in organizations, the greater their SCR.*

*Organisational capital* includes structures required for coordination (Eisenhardt and Sull, 2001; Subramaniam and Youndt, 2005; Kang and Snell, 2009). Essentially, knowledge is embedded in an organization's structures, systems, and processes (e.g., risk management plan), and augments its ability to survive, adapt, and grow in the face of turbulent change and uncertainty (Pettit et al., 2013). The result is increased preparedness, alertness to the environment, and agility to respond proactively. These attributes are critical to SCR (Mubarik et al., 2022). Additionally, standardized processes such as those utilized by Ericsson (Normann and Jansson, 2004) represent institutional knowledge (Johnson et al., 2013). Organisational capital facilities cross-functional information and knowledge sharing and the creation of a common understanding of standardized supply chain processes (Ataseven et al., 2018; Subramaniam and Youndt, 2005). The savvy manipulation and modification of these processes in response to environmental threats results in a higher level of SCR. We therefore hypothesize:

*H2c: The greater the organisational capital in organizations, the greater their SCR.*

While the above hypotheses (H1a-b and H2a-c) can clarify how individual IC elements impact SCR, an integrated perspective of how various IC elements impact on SCR could be more beneficial and practical. Our integrated model provides a comprehensive coverage of how various dimensions of IC can simultaneously impact on SCR. Daghar et al. (2023) investigate the role of cognitive capital, an element IC and found that cognitive capital does appear to be related to SCR; however, its exploratory nature demands further empirical testing. We test our hypotheses using a relatively large sample of firms for statistical generalization and include multiple IC dimensions to further explore the nature of the relationship. Furthermore, the following paragraphs introduce a mediation and

moderation perspective to our integrated model, testing a primary and competing model, which provide a more holistic and practical understanding (Calantone et al., 2017) of how various IC elements could impact SCR.

There is emerging evidence of mediation effects. Ataseven et al. (2018) demonstrate that social capital mediates the relationships between human and organisational capital and supply chain integration. In the context of SCR, we argue that human capital (such as employee knowledge, skills and abilities) enables firms to facilitate social capital (such as effective knowledge sharing, idea exchange and team collaboration) and organizational capital (such as organizational practices, routines, and processes), thereby facilitating SCR. Gölgeci and Kuivalainen (2020) show that social capital creates SCR, which consist of boundary spanning routines. We argue boundary spanning routines rely on relational ties and organizational routines such as meetings and procedures that identify and assess emerging disruption. Thus, organizational and social capital can create collective knowledge through joint interpretation of information and learning that leads to strategic actions and SCR (Yu et al., 2019a).

This study argues social and organizational capital each act as an intervention mechanism in transforming knowledge that resides within individuals into SCR. This is important because human capital can change due to the mobility and turnover of employees within an organization (Subramaniam and Youndt, 2005). However, organizational capital (such as processes, culture and systems) stays within the organisation and does not change easily (Walsh and Ungson, 1991). Thus, firms such as Ericsson (Normann and Wieland, 2020) try to embed knowledge required to build SCR into formal (organizational capital) and information processes (social capital). Knowledge created by a firm is stored into information technology systems and operational processes (Edvinsson and Malone, 1997). Structured methods such as risk management and business continuity planning are used to draw upon this knowledge to address new supply chain disruptions (Normann and Jansson, 2004).

Social and organizational capital are the mechanisms through which human capital can materialise as capability to build SCR; they provide a process and media to collectively deploy individual knowledge into actions (Hackman and Wageman, 1995). Social capital from "the network of relationships possessed by an individual or social unit" (Nahapiet and Ghoshal, 1998, p. 243) can facilitate the accumulation knowledge from various sources to address an emerging disruption. Blyler and Coff (2003, p. 679) state that "human capital (education, training, skills,

etc) will not bring in critical new resources unless it is coupled with social networks". It is the network ties that mobilize the use of knowledge in an emergency (Tompkins and Adger, 2004). Thus, we posit:

*H3: The relationship between human capital and SCR is mediated by (a) social capital and (b) organisational capital.*

### 3.2. Hypotheses for the moderation model

Subramaniam and Youndt (2005) argue human capital provides a variety of new knowledge to enable radical innovation. In the same vein, they argue organizational capital creates incremental innovation by providing structure and processes, for example, plan-do-check-act (PDCA) used by lean manufacturing, to achieve incremental innovation. They argue social capital cannot directly create innovation because interpersonal relationships can only "facilitate" the exchange of knowledge and social learning. As such, the effects of organizational capital and human capital on innovation are assumed to be moderated by social capital (Subramaniam and Youndt, 2005). Since innovativeness is required to create SCR (Gölgeci and Ponomarov, 2013), there is a potential that the interaction perspective also applies to SCR.

A moderator makes sense when it is an external environment (Venkatraman, 1989), but it is challenging to segment human, social and organization capital into the internal versus external environment. Despite this reservation, evidence shows interaction effects of different dimensions of IC on firm performance (Huang and Hsueh, 2007; Huang and Wu, 2010; Hitt et al., 2001; Reed et al., 2006; Subramaniam and Youndt, 2005). In a municipal context,Tompkins and Adger (2004) suggest community networks can help in coping with extreme weather events, but it is through individuals (human capital) that threats are better understood. It may be that in this context tacit knowledge is interpreted in the social setting and that the relationship ties among citizens increases the speed of information and knowledge flows essential for a response and recovery.

Collectively these arguments suggest the possibility of interactions between human and social capital. In addition, when organizations gain experience from several disruptions, they may use the accumulated knowledge to develop future risk management plans, thus forming organizational capital. Such organizational capital can be enhanced by drawing ideas and knowledge from diverse people (human capital) and social interactions (social capital). In a supply chain context, while human capital provides a strategic platform for firms to capture diverse ideas,

social capital encourages collaboration with external partners, and organisational capital emphasizes knowledge sharing among employees and trading partners (Ataseven et al., 2018; Pettit et al., 2013). Thus, it is possible that each of the three IC dimensions and their interactions may help firms develop resilient supply chains.

*H4a: The interaction between human capital and social capital is positively associated with SCR.*

*H4b: The interaction between human capital and organisational capital is positively associated with SCR.*

*H4c: The interaction between social capital and organisational capital is positively associated with SCR.*

*H4d: The interaction among human capital, social capital and organisational capital is positively associated with SCR.*

## 4. Research methodology

### 4.1. Measures and control variables

Existing constructs and their measurement scales were used to develop a questionnaire. These constructs were then translated into Chinese and then back translated to ensure consistency. Furthermore, the instrument was pilot tested with academics and practitioners to ensure relevance to practices in China. As a result, some minor word changes were made to better communicate the meaning of the items in the Chinese context. Four academic researchers and four manufacturing managers were asked to provide feedback and evaluate the content validity and reliability of the measurement scales. Table 2 shows the measurement items used in this study. The three dimensions of *IC* (human, social, and organisational capital) were measured by a total of 14 items developed by Subramaniam and Youndt (2005). We measured *SCR* by adapting five items developed by Gölgeci and Ponomarov (2013), which reflected a firm's ability to effectively adapt, respond and recover from supply chain disruptions. All items were measured using a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree).

---------- Insert Table 2 ----------

In this study, we used three control variables, namely *firm size* (number of employees), *firm age* (the number of years since the establishment of the firm), and *industry type* (a dummy variable) (Yu et al., 2019b). Firm size was controlled because larger firms may possess higher levels of IC for developing SCR. Firm age might be related to resilience because older firms may

have the experience to quickly respond to unexcepted disruptions. Firms operating in different industries may develop capabilities for SCR at different rates and robustness, thus industry type was also controlled in our model.

### 4.2. Sampling and data collection

We randomly selected 1,000 firms from the government directories of China's manufacturing firms offered by Provincial Economic and Information Technology Commissions (Li et al., 2010), and then sent the questionnaires to 890 firms that agreed to take part in the research. We made follow-up telephone calls and sent follow-up emails to encourage further response. After several reminders, we received 257 questionnaires. Sixteen responses were discarded due to missing data, which yielded 241 useable questionnaires and a 27.08% response rate. Table 3 summarises the demographic details of the respondents and their firms. The respondents included CEO/presidents, vice presidents, directors, or managers, and most of them had five years or more of tenure with their current employer. Thus, they were expected to be qualified and experienced enough to answer the survey questions. As shown in Table 3, the responding firms operated in different industries and geographical regions with different number of employees and annual sales.

---------- Insert Table 3 ----------

The demographics of early and late respondents (e.g., number of employees and annual sales) were compared to indirectly assess non-response bias (Hair et al., 2018). The t-test results show that there were no significant differences between the two groups, suggesting non-response bias is not a serious concern in this survey research.

A single-respondent design was employed to maximise the response rate (Zhao et al., 2006). Thus, we undertook several steps to reduce common method variance (CMV) during the data collection (Podsakoff et al., 2012). We randomised the order of the measurement items when designing the questionnaire, which makes sure single respondents cannot identify the independent and dependent variables. We suggested to respondents that different sections of the questionnaire should be consulted or completed by the relevant senior functional managers across the firm, which ensures an overall perspective can be obtained from the top management team and an expert perspective from the relevant functional area (Zhao et al., 2006). For example, the intellectual capital section was suggested to be completed with the help of a human resource manager.

Post data collection, we assessed CMV using three different tests. First, confirmatory factor

analysis (CFA) was used because Harman's single-factor test is insufficient for detecting CMV (Podsakoff et al., 2012), and the CFA results reveal unacceptable model fit: $\chi^2$/df (1069.509/153) = 6.990, CFI = 0.726, IFI = 0.727, and RMSEA = 0.158 (Hair et al., 2010; Hu and Bentler, 1999). Second, one measurement model with the traits (multiple factors) and the other model with both the traits and a method factor were tested and compared (Podsakoff et al., 2012). The results reveal that model fit indices for the model with a method factor improved only marginally ($\Delta$CFI = 0.018 and $\Delta$IFI = 0.019). Third, we applied the method variance (MV) marker variable technique (Lindell and Whitney, 2001). We used demand uncertainty (Chen and Paulraj, 2004) as a MV marker (Cronbach's alpha = 0.741) as it is theoretically unrelated to other scales in our model. As shown in Table 4, the lowest positive correlation (r = 0.006) between the MV marker and other variables was chosen to adjust the inter-construct correlations (Lindell and Whitney, 2001), and the adjusted correlations remain statistically significant. In summary, all the above tests failed to prove the existence of CMV.

---------- Insert Table 4 ----------

## 5. Analysis and results

### 5.1. Measurement model

The CFA results in Table 2 reveal a good-fitting measurement model, which confirms the scale's unidimensionality (Gerbing and Anderson, 1988; Hair et al., 2018). The Cronbach's Alpha (ranged from 0.844 to 0.919) and composite reliability values (ranged from 0.851 to 0.920) are well above 0.70 (Hair et al., 2018), and the corrected item-total correlation (CITC) values (ranged from 0.619 to 0.836) are greater than the minimum desirable level of 0.30 (Kerlinger, 1986). Thus, the results provide reliability evidence in our measurements.

Table 2 shows that factor loading for each item over 0.50 is statistically significant and all the theoretical constructs have average variance extracted (AVE) higher than 0.50, which confirm convergent validity (Fornell and Larcker, 1981; Hair et al., 2018). Table 4 indicates that the square root of each construct's AVE is greater than its highest correlation with any other construct (Fornell and Larcker, 1981). Thus, discriminant validity is ensured.

### 5.2. Testing mediation model

We used SEM with AMOS 25 to test the mediation model (Figure 1a) and reported the results in Table 5 and Figure 2. The results indicate good model fit (Hu and Bentler, 1999). We found no

significant effect of the three control variables (firm size, age, and industry) on SCR. Table 5 also indicates that human capital is positively and significantly related to social capital (β = 0.826, $p \leq 0.001$) and organisational capital (β = 0.727, $p \leq 0.001$). Thus, H1a and H1b are supported. Human capital has no significant direct impact on SCR (β=-0.015, *n.s.*) while social capital (β = 0.403, $p \leq 0.001$) and organisational capital (β = 0.323, $p \leq 0.001$) have a significant positive impact on SCR. Thus, H2a is rejected; H2b and H2c are supported.

---------- Insert Table 5 ----------

---------- Insert Figure 2 ----------

We used the bias-corrected bootstrap method with 2,000 bootstrap samples to test the mediating effects of social and organisational capitals (Zhao et al., 2010). The results reported in Table 6 indicate an insignificant direct impact of human capital on SCR (β = -0.015, *n.s.*), but a significant positive indirect effect of human capital on SCR via social capital (β = 0.333, $p \leq 0.01$; 90% CI ranges from 0.122 to 0.498). In addition, the Sobel test also indicates that social capital (z = 3.234, $p \leq 0.001$) fully mediates the human capital–SCR relationship. Similarly, with regard to the human capital → organisational capital → SCR relationship, the results of the bootstrap test and the Sobel test indicate that organisational capital also fully mediates the human capital– SCR relationship. Thus, H3a and H3b are supported.

---------- Insert Table 6 ----------

### 5.3. Testing moderation model

To test the moderation model (Figure 1b), we conducted a moderated regression analysis. Because of the potential for multicollinearity, mean-centred values were used and each interaction term was entered separately (Williams et al., 2013). Table 7 shows variance inflation factor (VIF) values in all interaction models are below 3, which indicates that multicollinearity is not a problem (Hair et al., 2018). Models 3, 4, 5 and 6 include three two-way interaction terms (HC × SC, HC × OC and SC × OC) and one three-way interaction term (HC × SC × OC). The results reveal no significant interaction effect. Thus, H4a-d and the moderation model are rejected.

---------- Insert Table 7 ----------

## 6. Discussion

### 6.1. Discussion of results and contributions to theory

Since the early work on IC (e.g., Bontis, 1998; Edvinsson and Malone, 1997; Nahapiet and

Ghoshal, 1998) studies have tested the effects of various IC dimensions on firm performance (Hsu and Wang, 2012; Reed et al., 2006), innovation performance (Subramanian and Youdnt, 2005), and competitive advantage (Edvinsson and Malone, 1997). Recent evidence suggests that organizational learning has a role in SCR (Gölgeci and Kuivalainen, 2020; Mubarik et al., 2022). The present study provides crucial evidence for advancing the understanding of how the three IC dimensions may be managed to achieve SCR, which is of critical importance for addressing the many unprecedented disruptions facing global supply chains and economies.

This study clarifies whether human, social, and organizational capitals affect SCR independently or collectively. For explaining collective effects there are two competing models. Subramanian and Youndt (2005) argue the effects of human and organizational capitals on innovation performance are moderated by social capital. Alternatively, human capital is argued to enhance (mediate) social and organizational capital (Atavesen et al., 2018; Gonzalez-Loureiro and Dorrego, 2012; Jardon and Martos, 2009). Whether to model such interrelationships as moderators or as mediators has significant implications for how we understand the joint effects of the IC dimensions.

The results of this study reject the moderation model and provide full support for the mediation model. We found evidence that human capital positively affects SCR through the mediation of organizational and social capitals. This finding is consistent with a review of studies by Inkinen (2015, p. 532) that concluded "the relation between IC and firm performance is best comprehended via mediator models". The evidence of the mediation effects advances the SCR literature by showing that the effects of IC on SCR (Gölgeci and Kuivalainen, 2020; Polyviou et al., 2020) are not only mediated by constructs like supply chain learning (Mubarik e al., 2022) and network capabilities (Johnson et al., 2013). Thus, it is important to consider the mediation effects of social and organizational capital on the effects of human capital.

An important question to address is why the moderation results were not supported. We believe it is related to how knowledge flows through an organization. This flow is from HC to SC and OC. Essentially the flow from HC activates the others. There is no benefit to trying to merge flows. Our study provides a significant theoretical understanding to address the profoundly serious problem of how to manage knowledge residing within individuals, interpersonal relationships, and organizational routines to build resilience in supply chains.

The differences between moderation and mediation effects imply different mechanisms in which knowledge stocks are managed and connected to create SCR. A moderation model implies

the knowledge stock in each IC dimension affects SCR directly while knowledge stock from others may be drawn upon to enhance this effect. We suggest that each IC dimension acts as a knowledge stock for informing other IC dimensions. There may also be the case that knowledge processes integrate knowledge from other IC dimensions into a collective deployed knowledge. In other words, IC dimensions play dual roles. Human capital contains not only technical expertise, but also know-how of the processes by which organizational routines (organizational capital) and social interactions (social capital) can be improved or altered so that appropriate knowledge can be deployed to address different types of disruptions. In addition, organizational routines (capital) and social interactions (capital) draw appropriate knowledge from individuals (human capital), depending on the situations.

The dual roles of IC dimensions suggest two major processes are involved in building SCR. First, individual knowledge (human capital) is used to improve organizational and social capital. Second, individual knowledge (human capital) is transformed into deployed knowledge through organizational routines and social interactions. From a human resource management perspective, that means hiring and training employees should have two purposes. One is hiring employees (or training them) with new knowledge and ideas about how (use social interactions and organizational routines) to address supply chain disruptions. Second is hiring employees (or training them) in possession of new knowledge and ideas about the development of organizational methods and relationship management for addressing SCR. Both processes ensure employees can utilize their expertise to improve the existing routines, procedures, and network relationships, as well as apply their expertise into existing/new routines, procedures and network relationships when needed.

Improving all three IC dimensions is particularly crucial during times of crisis, such as the C OVID-19 pandemic. Our study highlights the importance of understanding how employees and organizations develop competencies to assess and revise existing organizational routines, social interaction structures, and knowledge management systems to allow relevant individual knowledge to be collectively deployed at an organizational level. Equally important is how a focus on renewal helps challenge core rigidities (Leonard-Barton, 1992) within existing organization routines, social interactions structures and knowledge management system that no longer fit for emerging global disruptions.

### 6.2. Contributions to practice and policy makers

A recent report from McKinsey & Company (2020) urged firms to do more and redesign their supply chain networks to tackle the current COVID-19 outbreak and future disruptive events. Our study provides useful and timely principles for managers to create more resilient supply chains, especially in volatile environments. We show the importance of renewing human, social and organisational capitals with a new perspective. Specifically, that IC elements function with dual roles. Namely that OC acts as essential knowledge stock for developing capital, and the knowledge stock within individuals can help build a resilient supply chain when working through social interactions and organizational routines. As such, managers should refresh employees' knowledge, abilities, and motivation to help position employees to effectively address emerging disruptions.

There are some specific approaches managers might consider to operationalizing these principles. One is to ascertain best practices and then create training and communications programs to disseminate them. Another would be to assess which organizational structures were most effective and investigate why this was so. The knowledge gained from this analysis should then be used to inform restructuring of the supply base and internal functions. This knowledge should also be pushed out to employees.

Because the potential for deploying individual knowledge depends on how the knowledge stock is draw into existing organization routines and social interaction processes, it is important to allow employees to challenge and alter the existing organization routines and social interaction processes. For this reason, managers should actively and appreciatively seek the input of those employees directly involved. Rigid processes are not suitable for uncertain environments. Managers need to review existing social interactions, organisational routines, structures, and procedures with a focus on how they may maximize the supply of new ideas and knowledge from employees into processes that draw and integrate such knowledge. To reduce rigidity of the existing hierarchy, firms should emphasize knowledge created by groups and networks of people (social capital) using more loosely defined routines (organizational capital). Moreover, managers often resort to hiring staff with the technical knowledge required to address emerging disruptions. It is important to recognize the codifying and integrating of new knowledge into existing organisational routines and structures is often created by social interactions and learning processes among employees when they work together to address supply chain disruptions. As such, managers should ensure the new hires with technical knowledge can influence SC and OC.

The above highlights implications for public policy. Politicians should create opportunities

for citizens to learn new skills and grow their knowledge base. Importantly, politicians should not adopt a one size fits all approach. There is benefit in citizens learning different approaches to problems (Jacobs and Swink, 2011). It urges for continued or increased support of university education.

## 7. Conclusion and future research

This study extends the ICV literature in several important ways. First, this study to our knowledge is the first to investigate the role of IC in its totality as the driver of SCR using both interaction and mediation models. The results show individual knowledge (human capital) builds SCR *indirectly* through knowledge residing within interactions among people (social capital) and codified experience and institutionalized knowledge (organizational capital). Second, the study highlights the dual roles of human, social, and organizational capitals, as knowledge stock and knowledge processes. The study shows resilient supply chains are built by knowledge on how human capital as a knowledge stock is used to inform and improve organizational routines and social interactions, and how organizational routines and social interactions deploy and create collective knowledge. Third, the highlighting of these dual roles for IC represents a significant theoretical contribution and a new perspective for mangers to better manage the development of knowledge within employees, organizational routines and social interactions processes, and the processes in which employees, organizational routines and social interaction processes create collective knowledge to build SCR.

This study has some limitations. First, in this study we examine three prominent dimensions of IC (i.e., human, social, and organisational capital), which have been widely recognised by previous IC researchers (e.g., Kang and Snell, 2009; Youndt and Snell, 2004) and more recently used to explain SCR (Gölgeci and Kuivalainen, 2020; Mubarik et al., 2022). Previous research as particular facets of IC, which are not studied herein. Future studies should investigate the effects of additional forms of capital e.g., customer and innovation capital (Bontis, 1998) and the relationships between social and organizational capital (Carmona-Lavado et al., 2010). Second, the IC–SCR relationship is complex and might be contingent upon business environment e.g., environmental uncertainty and dynamism, and multifaceted organizational attributes e.g., organisational learning and innovative capabilities (Gölgeci and Kuivalainen, 2020; Mubarik et al., 2022). Future research could investigate the influence of these contingency factors on the IC–SCR relationship. Third, this study empirically tests a conceptual framework using survey data

gathered from China's manufacturing industry and our sample is therefore based in a single economy. Future empirical research could gather data from other industries in different countries to see whether the same relationships are held in other research contexts. Additionally, future research should also consider the representativeness of the sample and the potential for response bias. It is important for future researchers to take these factors into account when designing and conducting empirical studies.

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**Table 1: Previous empirical research that examines the antecedents for developing SCR**

| Research objectives and findings | Research methods | Theories | Empirical research |
|---|---|---|---|
| The research investigates how three dimensions of social capital (cognitive, structural and relational) act as facilitators or enablers of SCR. | A single case study | n/a | Johnson et al. (2013) |
| The research develops an integrated framework that captures the interplay of disaster management processes and capabilities required to build SCR. | An in-depth, single qualitative case study | n/a | Scholten et al. (2014) |
| The research finds that SC visibility, cooperation, and trust are the predictors of SCR, and behavioral uncertainty moderates the effects of trust and cooperation on SCR. | Questionnaire survey and hierarchical moderated regression analysis | Resource-based view and relational view | Dubey et al. (2017) |
| The research identifies six learning mechanisms and their antecedents for building SCR, including processual learning, anticipative learning, situational learning, collaborative learning, experiential learning, and vicarious learning. | An in-depth, multiple qualitative case study | n/a | Scholten et al. (2019) |
| The research examines the roles of digital SC technology competency and use in developing SCR. | Questionnaire survey and structural equation modelling (SEM) | n/a | A.S. and Ramanathan (2021) |
| The research examines the effects of three dimensions of IC (human capital, structural capital, and relational capital) on SC learning and SCR. | Questionnaire survey and PLS-SEM, PLS multigroup analysis and one-way analysis of variance (ANOVA) | Dynamic capability view, knowledge-based view, and organization learning theory | Mubarik et al. (2022) |
| The research identifies a set of managerial antecedents (such as SC manager's social capital, human capital, and cognition) and organizational antecedents (such as SC visibility, responsiveness, and flexibility) that contribute to SCR. | Questionnaire survey and bootstrapping parallel multiple mediator models | Dynamic capability view | Nikookar and Yanadori (2022) |
| The research examines the effects of openness to technological innovation, inter-functional coordination, and inter-partner informational justice on SCR. | Questionnaire survey and SEM | Organizational information processing theory | Yu et al. (2022) |
| The research examines the effects of SC memory and digital technologies (such as Internet of Things, cloud computing, big data analytics, digital twins, blockchain technology) on SCR. | Questionnaire survey and SEM | Knowledge-based view | Alvarenga et al. (2023) |

| | | | |
|---|---|---|---|
| This research examines the significance of cognitive capital in SC risk SCR. | A single case study | n/a | Daghar et al. (2023) |
| The research examines the effects of digital agility and digital adaptability on SCR. | Questionnaire survey and PLS-SEM | Dynamic capability view | Dubey et al. (2023) |
| The research finds Industry 4.0 technological capabilities directly and positively affect SCR. | Questionnaire survey and PLS-SEM | n/a | Nakandala et al. (2023) |

**Table 2: Measurement model**

| Theoretical Constructs and Items | Factor loadings | CITC |
|---|---|---|
| **Human capital** (Subramaniam and Youndt, 2005) | | |
| [Cronbach's alpha (α) = 0.919; Composite reliability (CR) = 0.920; AVE = 0.698] | | |
| Our employees are highly skilled | 0.800 | 0.757 |
| Our employees are widely considered the best in our industry | 0.835 | 0.797 |
| Our employees are creative and bright | 0.879 | 0.836 |
| Our employees are experts in their particular jobs and functions | 0.825 | 0.792 |
| Our employees develop new ideas and knowledge | 0.837 | 0.783 |
| **Social capital** (Subramaniam and Youndt, 2005) | | |
| [α = 0.917; CR = 0.918; AVE = 0.692] | | |
| Our employees are skilled at collaborating with each other to diagnose and solve problems | 0.852 | 0.792 |
| Our employees share information and learn from one another | 0.889 | 0.832 |
| Our employees interact and exchange ideas with people from different areas of the company | 0.815 | 0.780 |
| Our employees partner with customers, suppliers, alliance partners, etc., to develop solutions | 0.799 | 0.783 |
| Our employees apply knowledge from one area of the company to problems and opportunities that arise in another | 0.800 | 0.753 |
| **Organisational capital** (Subramaniam and Youndt, 2005) | | |
| [α = 0.844; CR = 0.851; AVE = 0.590] | | |
| Our organization uses patents and licenses as a way to store knowledge | 0.669 | 0.619 |
| Much of our organization's knowledge is contained in manuals, databases, etc. | 0.731 | 0.689 |
| Our organization's culture (stories, rituals) contains valuable ideas, ways of doing business, etc. | 0.844 | 0.744 |
| Our organization embeds much of its knowledge and information in structures, systems, and processes | 0.816 | 0.684 |
| **Supply chain resilience** (Golgeci and Ponomarov, 2013) | | |
| [α = 0.879; CR = 0.884; AVE = 0.606] | | |
| Our company's supply chain is able to adequately respond to unexpected disruptions by quickly restoring its product flow | 0.684 | 0.652 |
| Our company's supply chain can move to a new, more desirable state after being disrupted | 0.682 | 0.683 |
| Our company's supply chain is well prepared to deal with financial outcomes of supply chain disruptions | 0.837 | 0.738 |
| Our company's supply chain has the ability to maintain a desired level of control over structure and function at the time of disruption | 0.868 | 0.775 |
| Our company's supply chain has the ability to extract meaning and useful knowledge from disruptions and unexpected events | 0.801 | 0.735 |
| Model fit indices: $\chi^2 = 378.344$; df = 146; $\chi^2$ / df = 2.591; RMSEA = 0.081; CFI = 0.931; IFI = 0.931; SRMR = 0.051 | | |

**Table 3: Demographics of respondents and their firms**

| | Percent (%) | | Percent (%) |
|---|---|---|---|
| **Industry types** | | **Geographical locations** | |
| Automobile | 30.7 | Pearl River Delta | 8.7 |
| Chemicals and petrochemicals | 10.4 | Yangtze River Delta | 8.7 |
| Electronics and electrical | 12.4 | Bohai Sea Economic Area | 20.7 |
| Fabricated metal product | 6.2 | Northeast China | 1.7 |
| Food, beverage and alcohol | 13.7 | Central China | 14.9 |
| Rubber and plastics | 2.5 | Southwest China | 38.6 |

| | | | |
|---|---|---|---|
| Textiles and apparel | 4.6 | Northwest China | 6.6 |
| Others | 19.5 | | |
| **Number of employees** | | **Annual sales (in million Yuan)** | |
| 1 – 100 | 19.1 | Below 10 | 10.0 |
| 101 – 200 | 15.4 | 10 – 50 | 15.8 |
| 201 – 500 | 13.3 | 50 – 100 | 10.4 |
| 501 – 1000 | 8.7 | 100 – 500 | 17.0 |
| 1001 – 3000 | 17.8 | 500 – 1000 | 12.9 |
| > 3000 | 25.7 | Above 1000 | 34.0 |
| **Job titles** | | **Years in current position** | |
| President / Chief executive officer (CEO) | 5.4 | ≤ 5 | 45.2 |
| Vice President | 7.1 | 6-10 | 24.5 |
| Director | 4.6 | > 10 | 30.3 |
| Manager | 49.4 | | |
| Other senior executive | 33.6 | | |

**Table 4: Descriptive statistics and correlations**

| | Mean | S.D. | HC | SC | OC | SCR |
|---|---|---|---|---|---|---|
| **1. Human capital (HC)** | 5.054 | 1.178 | **0.836**[a] | 0.748** | 0.639** | 0.494** |
| **2. Social capital (SC)** | 5.204 | 1.034 | 0.750** | **0.832** | 0.631** | 0.554** |
| **3. Organisational capital (OC)** | 5.354 | 1.108 | 0.641** | 0.633** | **0.768** | 0.495** |
| **4. Supply chain resilience (SCR)** | 5.020 | 1.029 | 0.497** | 0.557** | 0.498** | **0.778** |
| **6. Demand uncertainty (marker variable)** | 3.832 | 1.139 | 0.021 | 0.078 | 0.006 | -0.009 |

Note: [a] Square root of AVE appear on the diagonal; unadjusted correlations appear below the diagonal; adjusted correlations for potential CMV appear above the diagonal.

**Table 5: Hypothesis test: direct effects**

| Hypothesised relationships | Standardised coefficient | t-values | Hypothesis test |
|---|---|---|---|
| H1a: Human capital → Social capital | 0.826*** | 12.408 | Accept |
| H1b: Human capital → Organisational capital | 0.727*** | 8.644 | Accept |
| H2a: Human capital → Supply chain resilience | -0.015 | -0.105 | Reject |
| H2b: Social capital → Supply chain resilience | 0.403*** | 3.349 | Accept |
| H2c: Organisational capital → Supply chain resilience | 0.323*** | 3.231 | Accept |
| **Control variable** | | | |
| Firm size → Supply chain resilience | -0.007 | -0.099 | |
| Firm age → Supply chain resilience | 0.001 | 0.012 | |
| Industry1-automobile → Supply chain resilience | 0.099 | 1.524 | |
| Industry2-food, beverage, and alcohol → Supply chain resilience | 0.047 | 0.762 | |
| Industry3-electronics and electrical → Supply chain resilience | -0.075 | -1.228 | |
| Industry4-chemicals and petrochemicals → Supply chain resilience | 0.048 | 0.799 | |
| **Variance explained ($R^2$)** | | | |

| | |
|---|---|
| Social capital | 0.683 |
| Organisational capital | 0.528 |
| Supply chain resilience | 0.433 |
| Model fit indices: $\chi^2$ = 569.294; df = 249; $\chi^2$/df = 2.286; RMSEA = 0.073; CFI = 0.912; IFI = 0.913; SRMR = 0.056 | |

*** $p \leq 0.001$.

**Table 6: Hypothesis test: mediation effects**

| Hypothesised relationships | Direct effect | Indirect effect | 90% CI for indirect effect | Sobel test | Hypothesis test |
|---|---|---|---|---|---|
| H3a: HC→SC→SCR | -0.015 | 0.333** | 0.122–0.498 | z=3.234*** | Accept |
| H3b: HC→OC→SCR | -0.015 | 0.235** | 0.103–0.322 | z=3.044** | Accept |

Note: HC: human capital; SC: social capital; OC: organisational capital; SCR: supply chain resilience; SE: bootstrap standard error; CI: bootstrap confidence interval; Standardized effects; 2,000 bootstrap samples.

*** $p \leq 0.001$; ** $p \leq 0.01$.

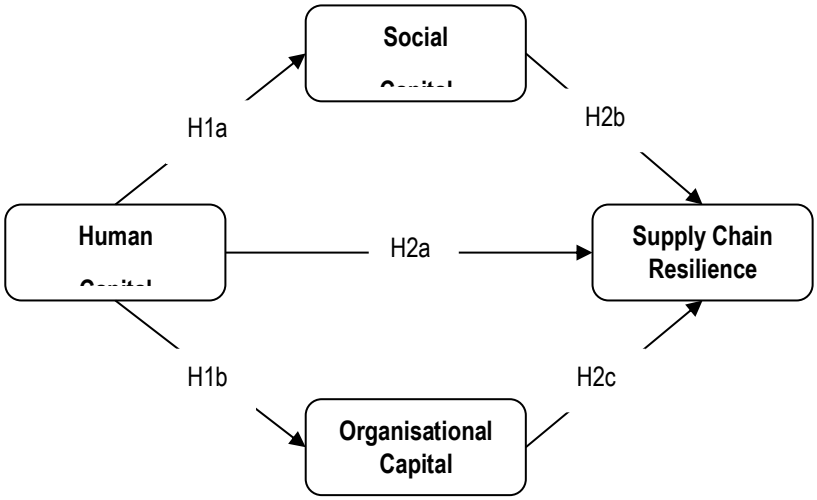
**Table 7: Hypothesis test: interaction effects**

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| **Control variables** | | | | | | |
| Firm size | 0.039 (0.464) | -0.026 (-0.370) | -0.023 (-0.330) | -0.025 (-0.368) | -0.023 (-0.329) | -0.023 (-0.335) |
| Firm age | -0.003 (-0.034) | -0.012 (-0.181) | -0.012 (-0.185) | -0.012 (-0.179) | -0.013 (-0.192) | -0.012 (-0.184) |
| Industry1-automobile | 0.203 (2.685)** | 0.112 (1.795)† | 0.116 (1.857)† | 0.113 (1.790)† | 0.113 (1.817)† | 0.116 (1.846)† |
| Industry2-food, beverage, and alcohol | 0.116 (1.590) | 0.045 (0.741) | 0.041 (0.679) | 0.045 (0.742) | 0.045 (0.745) | 0.044 (0.724) |
| Industry3-electronics and electrical | 0.009 (0.125) | -0.078 (-1.319) | -0.076 (-1.284) | -0.078 (-1.299) | -0.077 (-1.294) | -0.076 (-1.278) |
| Industry4-chemicals and petrochemicals | 0.047 (0.675) | 0.045 (0.782) | 0.044 (0.769) | 0.045 (0.780) | 0.044 (0.756) | 0.044 (0.770) |
| **Independent variables** | | | | | | |
| Human capital (HC) | | 0.095 (1.098) | 0.094 (1.080) | 0.095 (1.093) | 0.087 (0.987) | 0.094 (1.083) |
| Social capital (SC) | | 0.331 (3.817)*** | 0.332 (3.821)*** | 0.331 (3.811)*** | 0.336 (3.846)*** | 0.331 (3.816)*** |
| Organisational capital (OC) | | 0.236 (3.208)** | 0.236 (3.195)** | 0.236 (3.198)** | 0.238 (3.221)*** | 0.236 (3.196)** |
| **Interaction effects** | | | | | | |
| HC × SC | | | 0.034 (0.637) | | | |
| HC × OC | | | | 0.007 (0.128) | | |
| SC × OC | | | | | 0.029 (0.541) | |
| HC × SC × OC | | | | | | 0.030 (0.557) |
| $R^2$ | 0.040 | 0.373 | 0.374 | 0.373 | 0.374 | 0.374 |
| *Adjust* $R^2$ | 0.015 | 0.348 | 0.347 | 0.345 | 0.346 | 0.346 |
| *F-value* | 1.623 | 15.250*** | 13.371*** | 13.668*** | 13.713*** | 13.715*** |
| *Max VIF* | 1.683 | 2.766 | 2.767 | 2.767 | 2.838 | 2.766 |

*** $p \leq 0.001$; ** $p \leq 0.01$; † $p \leq 0.10$.

Note: t-values are shown in parentheses; dependent variable is supply chain resilience.

**Figure 1a: Proposed mediation model: mediation effect**




H3a: human capital → social capital → SCR

H3b: human capital → organisational capital → SCR

**Figure 1b: Proposed moderation model: interaction effect**

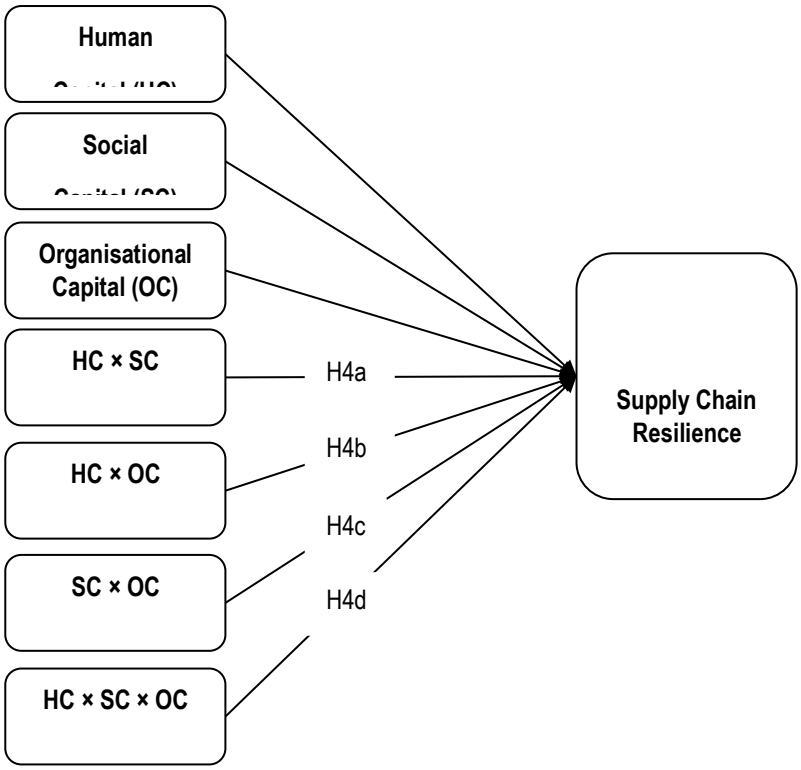
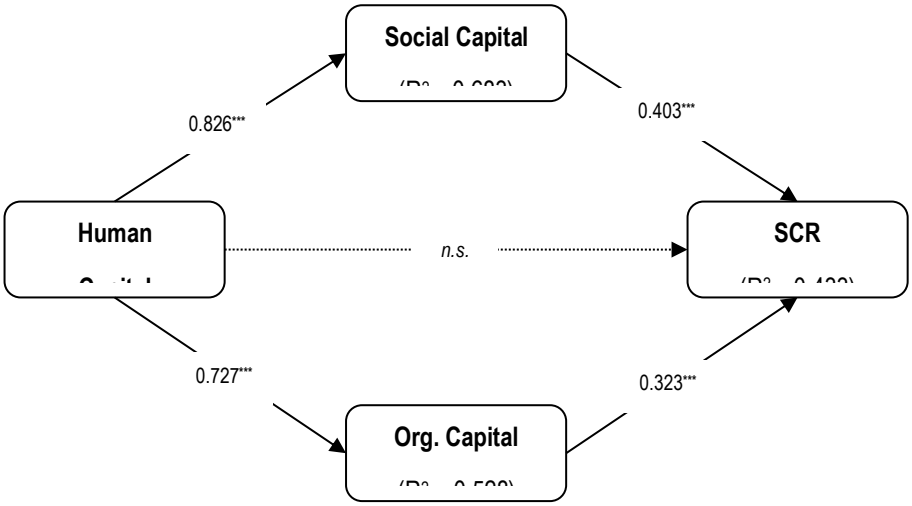


**Figure 2: SEM results for mediation model**




$\chi^2$/df = 2.286; RMSEA = 0.073; CFI = 0.912; IFI = 0.913; SRMR = 0.056

Note: *** $p \leq 0.001$.