Int. J. Production Economics 288 (2025) 109728

Contents lists available at ScienceDirect

International Journal of Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Diffusion of digital transformation initiatives in multi-tier supply chains: The double agency role of Tier-1 suppliers

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ARTICLE INFO

Keywords:
Digital transformation
Multiple case study
Triadic relationships
Relational and cognitive capital

ABSTRACT

Growing global supply chain complexity has generated interest in multi-tier management, yet most research focuses on focal firm and Tier–1 ties, overlooking Tier-2 dynamics. A specific gap exists in investigating Digital Transformation Initiatives (DTI) within triadic relationships among the focal firm and its Tier-1 and Tier-2 suppliers. This study addresses this gap by utilizing a multiple-case study approach across diverse sectors, drawing on 30 interviews, to examine the diffusion of DTI across multi-tier supply chains, with particular attention to the Double Agency Role (DAR) of Tier-1 suppliers. Using social capital theory and agency theory, our findings emphasize the key role of social capital in the DAR of Tier-1 suppliers. The importance of relational and cognitive capital varies as we shift from downstream to upstream segments of the supply chain. Relational capital is crucial in the downstream segment (focal firm–Tier-1 supplier), while cognitive capital grows in significance as we move upstream (Tier-1–Tier-2 suppliers). Additionally, we create a matrix to illustrate the relationships among social capital, the DAR, and the effectiveness of DTI diffusion. This study contributes to the digital transformation literature by expanding its focus from dyadic to triadic relationships. It also offers practical implications for supply chain managers, providing actionable insights to enhance the diffusion of DTI.

1. Introduction

In the digital transformation era, focal firms often initiate Digital Transformation Initiatives (DTI) to enhance transparency, compliance, and the competitiveness of the supply chain. For instance, leading firms like Volkswagen, Walmart, and Samsung are leveraging digital technologies to enhance multi-tier supply chain visibility and efficiency. Volkswagen collaborates with OEMs and DHL to deploy analytics and IoT via Tier-1 partners (DHL, 2019), while Walmart uses machine learning for real-time data sharing with Tier-1 and Tier-2 suppliers (Banker, 2021). Samsung adopts digital shipping tools to ensure compliance across its sub-tier suppliers and logistics partners (Samsung SDS, 2024). Tier-1 suppliers play a critical double agency role: they not only absorb and implement the focal firm's digital transformation standards but also influence how these initiatives propagate to lower-tier suppliers. They, thus, hold a "double agency" role: they incorporate the focal firm's standards and guide sub-tier suppliers. Examples from Apple underscore the importance of advanced analytics across all tiers (Apple, 2024). Enabled by relational and cognitive capital (trust, shared vision), they ensure end-to-end digital adoption and robust integration. Strong commitment from the focal firm is crucial for Tier-1 suppliers to convey broader strategic objectives to lower-tier suppliers.

Technology-driven Multi-Tier Supply Chains (MTSCs) primarily aim to support firms in reorganizing their processes and developing digital capabilities, skills, knowledge, and routines essential for sustainability in a technology-driven environment (Chirumalla, 2021). This distinction underscores the importance of differentiating between the adoption of standalone digital tools and a more comprehensive, strategic DTI. The latter refers to coordinated, multi-project programs that align strategy, processes, and technology to achieve transformation goals within MTSCs—going beyond mere technology implementation. The diffusion

This article is part of a special issue entitled: Multi-tier supply chain relationships published in International Journal of Production Economics.

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https://doi.org/10.1016/j.ijpe.2025.109728
Received 30 August 2024; Received in revised form 23 June 2025; Accepted 3 July 2025
Available online 4 July 2025
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of DTI, as analyzed in this study, involves three key elements: (1) the efficient implementation of new technologies across supply chain stakeholders; (2) the development of critical digital capabilities, including knowledge sharing and digital literacy; (3) the integration of digitally enabled risk management strategies across all tiers of the supply chain, with particular attention to the intermediary role of Tier-1 suppliers in facilitating the digital transformation initiated by the focal firm for sub-tier suppliers.

Despite the increasing attention to and strategic relevance of DTI, their contribution to multi-tier SCM remains underexplored (Pfaff et al., 2023). Most existing literature focuses on intra-firm dynamics or buyer-supplier dyads vis-à-vis DTI (Obal & Lancioni (2013); Faruquee et al. (2021); Kauppi et al. (2024); Lee et al. (2015)). A more convenient dyadic (focal firm–Tier-1) approach is insufficient to comprehend digital transformation's full impact that reverberates across multiple SC actors. Given their intermediary position, Tier-1 suppliers must navigate both coupling and decoupling pressures. This dual responsibility amplifies agency problems as digital transformation advances across tiers, heightening the issue of power asymmetries, information gaps, and diverging incentives. A multi-tier perspective is vital for understanding how the focal firm's DTI propagates throughout the entire SC network. Tier-1 suppliers serve as both intermediaries and gatekeepers in digital transformation processes, influencing how Tier-2 suppliers respond. The agency problem intensifies as digital transformation advances across tiers due to differences in power dynamics, information asymmetry, and incentives. Neglecting the Tier-1 to Tier-2 relationship results in a fragmented understanding of digital adoption, hindering the ability to leverage the potential benefits of digital transformation.

Following Alvesson and Sandberg's (2024) framework on phenomenon construction, this article reconceptualizes Tier-1 suppliers as boundary-spanning digital intermediaries and develops an innovative framework. The proposed framework integrates social capital theory (structural, cognitive, and relational capital; Nahapiet and Ghoshal, 1998) and double agency theory (coupling and decoupling; Wilhelm et al., 2016) to explain the diffusion of DTI in MTSCs. The main objective is to examine *how social capital between the focal firm and Tier-1 supplier, as well as between Tier-1 and Tier-2 suppliers, influences Tier-1 suppliers' assumption of a DAR in the diffusion of DTI to Tier-2 suppliers*. A holistic view of multi-tier SC relationships (focal firm to Tier-1 supplier to Tier-2 supplier) is critical for understanding the true impact of a focal firm's DTI.

This study offers several key contributions to the analysis of multi-tier supplier relationships through innovative theoretical, methodological, and empirical approaches. First, we extend classical dyadic agency theory by introducing a triadic governance model that captures the Double Agency Role (DAR) of Tier-1 suppliers. Second, we present a novel theoretical synthesis by integrating social capital theory with agency theory which are traditionally examined in isolation. Our findings demonstrate how relational and cognitive dimensions of social capital shape Tier-1 suppliers' agency behaviour in DTI. Specifically, the level of cognitive and relational capital between the focal firm and Tier-1 suppliers influences whether suppliers adopt coupling (supportive) or decoupling (symbolic) behaviours. We challenge the assumption within social capital theory that relational capital always facilitates innovation. Our findings reveal that high relational capital can hinder technology diffusion when not accompanied by sufficient cognitive alignment. We further advance agency theory by incorporating digital mediation and triadic structures as key modifiers of agency behaviour in MTSCs. Our empirical evidence shows that agency behaviour is not solely driven by incentives, contracts, or self-interest, but also by social capital dynamics. Additionally, we challenge the traditional linear view of digital implementation by proposing a cyclical, evolving agency model. Methodologically, we adopt a cross-sector, multiple-case design addressing a gap in the MTSCs literature, which predominantly focuses on dyadic or single-sector studies. This approach uncovers both common patterns and sector-specific variations in DTI diffusion, offering theoretical and practical insights for managing multi-tier digital transformation.

The structure of this manuscript is as follows: Section 2 presents the theoretical background, while Section 3 outlines the research methodology. Section 4 discusses empirical findings in depth, followed by a discussion in Section 5. Finally, Section 6 concludes the paper by outlining the implications and suggesting directions for future research.

2. Theoretical background

The literature review is structured into three subsections. First, we will discuss the existing research on multi-tier digital transformation in SCs. Next, we explore the role of agency theory. Finally, we discuss social capital theory and its relevance to DTI in MTSCs. Table 1 provides the definitions of different aspects of social capital and the double agency theory used in this article.

2.1. Multi-tier digital transformation

Existing literature on MTSCs has examined various themes such as risk management, sustainability, and governance (Hannibal and Kauppi, 2019; Sauer and Seuring, 2019). Scholars have shown that Tier-1 suppliers play a critical role in extending focal-firm-led sustainability initiatives to sub-tier actors effectively (Oyedijo et al., 2024; Jia et al., 2021). The vulnerability of lower-tier suppliers stemming from limited governance, resource slack, and transparency has also been well documented (Villena and Gioia, 2018; Wilhelm and Villena, 2021; Durach et al., 2024). While these studies provide valuable insights into managing sustainability across tiers, they have predominantly examined static contexts and generally fail to capture the dynamic and evolving

Table 1
Key deductive constructs used in abductive reasoning.

Construct	Definition	Relevance to This Study	Supporting Literature
Social Capital	The sum of resources embedded in, available through, and derived from a firm's network of relationships, including structural, relational, and cognitive dimensions.	Explains how relational, cognitive, and structural capital foster collaboration and knowledge diffusion in multi-tier supply chains.	Nahapiet and Ghoshal (1998); Jia et al. (2021)
Double Agency Role (DAR)	The role of Tier-1 suppliers as intermediaries who both comply with focal firms' directives and facilitate knowledge transfer to lower-tier suppliers.	Highlights how Tier-1 suppliers balance focal firm requirements and supplier engagement to diffuse digital transformation initiatives.	Wilhelm et al. (2016)
Cognitive Capital	Shared language, goals, and understanding that enable effective coordination among supply chain actors.	Essential for aligning digital transformation objectives across supply chain tiers.	Nahapiet and Ghoshal (1998); Jia et al. (2021)
Relational Capital	Trust-based relationships that enhance collaboration and reduce opportunism between supply chain actors.	Enables commitment to long-term digital transformation rather than short-term compliance.	Krause et al. (2007); Jia et al. (2021)
Structural Capital	Formal systems, governance mechanisms, and communication channels that facilitate knowledge sharing.	Provides a foundation for Tier-1 suppliers to act as digital intermediaries.	(Nahapiet and Ghoshal, 1998; Krause et al., 2007; Zhu and Lai, 2019)

nature of digital transformation. A gap remains in understanding how emerging technologies influence inter-tier relationships and long-term strategic outcomes (Villena and Gioia, 2018; Oyedijo et al., 2024; Jia et al., 2021).

Recent studies have begun to examine the digital aspects of MTSCs, particularly through the lens of technological enablers. For example, blockchain has emerged as a tool to enhance pricing strategies and channel selection (Dong et al., 2023). It has the potential to increase transparency and ensure compliance (Senyo and Osabutey, 2023). Advancements in **SC** governance frameworks increasingly favor **relational governance approaches** (Pfaff et al., 2023), **thereby reducing** agency-related concerns in **digital SCs** (Sternberg et al., 2023). Social capital between different SC stakeholders can help to enhance transparency and reduce resistance to integration and technological challenges (Wong et al., 2024). Most existing frameworks rely on dyadic views, offering a fragmented perspective of digital transformation across supply networks (Son et al., 2021). A multi-tier approach is essential to understand how digital initiatives from focal firms cascade through SCs. Tier-1 suppliers act both as intermediaries and gatekeepers, influencing sub-tier adoption through control over information, incentives, and resources. Ignoring these dynamics may result in inconsistent adoption and lost strategic value. It is critical to assess how digital knowledge and capabilities are diffused or hindered from focal firms to Tier-1 and Tier-2 suppliers (Nahapiet and Ghoshal, 1998; Wilhelm et al., 2016). In the next section, we will explore the literature related to Agency Theory.

2.2. The role of agency theory in MTSCs

Agency theory has been widely used to explain principal-agent relationships, align incentives, and structure governance contracts in supply chains, particularly in contexts where focal firms delegate operational responsibilities to intermediaries (Eisenhardt, 1989a). Recent research recognizes both the strengths and limitations of agency theory in digital contexts. Digital transformation can enhance financial performance and reduce opportunism through collaborative risk-sharing (Li et al., 2015). Technologies like blockchain mitigate agency problems by improving transparency and monitoring (Sternberg et al., 2023).

However, these technologies also introduce new risks, such as concerns over data privacy, technological dependency, and uneven digital capability across SC tiers. These are factors that are not fully addressed within the conventional boundaries of agency theory (Sternberg et al., 2023). To address these limitations, the concept of "double agency" has emerged. It is an extension of traditional agency theory and is commonly used in MTSCs. It covers the unique position of Tier-1 suppliers in MTSCs that act as agents of the focal firm to their sub-tier suppliers. Tier-1 suppliers act as a mediator who balances upward accountability with downward control and helps manage risk effectively (Wilhelm et al., 2016). These additional delegations intensify traditional agency problems by multiplying opportunities for moral hazard and information distortion across the chain. While monitoring and incentive systems of Tier-1 suppliers' agency role are effective to some extent, if incentives are not aligned across all actors in the SC, they may exacerbate strategic non-compliance (Maestrini et al., 2018). The success of an agency system is dependent on rational self-interest, trust, collaboration, and shared norms between SC stakeholders. These limitations become particularly pronounced in digitally transforming SCs, where success depends not only on contracts and incentives but also on mutual learning and social coordination.

To address this issue in the literature, social capital theory has been used to complement agency theory. It is observed that relational, cognitive, and structural dimensions can foster collaboration and reduce opportunism (Nahapiet and Ghoshal, 1998). Scholars argue for shifting away from principal-agent dyads toward relational frameworks prioritizing long-term partnerships, especially in dynamic and technology-intensive environments (Matinheikki et al., 2022). This is particularly relevant in digitally transforming MTSCs, where the ability to manage change and adopt new technologies hinges on strong inter-organizational relationships and shared vision. Agency theory and social capital theory offer a more holistic and robust framework for analysing digital transformation in MTSCs. Agency theory can be used to examine how firms align incentives and mitigate risk. Social capital theory provides insights into how trust-based relationships enhance collaboration and enable the effective diffusion of digital innovations. Together, these perspectives offer a richer understanding of how organizations navigate the dual pressures of governance and cooperation within complex, multi-tiered, digitally evolving SCs. In the next section, we examine the contributions of social capital theory in more depth.

2.3. Social capital theory and digital transformation initiatives in multi-tier supply chains

Definitions of social capital vary across disciplines, reflecting its broad applicability. It is commonly defined as the networks, relationships, and social interactions that individuals or organizations leverage to foster cooperation, access resources, or achieve goals (Nahapiet and Ghoshal, 1998; Jia et al., 2021). Coleman (1988), in early work, framed social capital within a rational-choice perspective, linking it to coordinated action in structured relationships. Despite diverse interpretations, scholars generally converge on a tripartite model: structural (network ties and formal linkages), cognitive (shared goals, language, and narratives), and relational (trust, norms, and mutual obligations) (Nahapiet and Ghoshal, 1998). In the literature, it has been extensively used to study inter-firm collaborations, particularly in innovation, entrepreneurship, and supply chain partnerships. Strong relational ties are shown to enhance supplier development and performance by fostering trust, shared understanding, and long-term commitment (Krause et al., 2007). It also mitigates opportunism and promotes cooperation, boosting supplier profitability and compliance through collaborative norms and external monitoring (Dai et al., 2024). While these studies affirm the value of social capital, most focus on dyadic partnerships, overlooking its role in complex, multi-tier, digitally transforming SCs.

In the digital transformation landscape, interorganizational collaboration is essential, requiring firms to integrate technologies, share resources, and co-create solutions. Literature on social capital in R&D and tech-driven projects highlights how relational networks support knowledge diffusion and innovation. For instance, social capital enhances knowledge sharing and innovation in geographically dispersed R&D teams and improves communication among corporate and tech professionals (Mazzucchelli et al., 2021; Lee et al., 2015). These insights align with research on cooperative resilience, showing that social capital-driven frameworks strengthen adaptability and sustainability under uncertainty (Wulandhari et al., 2022). Despite this, the application of social capital theory in digital transformation within MTSCs remains underexplored. Most studies focus on dyadic alliances, overlooking the complex collaboration required across multiple SC tiers. Addressing this gap, our study argues that while social capital theory provides a strong foundation for understanding digital transformation, it must be integrated with other perspectives to capture MTSCs complexities. We propose a novel framework combining social capital and double agency theories to reveal how social dynamics and agency conflicts unfold across SC tiers.

3. Research methodology

We have adopted an exploratory case study method (Yin, 2018) to investigate how social capital interactions affect the DAR of Tier-1 suppliers. We employ a multiple case study design, encompassing five distinct cases, to develop a theory and elaborate on how these triadic interactions influence the diffusion of DTI (Yin, 2018). We have employed a multiple qualitative case study method for two major reasons. First, digital transformation within MTSCs is an intricate and

under-investigated aspect that cannot be sufficiently captured via quantitative and survey-based approaches. Investigating multiple cases facilitates the identification of significant patterns within technological, social, and relational ties, which are distinctive to various SC settings. This method is crucial in capturing the complex interplay of social capital and agency roles across various industries. Second, aggregating data from focal firms, Tier-1, and Tier-2 suppliers provides a holistic triadic viewpoint on these exchanges. This enables a granular understanding of how digital competencies are disseminated and how social capital attributes foster Tier-1 suppliers' DAR. By amalgamating insights from multiple cases, this study develops a robust foundation for unpacking the diffusion of DTI within MTSCs. We have applied agency theory and social capital theories with the following underpinning assumptions. We assumed that without a direct contract between focal firms and Tier-2 suppliers, SC actors would act in self-interest, leading to information asymmetry and misaligned incentives. In this situation, Tier-1 suppliers play dual accountability, acting as both agents and principals, creating a double-layered agency structure. We also assumed that trust, shared norms, and a common understanding usually develop over time and act as informal ways to manage relationships. Further, we expected that these social factors differ across SC tiers and affect how much Tier-1 suppliers participate in digital transformation efforts beyond what formal contracts require.

3.1. Research context and case selection

To achieve the goal of this research, namely, theory development and elaboration, we integrated existing theoretical constructs with newly emergent concepts derived through abductive analysis (Ketokivi and Choi, 2014; Jia et al., 2021). We adopted a multiple-case design and collected data from various sectors, including service, retail, and manufacturing. This cross-sectoral approach enhanced the analytical generalizability of our findings. It allowed us to capture and compare digital transformation dynamics across diverse SC environments—a topic that remains underexplored in the existing literature. One of our team members compiled a list of potential case firms, and we applied literal replication logic to derive findings that are both consistent and complementary (Yin, 2018). Furthermore, we selected case companies that satisfy the following criteria: (1) The focal firm has initiated a digital transformation process and is working closely with its suppliers; (2) Tier-1 suppliers delegate the assignment to develop digital capabilities and monitor Tier-2 suppliers' compliance; (3) There is no direct contractual relationship between the focal firm and Tier-2 suppliers; (4) Tier-1 is a critical supplier of the focal firm. We secured access to focal firms and relied on their support to identify a suitable Tier-1 supplier. Subsequently, we located a Tier-2 supplier via Tier-1, using literal replication logic to select five MTSCs. It satisfies the appropriate number to enrich the understanding of the under-explored phenomenon and strike a balance between the volume of data and complexities (Yin, 2018).

3.2. Data collection

To support this triadic exploration, we developed a case study protocol (see Appendix 1) that incorporated theoretical foundations, research objectives, and interview protocols (Yin, 2018). Data was collected through multiple methods, including both primary and secondary data. Primary data was collected in the third quarter of 2023 over four months. We conducted a total of 30 interviews, two participants from each company across the focal firm, Tier-1, and Tier-2 suppliers (six participants per case). Interviewees were chosen based on expertise in digital transformation. We designed different interview questions for the focal firms, Tier-1 suppliers, and Tier-2 suppliers, respectively. Each interview lasted 60–90 min. To overcome any confusion, we kept regular contact and modified the analysis based on interviewees' suggestions. After obtaining permission from the company, we reviewed the website's contents to find relevant information regarding the digital transformation topic. Secondary data helped us to analyze further and complement the interview data. After completing 30 interviews, no new themes had developed, which indicates that we had reached a satisfactory level of theory saturation and provided enough evidence for us to proceed with the data analysis (Eisenhardt, 1989b). Table 2 presents a summary of the basic information for five cases.

3.3. Theoretical hierarchy and unit of analysis

This study employs social capital theory as the primary lens and double agency theory as a complementary perspective to analyze primary data. Social capital theory is central to understanding how trust, relationships, and shared goals between focal firms and Tier-1 suppliers facilitate the effective diffusion of DTI. Double agency theory adds depth by examining the delegation and monitoring mechanisms that shape Tier-1 suppliers' roles as both agents to focal firms and principals to Tier-2 suppliers within triadic structures. The primary level of analysis is triadic, focusing on the interactions among focal firms, Tier-1, and Tier-2 suppliers. The unit of analysis is the triadic relationship in MTSCs, capturing the interplay between social capital dimensions and agency mechanisms.

We have used the Gioia et al. (2013) approach to systematically develop the theory using the above-mentioned theoretical hierarchy. It has been extensively applied in studies of organizational change and identity. We extend this approach to examine triadic interactions in MTSCs. Firstly, interview data were analyzed to extract key informant-centric first-order constructs on how focal firms, Tier-1 suppliers, and Tier-2 suppliers interact in digital transformation efforts, including trust-building mechanisms, knowledge-sharing practices, and governance structures. Thereafter, these first-order codes are linked to well-established second-order themes mentioned in the literature, such as cognitive capital, relational capital, and the degree of agency role assumption. Finally, second-order codes are linked to an aggregate theoretical framework to illustrate how social capital enables or hinders the DAR of Tier-1 suppliers in facilitating DTI. A detailed description of interview coding is given in the next section. By leveraging the Gioia methodology, the current study ensures qualitative rigor and offers a new theoretical lens for understanding digital transformation governance beyond dyadic alliances.

3.4. Data analysis procedure

We employed an abductive approach to analyze data. Multiple iterations between data and theory have been conducted using Gioia et al. (2013) approach. Table 1 illustrates our deductive starting point, which comprises predefined deductive codes obtained from extant literature and theoretical framework. NVivo 14 was employed for comprehensive data analysis. The coding structure is illustrated in Fig. 1. We followed the case study research design adopted from Yin (2018) to raise academic rigor, and the four measures accommodated are shown in Table 3. Initially, researchers read the interview transcripts numerous times to detect preliminary themes, such as the interview statement, *"We prioritize cost efficiency and timeliness of delivery"* labelled as performance metrics. Then, open coding was conducted in NVivo. These codes were later classified into higher-order codes that aligned with theoretical dimensions such as relational and cognitive capital. For instance, "shared language and codes" and "mutual trust and respect" were combined in cognitive and relational capital, respectively. Themes such as "knowledge integration" and "joint development" were amalgamated within the coupling agency role.

NVivo's competencies are also supported by conducting comparative case analyses to identify variations across cases. For example, Case 1, driven by "performance metrics," indicated a decoupling of agency role. Meanwhile, Case 4 centred on "collaborative efforts in risk

Table 2
Details of case description and key informants.

Case No.	Industry	Digital transformation initiatives	Multi-tier level	Size and Location	Job title
Case 1	Services	Produce robotics kits	Focal Firm (FF1-1) Focal Firm (FF1-2)	Large (MNC), UK	Founder Head of Digital Transformation
			First Tier (FT1-1) First Tier (FT1-2)	Medium Enterprise, Vietnam	Operations Manager Sales Manager
			Second Tier (ST1-1) Second Tier (ST1-2)	Small Enterprise, Vietnam	Founder Operations Manager
Case 2	Retail	Blockchain-based, 3D design technology and Augmented reality adoption	Focal Firm (FF2-1) Focal Firm (FF2-2)	Large (MNC), USA	Operations Manager Digital Transformation Lead
			First Tier (FT2-1) First Tier (FT2-2)	Medium Enterprise, India	Director of Operations IT Director
			Second Tier (ST2-1) Second Tier (ST2-2)	Small Enterprise, India	Founder Production Manager
Case 3	Manufacturing	Digitized (including machine learning, RFID, IoT technology application) supplier assessments and audits	Focal Firm (FF3-1) Focal Firm (FF3-2)	Large (MNC), Germany	Vice-Presidents of the Engineering Department Chief Technology Officer
			First Tier (FT3-1) First Tier (FT3-2)	Medium Enterprise, Thailand	Director of Operations and Technology Engineering Manager
			Second Tier (ST3-1) Second Tier (ST3-2)	Small Enterprise, Thailand	Founder Operations Manager
Case 4	Retail	A bunch of cutting-edge technologies like IoT, Cloud computing, big data analytics, and blockchain	Focal Firm (FF4-1) Focal Firm (FF4-2)	Large (MNC), UK	Chief of Digital Transformation Officer Operations Director
			First Tier (FT4-1) First Tier (FT4-2)	Medium Enterprise, Indonesia	Chief of Digital Transformation Officer Sales Manager
			Second Tier (ST4-1) Second Tier (ST4-2)	Small Enterprise, Indonesia	Founder Operations Manager
Case 5	Manufacturing	Augmented reality and artificial intelligence in digital business operations	Focal Firm (FF5-1) Focal Firm (FF5-2)	Large (MNC), France	Senior Manager of Digital Transformation Operations Manager
			First Tier (FT5-1) First Tier (FT5-2)	Medium Enterprise, Bangladesh	Senior Manager of Digital Transformation Operations Manager
			Second Tier (ST5-1) Second Tier (ST5-2)	Small Enterprise, Bangladesh	Senior Manager of SC and Quality Assurance Operations Manager

management" denoted coupling behavior with high relational capital. NVivo's visualization toolkit facilitated the development of a relational vs cognitive capital matrix. It revealed how varying degrees of these aspects impacted the dissemination of DTI. The researcher iteratively linked themes derived from the data with corresponding theoretical constructs by abductive reasoning. For example, in Case 4, a high degree of cognitive capital reflected by "shared goals and vision" and relational capital represented by "trust and collaboration" were attributed to the comprehensive and effective diffusion of DTI. It resulted in the development of a Proposition, which postulates: *"High cognitive and relational capital between the focal firm and Tier-1 suppliers best enable Tier-1s to perform the DAR, ensuring effective DTI diffusion to Tier-2 suppliers."* This proposition was foundational in evidence provided from Case 4. NVivo's capability to contrast, envision, and organize data across cases resulted in theoretically sound and empirically grounded propositions. The iterative protocol of analysing and coding datasets, amalgamated with data triangulation and theoretical incorporation, yielded insightful findings into the contribution of social capital in the diffusion of DTI in the setting of MTSCs.

The data triangulation process played a critical role in our analysis,

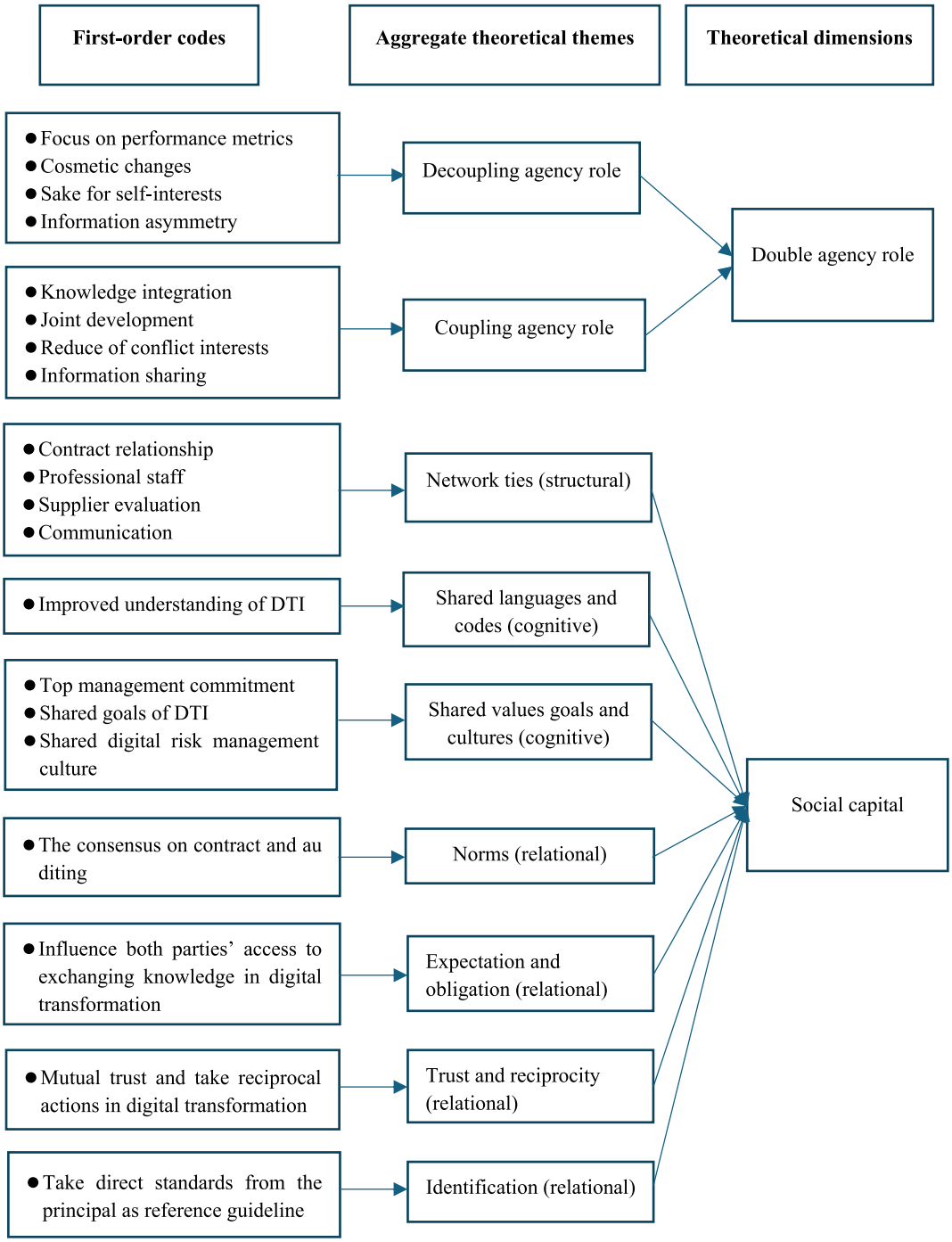

Fig. 1. Coding structure.

enabling us to identify both consistencies and contradictions across data sources. For example, in Case 2, Tier-1 managers reported active involvement in knowledge-sharing activities during interviews. It is corroborated by internal training manuals and policy documents. Similarly, in Case 4, strong cognitive and relational capital was supported by digital transformation roadmaps and performance reports. However, discrepancies were also observed. In Case 5, Tier-1 suppliers claimed to conduct frequent training sessions, but no supporting evidence was found in secondary data. Moreover, Tier-2 interviews described the training as sporadic and inadequate. Following best practices in qualitative research (Yin, 2018; Miles et al., 2014), we assigned greater interpretive weight to the secondary data and Tier-2 accounts, as they were more consistent and empirically verifiable. We also treated these contradictions as evidence of *decoupling agency behaviour*, where Tier-1 suppliers symbolically conform to expectations without fully implementing DTI in practice. Overall, triangulation enabled a more nuanced and credible understanding of the DAR of Tier-1 suppliers during the DTI process.

4. Findings

This section summarizes the DAR of Tier-1 suppliers and the social capital interactions between the focal firm and Tier-1 suppliers, illustrating how these factors influence the diffusion of DTI to Tier-2 suppliers. The interview data is collected and analyzed with a focus on the triadic relationships within MTSCs. The sample interview coding is

Table 3
Validity and reliability of research.

Criteria	Research Phase	Research Design	Case Selection	Data Collection	Data Analysis
Construct Validity	- Ensuring that the research precisely captures the intended theoretical construct.	- Gained access to numerous firms located within various tiers of the supply chain. - Developed a chain of evidence by aggregating data from several participants at different levels	N/A	- Employed multiple sources of data: semi-structured interviews, firm-specific documents, and secondary data from archives. - Attended various digital transformation events and training programs. - Employed triangulation of data to improve precision and coherence of findings	Conducted abductive analysis, iteratively improving themes derived from the empirical dataset. - Eliminated bias and reinforced the validity of findings by obtaining feedback from interviewees and critical discussion with the team of researchers.
Internal Validity	- Developing causal relationships and consistency amongst the dataset and theoretical constructs.	- Established a comprehensive framework based on reliable constructs obtained from social capital theory and agency theory.	N/A	- Conducted interviews of numerous participants with adequate experience in digital transformation. - Performed transcription and obtained validation of interviews by sharing transcripts with participants for approval.	- Developed theoretical coherence by moving back and forth between the dataset and extant literature to eliminate researcher bias. - Established propositions via a comprehensive chain of evidence.
External Validity	- Evaluating the generalizability of findings beyond studied cases.	- Selected firms proactively participated in digital transformation within supply chain. - Followed a multiple case study method for a wider perspective. - Applied protocol of literal and theoretical replication for selection of cases to capture varying contexts.	- Provided enhanced, comprehensive case data consisting of background information and situational to improve transferability.	- Maintained rich documentary evidence to reinforce analytic rigor. - Employed pattern matching to capture themes within difference cases to improve analytical generalization.	- Used pattern matching approach to develop theoretical generalizations associated with social capital and agency theory.
Reliability	- Ensuring coherence and repeatability of the research procedures.	- Established a comprehensive research protocol to retain consistency in the execution of research procedures. - Developed a dedicated case study repository to systematically store the collected datasets.	- Executed well-defined, reliable case selection protocol to achieve consistency across cases.	- Developed a standard interview protocol for all multi-tier participants. - Systematically recorded and saved all key documents and datasets.	- Performed iterative discussions with the research team to improve consistency in the interpretation of findings. - Employed NVivo software to perform efficient coding and analysis to improve accuracy, consistency and generalizability.

given in Appendix 2. The findings reveal the complex interdependencies and dynamics that shape digital transformation outcomes in multi-tier SCM. The findings are structured in the following parts: Coupling Agency role, Decoupling Agency role, Social Capital and Its Relevance to the DAR, Social capital within triadic relationships.

4.1. Double agency role

Building on the prior literature, particularly the work of Wilhelm et al. (2016), we distinguish the effectiveness of the double agency into two types: decoupling and coupling. All Tier-1 suppliers in our study assumed DAR, with their behaviors summarized in Table 4. To the best of our knowledge, these behaviors, including "*focus on performance metrics, knowledge integration, and joint development*," are presented for the first time in agency theory literature. Our findings reveal that Tier-1 suppliers assume DAR differently; some primarily focus on decoupling to protect their self-interests, resulting in information asymmetry between the focal firm and Tier-2 suppliers. Our analysis revealed that Tier-1 (T1) suppliers in all five cases play a DAR: they execute the focal firm's (FF) DTI along with diffusing knowledge to and supervising Tier-2 (T2) suppliers. However, the implementation of DAR behavior deviates significantly, owing to either coupling (proactively assisting T2) or decoupling (providing minimal support, usually characterized by shallow compliance) practices.

4.1.1. Decoupling agency role

All five Tier-1 suppliers responded reactively to DTI from their focal firm, focusing on audit compliance and performance metrics. However, Case 4 stood out for its strong collaboration and proactive learning, going beyond simple contract performance metrics to achieve strategic

Table 4
Double agency role assumed by each Tier-1 supplier.

Double agency role	References from prior literature (*indicates from our empirical evidence)	FT1	FT2	FT3	FT4	FT5
Decoupling agency role						
Focus on performance metrics	*	Y	Y	Y		Y
Cosmetic changes	Wilhelm et al. (2016)	Y		Y		
Sake for self-interest	Wilhelm et al. (2016)	Y				Y
Information asymmetry	(Miles, 2012; Wilhelm et al., 2016)	Y		Y		Y
Coupling agency role						
Knowledge integration	*		Y	Y	Y	Y
Joint development	*		Y		Y	
Reduce conflicts of interest	Wilhelm et al. (2016)		Y	Y	Y	
Information sharing	Wilhelm et al. (2016)		Y		Y	

alignment with the focal firm. This was confirmed by FF4-1: *"The way we work with our Tier-1 supplier goes beyond just signing contracts—it's more of a strategic partnership aimed at mutual benefits."* Activities such as training, digital workshops, and site visits were used to ensure compliance and performance. Most Tier-1 suppliers' role involves diffusing digital requirements to Tier-2 suppliers and monitoring implementation. FT1-1 mentioned: *"We rely on contracts to ensure clarity and accountability, and audits help maintain standards and transparency."* However, only FT1 and FT3 displayed behaviors associated with cosmetic changes, focusing on compliance and passing audits, only to revert to old practices afterward. These factors influenced some Tier-1 suppliers to perform only the decoupling, making superficial changes for compliance.

Regarding self-interest, empirical evidence from FT1 and FT5 shows that these Tier-1 suppliers prioritized self-interest before considering the value of diffusing DTI to their suppliers. FT1 noted: *"Sometimes, we need to invest more in training or new systems […], as certifications and tech upgrades require significant financial resources not always readily available."* Moreover, when Tier-1 suppliers diffuse DTI from the focal firm to Tier-2 suppliers, they may withhold information or actions, failing to disseminate the requirements fully. This behavior leads to information asymmetry, hindering the effectiveness of digital transformation implementation. FF1 confirmed: *"Right now, I believe the top-tier supplier (FT1) hasn't fully passed these actions down to the next-level suppliers (ST1)."* Additionally, some Tier-2 suppliers complained about the inadequacy of training provided by Tier-1 suppliers, describing it as theoretical rather than practical. ST5 stated: *"level of hands-on support has been limited […]; site visits and technical assistance from FT5 haven't been as frequent or in-depth to fully implement complex digital initiatives"* In the knowledge integration process, it was evident that FT1, FT3, and FT5 withheld information and actions, leading to information asymmetry between the focal firm and Tier-2 suppliers.

4.1.2. Coupling agency role

When T1 suppliers effectively implement DTI and pass it on to T2 suppliers, they usually engage in knowledge integration through training, workshops, support, and visits beyond audits. However, while most T1s (except FT1) participated in these activities, their impact on T2 implementation varied. For instance, FT2 actively set up a collaborative platform where they, their Tier-2 suppliers, and their representatives could regularly come together to share knowledge, tackle challenges, and develop solutions. One manager mentioned, "*We believe empowering our sub-suppliers strengthens the entire chain, so we regularly share updates and invite them to technology workshops*." However, others like FT3 and FT5 only organized workshops quarterly and did not consider further steps for collective knowledge sharing. ST4 recognized FT4's efforts to share digital knowledge: *"Our buyer (FT4) has provided us with comprehensive training programs, workshops, and hands-on sessions, which have helped bridge the digital skill gap."* Furthermore, FT2 and FT4 excelled in joint development, as highlighted by FT2-1: *"We're setting up a collaborative platform where we, our Tier-2 supplier, and their reps can […] share knowledge, tackle challenges, and co-develop solutions."*

In terms of reducing conflicts of interest, our empirical evidence shows that FT2, FT3, and FT4 drove the diffusion of DTI by aligning mutual interests. FT2-2 underscored this by stating, *"Profit impact and mutual interests […] drive us to implement digital initiatives with Tier-2 suppliers, which are critical to our success,"* For example, FT3-1 recognized the importance of digital transformation driven by mutual interests, and FT4-1 emphasized their engagement: *"We work closely with our Tier-2 suppliers to roll out digital transformation initiatives […], ensuring alignment with the focal firm's high standards and digital goals."* The information-sharing efforts of Tier-1 suppliers, particularly FT2 and FT4, were recognized by their Tier-2 suppliers. ST2-1 noted: *"Their (FT2) efforts in sharing learning resources and guidance have been particularly helpful, enabling us to enhance our operational capabilities and align with industry standards."* These statements highlight the importance of information sharing undertaken by Tier-1 suppliers in DTI.

4.2. Social capital and its relevance to the DAR

This section investigates the sector-based differences across cases 1 to 5 in the diffusion of DTI. Table 5 demonstrates that there are clear variations across sectors with respect to how relational and cognitive capital impacts Tier-1 suppliers' role and their contribution in diffusing DTI to downstream partners. To understand why some T1 suppliers adopt a coupling approach while others decouple. While all focal firms rely on contracts and basic supervision (structural capital), these mechanisms only sometimes influence whether T1 engages deeply or merely complies on the surface (Table 4). FF1-1 further elaborated on the structural capital aspect: *"We handle our Tier-1 suppliers mainly through direct meetings and phone calls, keeping emails to a minimum."* This shows that, beyond formal contracts, direct interactions are key to deeper engagement with their suppliers.

Relational capital influences whether T1 invests time and resources in supporting T2. In Case 2, the focal firm offers co-funding and specialized workshops to T1, fostering reciprocity that motivates T1 to extend similar resources to T2. As posited, "*We reward top-performing suppliers with training opportunities and long-term contracts*" (Case 2). This is also evident in training manuals and supplier evaluation reports of the focal firm and Tier-1 suppliers of Case Company 2. The joint structured training initiative by the focal firm and Tier-1 supplier mentioned in the report aligns with the interview response. FF4-1 emphasized the importance of relational capital: *"Our Tier-1 suppliers have stepped up in embracing digital transformation, showing they're committed to making real, meaningful changes, not just surface-level tweaks."*

Cognitive capital is important when T1 suppliers internalize and spread the focal firm's digital transformation goals. In Case 4, T1's top management fully embraces the focal firm's data-driven focus: "*Tier-1 supplier (FT4) is actively engaging in learning and exploration, with a clear commitment from top management to share knowledge and materials*" (Case 4). This shared terminology motivates T1 to embrace the focal firm's digital values into its workflows and consequently actively disseminate them to T2. FT4-2 reinforced this cognitive alignment: *"Our vision is to build a more agile, innovative, and efficient supply chain […] that ensures long-term success in a rapidly evolving market."* On the other hand, T1 in Case 1, although conscious of focal firms' DTI vision, does not completely adopt them, leading to limited or subpar communication with downstream: "*Right now, I believe the top-tier supplier (FT1) hasn't fully passed these actions down to the next-level suppliers (ST1)"* (Case 1).

Our study found that strong relational capital encourages T1 to actively support T2, beyond compliance. In contrast, Case 5 shows limited cooperation, with T1 resisting capital-sharing, meeting only basic requirements, and avoiding meaningful investment in T2 development. This is also evident in company reports, where structured training programs are missing, reflecting the Tier-1 suppliers' unwillingness to completely engage in capability-building initiatives for their sub-tier suppliers. FT5-1 highlighted the barriers to investment: *"Despite these challenges, we see them as opportunities […]—strengthening our ability to deliver cutting-edge products and services for our business and customers."* Trust and shared norms are driving factors that determine whether T1 just complies (decoupling) or envisions potential value in capability-building of T2 (coupling): *"However, there can be occasional conflicts of interest for them (FT5), primarily around cost-sharing for new technology implementation"* (Case 5).

4.3. Social capital within triadic relationships

Examining social capital between each focal firm–T1 pair reveals how structural, cognitive, and relational ties interact. In Case 2, strong collaboration and smooth information flow enable T1 to actively engage with its downstream suppliers. One of the managers remarked, *"a*

Table 5
Social capital presence in each case (FF-FT-1) dyadic relationship.

Social capital dimension	Reference from prior literature	Presence in our research (*indicate from our empirical evidence and first time present)	Case 1	Case 2	Case 3	Case 4	Case 5
Structural			M	H	L	H	H
Network ties	Network ties, network configuration, and appropriate organization (Nahapiet and Ghoshal, 1998); Information sharing, supplier evaluation and development (Krause et al., 2007); Small network size, geographical proximity among decision-makers, and low hierarchy (Polyviou et al., 2020); Contractual control and monitoring control (Zhu and Lai, 2019)	Contract relationship	Y	Y		Y	
		Professional staff		Y		Y	Y
		Supplier evaluation	Y	Y	Y	Y	Y
		Communication	Y	Y	Y	Y	Y
Cognitive			**L**	**H**	**L**	**H**	**H**
Shared languages and codes	Shared codes, languages, and shared narratives (Nahapiet and Ghoshal, 1998);	Improved understanding of DTI	Y	Y	Y	Y	Y
Shared values and goals	Languages and codes, narratives (Zhu and Lai, 2019); Goals and values (Krause et al., 2007); Long employee tenure (Polyviou et al., 2020); Degree of similar visions, ambitions, and values (Preston et al., 2017)	Top management commitment		Y		Y	Y
		Shared goals of DTI		Y		Y	Y
		Shared digital risk management culture (*)				Y	Y
Relational			**L**	**H**	**H**	**H**	**L**
Norms	Trust, norms, obligation, and identification (Nahapiet and Ghoshal, 1998);	The consensus of contract and auditing	Y	Y	Y	Y	Y
Expectation and obligation	Length of relationship, buyer dependency, supplier dependency (Krause et al., 2007); Relational closeness, commitment, and respect (Polyviou et al., 2020);	Influence both parties' access to exchanging knowledge in digital transformation (*)		Y	Y	Y	
Trust and reciprocity	Consensus on how to cooperate, mutual trust, and respect (Preston et al., 2017);	Mutual trust and take reciprocal actions under digital transformation		Y	Y	Y	
Identification	Reciprocity, cooperation, and interaction (Zhu and Lai, 2019)	Take direct standards from the principal as a reference guideline			Y	Y	

transparent, collaborative relationship with Tier-1 suppliers […] and follow the ACT Responsible Exit Policy when onboarding or phasing out suppliers to minimize negative impacts." This highlights strong relational and cognitive capital between the focal firm and the Tier-1 supplier. It helped them nurture training, exhibiting coupling behavior. Even in the early stages of adopting new technologies such as blockchain and 3D printing, T1's managers share the *"significance of mutual learning"* from the process of short pilot tests, suggesting that T1 perceives T2 as not just a subcontractor but a collaborative partner. In case 4, we have found strong cognitive and relational capital between the focal firm and T1, marked by regular digital knowledge sharing and a shared analytics-driven vision. It empowers T1 and strengthens support for T2. One key member of T1 from Case 4 remarked, *"We don't wait for T2 to reach out; we proactively check how their data integration is going and jump in with technical assistance if we see them struggling."* This shared belief of mutual commitment illustrates robust relational capital, where T1 visualizes its alliance with T2 in a wider, interlinked ecosystem.

Cases 1 and 5 show weak relational capital with T1 suppliers, causing doubts about ROI from investing in sub-tier suppliers. Their cognitive capital is also constrained as T1 managers exhibit less motivation to excel in the focal firm's digitally driven initiatives. Although the focal firm conducts audits to ensure compliance, these structural measures fail to overcome T1's reluctance to collaborate with T2. FT3-1 confirmed this trend: *"We participate in regular meetings, both face-to-face and electronic, held at least twice a year […] to discuss sustainability, resolve queries, and assess performance."* The resultant decoupling actions, involving cursory directions and delayed follow-up actions, strengthen T2's belief that they will not receive any support in adopting new technologies.

Case 3 presents a 'moderate' setup of cognitive and relational capital. Despite a long-term contract with moderate trust and partly aligned digital goals, collaboration between the focal firm and T1 is not deep enough to create robust coupling. One interviewee (FT3-2) noted, *"We are somewhat aligned with the focal firm's digital strategies […], but limited resources and lack of top-management push hinder consistent training for Tier-2 […]. Similarly, T2 recognized occasional support from T1 but felt it was inadequate for ongoing challenges: "We get support at the start, but after a few months, there isn't much follow-up."* These reflections revealed that partial coupling can happen when there is some extent of relational obligation and shared terminology, but inadequate resources or strategic inclination to develop stronger, ceaseless T2 collaboration.

Our data analysis reveals that trust, norms, collaboration, shared goals, vision, and mutual understanding significantly influence the diffusion of DTI. Fig. 2 presents a matrix illustrating the relationship between relational and cognitive capital and their combined impact on DTI diffusion. In suboptimal conditions where both forms of capital are low Tier-1 suppliers tend to exhibit decoupling behaviours, resulting in superficial compliance and fragmented implementation. When only one dimension is at a medium or high level, partial decoupling is observed. The optimal scenario arises when both relational and cognitive capital are high, enabling Tier-1 suppliers to fully assume their DAR and facilitate comprehensive DTI adoption across tiers. Effective diffusion requires the simultaneous development of both capital types. Trust and collaboration alone are insufficient without cognitive alignment, which may otherwise lead to resistance or superficial engagement. The proposed matrix offers a practical tool for managers to assess their current position, monitor progress, and design tailored interventions. It will help them to develop strategies such as targeted training and joint development strategies to build sustainable capabilities across all supply chain tiers.

5. Discussion

Our results indicate that the levels of relational and cognitive capital among the focal firm, Tier-1, and Tier-2 suppliers significantly impact the nature and effectiveness of the double agency function, as depicted in Table 6. We refined existing digital transformation research by emphasizing that digital transformation is not just about trust and engagement—cognitive alignment is essential for driving strategic change. Our findings advance both the theoretical and empirical understanding of social capital and agency theory within the context of DTI in MTSCs.

Previous research has indicated that strong structural ties enable suppliers to coordinate efforts and handle the complexity of MTSCs (Villena et al., 2011). This supports our findings that structural capital

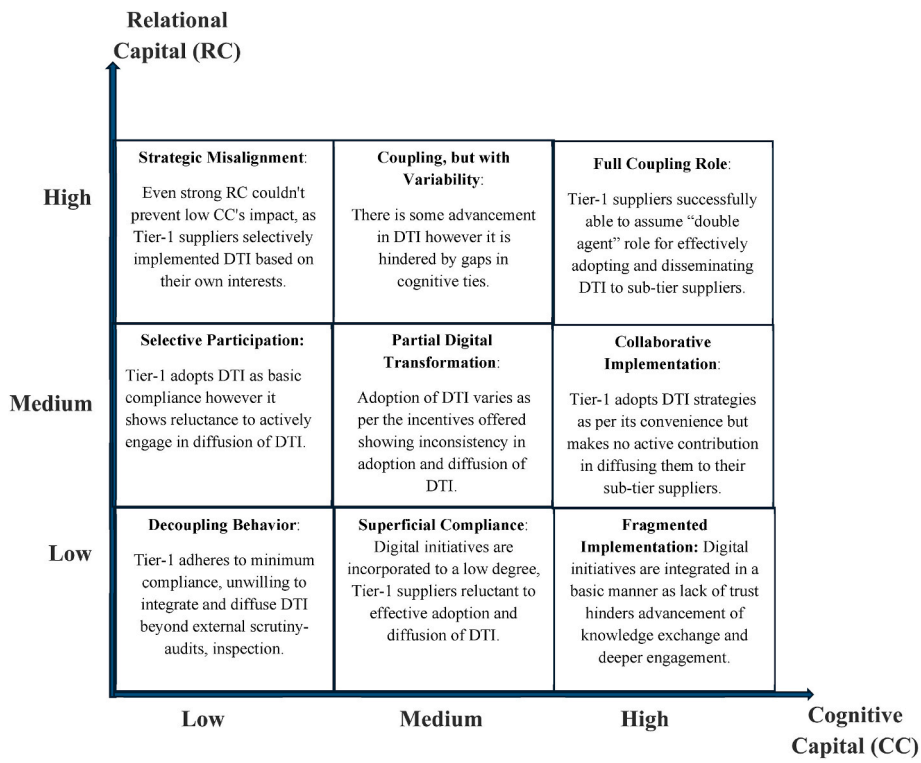

Fig. 2. The Matrix of Relational vs. Cognitive Capital vis-à-vis the Diffusion of Digital Transformation Initiatives.

Table 6
Summary of social capital and double agency behavior observed in data.

Case No.	Industry	Structural Capital (FF-T1)	Cognitive Capital (FF-T1)	Relational Capital (FF-T1)	Structural Capital (T1-T2)	Cognitive Capital (T1-T2)	Relational Capital (T1-T2)	Diffusion of Digital Transformation Initiatives	Transactional Compliance vs. Strategic Capability-Building	Tier-1 Supplier Coupling Role
Case 1	Services	Medium	Low	Low	Low	Low	Low	Fragmented	Transactional Compliance	Decoupling
Case 2	Retail	High	High	High	High	High	High	Comprehensive	Strategic Capability-Building	Robust Coupling
Case 3	Manufacturing	Low	Low	High	Low	Low	High	Selective	Transactional Compliance	Partial Coupling
Case 4	Retail	High	High	High	High	High	High	Comprehensive	Strategic Capability-Building	Robust Coupling
Case 5	Manufacturing	Medium	High	Low	Medium	High	Low	Partial	Mixed	Sporadic Coupling

forms the foundation for Tier-1 suppliers to act as double agents. This observation is further backed by Matinheikki et al. (2022) in their current research, emphasizing that, within the context of agency theory, information asymmetry can be diminished, and incentives between principals (focal firms) and agents (suppliers) can be clarified through well-defined structures. Aligning with the work of Wilhelm et al. (2016) and Jia et al. (2021), our results demonstrate that Tier-1 suppliers, embedded within the triadic relationship, are tasked by the focal firm to disseminate digital network ties to promote trust and transparency. Our findings also deviate from certain assumptions in traditional SCM literature, which often heavily emphasize relational and cognitive capital as primary drivers of collaboration. While relational and cognitive capital are undoubtedly significant, the complexity of DTI necessitates the foundational support of structural capital. This distinction highlights the unique demands of digital systems, where formalized processes and structured communication channels are crucial for coordinating complex multi-tier activities. The structural capital between the focal firm and Tier-1 suppliers allows for the assumption of DAR for Tier-1 suppliers, balancing their responsibilities to both the focal firm and Tier-2 suppliers. This dual alignment facilitates the successful implementation of digital transformation and underscores the pivotal role of structural capital as a foundational enabler in complex MTSCs. Based on these insights, we propose our first proposition.

Proposition 1. *The structural capital between the focal firm and Tier-1 suppliers provides a foundational enabler for Tier-1 suppliers to assume a double agency role in digital transformation initiatives.*

The interplay of cognitive and relational capital has been extensively discussed in prior research as crucial for fostering collaborative behaviors both within and across organizations (Galati, 2022). The observation that high cognitive capital alone is insufficient for effective collaboration aligns with findings in the literature. Cognitive capital provides a shared intellectual foundation for understanding objectives (Nahapiet and Ghoshal, 1998), but without relational capital, this knowledge often remains underutilized (Preston et al., 2017). This is consistent with the relational view (Moshtari, 2016), which emphasizes the importance of goodwill trust and collaborative norms in leveraging inter-organizational resources.

Dynamic capabilities theory (Teece et al., 1997) further highlights the limitations imposed by low relational capital. While cognitive capital equips organizations to sense opportunities, relational capital is essential for seizing and transforming these opportunities into actionable outcomes. In its absence, Tier-1 suppliers may struggle to effectively mobilize their technical knowledge, resulting in a fragmented diffusion of DTI. This fragmentation hinders the flow of innovation and knowledge to Tier-2 suppliers, undermining the overall effectiveness of the SC's digital transformation. Transaction cost economics further supports this perspective (Kanwal and Rajput, 2016), emphasizing that low relational capital heightens perceived risks and monitoring costs while discouraging cooperative behaviors. For instance, previous research in strategic alliances has demonstrated that even when partners share aligned goals, a lack of relational capital can lead to opportunism and disengagement (Villena et al., 2011). Similarly, in our study, Tier-1 suppliers' technical knowledge was underutilized due to a lack of trust and reciprocal incentives.

However, while past literature often examines the dyadic consequences of low relational capital, our study extends these insights by revealing how this dynamic affects downstream relationships. The fragmented diffusion observed among Tier-2 suppliers highlights a cascading effect, illustrating how relational gaps at one level propagate throughout the SC. This nuance may reflect the systemic interdependencies unique to digital transformation, where upstream trust deficits disrupt multi-tier collaboration. Both social exchange theory (Cropanzano et al., 2017) and stakeholder theory (Svensson et al., 2018) align with our findings, suggesting that addressing trust issues and involving suppliers as strategic stakeholders can help mitigate disengagement. Without meaningful engagement and reciprocal incentives, Tier-1 suppliers may feel excluded from the transformation process, further reinforcing their disengagement. Therefore, we propose the following.

Proposition 2. *When cognitive capital is high, but relational capital is low to medium between Tier-1 suppliers and focal firms, the lack of trust and reciprocal incentives results in decoupling behaviors of Tier-1 suppliers, and the diffusion of digital transformation will be fragmented as their technical knowledge remains underutilized.*

High relational capital fosters trust and cooperation, enabling SC stakeholders to engage in collaborative behaviors despite technical limitations (Alghababsheh and Gallear, 2021). This observation aligns with social capital theory (Coleman, 1988), which emphasizes the role of relational ties in facilitating resource exchange and mitigating conflicts. However, when cognitive capital is low or medium, these relational benefits are insufficient to drive innovation, leading to partial coupling behaviors focused on compliance (Wilhelm et al., 2016; Galati, 2022). Similar patterns have been observed in prior research on SC compliance, where trust-based relationships enable short-term coordination but struggle to address long-term strategic alignment (Villena et al., 2011). The reliance on relational capital in the absence of cognitive alignment is also reflected in contingency theory (Lawrence and Lorsch, 1967), which suggests that organizational effectiveness depends on the fit between internal capabilities and external demands. Furthermore, the importance of integrating and reconfiguring resources for new transformations has also been recognized in dynamic capabilities theory (Teece et al., 1997).

However, limited cognitive capital restricts the ability of businesses to contribute to these adaptive efforts, even when relational capital is high (Jia et al., 2021). The focus on meeting minimum standards rather than driving innovation leads to the incomplete diffusion of transformation initiatives. Our study revealed that Tier-1 suppliers lack the technical alignment needed to adapt to complex digital transformation requirements, resulting in sporadic coupling behaviors. This partial engagement mirrors findings in the strategic management literature, where reliance on relational ties often compensates for short-term gaps but limits long-term performance (Dyer and Hatch, 2006). Interestingly, cognitive load theory (Sweller, 1988) offers valuable insights by highlighting that businesses with low cognitive capital usually focus on compliance rather than innovation. The resource-based view (Hitt et al., 2016) and relational view (Dyer and Singh, 1998) emphasize that while strong relational ties lay the groundwork for collaboration, technical alignment is crucial to fully leverage these relationships. Our research shows that this misalignment often shifts the focus of DTI from innovation to compliance. Suppliers frequently adopt a "box-ticking" approach, meeting minimum requirements without engaging in the creative problem-solving necessary to advance transformation. The cognitive demands of digital transformation can overwhelm suppliers, prompting them to prioritize manageable, short-term tasks over innovative efforts. This shift away from innovation-focused objectives highlights the critical need to enhance cognitive capital through shared training programs and collaborative knowledge-building initiatives. Drawing on the above, we propose the following proposition.

Proposition 3. *When Tier-1 suppliers have high relational capital but low or medium cognitive capital with the focal firm, they rely on social ties to compensate for their technical limitations, resulting in partial or sporadic coupling behaviors. This will lead to the incomplete diffusion of digital transformation initiatives, often focused more on compliance rather than innovation.*

When both cognitive and relational capital are strong, Tier-1 suppliers achieve robust coupling, effectively aligning their efforts with the focal firm's strategic goals while facilitating downstream diffusion. This observation aligns with the relational view (Dyer and Singh, 1998), which emphasizes how strong inter-organizational relationships and shared knowledge form a foundation for collaboration and innovation (Preston et al., 2017). Previous studies in SC networks have similarly demonstrated that the combination of trust (relational capital) and shared understanding (cognitive capital) fosters joint problem-solving and co-development (Galati, 2022). Our research indicates that high cognitive capital ensures a shared understanding of digital transformation objectives, while high relational capital nurtures trust, reciprocity, and a commitment to shared goals. Together, these forms of capital enable Tier-1 suppliers to serve as double agents, bridging the strategic objectives of the focal firm with the operational realities of Tier-2 suppliers. Dynamic capabilities theory (Teece et al., 1997) further supports our findings by emphasizing the importance of resource reconfiguration in adapting to changing environments (Girod and Whittington, 2017). The alignment of cognitive and relational capital allows SC partners to sense opportunities, mobilize resources, and reconfigure processes to enable multi-tier transformation (Jia et al., 2021; Galati, 2022). This alignment fosters a culture of continuous improvement and innovation, promoting DTI comprehensively throughout the SC.

The relational view further bolsters this proposition, emphasizing that inter-organizational relationships and shared resources are crucial for creating competitive advantages (Dyer and Singh, 1998). By leveraging their relational and cognitive capital, companies can facilitate training, knowledge sharing, and innovation, effectively cascading DTI to all SC partners. This strong alignment ensures that the SC functions as a cohesive network, driving sustained transformation and long-term success. Our findings also resonate with systems theory (Von Bertalanffy, 1968), which suggests that interdependence and coordination among system components are vital for achieving holistic outcomes. In this context, our research reveals that Tier-1 suppliers function as integrators, ensuring that DTI cascades seamlessly throughout the SC. The strong alignment observed in our study highlights the potential for high cognitive and relational capital to drive systemic change, fostering innovation and adaptability across all tiers. Therefore, we propose the following proposition.

Proposition 4. *When cognitive capital and relational capital between Tier-1 suppliers and the focal firm are both high, Tier-1 suppliers will adopt robust*

coupling behaviors, effectively acting as double agents to enable comprehensive and successful multi-tier digital transformation through co-development, open data sharing, and continual training of Tier-2 suppliers.

Our study reveals that effective digital transformation requires rapid technological adaptation, continuous learning, and strong interdependence among SC actors. Its dynamic, non-linear nature requires deep trust, collaboration, and a shared understanding of digital goals and strategies both between the focal firm and Tier-1 suppliers and across upstream partners. This argument aligns with absorptive capacity theory, which highlights the importance of cognitive capital in acquiring, assimilating, and applying new knowledge. High cognitive capital among upstream SC partners enhances their absorptive capacity. It also allows them to grasp the value of emerging technologies and build capabilities to integrate and utilize these innovations effectively (Galati, 2022). Knowledge and technological inputs from downstream partners are critical in driving this process.

Complex Adaptive Systems Theory further supports this perspective by framing technology implementation as a dynamic, evolving process along the SC from downstream to upstream (Vachon and Klassen, 2006). Strategic capability-building, driven by downstream partners, is shaped by effective stakeholder relationships and knowledge exchange. Collaborative strategy helped them to mitigate resistance, foster innovation diffusion, and ensure cross-tier alignment (Nahapiet and Ghoshal, 1998; Galati, 2022). Institutional Theory also supports this argument by emphasizing that strong cognitive and relational capital support capability development. Institutional isomorphism—through coercive, mimetic, and normative pressures—encourages suppliers to adopt digital practices introduced by downstream partners (Lai et al., 2006). Shared norms and trust accelerate this process and help them to create a supportive ecosystem for broad technology adoption and transformation across the SC. Based on these insights, we propose the following.

Proposition 5. *When both cognitive capital and relational capital between Tier-1 and Tier-2 suppliers are high, Tier-1 suppliers will effectively assume a double agency role, facilitating the comprehensive diffusion of digital transformation initiatives to Tier-2 suppliers through knowledge sharing and collaborative implementation.*

Effective digital transformation requires digital capabilities and strategic alignment across all SC partners (Ciacci et al., 2024). The literature found that relational capital fosters trust and cognitive capital shapes deep collaboration among stakeholders (Preston et al., 2017; Alghababsheh and Gallear, 2021). Our study shows that limited shared understanding and moderate trust between Tier-1 and Tier-2 suppliers often reduce Tier-1's role in disseminating further. This is further supported by Transaction Cost Economics Theory (Williamson, 1981), which highlights that weaker commitments of lead firms limit their asset-specific investments and reduce uncertainty (Shi et al., 2018). Under these circumstances, inherent risks and coordination costs negate the potential for long-term positive returns, causing suppliers to concentrate on compliance in the short term rather than strategic transformation.

Furthermore, DTI is inherently costly, requiring ongoing technological advancements and employee upskilling, which further restricts suppliers' ability to establish stronger collaboration unless cognitive alignment is achieved. It is also noted that a high level of relational capital can result in reluctance to contribute to digital diffusion, as heightened trust and established procedures may reinforce reliance on familiar practices, thereby limiting adaptation to disruptive changes (Preston et al., 2017; Jia et al., 2021; Nahapiet and Ghoshal, 1998). Path Dependency Theory (Valorinta et al., 2011) describes how past choices create self-reinforcing cycles that impede deviations from established routines. Although strong alliances promote stability, they constrain adaptability by diminishing experimentation and the adoption of innovative strategies (Villena et al., 2011).

Sensemaking Theory (Weick, 1995) highlights these challenges, suggesting that if cognitive capital is low, organizations may struggle to recognize the strategic significance of new technologies or processes. Even with strong relational ties, limited cognitive capability can hinder their ability to navigate strategic innovation. As a result, they place more emphasis on operation-focused collaboration (Galati, 2022). Contingency Theory (Lawrence and Lorsch, 1967) further stresses that organizational effectiveness depends on aligning internal capabilities and external demands. In the complex digital ecosystem, the successful diffusion of digital transformation initiatives hinges on the presence of both cognitive and relational capital. In our study, we found that during the digital transformation process, strong relational capital alone facilitates only partial diffusion. Limited cognitive capital results in compliance-driven participation rather than collaboration to develop strategic competencies. These cognitive deficiencies must be addressed through knowledge dissemination strategies and collaborative innovation initiatives to fully leverage the benefits of DTI across various SC tiers. Based on these insights, we propose the following.

Proposition 6. *When relational capital between Tier-1 and Tier-2 suppliers is medium but cognitive capital is low, Tier-1 suppliers selectively engage with digital transformation initiatives, leading to partial diffusion characterized by transactional compliance rather than strategic capability-building. Conversely, when relational capital is high but cognitive capital remains low, digital transformation diffusion is further constrained, as Tier-1 suppliers prioritize maintaining established practices over enabling technological advancement at the Tier-2 level.*

6. Conclusion

Our study builds on previous research by explaining the DAR assumed by Tier-1 suppliers in implementing DTI based on focal firms' requirements for lower-tier suppliers and how social capital influences this double agency. This research makes several theoretical and practical contributions, as outlined below.

6.1. Research implications

Prior sustainability research has emphasized the intermediary role of Tier-1 suppliers in cascading mandates to sub-tier suppliers (Jia et al., 2019, 2021), focusing mainly on focal firm–Tier-1 relationships. However, neglecting Tier-1 to Tier-2 interactions offers a fragmented view of MTSCs. A holistic perspective (focal firm – Tier-1 supplier – Tier-2 supplier) is crucial to understanding how Tier-1 suppliers can either enable or hinder the diffusion of knowledge and capabilities. Existing frameworks also fall short in explaining the adoption of dynamic digital technologies across tiers and often rely on dyadic models focusing on individual governance mechanisms (Cao and Zhang, 2011; Nguyen and Zuidwijk, 2025). To address these gaps, we introduce a triadic governance model that captures the complexities of digital transformation in MTSCs. We define the *DAR* of Tier-1 suppliers and apply social capital theory to explain digital orchestration across tiers. This aligns with Burt's (2005) concept of structural holes, adapted for multi-tier digital SCs. Unlike previous studies that treat social capital and agency theory separately (Galati, 2022; Sternberg et al., 2023), our work reveals nuanced interactions between them. We show that social capital significantly supports Tier-1 suppliers in assuming the DAR, as illustrated in Fig. 3. Given the complexity of DTI, reliance extends beyond contracts to the accumulation of social capital. Our findings build on Son et al. (2021), showing that digital capability asymmetry not only increases inter-firm dependency but also reshapes agency behavior, particularly when focal firms are more digitally mature than their suppliers. Tier-1 suppliers are not passive implementers; they exercise strategic discretion, adopting either coupling or decoupling roles depending on their relational and cognitive capital. These insights advance understanding of social capital's role in double agency (Wilhelm et al., 2016).

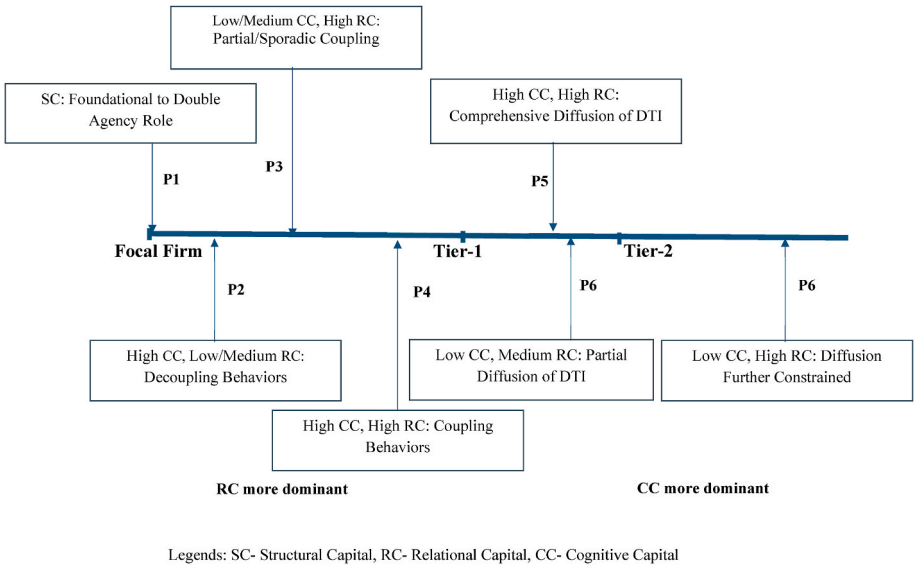

Fig. 3. Social Capital and its influence on degree of DTI diffusion.

Our findings show that the level of cognitive and relational capital between the focal firm and Tier-1 suppliers shapes how Tier-1s assume DAR in coupling and decoupling. Extending Yang et al. (2021), who emphasize relational ties in curbing supplier opportunism, we offer a more nuanced view by distinguishing the roles of cognitive and relational social capital. When both are strong, Tier-1s can effectively assume DAR. However, strong relational but weak cognitive capital may lead to path dependence, reinforcing established routines over innovation (Van Wijk et al., 2008). This challenges the assumption that relational capital always promotes innovation (Nahapiet and Ghoshal, 1998). Without sufficient cognitive capital, high relational capital can hinder technological diffusion. In such cases, Tier-1s selectively engage with DTI, leading to partial diffusion characterized by transactional compliance rather than strategic capability-building (Wilhelm et al., 2016). This finding refines digital transformation research by showing that trust and engagement alone are insufficient; cognitive alignment is also vital for strategic change.

In addition, we developed a matrix to illustrate the relationship between social capital, DAR, and DTI diffusion effectiveness. This extends prior research, which mainly explores social capital's role in boundary-spanning actions (Jia et al., 2021). We categorized Tier-1 suppliers into four intermediary roles based on engagement levels: collaborative orchestrators, reluctant intermediaries, passive transmitters, and transactional gatekeepers. The matrix offers a structured lens to explain why some Tier-1 suppliers actively supported focal firms' digital transformation, while others became bottlenecks. This builds on Noviaristanti et al. (2024) by conceptualizing intermediary roles using dual dimensions of social capital. It is the first framework to combine relational and cognitive capital diagnostically.

Our study also highlights the various ways Tier-1 suppliers assume DAR in DTI. Tier-1 suppliers may adopt either *coupling* (active integration of the focal firm's strategy with sub-suppliers) or *decoupling* (symbolic compliance without actual diffusion) roles when extending DTI to Tier-2 suppliers. This broadens current understanding by illustrating varied Tier-1 behaviors in DTI implementation. We find that beyond infrastructure and cultural factors (Adebanjo and Laosirihongthong, 2014), subjective intentions—such as self-interest—also shape technology adoption. These insights extend agency theory by incorporating self-interest as a driver of agency behavior (Eisenhardt, 1989a; Wilhelm et al., 2016). Moreover, we challenge the traditional linear view of digital implementation in supply chains, emphasizing instead the dynamic, cyclical nature of inter-tier relationships (Jamalnia et al., 2023). While focal firms typically initiate transformation, their success depends on Tier-1 suppliers' commitment and capability-building, shifting the narrative from a compliance-based top-down model to a collaborative, relational approach. To our knowledge, this is the first study to examine sector-specific variations in the digital transformation process (Scholten and Schilder, 2015). In highly regulated industries, Tier-1 suppliers prioritize compliance to align with focal firm expectations, while in service sectors, they focus on cost efficiency, scalability, and operational alignment. Overall, this study contributes to theory in several keyways.

First, prior research has largely examined social capital within Multi-Tier Supply Chains (MTSCs) in general terms (Jia et al., 2021), without critically exploring how its role and influence vary across tiers. Our study identifies a clear asymmetry in social capital's impact on DTI diffusion across the chain. Relational capital which is built on trust, shared norms, and collaboration is particularly vital in downstream dyads (focal firm to Tier-1 supplier), where it fosters technology adoption and mitigates opportunism. This aligns with existing literature on trust-based relationships supporting technology integration and alignment (Nahapiet and Ghoshal, 1998; Adler and Kwon, 2002; Taylor and Rosca, 2023). In contrast, upstream relationships (Tier-1 to Tier-2 suppliers) rely more on cognitive capital. Tier-1 suppliers, acting as intermediaries and knowledge brokers, help translate the focal firm's digital strategy into actionable steps. This is essential given the lower technological maturity of many Tier-2 suppliers, requiring shared knowledge, learning, and technical support. Our tier-contingent framework refines prior conceptualizations of social capital in inter-organizational settings (Adler and Kwon, 2002; Nahapiet and Ghoshal, 1998), offering clearer guidance for managing digital transformation in complex, multi-actor networks.

Second, our findings offer important contributions to the development of agency theory. We extend the classical dyadic agency model to a multi-tier context (Jensen and Meckling, 1976). This perspective oversimplifies governance in complex SCs. Yang et al. (2022) highlight the need to reframe classical agency problems in triadic structures, where multiple principals and agents interact across tiers. Our research demonstrated that Tier-1 suppliers often act as both agents (to the focal firm) and principals (to Tier-2 suppliers), creating layered accountability. It extends agency theory by incorporating digital mediation and triadic structures as key modifiers of agency behaviour in MTSCs. Our empirical data show that agency behavior is not solely driven by economic incentives, formal contracts, or self-interest, as highlighted in the classical agency literature (Eisenhardt, 1989a). Rather, we find that it is also mediated by relational and cognitive capital. The level of social capital influences whether firms adopt coupling (supportive) or

decoupling (minimalist) behaviors. Further, our findings also reveal that agency behavior varies across industries and technological contexts. This builds on Williamson's (1996) argument that transaction attributes significantly shape governance responses and is further supported by Schloetzer's (2012) findings on how process integration differs by sector. This variation in agency behavior also supports the argument that uniform agent behavior across sectors is unrealistic (Eisenhardt, 1989a). Finally, we propose a dynamic, socially embedded, relationship-oriented view of agency for digital SCs. Unlike static agency models, our findings suggest that agency roles evolve over time, influenced by trust, strategic alignment, mutual learning, and knowledge sharing (Ring and Van de Ven, 1994). This perspective enriches the understanding of how Tier-1 suppliers leverage digital transformation to enhance their market position while fulfilling the objectives of focal firms.

Third, we extend Paolucci et al. (2021) research by proposing a diagnostic matrix to divide Tier-1 intermediary behavior into four categories: collaborative orchestrators, reluctant intermediaries, passive transmitters, and transactional gatekeepers. To the best of our knowledge, for the first time in the literature, we have integrated both relational and cognitive dimensions of social capital to explain variance in digital transformation outcomes across SC actors.

Fourth, current literature usually describes governance mechanisms for managing information asymmetry only (Aben et al., 2021). We have extended this by demonstrating how agency roles dynamically evolve in triadic structures with socially embedded relationships, rather than only formal contracts. We have proposed a cyclical, evolving agency model in contrast to static views, where Tier-1 suppliers move from agents to principal roles to support the dynamic flow of digital initiatives upstream.

Finally, this study's important methodological innovation is its use of a cross-sectoral multiple-case design. This design allows us to uncover both commonalities and sector-specific distinctions in how DTI diffuses across MTSCs. This addresses a gap in the existing literature, which predominantly focuses on single-sector or dyadic designs.

6.2. Managerial implications

To effectively implement DTI, focal firms must prioritize cognitive and relational capital in their relationships with Tier-1 suppliers. These two dimensions of social capital strongly influence how Tier-1 suppliers assume DAR and derive economic value from DTI. For example, a high level of cognitive capital driven by shared transformation goals and top management commitment combined with relational capital grounded in clear expectations, trust, and reciprocity, enables Tier-1 suppliers to move beyond compliance. This supports effective DTI diffusion through aligned incentives and transparent information sharing. Focal firms should also cultivate a shared digital risk management culture and promote relational identification, encouraging Tier-1 suppliers to internalize the focal firm's mission and standards. This blend of cognitive and relational capital motivates a coupling DAR, leading to more effective DTI diffusion and clearer outcomes. Our findings highlight the tier-specific relevance of social capital. Downstream managers should strengthen relational capital between focal firms and Tier-1 suppliers by promoting trust, collaboration, and transparency to encourage digital investment and reduce opportunism. In contrast, upstream managers should enhance cognitive capital between Tier-1 and Tier-2 suppliers through training, knowledge-sharing, and technology transfer. A targeted approach, relational capital downstream, and cognitive capital upstream ensure successful digital adoption across supply chain tiers.

6.3. Limitations and future research

Our study utilized multiple case study methods to investigate the under-explored phenomenon in real-world business settings. We encourage future research to emphasize quantitative methods, using questionnaire surveys with large samples to test our propositions, and longitudinal case studies to evaluate the implementation effectiveness and performance of DTI in MTSCs over time. Secondly, the impact of firm size and firm location on DTI could be investigated in future research. We can also investigate how geographical proximity, access to technology and regional digital infrastructure impact digital transformation adaptation. Further, we can also examine organizational size, leadership and structure that could impact transformation outcome. Finally, further research could focus on the digital knowledge transfer and assimilation process from focal firms to suppliers, examined through various theoretical lenses to enhance theory.

CRediT authorship contribution statement

Zhi Zhang: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Nishikant Mishra:** Writing – review & editing, Validation, Supervision, Project administration, Methodology. **Nur Baiti Ingga Wulandhari:** Writing – review & editing, Writing – original draft, Conceptualization. **Ismail Gölgeci:** Writing – review & editing, Validation, Data curation. **Akshit Singh:** Writing – review & editing, Visualization, Formal analysis.

Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared of influence the work reported in this paper.

Acknowledgements

The first author gratefully acknowledged the PhD scholarship from University of Hull — China Scholarship Council scheme.

Appendices.

Appendix 1. Interview Protocol

For focal firms:

1. Please describe your company's main business, scale, position in the company, and how long you have been dealing with digital transformation.
2. How long has your company been working with each selected Tier-1 supplier?
3. How do you evaluate the relationship between your company and selected Tier-1 suppliers?
4. How do you deal with your Tier-1 suppliers, and how do you access your Tier-2 suppliers?
5. What kind of digital-related risks are there in your SC, and what are the impacts on SC operation? Please briefly explain the reasons for these risks.

6. Please describe your company's digital transformation initiatives for suppliers, what the goal of digital transformation is, and how you disseminate these initiatives to suppliers.
7. What are the barriers your company faces when proposing digital transformation initiatives, and how do you manage these barriers?
8. Please describe the actions used to help suppliers meet these digital initiatives.
9. How do digital transformation initiatives improve the relationship with suppliers, and what are the benefits of these initiatives?
10. Please describe the level of motivation of the selected Tier-1 suppliers to respond to the digital transformation initiatives and disseminate this to Tier-2 suppliers.
11. Please describe and evaluate the work the selected Tier-1 suppliers undertake in implementing the digital transformation initiatives and supporting Tier-2 suppliers.
12. How do you intend to address digital risks with suppliers? How do you reduce the agency problems with your Tier-1 suppliers?

For Tier-1 suppliers:

1 Please describe your company's main business, scale, position in the company, and how long you have been dealing with digital transformation.
2. How does your company do business with the focal firm? What metrics or indicators can be used to evaluate your performance?
3. How do you work with the focal firm?
4. What do you understand about the goal of digital transformation?
5. How would you describe your relationship with the focal firm and your dependence on them? Do these digital transformation initiatives influence the partnership with the focal firm?
6. What are the barriers to your company's implementation of digital transformation initiatives? What are the impacts on your operation? How do you solve them?
7. What strategies do you apply to build resilience against each of the barriers you mentioned?
8. How would you evaluate the actions provided by the focal firm to help you? How would you describe what you learned from digital transformation initiatives?
9. Who is responsible for interacting with the focal firm and Tier-2 supplier regarding digital transformation initiatives, and what role did they play in the process?
10. Do you have any work plans for the next step in responding to the digital transformation initiatives, and what additional support do you want to receive in the future?
11. How do you plan to further support or monitor the Tier-2 suppliers regarding implementing digital transformation initiatives?
12. What are the benefits of these digital transformation initiatives for your company?

For Tier-2 suppliers:

1. Please describe your company's business, scale, position in the company, and how long you have been dealing with digital transformation.
2. Please evaluate the actions from Tier-1 suppliers to help you regarding the implementation of the digital transformation initiatives. Furthermore, please describe your assimilation of the knowledge from digital transformation initiatives.
3. What do you understand about the goal of digital transformation? What are the benefits of the digital transformation initiatives for your operations and development?
4. How do you manage the digital risks in your company? How do you work with the Tier-1 suppliers?
5. Have you had any interactions with Tier-1 suppliers regarding digital transformation after daily operations?
6. How do you get these digital transformation initiatives? Do you have the ability to implement them?

Appendix 2

Summary of data quotes from empirical evidence

Aggregate theoretical themes	First-order codes	Data quotation from empirical evidence
Decoupling-based agency role	Focus on performance metrics	"We rely on contracts to ensure clarity and accountability, and audits help maintain standards and transparency." (FT1-1) "Our partnership with them is based on a set of key performance indicators (KPIs) that measure our performance in areas such as quality, delivery, sustainability, cost and pricing, and innovation and collaboration." (FT2-2) "Our performance is evaluated via clearly defined KPIs, and one of the key measures is how successfully we incorporate their digital platforms and initiatives" (FT3-1) "The focal firm keeps us on track through a mix of strategic alignment, regular check-ins, and performance metrics." (FT5-1)
	Cosmetic changes	"This dynamic tends to make our interactions more transactional and contract-based, focusing on fulfilling immediate needs rather than long-term collaboration … but they're not quite ready yet for certifications or investing in R&D for new technology integration in the making of kits." (FF1-1) "High initial costs for new technologies … strain our financial resources, slowing down our transformation process and potentially putting us at a competitive disadvantage. Additionally, the skill gap within our workforce … leads to underutilization of new technologies, increased errors, and reduced efficiency." (FT3-1) "We face challenges as a smaller player in the supply chain, resource constraints and the complexity of advanced technologies can sometimes hinder our ability to fully realize the advantages of digital transformation. To overcome this problem, we made small changes in our processes" (ST3-1)

(*continued on next page*)

Appendix 2 (*continued*)

Aggregate theoretical themes	First-order codes	Data quotation from empirical evidence
	Sake for self-interests	"Sometimes, we need to invest more in training or new systems to keep up, and acquiring certifications and upgrading to advanced technologies in the kits require significant financial resources that may not always be readily available." (FT1-1) "However, there can be occasional conflicts of interest for them (Tier-1 supplier), primarily around cost-sharing for new technology implementations." (FF5-1)
	Information asymmetry	"Right now, I believe, the top-tier suppliers haven't fully passed these actions down to the next-level suppliers, but we're discussing how to make that happen." (FF1-1) "We do find some of the information complex, especially when it comes to more advanced technologies … while the Tier-1 suppliers have tried to explain these concepts, translating them into practical applications for our rubber plantation operations isn't always straightforward" (ST3-2) "However, the level of hands-on support has been limited. While they've mentioned the possibility of technical support and site visits, these haven't been as frequent or in-depth as we might need to fully implement some of the more complex digital initiatives." (ST5-1)
Aggregate theoretical themes	**First-order codes**	**Data quotation from empirical evidence**
Coupling-based agency role	Knowledge integration	"We're setting up a collaborative platform where we, our Tier-2 supplier, and their representatives can regularly come together to share knowledge, tackle challenges, and develop solutions." (FT2-1) "They've (Tier-1 supplier) organized quarterly workshops where we can learn about digital tools and best practices. These sessions have been informative, helping us understand the broader picture of digital transformation in the supply chain." (ST3-1) "Our buyer (Tier-1 supplier) has provided us with comprehensive training programs, workshops, and hands-on sessions, which have helped bridge the digital skills gap." (ST4-1) "We primarily receive information about digital transformation initiatives through quarterly workshops organized by our Tier-1 suppliers." (ST5-2)
	Joint development	"This includes quarterly workshops highlighting successful digital implementations, a shared online resource center for training materials and best practices, and joint innovation projects with select suppliers to pilot new digital solutions." (FT2-1) "We're also prioritizing collaboration by working directly with suppliers to develop solutions that address their unique challenges." (FT4-1)
	Reduce conflicts of interest	"Mostly, profits impact and upholding mutual interests drive us to implement digital initiatives with Tier-2 suppliers. Our ability to implement digital initiatives with Tier-2 suppliers is critical to our success." (FT2-2) "When it comes to spreading digital initiatives to Tier-2 suppliers, we're driven by mutual interests and shared strategic goals." (FT3-2) "We work closely with our Tier-2 suppliers to roll out digital transformation initiatives, keeping mutual interests at the forefront, and aim to ensure everyone in our supply chain aligns with the focal firm's high standards and meets the required digital transformation goals." (FT4-1)
	Information sharing	"Their efforts in sharing learning resources and guidance have been particularly helpful, enabling us to enhance our operational capabilities and align with industry standards." (ST2-1) "They provide detailed instructions, samples, and templates that serve as valuable resources for our implementation efforts … and this support is invaluable, as it helps us navigate the intricacies of digital transformation and ensures that we can successfully implement these initiatives." (ST4-1)
Structural network ties	Contract relationship, Professional staff, Supplier evaluation, Communication	"We handle our Tier-1 suppliers mainly through direct meetings and phone calls, keeping emails to a minimum." (FF1-1) "I've been here for 8 years, and I've seen our company undergo significant digital transformation over the past 5 years." (FT2-2) "To evaluate our performance, we rely on outcome-based metrics like quality of our deliverables, on-time delivery rates, and overall cost efficiency." (FT1-1) "To keep getting orders, we maintain our A or A+ category status by sticking closely to their Supplier's Sustainable Policy and Green Procurement Policy." (FT3-2) "Our dealings with Tier-1 suppliers are very dynamic and open." (FF4-1) "As the chief digital transformation officer, I've driven our digital innovation for the last five years." (FT4-2) "We hold regular meetings quarterly and biannually to discuss ongoing projects, address any issues, and plan future collaborations." (FF5-1)
Cognitive shared values, goals, and visions cultures	Top management commitment	"As of now, we are not in touch with any external parties, but we get support from top management; their commitment to digital transformation is evident in the resources provided, including financial support, technical expertise, and ongoing guidance." (FT2-1) "Tier-1 suppliers are actively engaging in learning and exploration, with a clear commitment from top management to share knowledge and materials." (FF4-1) "Our management team supports us by encouraging innovation and providing resources when needed." (FT5-1)
Aggregate theoretical themes	**First-order codes**	**Data quotation from empirical evidence**
	Shared the goal of digital transformation initiatives	"I believe the goal for implementing these projects is to make a better product, make the supply chain efficient by implementing digital solutions that improve visibility, reduce complexity, increase collaboration with our suppliers and customers, get digitally capable, and attain profits." (FT2-1)

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Appendix 2 (*continued*)

Aggregate theoretical themes	First-order codes	Data quotation from empirical evidence
	Shared digital risk management culture	"Our vision is to create a more agile, innovative, and efficient supply chain that not only meets expectations but also positions us for long-term success in a rapidly evolving market." (FT4-2) "Yes, improving our digital capabilities and attaining business certifications can really streamline our operations, help to learn more about global standards and workings, and be ahead of the competition." (FT5-1) "We tackle digital risks with our suppliers by blending solid risk management strategies with a culture of collaboration and trust … we build strong, cooperative relationships with our Tier-1 suppliers that ensure our risk management efforts are both resilient and effective." (FF4-2) "Despite these challenges, we see them as opportunities to learn and grow. By overcoming these obstacles, we're better positioned to deliver cutting-edge products and services that benefit both our business and our customers." (FT5-2)
Relational norms	The consensus of contract and auditing	"Our current digital push is to encourage suppliers to get all necessary legal certifications." (FF1-1) "Their sourcing teams work closely with us to set targets, monitor progress, and identify areas for improvement." (FT2-1) "Meetings are crucial for discussing sustainability parameters, resolving queries, and assessing our performance. We also undergo regular audits conducted by the focal firm to ensure we meet their standards." (FT3-1) "Regular audits are also a big part of process—some of these are unscheduled visits, and we include document checks and worker interviews to ensure everyone is on the same page." (FF4-1) "Contracts are key in setting the terms of our relationships." (FF5-2)
Relational expectation and obligation	Influence both parties' access to exchanging and combining knowledge in digital transformation	"We have a super transparent and collaborative relationship with Tier-1 suppliers, they disclose details about these suppliers … when they onboard or phase out suppliers, they follow the ACT Responsible Exit Policy to minimize any negative impact. We reward top-performing suppliers with training opportunities and long-term contracts …" (FF2-1) "We have employed a robust data management system in place to collect data from its suppliers as part of its Business Responsibility and Sustainability Report (BRSR)" (FF3-2) "Our Tier-1 suppliers have stepped up in embracing digital transformation, showing they're committed to making real, meaningful changes, not just surface-level tweaks." (FF4-1)
Relational identification	Take direct standards or requirements from the principal as the reference guideline.	"As a Tier-1 supplier, extending digital transformation initiatives to our Tier-2 suppliers … is crucial for enhancing supply chain integration and sustainability … we plan to organize quarterly workshops for Tier-2 suppliers … we're implementing phased auditing requirements and offering dedicated technical support … we're launching a 'Digital Champions' program to empower and recognize individuals within Tier-2 suppliers who drive digital transformation within their organizations." (FT3-1) "Since we're not ready to design our standards yet, we'll rely on the focal firm's expertise to guide us." (FT4-2)

Data availability

Data will be made available on request.

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