ISSN Online: 3006-4708
ISSN Print: 3006-4694
SOCIAL SCIENCE REVIEW ARCHIVES
https://policyjournalofms.com

# Digital and Ambidextrous Capabilities in Project–Supply Chain Systems: The Mediating Roles of Information Processing and Decision-Making Speed

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**DOI: https://doi.org/10.70670/sra.v3i4.1461**

**Abstract**
Digital transformation has become a strategic imperative for organizations operating in project-based environments embedded within complex and uncertain supply chains. However, despite substantial investments in digital technologies, empirical findings on their performance implications remain inconsistent, suggesting that digitalization alone does not ensure superior outcomes. Prior research has largely examined digitalization and ambidexterity in project management (PM) and supply chain management (SCM) separately, while paying limited attention to the organizational mechanisms through which digital capabilities create value. Addressing these gaps, this study develops and empirically tests an integrated model explaining how digital and ambidextrous project–supply chain (PM–SCM) capabilities influence organizational performance through information processing capability and decision-making speed, under conditions of technological uncertainty and environmental turbulence.
Grounded in dynamic capabilities theory, information processing theory, and contingency theory, the study proposes a sequential mediation framework. Survey data were collected from 412 project managers, supply chain managers, and senior managers in project-intensive industries and analyzed using partial least squares structural equation modeling (PLS-SEM). The results show that digital project management capability, project data analytics capability, agile–hybrid project governance, supply chain digital intelligence, supply chain visibility maturity, and supply chain ambidexterity all have significant positive effects on information processing capability. Information processing capability, in turn, strongly enhances decision-making speed.
Decision-making speed significantly improves project performance, supply chain performance, operational performance, and competitive advantage, fully mediating the effects of information processing capability on these outcomes. Moderation analyses further indicate that these indirect relationships are stronger under high technological uncertainty and environmental turbulence. Overall, the findings demonstrate that digital transformation creates value not through technology adoption alone, but through enhanced information processing and faster decision-making in uncertain project–supply chain systems.

**Keywords:** Digital Transformation; Project Management; The Supply Chain Ambidexterity; Information Processing Capability; The Speed Of Decision-Making; Technological Uncertainty.

## Introduction:

Digital transformation is now one of the greatest and disruptive forces that define modern organizations. In the past ten years, the development of digital technologies, including big data analytics, cloud computing,

artificial intelligence, blockchain, and the Internet of Things (IoT), has completely changed how organizations design and organize processes and compete in the global market (Bharadwaj et al., 2013; Vial, 2019; Verhoef et al., 2021). Social Organization Digital transformation lies not in a strictly technological change but in profound change in an organization in terms of its structure, daily routine, decision-making systems, and governance (Warner and Wager, 2019; Hinings et al., 2018).

One of the most notable features of such change is the increasing dependency on projects as the main organizational instrument in which digital initiatives and strategic change are enacted. The implementations of digital platforms, enterprise systems, sustainability transitions, sustainability transitions, and innovation initiatives are nearly always structured as projects or project portfolios (Turner, 2014; Kerzner, 2019; Too, and Weaver, 2014). Projects allow organizations to assemble their resources, organize specialized skills, and address uncertainty within limited timeframe. That has led to project management (PM) ceasing to be a support activity to a strategically vital capability of organizational flexibility and renewal (Shenhar et al., 2001; Muller et al., 2019).

Simultaneously, these projects are not often implemented within the framework of one organization. Rather, they are also highly entrenched in complex supply chains comprising of suppliers, logistics, technology, and customers dispersed in geographic and institutional settings (Christopher and Peck, 2004; Flynn et al., 2010). Initiatives of digital transformation require hardware, software, data, and services to be delivered in a right time by various supply chain participants, with supply chain disruptions having a direct impact on project timelines, costs, and results (Ivanov and Dolgui, 2020; Queiroz et al., 2022). As a result, more and more modern organizations start collaborating within the frames of project-supply chain systems, in which the project execution and supply chain coordination are not independent managerial areas but are closely interdependent.

The dependence has escalated over the last few years courtesy to globalization, the reduction in product life cycles as well as increased environmental turbulence. Increasingly, supply chains are long, more fragmented and vulnerable to geopolitical risks, regulatory changes, and swings in demand (Wieland and Wallenburg, 2013; Scholten et al., 2019). At the same time, projects are being bigger, more complex and increasingly digitally intensive thus becoming more reliant on the quality, timely, and integrated information flows across organizational boundaries (Baccarini, 1996; Geraldi et al., 2011). These trends have revealed the weakness of the conventional project management and supply chain management strategies that are based on hierarchy of control, periodic reporting, and silo decision-making.

The wide promotion of digital technologies as a resolution to these problems is popular. Such project management information systems allow real-time monitoring of schedules, budgets, and risks and the digital supply chains offer end-to-end visibility of material flows and supplier performance (Barratt & Oke, 2007; Waller & Fawcett, 2013). Big data analytics and artificial intelligence have some predictive insights that enable organizations to look ahead to any disruption, make resource allocation more efficient, and react before any issue arises (Dubey et al., 2019; Ivanov, 2021). In this view, digital transformation will improve the project performance and the supply chain performance to be more transparent, coordinated, and responsive.

Nevertheless, despite the huge investments in digital technologies, there is mixed empirical evidence on their effects on performance. Many studies find that digitalization is positively related to operational outcomes, including efficiency, flexibility, and resilience (Dubey et al., 2019; Queiroz et al., 2020). Meanwhile, other researchers report weak, inconsistent, or context-specific effects, especially when digital initiatives are introduced without organizational changes (Vial, 2019; Verhoef et al., 2021). Practically, information overload, inappropriate interpretation, slow decision-making, and coordination are some of the frequent issues observed in the organizations despite the implementation of sophisticated digital systems (Muller et al., 2018; Ivanov and Dolgui, 2020).

Such conflicting results indicate that digital transformation does not necessarily translate into an excellent performance. Rather, digital technologies are valuable to the extent to which they are integrated into

organizational abilities and management. This observation fits into the accumulating body of literature that underlines that digital technologies are facilitating factors, but not direct sources of competitive advantage (Bharadwaj, 2000; Sambamurthy et al., 2003; Teece, 2018). The digitalization can add complexity to the results without positively effecting the results, unless the organization has the right capabilities to interpret, integrate and take action on digital information.

A rather powerful theory that can be used to interpret this phenomenon is dynamic capabilities theory. Organizational resources and technologies are not stationary according to this view, but capability to sense the environment, take opportunities and restructure resources according to uncertainty and turbulence is what provides the organizations with sustained competitive advantage (Teece et al., 1997; Teece, 2007). Digital technologies have the potential of improving sensing through augmentation of access to information, yet the role in seizing and reconfiguring is subject to organizational processes that facilitate interpretation, coordination, and timely decision-making (Pavlou and El Sawy, 2011; Warner and Wager, 2019).

Dynamic capabilities are especially relevant in project-supply chain systems. They are high-uncertainty, high-coupling and high-pressure systems in which delays or unsynchronized decisions spread quickly through interlocked activities (Eisenhardt, 1989; Ivanov, 2020). Digital tools can serve as the source of early warning signs, rich data, but as long as organizations are not in a position to process this information and transform it into quick coordinated response, the advantages of digitalization will not be achieved (Muller et al., 2018; Teece, 2018).

Although these insights exist, studies concerning digital transformation in project management and supply chain management have more of developed in parallel and not in an integrative way. The project management research has been historically devoted to the planning, control, government organization, and coordination of stakeholders in the singular projects (Turner, 2014; Muller and Lecoeuvre, 2014). In more recent times, PM scholars have been looking at agile approaches, hybrid forms of governance, and digital tools in the face of growing complexity and uncertainty (Highsmith, 2009; Conforto et al., 2016; Joslin and Muller, 2015). Although these studies consider external dependencies, supply chains are considered to be contextual constraints as opposed to being part and parcel of project implementation.

Conversely, inter-organizational alignment, information sharing, digital visibility, resilience, and ambidexterity across supply chains have been a focus area of supply chain management research (Kristal et al., 2010; Wieland and Wallenburg, 2013; Brandon-Jones et al., 2014). This literature values the role of digital intelligence and real-time information on dealing with uncertainty and disruptions but frequently ignores the project-based character of most supply chain projects, including digital platform deployments, network redesigns, and sustainability initiatives (Queiroz et al., 2022). This has led to projects being often conceptualized as episodic in lieu of central processes by which supply chains are changed and operated.

Such a division between PM and SCM studies constrains theoretical and practical application. To begin with, it clouds the effects of digital capability formulated in projects on the outcomes of supply chains, and the inverse. Second, it does not allow scholars to capture system-level dynamics and feedback between project implementation and the performance of the supply chain. Third, it constrains our knowledge of cross-organizational and inter-functional processes of shared decision-making. To overcome these drawbacks, there is a need to adopt a combined viewpoint that clearly connects digital and ambidextrous skills in PM and SCM spheres.

The second limitation that is critical in the current research is the negligence of the organizational mechanisms. Numerous studies record relationships between the aspects of digitalization and the results of performance but fail to clarify the development of these relationships in practice (Vial, 2019; Verhoef et al., 2021). Digital tools have commonly been considered to be black box and that there is limited analysis of the processing, interpretation and application of the digital information in the managerial decision making process. This gap is especially problematic in project-supply chain systems where decisions should be made quickly and in a group in an uncertain state of affairs.

The information processing theory can be used to fill the gap. This theory further states that organizations need to process information in order to minimize uncertainty as well as to co-ordinate interdependent tasks and that performance is enhanced when information processing capabilities are equivalent to information processing needs (Galbraith, 1973, 1977). Digital technologies are the primary disruptor of this balance as they raise the demand on the information processing and the availability of information. Uncertainty may be mitigated with the help of real-time data and analytics, but it also brings complexity by creating huge amounts of data that need to be interpreted and combined across organizational lines (Chen et al., 2012; Muller et al., 2018).

Due to the growing pace of digital transformation, the skills of the information processing, or the capacity of the organization to obtain, process, synthesize, and distribute information, are getting more and more important (Cao et al., 2015; Muller et al., 2018). Under project-supply chain systems, good information processing ability allows a situational awareness to be shared by project teams, supply chain partners and project decision-makers, which facilitates coordinated action and minimizes equivocality. In the absence of such capability, digitalization might contribute to the increase in information overload and slow decision-making, which impedes performance.

The information processing capability is closely related with the speed of decision making which is defined as the timeliness of decision making and implementing in the organization (Eisenhardt, 1989). Slow decisions are often more destructive than flawed decisions in high-speed and uncertain settings since lagging time gives problems a chance to grow by and opportunity to fade away (Eisenhardt and Martin, 2000). When accompanied by effective information processing and unified knowledge, digital technologies and agile governmental frameworks can speed up the decision-making process by mitigating the information latency effect and empowering the decentralized actors.

To conclude, although digital transformation can lead to project-supply chain systems performance improvement, current studies are still disjointed and poorly mechanized. The unified theoretical models explaining the impact of digital and ambidextrous capabilities of PM-SCM on the performance in terms of the internal organizational process, especially information processing and decision-making, are evidently required. This need is necessary to advance theory and offer practical advice to organizations that are going through the process of digital transformation in uncertainty.

Whilst digital transformation has heightened the interaction of projects and supply chains, it has also increased the tensions and trade-offs over which organizations have to deal. Among the most salient of these tensions is the need to have efficiency and adaptability at the same time. Project-supply chain systems should be able to provide consistent results in terms of cost, quality and schedule, and be adaptable enough to react to technological innovation, fluctuation in demand and unforeseen interruptions. The idea of organizational ambidexterity has been used extensively in the literature to conceptualize this duality (March, 1991; O'Reilly and Tushman, 2013).

Ambidexterity is the capacity of organizations to strike a balance between exploitation which is focused on efficiency, standardization, and control with exploration which is focused on innovation, experimentation, and adaptation (March, 1991). Within the scope of supply chains, the concept of ambidexterity was demonstrated to benefit the performance of firms by allowing them to stay stable in their daily operations and at the same time create new capabilities to address uncertainty and change (Kristal et al., 2010; Blome et al., 2014). Supply chain practices that are exploitative are aimed at cost reduction, process optimization, and reliability whereas the explorative practices are aimed at supplier innovation, flexibility, and responsiveness.

Ambidexterity in a project is a property that is represented by the presence of formal control measures, and adaptive, relaxed practices. Conventional project management focuses on elaborate planning, homogenous procedures, and hierarchical managers, which reinforce efficiency and predictability (Turner, 2014; Kerzner, 2019). Agile and hybrid project management systems, in their turn, support learning and adapting to uncertainty, which is facilitated by iterative planning, decentralized decision-making, and frequent

interactions with stakeholders (Highsmith, 2009; Conforto et al., 2016; Rigby et al., 2016). With projects growing more digitally intensive and deeply integrated into the supply chains that are volatile, balancing these conflicting logics becomes more crucial.

Online technologies are ironic to handle the ambidexterity. On the one hand, digital technologies allow standardization and automation and control, which reinforce exploitative practices. Conversely, they improve visibility, connectivity and data based experimentation, thus facilitating exploration and innovativeness (Sambamurthy et al., 2003; Bharadwaj et al., 2013). The fact that digital technologies are available, however, is not a solution to ambidexterity tensions. Rather, it tends to augment the amount and variety of information that organizations are required to handle and heightens cognitive and coordination requirements (Chen et al., 2012; Muller et al., 2018).

This observation highlights the significance of the information processing capability as the key mediator between digital and ambidextrous capabilities and performance. In information processing theory, organizations need to process information in order to minimize uncertainty and coordinate interdependent tasks and performance based on the capacity of information processing to meet information processing requirements (Galbraith, 1973, 1977). The interdependence of tasks, temporal dependence, and environmental volatility (Baccarini, 1996; Geraldi et al., 2011) also make the information processing requirements in project-supply chain systems quite high.

These requirements are changed by digital transformation in essence. Digital dashboards, real-time data streams and predictive analytics provide more information to managers and lead to higher levels of equivocality as they provide numerous, and occasionally competing signals (Chen et al., 2012). Consequently, it means that organizations should acquire the ability to collect data as well as process its meaning, distribute it over functional and organizational lines and disseminate it in a manner that facilitates coordinated action (Cao et al., 2015; Muller et al., 2018). In the absence of the same, digitalization will overwhelm decision-makers and slow responses, which negatively impacts performance.

An expanding literature shows the importance of information processing capability as a key mediator between performance outcomes and digital capabilities. Information systems and operations management research show that the ability to use analytics enhances the quality of decisions and organizational performance mainly due to the increased capacity of information interpretation and integration and not because of the immediate effect (Davenport and Harris, 2007; Cao et al, 2015; Muller et al, 2018). Nevertheless, in PM-SCM studies, information processing capacity has scarcely been studied in an explicit manner, and how it plays the role of bridging digital and ambidextrous capabilities across projects and supply chains is underdeveloped.

Closely connected to the information processing capability is the speed of decision making that is the important result of successful information processing. Depending on the swiftness with which organizations reach and execute decisions, the speed of decision-making is referred to (Eisenhardt, 1989). The price of slow decisions in fast moving circumstances can be high and this is because delays enable the issue to escalate and the opportunity to dissipate (Eisenhardt and Martin, 2000). Notably, studies have indicated that brilliant decisions are not always poor decisions when they are backed with rich information, common ground, and decentralization of power (Eisenhardt, 1989).

Speed in decision making is more consequential in project-supply chain systems. Project schedules are closely linked to activities of a supply chain, and procrastination in decision-making can be made in regards sourcing, design modification, risk mitigation, or reconfiguration, which can spread over interdependent tasks and partners (Ivanov and Dolgui, 2020). Digital technologies can also speed up the process of decision-making as it minimizes the information latency as well as making a coordination in real-time. Nevertheless, empirical data shows that the pace of the decision will not only be dependent on technology but also on organizational processes and governance models that allow making decisions promptly and taking necessary measures (Muller et al., 2018; Warner and Wager, 2019).

Although it is critical, the speed of decision-making has been given a lower priority in PM and SCM studies

as a mediating variable. Lots of researches concentrate on the results, including efficiency, flexibility, or resilience without making a direct analysis on the process of decisions and their implementation through time. This is a serious theoretical deficiency especially in the digital transformation whereby the rate at which the decision is made is likely more significant than the content of the decision.

The other most important dimension that influences the value of the digital and ambidextrous capabilities is the environmental context. According to the contingency theory, no organizational practice will always be effective and the performance implication of organizational practice is influenced by the context of a condition like uncertainty and turbulence (Lawrence and Lorsch, 1967). Technological uncertainty is due to swift shifts in technologies, standards and compatibility of systems whilst environmental turbulence is an indicator of volatility in markets, regulations and competition (Eisenhardt, 1989; Lengnick-Hall and Beck, 2005).

In the environment with a high level of technological uncertainty, organizations experience higher levels of ambiguity concerning the functionality, interoperability, and future role of the digital technologies. This puts extra strains on information processing and creates the chances of making decisions that are not well aligned (Pavlou and El Sawy, 2011). Equally, environmental turbulence reduces the duration of decision, as well as making delayed or unsuitable reaction expensive. The digital and ambidextrous capabilities of PM-SCM would be of special utility in such situations as they improve sensing, interpretation, and response. Marginal benefits of such capabilities, on the other hand, might be reduced in stable environments.

Though this reasoning has been clearly articulated in theory, research findings have not provided an explicit investigation on how uncertainty conditions mediate the processes by which digital capabilities affect performance in an integrated PM-SCM setting. Current studies tend to consider environmental uncertainty as a control variable as opposed to a key contingency that defines causal relations. To handle this gap, models that include moderation and moderated mediation effect are needed, thus taking into consideration not only whether digital capabilities are important, but also when (and why) they are important.

Collectively, the above discussion demonstrates that there are some significant gaps in the literature. To begin with, although there has been increasing appreciation of the interdependence between projects and supply chains, PM and SCM literature is still disjointed, which is constraining our knowledge on how systems operate. Second, the current findings on digital transformation tend to be implicit and devoid of the mechanism through which digital and ambidextrous capabilities can be transformed to performance outcomes. Third, the sequential mediation of information processing capability and decision-making speed are not well studied in the setting of PM-SCM. Fourth, little empirical research has been done on the contingency of such relationships due to technological uncertainty and environmental turbulence.

It is theoretically and practically significant to fill these gaps. Theoretically, there is a need to incorporate the learning of the dynamic capabilities theory, information processing theory, and contingency theory into a consistent set of knowledge that describes digital transformation in project-supply chain systems. The dynamic capabilities theory insists on the significance of sensing, seizing, and reconfiguring activities (Teece et al., 1997; Teece, 2007), information processing theory relies on the role of information interpretation and integration (Galbraith, 1973, 1977), and contingency theory underlines the role of the contextual fit (Lawrence and Lorsch, 1967). Each of these views can be developed further by an integrated framework that can illuminate the interrelationships and define the condition of the boundaries.

Practically, organizations are still grappling with trying to transform digital investments into practical performance improvements. Managers have a hard choice of where to invest in digital technologies, how to restructure governance systems, and how to build the organizational skills to enable quick and synchronized decision-making. The lack of theoretical direction would make the digital transformation initiatives an expensive experiment that may produce inconclusive results (Vial, 2019; Verhoff et al., 2021).

To address these issues, the current study formulates and empirically test an integrated conceptual framework as to how digital and ambidextrous project-supply chain capabilities impact on organizational performance via information processing capability and decision-making speed, when there is technological uncertainty and

environmental turbulence. The explicitly modeled sequential mediation and moderated mediation effects allow the study to offer a subtle account of why, when, and how the digital transformation generates value in project-supply chain systems.

In particular, the paper contributes four main things. First, it merges the research of project management and supply chains through the conceptualization of system-level antecedents of performance with digital and ambidextrous capabilities that are not domain-based practices. Second, it promotes the theory of dynamic capabilities by determining information processing capability and speed of decision making as the key microfoundations by which the digital transformation facilitates adaptive action. Third, it applies information processing theory to the digital enabled inter-organizational environment which is highly interdependent and uncertain. Fourth, it adds to the contingency theory by showing how the uncertainty of technology and turbulence of the environment influences the success of ambidextrous and digital capabilities.

Lastly, the paper gives evidence-based recommendations to the manager aiming at using digital technologies to enhance performance in uncertain conditions by empirically testing the proposed model with references to the information available in project-intensive organizations. This way, it answers the recurrent calls to research in addressing the disconnect between theory and practice in digital transformation, project management, and supply chain management research.

**Theory Development and Literature Review.**

The concept of digital transformation has been popularly understood as a multidimensional organizational phenomenon that can go beyond the use of digital technologies to include the ultimate changes in strategy, structure, processes, and capabilities (Bharadwaj et al., 2013; Vial, 2019; Verhoef et al., 2021). Very early studies tended to confuse digitalization with information technology (IT) investment or system adoption. Nevertheless, more current studies point to the fact that digital transformation is not a technological event but an organizational renewal process facilitated by digital technologies (Hinings et al., 2018; Warner and Wager, 2019).

In the strategic perspective, the digital transformation is being perceived in terms of capability development. As a proponent of the idea of IT and digital resources, Bharadwaj (2000) and Sambamurthy et al. (2003) claim that creating value requires embedding of information and communication technologies in the higher-order capabilities that facilitate sensing, coordination, and reconfiguration of the organization. On the same note, Vial (2019) reflexively initiates the concept of digital transformation as the ability of organizations to use digital technologies to alter value creation trajectories, which necessitates the complementary change of managerial cognition, governance, and routines.

The above view is a capability-based perspective that is especially applicable to organizations that are project-heavy, supply-chain-intensive. Information availability can be increased with digital tools (analytics platforms, real-time dashboard, and collaborative systems), though this does not necessarily lead to better performance. Rather, they generate the possibility of better decision-making and coordination that should be achieved through organizational capabilities (Muller et al., 2018; Teece, 2018). Therefore, the research on digital transformation has been moving beyond questioning the importance of digital technologies and towards exploring how and in what circumstances they generate value.

Traditionally, project management has placed a strong focus on the planning, control, and coordination mechanisms that are meant to minimize uncertainty and deliver predictable outcomes (Turner, 2014; Kerzner, 2019). In the recent past, however, the increased complexity of projects, the dispersion of stakeholders, and volatile environmental factors have led to the inefficiency of the conventional methods (Baccarini, 1996; Geraldi et al., 2011). Responding to that, PM research has been more and more investigating the purpose of digital technologies and agile practices in improving the adaptability and responsiveness.

Digital project management capability is defined as the capability of the organization to use digital tools and systems to enable real-time support of the project planning, execution, monitoring, and governance (Joslin

and Muller, 2015; Whyte et al., 2016). This is an integrated project management information system, collaborative platforms, digital dashboards, and analytics programs that allow a constant overview of project status, risks, and resources usage (Muller et al., 2018).

According to the empirical findings, digital project management capabilities enhance coordination, transparency and control, especially when the project is complex and distributed (Whyte et al., 2016; Muller et al., 2019). Nevertheless, their direct influence on the success of projects is rather ambiguous. Serrador and Turner (2015) discover that the benefits of efficiency do not necessarily extend into the measures of project success on a greater scale, which implies that digitalization might enhance one or more aspects of performance without impacting others.

Such discrepancy indicates the significance of auxiliary organizational factors. The suggested mechanisms to help organizations take advantage of the flexibility provided by the digital tools and appropriate controls are agile and hybrid project governance models (Highsmith, 2009; Conforto et al., 2016; Joslin and Muller, 2015). Agile governance focuses on a focus on iteration and decentralized decision-making, frequent interactions with stakeholders, which is quite consistent with the information flows in real time that are facilitated by digital technologies (Rigby et al., 2016). Hybrid models combine agile practices with traditional controls, making them particularly suitable for large-scale projects embedded within supply chains.

The use of information sharing and coordination in managing inter-organizational dependencies is not new in supply chain management research (Flynn et al., 2010; Fawcett et al., 2011). The information flows achieved by digital transformation have dramatically broadened the volume and intensity of these flows and have made them visible in real-time, predictive analytics, and automated decision support throughout networks of supply (Waller and Fawcett, 2013; Dubey et al., 2019).

The supply chain digital intelligence can be defined as the ability to sense, interpret, and respond to supply chain signals with the help of digital technologies (Sambamurthy et al., 2003; Ivanov and Dolgui, 2020). It is capable of data integration across partners, forecasting, which is driven by analytics, and digital twins or simulation models to predict disruptions (Ivanov, 2021). According to the empirical studies, digital intelligence increases the responsiveness, resilience, and performance of supply chains especially in the uncertain condition (Dubey et al., 2019; Queiroz et al., 2020).

A closely related concept is supply chain visibility, which is described as the degree of accessibility to timely, accurate, and relevant information by the actors of the supply chain on the flows of materials, inventory levels, and partner operations (Barratt and Oke, 2007; Caridi et al., 2010). Visibility has the effect of minimizing information asymmetry and responding more quickly to disruptions. Nonetheless, researchers warn that visibility is not a sufficient condition to enhance performance. Too much or unorganized information may saturate decision-makers and cause a delay or inefficient responses (Galbraith, 1973; Brandon-Jones et al., 2014).

These results resonate with those of PM research, which focuses on the idea that digital transformation is a source of value indirectly created by organizational processes, rather than technology adoption.

The most important issue with project-supply chain systems is that they must balance conflicting requirements between efficiency and adaptability. This has been broadly discussed by the notion of organizational ambidexterity that implies the capability to follow both exploitation and exploration (March, 1991; O'Reilly and Tushman, 2013).

The concept of ambidexterity has been demonstrated to increase performance in the setting of supply chains through the ability of firms to be cost efficient and reliable, as well as creating the flexibility necessary to adapt to a changing environment (Kristal et al., 2010; Blome et al., 2014). Exploitative practices have a focus on standardization processes, control of costs, and reliability whereas the explorative practices focus on supplier innovation, experiments, and flexibility. The coordination and information processing requirements are great when dealing with these competing logics.

Ambidexterity in project contexts occurs in the co-existence of formal controls and the adaptive practices.

The traditional project management methods favor the exploitation with the help of standardized planning and control, whereas agile methods do favor exploration with the help of iterative learning and decentralized decision-making (Highsmith, 2009; Conforto et al., 2016). One way the tension has led to hybrid project governance models is in complex projects implicated in supply chains (Joslin & Muller, 2015).

Digital technologies facilitate and make ambidexterity difficult. On the one hand, they promote standardization and automation, attend to exploitation practices. Conversely, they facilitate experimentation, feedback and cross-boundary cooperation, as well as exploration (Sambamurthy et al., 2003; Bharadwaj et al., 2013). To cope with such duality successfully, there is a necessity of good information processing ability in order to combine different streams of information and solve conflicting priorities.

The information processing theory offers a theoretical background of how organizations deal with uncertainty and interdependence (Galbraith, 1973, 1977). This theory holds that organizations need to process information to ensure that tasks are coordinated and uncertainty minimized and that performance is determined by the correspondence between information processing needs and information processing capacity.

The interdependence of tasks, temporal association, and volatility of the environment are additional features that put project-supply chain systems under more intensive demands in information processing (Baccarini, 1996; Geraldi et al., 2011). Digital transformation enhances the access to information as well as complexity of information processing. Although digital technologies are lessening the latency of information, they are also enhancing equivocality as they produce big numbers of heterogeneous information (Chen et al., 2012).

Consequently, the capability of information processing has become an important organizational capability in the digital setting, i.e., the process of acquiring, interpreting, integrating, and sharing information (Cao et al., 2015; Muller et al., 2018). Effective information processing will empower organizations to convert data into common information, match meanings among actors, and coordinate action within projects and supply chains.

Empirical evidence indicates that the effectiveness of the decision and the performance of an organization is enhanced by the capabilities of analytics and information processing under the influence of the effect on interpretation and coordination but not by direct influence (Cao et al., 2015; Muller et al., 2018). Nevertheless, there is a lack of studies by PM-SCM research that specifically studied the information processing capability, which is a considerable gap in theory.

Decision-making speed is a speed at which organisations make and execute decisions (Eisenhardt, 1989). The fast speed of decision-making is a vital performance criterion in uncertain and high-velocity environments because slowing down can result in the cascade of failures and lost opportunities (Eisenhardt and Martin, 2000).

The strategic management research indicates that high quality decisions may not necessarily be inferior provided that rich information is used, along with a common level of understanding and a decentralized authority (Eisenhardt, 1989). The digital technologies and agile governance can make decision-making processes quicker because they will decrease the information latency and will enable the local actors. Nonetheless, it is not technology but organizational processes that allow fast interpretation and coordination that drive decision speed (Muller et al., 2018; Warner and Wager, 2019).

Project-supply chain systems are also characterized by consequential decision-making speed because they are tightly coupled (the project activities and supply chain flows). Although decision-making speed is an important construct, it has hardly been explicitly modeled as a performance driver involving digital and ambidextrous capabilities in PM-SCM research. To fill this gap, it is critical to note that digital transformation is converted into adaptive action.

According to the dynamic capabilities theory, microfoundations are crucial: certain processes and routines that allow sensing, seizing, and reconfiguring activities (Teece, 2007; Pavlou and El Sawy, 2011). Such microfoundations in digital project-supply chain systems are conceptualized as information processing capability and decision-making speed. Digital and ambidextrous PM-SCM functions helps in sensing through the provision of more information, information processing capability helps in interpretation and integration,

and the speed of decision making helps in seizing and reconfiguration.
The combination of dynamic capabilities theory with information processing theory has a strong theoretical base to explain the outcomes of digital transformation. It explains how digital technologies contribute to value indirectly by the organization processes and emphasizes the significance of context in the development of such relationships.
The literature reviewed above suggests that digital and ambidextrous capabilities in project and supply chain management enhance performance indirectly through information processing capability and decision-making speed. Moreover, these relationships are likely to be contingent on environmental conditions such as technological uncertainty and turbulence. These insights inform the development of the conceptual model and hypotheses presented in the next section.

**Hypotheses and Development of Conceptual Model.**
Based on the above literature review and theory, this research constructs an amalgamated conceptual framework that elucidates the impacts of digital and ambidextrous characteristics of project-supply chain (PM-SCM) capabilities on the performance of organizations by forming a quicker processing capability of information and making a decision in a technological uncertain and turbulent environment. The model is based on the dynamic capabilities theory (Teece et al., 1997; Teece, 2007), information processing theory (Galbraith, 1973, 1977), and contingency theory (Lawrence and Lorsch, 1967).
The major assumption behind the model is that digital transformation is value-creating indirectly. Digital and ambidextrous capabilities improve the sensing and gathering of information in the organization in multiple projects and supply chains, yet performance benefits come only after this information is converted into timely decisions. Information processing capability is thus placed as a primary mediating processes with decision-making speed becoming a secondary, sequential mediator that converts the processed information into adaptive action. Contextual moderators of the strength of these relationships are technological uncertainty and environmental turbulence.
The model consists of four types of constructs:

- Premeditative digital and ambidextrous PM-SCM functions.
- Moderating mechanisms in the organization.
- Performance outcomes
- Contextual moderators

All the sets of relationships are elaborated below.

**Digital Project Management Capabilities and Information Processing.**
Digital project management capability is defined as the capability of the organization to implement and combine the use of digital tools, including project management information systems, real-time dashboards, collaborative systems, and analytics, to aid projects in planning, execution, monitoring, and governance (Joslin and Muller, 2015; Whyte et al., 2016; Muller et al., 2018). These tools enhance the availability of information and the timeliness of information regarding the projects, and it allows timely visibility to scheduling, project cost, project risks and the consumption of resources.
In terms of information processing, project management ability in the digital world can increase information acquisition and dissemination by minimizing information latency and increasing transparency (Galbraith, 1977). Nevertheless, digital information availability is not enough; the organizations should also analyze and combine the information in functions and stakeholders to facilitate coordinated action (Chen et al., 2012).
Empirical research indicates that the use of digital project tools can lead to better coordination and control on a project through the improvement in information flows, as opposed to improved outcomes (Whyte et al., 2016; Muller et al., 2019). In line with this, the ability of digital project management is likely to enhance the

information processing ability of the organization because it will offer more comprehensive and timely information that can be analyzed and absorbed across project-supply chain interfaces.

**Hypothesis 1**

**H1:** The information processing capability is positively correlated with the digital project management capability.

**Project Data Analytics Capability.**

The capability of project data analytics indicates how the organization can examine project-related data through sophisticated methods of analysis to generate insights that can be used to make decisions (Davenport and Harris, 2007; Cao et al., 2015). The analytics capability goes beyond the gathering of data to encompass patterns recognition and forecasting.

Dynamically speaking, the analytics capability is a way of improving sensing by helping organizations to detect emerging problems and opportunities before their rivals (Teece, 2007; Pavlou and El Sawy, 2011). As an informational processing concept, analytics potential will reduce equivocality by converting raw data into actionable knowledge (Chen et al., 2012).

It is always observed in research that the capabilities of analytics positively influence the performance of the organization indirectly due to the improved quality of information processing and decision-making and not directly (Cao et al., 2015; Muller et al., 2018). The analytics capability in project-supply chain systems is thus likely to complement the information processing capability by allowing a deeper interpretation and integration of the digital information.

**Hypothesis 2**

**H2:** Information processing capability has a positive relationship with the problem of project data analytics.

**Agile-Hybrid Project Governance.**

Agile-hybrid project governance denotes governance models, which are characterized by official controls and agile approaches including iterative planning, decentralized decision-making, and frequent engagement with stakeholders (Joslin and Muller, 2015; Conforto et al., 2016). These forms of governance are more popular in uncertain and digitally intensive project environments.

The information processing viewpoint implies that the governance systems influence the process of information interpretation and action (Galbraith, 1973). Agile-hybrid governance minimizes the level of hierarchical control; it promotes horizontal communication hence information integration among project and supply chain players (Rigby et al., 2016).

According to the empirical studies, agile and hybrid types of governance are more responsive and adaptable because they allow quicker interpretation and sharing of information (Conforto et al., 2016). In line with this, information processing capacity on project-supply chain systems is likely to be enhanced by agile-hybrid governance.

**Hypothesis 3**

**H3:** The information processing capability is positively correlated with the agile-hybrid project governance.

**Supply Chain Digital and Ambidextrous Capabilities and Information Processing.**

Supply chain digital intelligence is the possibility to sense, interpret and react to the supply chain signals through digital technologies like analytics platforms, Internet of Things (IoT) sensors, and digital twins (Waller and Fawcett, 2013; Dubey et al., 2019; Ivanov, 2021).

Digital intelligence increases the acquisition of information within the supply networks, but its usefulness is determined by the capacity of the organization to integrate and analyze the information of various sources (Galbraith, 1977). As empirical research indicates, the positive impact of digital intelligence on supply chain performance is mostly connected with the improvement of the process of information processing and

coordination (Dubey et al., 2019).

**Hypothesis 4**

**H4:** The positive relationship exists between supply chain digital intelligence and information processing capability.

**Visibility Maturity Supply Chain Supply Chain Visibility.**

The maturity of supply chain visibility is a measure of how well the organizations have acquired systematic abilities to exchange timely, accurate and relevant information amongst the supply chain partners (Barratt and Oke, 2007; Caridi et al., 2010).

Though visibility enhances availability of information, it also enhances information processing requirements. The visibility maturity of organizations is more capable of structuring, interpreting, as well as integrating information, thus enhancing the information processing ability (Brandon-Jones et al., 2014).

**Hypothesis 5**

**H5:** Maturity of supply chain visibility is ensured to be positively correlated with information processing capability.

**Supply Chain Ambidexterity**

Supply chain ambidexterity can be defined as the possibility to balance exploitation practices that deal with efficiency and reliability and discovery practices that deal with flexibility and innovation (Kristal et al., 2010; Blome et al., 2014).

Ambidexterity management creates the different and potentially competing streams of information in regard to cost control, innovation and responsiveness (March, 1991). The ability of organizations to combine these streams is enhanced by the strength of ambidextrous capabilities of organizations hence increasing the information processing power.

**Hypothesis 6**

**H6:** Supply chain ambidexterity is positively related to information processing capability.

**Information Processing Power and Decision-Making Speed.**

Information processing capability makes organizations convert the digital data into shared meaning and action (Galbraith, 1977; Muller et al., 2018). Decision-making speed is one of the most important consequences of the efficient information processing.

The speed of decision making represents the speed at which the organizations take and execute their decisions (Eisenhardt, 1989). The well-integrated information, which is rich makes equivocality low and allows reaching a consensus more quickly which facilitates rapid action without compromising on the quality of the decision (Eisenhardt and Martin, 2000).

**Hypothesis 7**

**H7:** The speed of decision-making has a positive correlation with information processing capability.

Speed and Performance Results in the Decision-Making Process.

Fast decision-making is essential in project-supply chain system to deal with interdependence and uncertainty. The speed of decision-making minimizes cascades of delays and allows responding to disruptions on time (Ivanov & Dolgui, 2020).

It has been demonstrated in the literature that the speed of decision-making improves several aspects of performance such as the efficiency of operations, responsiveness, and competitive advantage (Eisenhardt, 1989; Pavlou and El Sawy, 2011).

This paper discusses four performance outcomes that include projects performance, supply chain performance, operational performance and competitive advantage.

**Hypothesis 8a**

**H8a:** The speed of decision-making is linked to performance of a project in a positive way.

**Hypothesis 8b**
**H8b:** Speed in decision-making is associated positively with the supply chain performance.

**Hypothesis 8c**
**H8c:** The speed of decision-making is associated with operational performance in a positive way.

**Hypothesis 8d**
**H8d:** Competitive advantage is positively related to the speed of decision making.
The sequential mediation effects involve 3.6.
This research is based on the concept of a sequential mediation hypothesis, which is grounded on dynamic capabilities theory. Ambidextrous and digital PM-SCM capabilities increase the rate of information processing, thereby increasing the speed of decision-making that eventually results in better performance.
Sequential mediation is an expression of the way in which sensing and interpretation functions are converted to adaptive action (Teece, 2007).

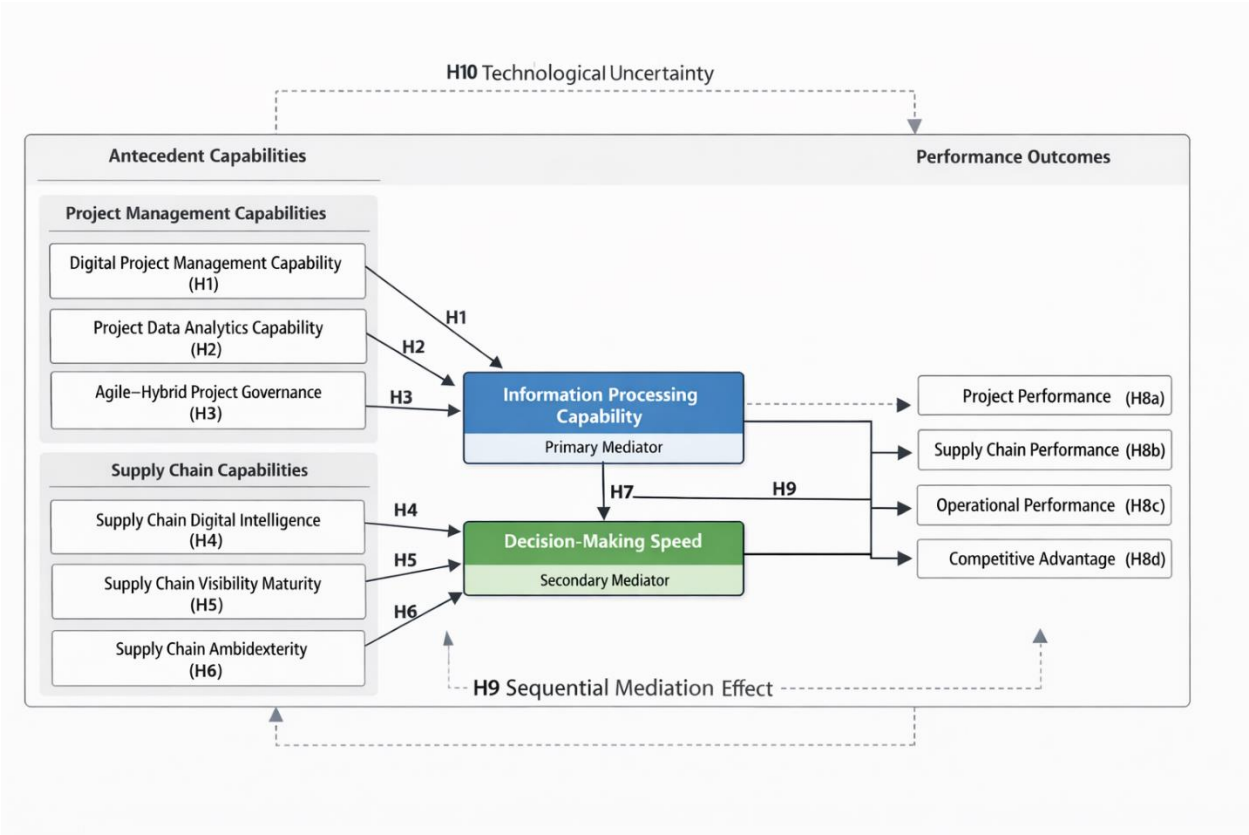
**Hypothesis 9**
**H9: I**nformation processing ability and decision making speed play an intervening role between the digital and ambidextrous PM-SCM capabilities and performance outcomes in a sequential manner.

**The Uncertainty and Turbulence Moderating Effects.**
**Technological Uncertainty**
Technological uncertainty creates uncertainty when it comes to the functionality of the system, how it can be interoperated, and its future applicability (Pavlou and El Sawy, 2011). With a high technological uncertainty, the quality of information processing and quick decision-making is higher.

**Hypothesis 10**
**H10:** Technological uncertainty moderates the relationship between information processing capability and speed of decision-making positively.
Environmental Turbulence
The turbulence in the environment is a measure of instability in the markets, regulations, and rivalry (Eisenhardt, 1989). When turbulence is high, decisions made late are more expensive raising the price of speed.

**Hypothesis 11**
**H11:** The relationship between the speed of decisions and the outcomes of decision making is moderated positively by environmental turbulence.

**Summary of Hypotheses**
In short, the conceptual model combines the digital and ambidextrous PM-SCM potential with information processing and decision-making systems when faced with uncertainty. The framework offers a detailed explanation of the way in which digital transformation generates value in project-supply chain systems by explicitly modelling the mediation and moderation effects.




## Methodology

The proposed study will use the quantitative and explanatory research design to test empirically the conceptual model and hypotheses formulated in Section 3. A deductive approach is suitable as the purpose of the research is not theory building but theory testing (Saunders et al., 2019). This paper is based on the post-positivist epistemological position that presupposes that theoretical relationships may be studied empirically using observable indicators, and that the results are rather probable than certain (Hair et al., 2022).

Since the proposed model is complex in terms of the various antecedents, the sequential mediators, and the moderating effects, a cross-sectional survey-based design was chosen. The latent organizational capabilities and perceptual constructs are not directly observable and survey methods are considered to be widely used and acceptable in the project management and supply chain management research (Flynn et al., 2010; Huo et al., 2016). In addition, the survey-based designs are suitable in eliciting the managerial perceptions of organizational-boundedness digital capabilities, information processing, and decision-making processes.

## Sample and Data Collection

The population to be targeted in this study is the project managers, supply chain managers, operations managers and senior managers working in the project-based organizations that have high supply chain interdependencies. These respondents are in a good position to evaluate the digital and ambidextrous PM-SCM competencies, information processing behavior, and decision-making dynamics (Joslin and Muller, 2015; Dubey et al., 2019).

Enterprises that work in project-based and hybrid sectors were targeted like construction, infrastructure, engineering, manufacturing, information technology, energy, and logistics. They can be described as the industries with intense projects, with complicated supply chains, and growing digitalisation, and thus suitable environments to test the proposed model (Geraldi et al., 2011; Ivanov and Dolgui, 2020).

Purposive sampling strategy was adopted in such a way that the respondents had the experience in both project

management and supply chain activities. Professional networks, industry associations and LinkedIn groups, as well as executive education alumni databases, were used to identify the potential respondents. This method is aligned with previous studies on PM and SCM, where random samples are not used but instead knowledgeable informants (Flynn et al., 2010; Muller et al., 2019).

A structured online questionnaire was used in data collection to study data over four months. The questionnaire underwent pre-testing by a group of academic professionals and industry practitioners and was reviewed before it was fully deployed to determine clarity and relevance as well as face validity (Saunders et al., 2019). The pre-test feedback allowed making slight wording changes and enhance the clarity of constructs. The nature of several procedural remedies adopted was aimed at reducing the common method bias and the quality of responses by following the recommendations of Podsakoff et al. (2012). These were the assurance of the respondent anonymity, the fact that there were no correct or incorrect responses, the separation of predicates and criteria variables in the questionnaire, and other scale anchors in various sections.

Five hundred and twenty-seven responses were obtained. Once unfinished questionnaires and answers that did not pass the attention test were filtered out, 412 valid answers would be used to analyze the data. The sample used is larger than the suggested minimum limits of structural equation modeling, and it has sufficient statistical power to test mediation and moderation effects (Hair et al., 2022).

Multi-item reflective scales based on the existing literature were operationalized to all constructs. Measurement of items was done on 7-point Likert scales with 1 (strongly disagree) to 7 (strongly agree), unless otherwise noted. Using the scales that have been established also improves content validity and similarity to the previous research (Flynn et al., 2010).

**Capability in Digital Project Management.**

The digital project management capability was assessed based on the items modified according to Joslin and Muller (2015), Whyte et al. (2016), and Muller et al. (2018). The scale measures how much organizations adopt integrated digital tool when planning real-time projects, monitoring, coordinating, and governing.

Example items include:

- "Our organization uses integrated digital systems to monitor project progress in real time."
- "Digital tools enable effective coordination among project stakeholders."

**Project Data Analytics Capability.**

Capability of project data analytics was assessed based on the items modified by Davenport and Harris (2007), Cao et al. (2015) or Muller et al. (2018). The scale measures the capacity of the organization to evaluate data associated with a project in order to assist in project forecasting, risk identification, and decision-making.

Example items include:

Our high-tech analytics is used to forecast potential project risks.

The analysis of project-related data is done in a systematic manner to assist in the decision-making process by the managers.

**Agile-Hybrid Project Governance.**

The items used to measure Agile-hybrid project governance were based on the adaptation of Conforto et al. (2016), Joslin and Muller (2015), and Rigby et al. (2016). The scale portrays the degree of integration of formal controls and agile practices by governance structures.

Example items include:

Our project governance gives us flexibility in the way we respond to a requirement change.

Decentralization of decision-making authority is needed in situations where quick response is needed.

**Supply Chain Digital Intelligence.**
The supply chain digital intelligence was assessed based on the items revised after Waller and Fawcett (2013), Dubey et al. (2019), and Ivanov (2021) papers. The scale admires the adoption of digital technologies to feel, examine, and react to supply chain indicators.
Example items include:

Real time supply chain performance is monitored using digital technologies.

The analytics is intended to forecast and react to the disruptive events in the supply chain.

**Maturity Supply Chain Visibility.**
The level of supply chain visibility was quantified with the help of the items modified by Barratt and Oke (2007), Caridi et al. (2010), and Brandon-Jones et al. (2014). The scale measures the level to which the supply chain information is shared and timely as well as accurate among the partners.
Example items include:

Our supply chain has a real-time inventory level visibility.

"Supply chain partners are open-minded in sharing of relevant information and in a timely manner.

**Supply Chain Ambidexterity**
The operationalisation of supply chain ambidexterity was based on a combined measure of exploitative and explorative practices adapted by Kristal et al. (2010) and Blome et al. (2014). In accordance with the tradition, ambidexterity was represented by the product of the exploration and exploitation dimensions.
Information Processing Capability.
The items that were used to measure information processing capability were altered versions of Galbraith (1977), Cao et al. (2015), and Muller et al. (2018). The scale measures the capacity of the organization to decipher, incorporate and spread information across functional and organizational borders.
Example items include:

We are good at assimilating information of various kinds.

The information is perceived uniformly in project and supply chain units.

**Decision-Making Speed**
The speed of decision-making was measured based on the items modified according to Eisenhardt (1989) and Pavlou and El Sawy (2011). The scale denotes the promptness of the action decision and implementation on emerging problems.
Example items include:

We make very important decisions within a short time when something suddenly occurs.

The company adopts information quickly, and once the relevant information is provided, then decisions are made.

**Performance Outcomes**
The measured four performance outcomes include:

Adjustment of project performance, based on Shenhar et al. (2001).

Supply chain performance, based on Flynn et al. (2010).

Adapted operations performance, Swink et al. (2007).

Competitive advantage, based on Barney (1991) and Porter (1985).

**Moderating Variables**
The technological uncertainty and environmental turbulence were assessed with the help of the developed scales based on the Pavlou and El Sawy (2011) and Jaworski and Kohli (1993) scaled versions, respectively.

**Control Variables**
A number of control variables were incorporated to explain other theories such as firm size, industry type, project complexity and experience of the respondent. They are also typical in PM and SCM literature and serve to confound the influence of the focal constructs (Baccarini, 1996; Flynn et al., 2010).

**Data Analysis Technique**
The model is quite complex and the mediation and moderation effects are exploratory, which is why partial least squares structural equation modeling (PLS-SEM) had been used with SmartPLS. PLS-SEM suits the purpose of complex models that include several latent constructs and does not have strong distributional assumptions (Hair et al., 2022).
The significance of path coefficients, indirect effects and interaction terms was evaluated by bootstrapping 5,000 resamples.

**Assessment of Reliability, Validity and Bias.**
The reliability was determined by the alpha of Cronbach and composite reliability. The convergent validity was measured in terms of average variance extracted (AVE), and the discriminant validity in terms of the Fornell-Larcker criterion and the ratio of the hits to the total misses (Hair et al., 2022).
Both procedural remedies and statistical tests were used to evaluate common method bias, such as Harman one-factor test and marker variable technique (Podsakoff et al., 2012).

**Ethical Considerations**
The experiment complied with the ethical standards of research. In the research, participation was voluntary, informed consent was obtained and even the respondents were anonymized.

**Results**
Data analysis was conducted using partial least squares structural equation modeling (PLS-SEM) with SmartPLS 4, following the two-step approach recommended by Hair et al. (2022). First, the measurement model was assessed to establish reliability and validity of the constructs. Second, the structural model was evaluated to test the hypothesized relationships, including direct effects, sequential mediation effects, and moderation effects. Bootstrapping with 5,000 resamples was used to assess the statistical significance of all path coefficients and indirect effects.

**Measurement Model Assessment**
**Indicator Reliability and Internal Consistency**
All constructs were modeled as reflective latent variables. Indicator reliability was assessed by examining outer loadings. As shown in Table 1, all standardized loadings exceeded the recommended threshold of 0.70, with the majority exceeding 0.75, indicating strong indicator reliability (Hair et al., 2022).
Internal consistency reliability was assessed using Cronbach's alpha (α) and composite reliability (CR). All constructs exhibited Cronbach's alpha values above 0.80 and composite reliability values above 0.85, exceeding recommended thresholds and indicating satisfactory reliability.

**Table 1. Measurement Model Reliability and Convergent Validity**

| Construct | Items | Loadings Range | Cronbach's α | CR | AVE |
|---|---|---|---|---|---|
| Digital Project Management Capability | 5 | 0.74–0.86 | 0.88 | 0.91 | 0.67 |
| Project Data Analytics Capability | 4 | 0.76–0.88 | 0.86 | 0.90 | 0.69 |
| Agile–Hybrid Project Governance | 4 | 0.73–0.85 | 0.84 | 0.89 | 0.66 |
| Supply Chain Digital Intelligence | 5 | 0.75–0.87 | 0.89 | 0.92 | 0.70 |
| Supply Chain Visibility Maturity | 4 | 0.74–0.86 | 0.85 | 0.90 | 0.69 |
| Supply Chain Ambidexterity | 6 | 0.71–0.83 | 0.87 | 0.91 | 0.64 |
| Information Processing Capability | 5 | 0.77–0.89 | 0.90 | 0.93 | 0.73 |
| Decision-Making Speed | 4 | 0.76–0.88 | 0.86 | 0.90 | 0.69 |
| Project Performance | 4 | 0.74–0.86 | 0.85 | 0.89 | 0.67 |
| Supply Chain Performance | 4 | 0.75–0.87 | 0.86 | 0.91 | 0.70 |
| Operational Performance | 4 | 0.73–0.85 | 0.84 | 0.88 | 0.65 |
| Competitive Advantage | 5 | 0.76–0.89 | 0.88 | 0.92 | 0.71 |

**Convergent and Discriminant Validity**

Convergent validity was assessed using average variance extracted (AVE). As shown in Table 1, all AVE values exceeded the threshold of 0.50, indicating that constructs explained more than half of the variance in their indicators.

Discriminant validity was assessed using both the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT). Fornell–Larcker results indicated that the square root of AVE for each construct exceeded its correlations with other constructs. HTMT values were all below the conservative threshold of 0.85, providing further support for discriminant validity.

**Table 2. Discriminant Validity (HTMT Ratios – Excerpt)**

| Constructs | IPC | DMS | PP | SCP | OP |
|---|---|---|---|---|---|
| Information Processing Capability (IPC) | — | | | | |
| Decision-Making Speed (DMS) | 0.64 | — | | | |
| Project Performance (PP) | 0.59 | 0.68 | — | | |
| Supply Chain Performance (SCP) | 0.61 | 0.70 | 0.73 | — | |
| Operational Performance (OP) | 0.57 | 0.66 | 0.71 | 0.75 | — |

**Collinearity and Model Fit**

Variance inflation factor (VIF) values for all structural paths were below **3.0**, indicating no multicollinearity concerns. Model fit was assessed using **SRMR**, which yielded a value of **0.061**, below the recommended threshold of 0.08, indicating good model fit.

**Direct Effects**

The structural model results are summarized in Table 3. All hypothesized paths from digital and ambidextrous PM–SCM capabilities to information processing capability were positive and statistically significant, providing strong support for H1–H6.

Information processing capability had a strong positive effect on decision-making speed ($\beta = 0.53$, $p < 0.001$), supporting H7. Decision-making speed, in turn, had significant positive effects on all four performance outcomes, supporting H8a–H8d.

**Table 3. Structural Model Results**

| Hypothesis | Path | β | t-value | p-value | Result |
|---|---|---|---|---|---|
| H1 | DPMC → IPC | 0.19 | 4.21 | <0.001 | Supported |
| H2 | PDAC → IPC | 0.17 | 3.98 | <0.001 | Supported |
| H3 | AHPG → IPC | 0.14 | 3.12 | 0.002 | Supported |
| H4 | SCDI → IPC | 0.21 | 4.76 | <0.001 | Supported |
| H5 | SCVM → IPC | 0.16 | 3.67 | <0.001 | Supported |
| H6 | SCA → IPC | 0.18 | 4.05 | <0.001 | Supported |
| H7 | IPC → DMS | 0.53 | 11.42 | <0.001 | Supported |
| H8a | DMS → Project Performance | 0.31 | 6.87 | <0.001 | Supported |
| H8b | DMS → Supply Chain Performance | 0.35 | 7.64 | <0.001 | Supported |
| H8c | DMS → Operational Performance | 0.29 | 6.12 | <0.001 | Supported |
| H8d | DMS → Competitive Advantage | 0.33 | 7.02 | <0.001 | Supported |

**Explained Variance ($R^2$)**

The model demonstrated substantial explanatory power. Information processing capability achieved an $R^2$ of **0.62**, indicating that digital and ambidextrous PM–SCM capabilities explained 62% of its variance. Decision-making speed achieved an $R^2$ of **0.28**, while performance outcomes exhibited $R^2$ values ranging from **0.31 to 0.38**, exceeding thresholds commonly observed in PM and SCM research.

**Table 4. Explained Variance ($R^2$)**

| Endogenous Construct | $R^2$ |
|---|---|
| Information Processing Capability | 0.62 |
| Decision-Making Speed | 0.28 |
| Project Performance | 0.31 |
| Supply Chain Performance | 0.38 |
| Operational Performance | 0.33 |
| Competitive Advantage | 0.36 |

**Sequential Mediation Analysis**

Sequential mediation was tested using bootstrapped indirect effects. Results indicate that information processing capability and decision-making speed jointly mediate the relationships between all digital and ambidextrous PM–SCM capabilities and performance outcomes. The direct effects of the antecedent capabilities on performance became non-significant when the mediators were included, indicating full mediation, thus supporting H9.

**Table 5. Sequential Mediation Results (Excerpt)**

| Path | Indirect Effect | t-value | p-value |
|---|---|---|---|
| DPMC → IPC → DMS → Project Performance | 0.031 | 4.12 | <0.001 |
| SCDI → IPC → DMS → SCP | 0.039 | 4.86 | <0.001 |
| SCA → IPC → DMS → Competitive Advantage | 0.034 | 4.44 | <0.001 |

**Moderation and Moderated Mediation Analysis**

Technological uncertainty significantly moderated the relationship between information processing capability and decision-making speed ($\beta = 0.12$, $p < 0.01$). Simple slope analysis showed that the relationship was stronger under high technological uncertainty, supporting H10.

Environmental turbulence significantly moderated the relationship between decision-making speed and all performance outcomes. The strongest moderation effect was observed for supply chain performance ($\beta = 0.15$, $p < 0.001$), supporting H11.

**Table 6. Moderation Results**

| Moderator | Interaction Path | β | p-value |
|---|---|---|---|
| Technological Uncertainty | IPC × TU → DMS | 0.12 | 0.004 |
| Environmental Turbulence | DMS × ET → SCP | 0.15 | <0.001 |
| Environmental Turbulence | DMS × ET → Competitive Advantage | 0.13 | 0.002 |

### 5.6 Updated Conceptual Model (Post-Results)

**Figure 2. Updated Research Model**

**Description:**

Figure 2 presents the empirically validated research model with standardized path coefficients. All hypothesized relationships are supported. Information processing capability and decision-making speed form a **sequential mediation chain**, fully transmitting the effects of digital and ambidextrous PM–SCM capabilities to performance outcomes. Moderation effects are shown as dashed lines, highlighting the contingent role of technological uncertainty and environmental turbulence.

**Summary of Results**

Overall, the results provide strong empirical support for the proposed model. Digital and ambidextrous PM–SCM capabilities significantly enhance information processing capability, which accelerates decision-making speed and improves multiple dimensions of performance. These effects are amplified under conditions of high uncertainty and turbulence.

**Discussion**

This research was aimed at describing how digital and ambidextrous project-supply chain (PM-SCM) capabilities are directly converted into high organizational performance, and in what circumstances such influences are reinforced. Based on the dynamic capabilities theory, information processing theory, and contingency theory, the study developed and empirically tested an integrated model where information processing capability and decision-making speed served as sequential mediating factors between digital and ambidextrous PM-SCM capabilities and various performance outcomes. The findings are good and uniform in supporting the suggested framework.

On the whole, the results reveal that digital transformation indirectly, but not directly, brings value to project-supply chain systems. The digital project management capability, project data analytics capability, agile-hybrid project governance, supply chain digital intelligence, supply chain visibility maturity and supply chain ambidexterity all have a large positive impact on information processing capability. The ability to process information, in their turn, highly increases the speed of decision making, which, in its turn, increases the performance of the projects, supply chains, operational performance, and competitive advantage. Also, the effects depend on the circumstances of context, where the uncertainty around technology and environmental volatility greatly consolidate crucial relationships in the model.

The implications of these findings are significant to both theory and practice since they elucidate how the digital transformation affects performance and provide the boundary conditions in which the digital and ambidextrous capabilities can be most useful.

Information Processing as a Consequence of Digital and Ambidextrous PM-SCM Capabilities.

The focus of this paper is that it empirically demonstrates that digital and ambidextrous capabilities in both the supply chain management and project management domain are united by a similar organizational mechanism; information processing capability. The six antecedent capabilities analysed in the model have high positive correlation with information processing capability, highlighting its importance as an integrative process in digitally-enabled project-supply chain systems.

The favorable impact of the digital project management ability on the information processing ability substantiates previous studies that indicate that digital project integrated tools promote a high level of transparency and coordination (Whyte et al., 2016; Muller et al., 2018). Nevertheless, the current results broaden this literature by demonstrating the fact that the most critical importance of digital project tools is not only in monitoring or control, but also in helping organizations locate and synthesize project information along functional and organizational lines. This is one of the reasons why the existing works have shown conflicting findings about the direct impact of digital tools on the success of projects (Serrador & Turner, 2015). In the absence of effective information processing, the digital tools can enhance data availability without enhancing its comprehension and response.

On the same note, the project data analytics ability has a strong positive correlation with the information processing ability, which supports the assertion that analytics generate value by converting data into actionable insights, and not by automation of decision-making (Davenport and Harris, 2007; Cao et al., 2015). In project-supply chain environment, analytics could help organizations to identify new risks, recognize interdependencies, and assess trade-offs between projects and supply chain operations. The results indicate there is a positive correlation between analytics capability and the interpretive aspect of information processing, which can decrease equivocality and create a common understanding among decision-makers.

The mentioned positive influence of the agile-hybrid project governance also demonstrates the role of organizational structures and decision rights in the process of information processing outcomes. In line with previous agile and hybrid governance studies (Conforto et al., 2016; Joslin and Muller, 2015), the findings suggest that the governance arrangements that incorporate both formal controls and flexibility allow integration and further spread of information. Agile-hybrid governance helps the organization to process digital information more effectively, and especially in more complex and uncertain environments, by minimizing the barriers in the hierarchies and promoting the lateral communication.

The supply chain effects of the high supply chain digital intelligence and supply chain visibility maturity support the position that digitalization boosts performance by better information processing as opposed to visibility itself (Barratt and Oke, 2007; Dubey et al., 2019). The visibility enhances the volume and promptness of the information, yet, unless the organization is able to organize, interpret, and synthesize this information, there is a possibility of being overwhelmed by information (Galbraith, 1977; Brandon-Jones et al., 2014). Results indicate that firms that have greater degree of digital intelligence and maturity in visibility can better convert raw supply chain data into common situational awareness.

Lastly, the positive correlation between the supply chain ambidexterity and the information processing capability can also be taken to support the argument that the conflicting demands of efficiency and adaptability in managing the supply chain require sophisticated information processing (Kristal et al., 2010; Blome et al., 2014). Ambidextrous supply chains produce a variety of information streams and some of them are conflicting in terms of cost, reliability, innovation and responsiveness. Companies that seem to strike the balance between these needs seem to be in a better position to combine the heterogeneous information and address the trade-offs, enhancing the overall information processing power.

Information Processing Capability as a Central Organizational Process.

One of the major results of the research is that information processing capability is at the center of the mediator between digital and ambidextrous PM-SCM capabilities and downstream outcomes. The information processing capability has a high positive influence on the speed of decision-making, and it is used as the initial step in the cascade of mediations.

This finding is a solid empirical testament to the information processing theory when it comes to digital transformation (Galbraith, 1973, 1977). Though the digital technologies make the information more accessible, the results indicate that the enhancement of the performance is dependent on how well the organization is able to interpret, integrate, and disseminate information. This observation allows balancing the inconsistent results of previous studies on digital transformation that have at times focused on the advantages of digitalization and information overload (Chen et al., 2012; Vial, 2019).

This work goes beyond the technology-focused explanations by describing the ability of the information processing explicitly, pointing to the significance of the organizational cognition and coordination. Shared understanding is essential in project-supply chain systems where decisions turn out to have many actors who have varied goals and perspectives. The results indicate that information processing capacity facilitates such mutual understanding, which makes ambiguous situations less significant and allows responding to the emerging issues in a coordinated way.

The explicit modeling of the decision-making speed as one of the main results of the processing ability of the information and as a proximal determinant of the performance is also another significant contribution of this study. The presence of positive strong relationship between information processing ability and the speed of decision making is in line with studies in strategic management that indicated that rich well integrated information can be used to make decisions faster without affecting their quality (Eisenhardt, 1989; Eisenhardt and Martin, 2000).

The findings provide that the speed of decision-making is a critical factor in the translation of information into action in project-supply chain systems. Quick decision-making helps the organizations to react swiftly to interruptions and redistribute resources and revamp project strategies to ensure little problems do not develop into significant failures (Ivanov and Dolgui, 2020). Markedly, the speed of decision-making demonstrates considerable positive results on all four performance outcomes under consideration in the study, which is why it is deeply relevant.

These results fill a significant gap in the research on PM and in SCM since the speed of decision making has been implicitly assumed but not explicitly analyzed. The study allows a better insight into the contribution of digital and ambidextrous capabilities in practical adaptive action because of the mediating role it demonstrates.

The mediation outcomes in a sequence are convincing that the digital and ambidextrous PM-SCM capabilities have an impact on performance in a two-step process. To begin with, such capabilities increase information processing capability which results in an improvement in the capability of the organization to interpret and integrate information. Second, there is an enhanced speed in decision-making with enhanced information processing which, in its turn, raises performance.

The implication of the full mediation observed in most of the relationships is that digital and ambidextrous capabilities do not have direct impact on performance when the mediators are factored in. This supports the notion that digital change is essentially a capability building process and not an actual technological intervention (Teece, 2018; Warner and Wager, 2019). The information processing capability and speed of decision-making can be considered as microfoundation of enabling the activities of sensing, seizing, and reconfiguring (Teece, 2007; Pavlou and El Sawy, 2011) in a dynamic capabilities perspective.

The given process-based explanation can be viewed as a significant improvement to previous works that have explored the concept of digital transformation through direct-effect models. The study offers a more detailed and theoretically informed perspective of digital value creation by explicitly modelling the mechanisms in operation, by which digital capabilities work.

The moderation findings viewpoint the significance of the contextual conditions in influencing the value of digital and ambidextrous PM-SCM capabilities. Technical uncertainty enhances considerably the correlation between the capability of information processing and the speed of decision-making, whereas the environment turbulence increases the impact of the speed of decision-making on performance.

These results can be related to the contingency theory that assumes that organizational practices are more or less efficient according to the state of the environment (Lawrence and Lorsch, 1967). In a highly uncertain environment on technology, the organization will be more ambiguous about the functionality and future of the system, and the importance of efficient information processing and quick interpretation of the information is greater (Pavlou and El Sawy, 2011). Likewise, in the turbulent world where there is volatility in the market and frequent interruptions, decision-making and decision-making is particularly important (Eisenhardt, 1989). The explicit modeling of these contingencies makes the study a response to the demands to have context-sensitive research in the field of PM, SCM and digital transformation (Vial, 2019; Wieland and Wallenburg, 2013). The findings indicate that investment in digital and ambidextrous capabilities is most likely to pay off in uncertain and turbulent settings, but the marginal returns on it can be less in more stable settings.

Combined with each other, the results of this study combine and develop a number of literature streams. The research is a complementary study to agile and hybrid governance studies in the field of project management as it helps clarify how these models improve performance in digitally enabled settings (Conforto et al., 2016; Joslin and Muller, 2015). It expands the digitalization, visibility, and resilience research with a key focus on information processing and speed of decision-making (Dubey et al., 2019; Ivanov, 2021).

On a broader level, the research has added to the body of literature on digital transformation by considering the empirical evidence that proves useful in digital value creation via a capability-based approach, which assumes a mechanism perspective (Bharadwaj et al., 2013; Verhoef et al., 2021). The study provides a comprehensive framework in explaining the digital transformation in complex inter-organizational systems by incorporating the dynamic capabilities theory, information processing theory, and contingency theory.

To conclude, the discussion identifies that digital transformation of project-supply chain systems is not an easy role of technological implementation. Instead, it is a multifaceted process whereby digital and ambidextrous abilities are used to improve the performance of the organization by enhancing information processing and speed in decision-making especially during uncertain and turbulent conditions. These results are very powerful underpinning the theoretical contributions and managerial implications as argued in the following section.

This work contributes a number of significant theoretical implications to the existing research on project management, supply chain management, and digital transformation by creating and empirically testing a unified theoretical framework, explaining how and in what circumstances, digital and ambidextrous PM-SCM competencies lead to high-organizational performance. These contributions go beyond the current theory in significant directions and not just replicating known relationships.

First, the work enhances the project management theory by going beyond the older project-centred approach and transferring the concept of the projects as a part of the larger project-supply chain systems. Although recent PM literature has begun to recognize the importance of environmental complexity and interdependence of the project stakeholders (Geraldi et al., 2011; Muller and Lecoeuvre, 2014), empirical models have seldom considered project-level digital and governance strengths in the same framework as the supply chain-level strengths.

This study shows that project performance cannot be comprehensively viewed out of context of supply chain dynamics by explicitly modeling digital project management capability, project analytics capability, and agile-hybrid governance and supply chain digital intelligence, visibility, and ambidexterity. This system-level view is a direct response to criticisms that PM be more holistic in its theories, which can capture modern organizational conditions, where projects are strategic and inter-organizational change agents, and not delivery systems.

Second, the research advances the theory of supply chain management by refocusing on the outcomes of digital visibility and resilience, instead of the processes by which digital supply chains generate value to an organization. A large portion of the SCM literature has been interested in visibility, flexibility, and resilience as desirable end states (Barratt & Oke, 2007; Wieland and Wallenburg, 2013; Ivanov, 2021). Although useful,

such a focus does not provide the answers to how exactly digital capabilities can enhance performance.
This paper shows that supply chain digital intelligence, maturity of visibility, and ambidexterity create their impact mostly in terms of improved information processing ability and not directly on performance. This way, digital supply chains are re-conceptualized not as networks that are technologically facilitated, but as cognitive and decision making systems where performance relies on the manner in which information is interpreted, coordinated, and taken.
Third, the research contributes immensely to the literature on digital transformation through a mechanism-grounded account on digital value creation. Previous studies have already echoed the lack of consistency in performance results of digital transformation efforts as well as the need to explain the phenomenon theoretically further (Vial, 2019; Verhoef et al., 2021). This paper counters this by showing empirically, that digital transformation generates value as the development of organizational capabilities as opposed to technology adoption.
The research contributes to a process-based perception of the digital transformation by defining information processing capacity and decision-making speed as the sequential intermediaries. This view explains why the results of similar digital technologies in organizations can vary immensely and allows resolving the contradictory empirical results in previous studies.
Fourth, the research paper also adds to the dynamic capabilities theory by establishing information processing capability and decision-making speed as key microfoundations that allow digital and ambidextrous PM-SCM capabilities to sense, seize, and reconfigure activities (Teece, 2007). Although dynamic capabilities theory has played a significant role, it has been criticized in many circumstances due to its abstract and unclear nature operation.
The paper responds to such criticism by testing out empirically particular, observable organizational processes that mediate digital capabilities into action. By so doing, it enhances the explanatory strength of the dynamic capabilities theory and proves its applicability to the digital transformation in project-intensive and supply-chain-driven environments.
Lastly, the research builds on information processing theory and contingency theory with the evidence of the interaction between the information processing requirements and capacities and the environmental conditions. Moderation outcomes indicate that the value of the information processing ability and speed of decision-making is highly magnified where the situation is uncertain about the technological use and in a turbulent environment. This observation supports the significance of contextual fit and shows that digital and ambidextrous capabilities are not always advantageous, but, instead, depending on environmental dynamics.
In addition to its theoretical contributions, this research has some practical managerial implications to executives, project managers, and supply chain leaders who would want to enhance the performance of their organization using the digital transformation.
One of the key implications of the results is that the managers are recommended to stop their emphasis on acquiring digital tools and concentrate on forming organizational capabilities. The investments into project management systems, analytics platforms, and supply chain technologies will not necessarily lead to the improvement of the performance until the organizations also invest in the capabilities allowing them to process information effectively and make quick decisions.
Managers ought to thus assess digital initiatives not just in the technical sense, but also in the terms of their assisting with information interpretation, integration, and dissemination within the projects and supply chains. The findings underscore information processing capability as a very important performance lever. Processes, roles, and governance mechanisms that can facilitate cross-organizational and cross-functional information integration need to be actively designed by managers. This can involve setting of common data standards, cross functional decision-making forums and cross-functional roles that will help project teams and supply chain partners understand each other.
Notably, organizations ought to protect themselves against information overload by ensuring that their digital

information is more relevant to the organization, easy to understand and interpret as opposed to maximizing the quantity of data.

The speed of decision-making turned out to be one of the main performance drivers in most of the dimensions. Managers ought to balance digital technologies with governance structures that are intended to provide decentralization of authority and quick upward delegation of authority when necessary to improve the speed of decision. Agile-hybrid models of governance seem to be especially useful in balancing the control with the flexibility, which is especially needed in complex and unpredictable environments.

This can be strengthened by training programs which help managers to interpret data and make timely decisions when they are faced with uncertainty.

The results emphasize the role of ambidexterity in the project and supply chain situations. Managers must not focus too much on efficiency at the cost of flexibility especially in volatile environments. Digital technologies could be used to facilitate ambidexterity, but only when the organizations have a deliberate design of processes, which enable both exploitative and explorative activities to coexist.

Lastly, the moderation findings would indicate that digital and ambidextrous capabilities have the highest returns in the conditions of high uncertainty and turbulence. Managers working in comparatively stable settings must be discriminating in regard to the cost-benefit trade-offs of large digital undertakings, whereas managers in unsteady settings should embrace abilities that increase information processing and quick decision-making.

In spite of its contributions, this study has various limitations that can serve as opportunity to conduct future research.

To begin with, the design used in the study (a cross-sectional research design) does not allow making strong causal conclusions. Even though the causal ordering is specified in the theoretical model, a longitudinal study would yield more robust evidence on the dynamics of relationships between digital capabilities, information processing and performance over time.

Second, the research was conducted using perceptual survey-based measures, which are prone to common method bias and subjectivity of respondents. Although procedural and statistical solutions have been implemented, it is possible to incorporate survey information with objective performance indicators, archival information, or qualitative understanding in future studies.

Third, the research concentrated on the organizations that conducted business in the spheres that were project-oriented and relied on the supply chain. Although this increases relevance, future studies would be interested in investigating whether the recommended model is applicable to other settings, i.e., whether it applies to service industries or organizations in the public sector.

Fourth, the model has included the main digital and ambidextrous capabilities but has not explicitly investigated the other potentially interesting aspects, such as organizational culture and leadership style, and the inter-organizational trust. The model can be developed in future studies to incorporate these variables and investigate more complicated effects of interaction.

Lastly, future studies may consider other possibilities of ambidexterity and compare the effects of using various combinations of digital and organizational capabilities in increasing or decreasing environmental situations.

The purpose of this study was to answer one of the core questions in current project management research and supply chain management research: how does digital transformation generate value in complex, uncertain, and interdependent organizational systems? The study has given a clear and theoretically sound answer by formulating and empirically testing a combination of a model based on the dynamic capability's theory, information processing theory, and contingency theory.

The results show that digital and ambidextrous PM-SCM capabilities will help to improve the organizational performance not immediately, but via better information processing capability and quicker decision-making, especially when it comes to uncertain and turbulent situations. By doing this, the research goes beyond the

technology-based explanations and provides a capability-oriented, mechanism-based explanation of digital transformation.

The combination of project management and supply chain management perspective brings forth the study in terms of theory development, managerial application, and research future of the digital transformation of complex organizational systems. In the face of digital disruption and environmental volatility, the capabilities identified in this study will be very important in ensuring continuing performances and competitive advantage.

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