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Influence of IoT Implementation on Supply Chain Performance: Role of Information Integration and Decision-making Uncertainty

Abstract

Purpose - Implementing IoT is fundamental to the digitalisation of modern supply chains. This paper aims to provide a theory-based explanation for the impact of IoT implementation on information integration, decision-making uncertainty, and hence supply chain performance.

Design/methodology/approach—This study adopts a qualitative multiple-case study approach to investigating three fast-fashion supply chains in China through 30 semi-structured interviews.

Findings – Our findings demonstrate that IoT is implemented in the information collection, selection, and sharing processes of information integration. Implementing firm-level information collection and selection processes impacts information quality and is linked to environmental uncertainty. Whereas implementation in the supply chain level information sharing process impacts information accuracy and efficiency and is linked to industry uncertainty.

Theoretical implications – This research advances the theoretical understanding of IoT's role in supply chain management through a two perspective Information Processing Theory based framework, capturing the mechanisms which underpin the interactions between IoT-enabled information integration and decision-making uncertainty and resultant impact on performance.

Practical implications - This research provides a road map for supply chain managers demonstrating how IoT implementation in information integration processes within the firm can improve operational performance. However, when this implementation progresses to supply chain level information-sharing processes, management costs improvements are ultimately realised.

Originality/value – This study contributes an empirical, evidence-based explanation of the impact of IoT implementation on supply chain performance. Case study evidence from firms in the early and middle stages of IoT implementation reveal that the mechanisms governing the interactions between information integration, decision-making uncertainty, and their impact on performance are fundamentally different for firm and supply chain IoT implementation processes. It is only in implementing the information sharing process at the supply chain level that cost benefits are achieved.

Keywords: Internet of Things, Supply chain performance, Information integration, Decision-making uncertainty, Information processing theory

1. Introduction

Key global trends such as geopolitical disruption and product proliferation make modern supply chains complicated entities which are challenging to manage (Holgado and Niess, 2023). This context forces supply chain managers to make decisions based on incomplete information, resulting in uncertainty (Um and Han, 2021). This decision-making uncertainty leads to additional issues, such as demand forecast distortion and increased inventory, which make determining the impact of the decision on performance unclear (Wu *et al.*, 2019). Information integration is a key tool in reducing the negative impact of decision-making uncertainty (Huo *et al.*, 2016; Swierczek, 2023). It has been demonstrated to positively influence the accuracy of demand forecasts, improve the relationship between supply chain stakeholders and enhance decision-making by providing sufficient information (Niu and Zou, 2017).

As a novel technology, the Internet of Things (IoT) has excellent potential to improve information integration in the supply chain (Bravo *et al.*, 2023). However, implementing this technology is not without its challenges. The high cost of IoT implementation means that firms do not consistently achieve short-term financial returns (Raj *et al.*, 2020). Adoption risks, such as revealing a firm's information to its competitors or becoming over-reliant on the system, may challenge a firm's competitive position in the market (Chang and Sanchez-Loor, 2020). IoT implementation challenges include issues in adopting heterogeneous technologies and data services (Haddud *et al.*, 2017) and security and privacy concerns (Ben-Daya *et al.*, 2022). Addressing ethical, environmental and standardisation issues with IoT automation (Alieva and Haartman, 2020; Attaran, 2020; along with legal and accountability issues continue to hinder adoption (De Vass *et al.*, 2021).

While information integration is vital for supply chain management, the challenges of achieving the necessary technology adoption discourage organisations from adopting it. To date, few studies explicitly connect IoT-enabled information integration and decision-making uncertainty in one framework (Harju *et al.*, 2023). Ultimately, managers seek to improve supply chain performance (Zhou *et al.*, 2023). Therefore, a clear explanation which illustrates how IoT influences information integration, decision-making uncertainty, and ultimately impacts supply chain performance is required. This research seeks to identify the critical factors impacting this relationship and their impact on supply chain performance. This leads to the following research questions:

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RQ1. How does the implementation of IoT change the relationship between information integration and decision-making uncertainty?

RQ2. How do the changes in the relationship between information integration and decision-making uncertainty impact supply chain performance?

The major contribution of the study is to empirically uncover the detailed interactions between IoT-enabled information integration and decision-making uncertainty. Prior studies have established that IoT can enhance visibility, efficiency and collaboration (Bhandal et al., 2022; Al-Khatib, 2023). However, less is known about how these effects differ by implementation level (firm versus supply-chain), information integration stage (collection, selection and sharing), or impact decision-making uncertainty and performance outcomes. Drawing on three fast-fashion supply chains in China, we elaborate an Information Processing Theory (IPT)-based framework and propositions that specify stage- and level-contingent mechanisms linking IoT-enabled information integration to environmental and industry uncertainty. This highlights that IoT does not directly enhance supply chain performance but rather improves information integration processes, thereby indirectly impacting performance. Specifically, in our cases financial benefits are not observed until supply chain level information sharing has been implemented. Adoption of firm-level information collection and selection processes leads to operational improvements without direct cost advantages. This differentiation challenges the common assumption that IoT directly affects performance (Rejeb *et al.*, 2019; Zubairu *et al.*, 2021). By challenging this assumption and clarifying what is actually changed and under what circumstances, this study advances the literature, offering a more detailed, conceptually grounded account of IoT's role in supply chains. Managerially, it offers a practical roadmap for implementing IoT in supply chains, guiding managers in leveraging it to enhance agility, efficiency, and cost-effectiveness.

The remainder of the paper is organised as follows. Section 2 presents a critical literature review and theoretical grounding for the study. The research methodology based on semi-structured interviews is described in Section 3 before the findings are reported in Section 4. The discussion is presented in Section 5, along with theoretical and managerial contributions. The paper concludes with limitations and future research directions in Section 6.

2. Literature Review and Theoretical Grounding

2.1 The Relationship between Information Integration and Decision-Making Uncertainty

Following the seminal work of Duncan (1972), decision-making uncertainty has been categorised using three aspects: environmental uncertainty, industry uncertainty, and firm uncertainty (Tseng and Lee, 2010). Environmental uncertainty complicates the prediction of decision outcomes and is widely recognised as a driver of information integration (Benfratello and Yu, 2021). Industry uncertainty arises from interactions between supply chain stakeholders, which complicates forecasting and affects inventory levels (Adenso-Díaz *et al.*, 2012). Firm uncertainty arises from internal operational processes, often reducing managerial willingness to adopt technologies and delaying product innovation (Lin and Lin, 2014). Across these levels, uncertainty impedes supply chain stakeholders ability to process sufficient information to evaluate the outcomes of their decisions, negatively impacting supply chain performance (Wu *et al.*, 2019).

Information integration is the practises stakeholders adopt to collect, process, and share information (Wong *et al.*, 2015). It has been shown to enhance accuracy, quality, efficiency, and security in supply chains (Mirzabeiki and Saghiri, 2020). Extant work highlights its benefits in reducing error and bias (Acar and Atadeniz, 2015), optimising stakeholder communication and collaboration (Jain and Sohoni, 2015; Kache and Seuring, 2017), and improving demand forecasting and information utilisation in the information-sharing process (Singh and Garg, 2015; Chang and Sanchez-Loor, 2020). Recent studies have also demonstrated that combining information integration with other emerging technologies, such as Blockchain, can positively influence information security (Vu *et al.*, 2024).

While extant literature establishes the relationship between decision-making uncertainty and information integration (Singh and Garg, 2015; Moyano-Fuentes and Martínez-Jurado, 2016), the mechanisms underpinning this relationship are only partially addressed. Prior research typically assumes that environmental uncertainty drives cooperation among firms but falls short of specifying which aspects of uncertainty create this need, or how information integration facilitates cooperation (Sniazhko, 2019). Similarly, previous studies show that information integration mitigates demand distortion and reduces decision-making uncertainty (Wong *et al.*, 2015), but lacks specific explanation of the key factors governing this interaction with decision-making uncertainty. This gap limits our understanding of how different types of decision-making uncertainty interact with distinct dimensions of information integration, ultimately impacting supply chain performance. Addressing this gap advances supply chain management research by moving beyond considering decision-making uncertainty as merely a driver and unpacking the specific

relationship through which information integration interacts with and improves supply chain performance.

2.2 Role of IoT in Information Integration and Decision-Making Uncertainty

IoT is a network of physical devices (or a platform) used in the supply chain for processing information through the Internet (de Vass *et al.*, 2018). Compared to other Industry 4.0 technologies, IoT has been found to have a superior impact in enhancing information integration and strengthening overall information processing capability across the supply chain (Kache and Seuring, 2017).

IoT enables real-time data collection, transmission, and sharing, which collectively enhances information integration. For example, RFID-based sensor networks improve inventory information management (Aryal *et al.*, 2018), IoT platforms support more effective information selection (Peng *et al.*, 2011), and advanced transmission technologies such as 5G facilitate fast, reliable data transfer with minimal error (Bravo *et al.*, 2023). These capabilities improve the accuracy of forecasts and decision-making processes by ensuring timely and reliable information exchange among supply chain stakeholders (Chaudhuri *et al.*, 2018). Prior studies confirm that IoT-enabled integration reduces uncertainty and enhances supply chain efficiency, particularly when decision-making uncertainty is high (Wong *et al.*, 2015; Khanuja and Jain, 2019). Despite these benefits, IoT implementation faces challenges. Risks include unexpected information leakage and overdependence on technology (Chang and Sanchez-Loor, 2020), concerns about information security (Almomani *et al.*, 2021), and high implementation and maintenance costs associated with equipment, operations, and training (Kamble *et al.*, 2022).

At the same time, recent digital supply chain research highlights that IoT's value is often realised as part of broader digital transformation. Where benefits depend on complementary analytics and orchestration capabilities that translate data into actionable decisions. For example, evidence from crisis contexts suggests that digital asset deployment supports performance when paired with capabilities such as supply chain visibility and agility, indicating that data capture alone is insufficient without interpretive and action-oriented routines (Ye *et al.*, 2022). In this sense, IoT can be understood as strengthening the data layer of information processing, while analytics and decision-support capabilities strengthen the interpretation and response layers (Bahrami and Shokouhyar, 2022; Gopal and Schnabl, 2022). Specifically, supply chain management research increasingly views IoT not as a standalone technology, but as a foundational data layer within platform-enabled, multi-tier digital integration and wider digital ecosystems. Platformed supply chains support information flows beyond dyadic ties and enable multi-tier visibility and coordination (Jia *et al.*, 2026). In this context, IoT-generated real-time data delivers value when combined with complementary

capabilities such as big data analytics and, increasingly, AI/ML to filter signals, improve forecasting, and support coordinated decisions (Gopal et al., 2024). These benefits also depend on digital maturity and diffusion across tiers, as integration may be constrained by uneven readiness among partners (Zhang et al., 2025).

IoT implementation also entails well-recognised risks and constraints, including information security concerns, overdependence on technology, and substantial costs associated with equipment, maintenance, and training (Chang and Sanchez-Loor, 2020; Kamble et al., 2022). In addition, standardisation and interoperability challenges can create barriers to cross-firm integration (Ferreira et al., 2021). These constraints are especially salient when IoT moves from firm-level deployment to inter-firm information sharing, where governance of data access, ownership, and compliance becomes critical.

2.3 IoT implementation in China's fast-fashion industry

The feasibility and scope of inter-firm information sharing in China's fast-fashion supply chains form a functional boundary condition for our study. These will be shaped by institutional and governance conditions, including evolving data protection and security requirements and heightened sensitivity around data access and cross-organisational transparency in this context. Measures such as China's Personal Information Protection Law (effective November 2021) have introduced stronger compliance obligations for personal data processing, which affect firms' data collection and sharing practices (Liu et al., 2022). However, previous studies have demonstrated that despite specific contractual and relational governance requirements and implementation restrictions digital technologies have shown promise in this context (Ming et al., 2025; Zhou et al., 2023). In addition, fast fashion frequently involves multi-tier networks with digital infrastructure and digital maturity uneven across tiers. This potentially constrains end-to-end visibility and limits diffusion of integration practices (Hellweg et al., 2021).

Taken together, the literature provides strong evidence that IoT can enhance information integration and support decision-making under uncertainty, while also highlighting important cost, risk, and governance trade-offs. However, existing studies often treat IoT implementation holistically or focus on isolated mechanisms. They are not specific regarding how IoT-enabled information integration differs by implementation level and integration stage. In addition, how these contingencies align with distinct uncertainty-driven information-processing needs and different performance dimensions (operational versus cost-related) is not clear. Addressing this gap contributes by clarifying the specific mechanisms by which IoT reduces decision-making uncertainty, the conditions under which it generates performance improvements, and the trade-offs associated with its costs and risks.

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2.4 Theory-Based Relational Framework

To analyse this relationship, we draw on the concept of “fit” from Information Processing Theory (IPT). Originating in Contingency Theory (Cao *et al.*, 2015), “fit” is defined as the alignment between the needs, demands, and structures of one component and those of another (Tushman and Nadler, 1980). IPT posits that firms must match their information processing capabilities with their information processing needs to manage uncertainty effectively (Yuen and Thai, 2017). When capability aligns with need, performance improves (Daft and Lengel, 1986). In the supply chain context, decision-making uncertainty elevates information processing needs because stakeholders struggle to evaluate the consequences of their actions on performance (Yu *et al.*, 2019; Wang *et al.*, 2024). Information integration enhances firms’ information processing capability by improving data collection (Seyedghorban *et al.*, 2020) and facilitating more effective inter-firm sharing (Odważny *et al.*, 2018), thereby reducing the issues created by decision-making uncertainty (Kache and Seuring, 2017). The concept of fit in IPT proposes that a firm’s information processing capability must match its information processing needs (Wong *et al.*, 2011). When there is a balance between information processing capability and information processing needs, supply chain performance is improved (Sacristán-Díaz *et al.*, 2018; Zhang *et al.*, 2021).

We propose an IPT-based relational framework (Figure 1) that explicitly links decision-making uncertainty, IoT-enabled information integration, and supply chain performance. In this framework, decision-making uncertainty is the source of information processing needs, information integration is the mechanism that builds processing capability, and “fit” captures the alignment between these two. IoT serves as a critical enabler of this fit by providing real-time, accurate, and secure information flows, thereby reducing uncertainty and improving performance outcomes. This framework builds upon prior studies by going beyond broad associations, demonstrating more clearly how and under what conditions IoT-driven integration creates value in supply chains.

This theoretical framing firstly, grounds the study in IPT while engaging with contemporary digital supply chain management insights that highlight information integration capability and decision-making under uncertainty. Whilst secondly, providing a clear bridge from literature to the empirical design: the framework guides our within-case and cross-case analysis by identifying expected patterns of fit (or misfit) across stages and levels, and structuring findings by linking observed integration practices to specific uncertainty conditions and performance dimensions.

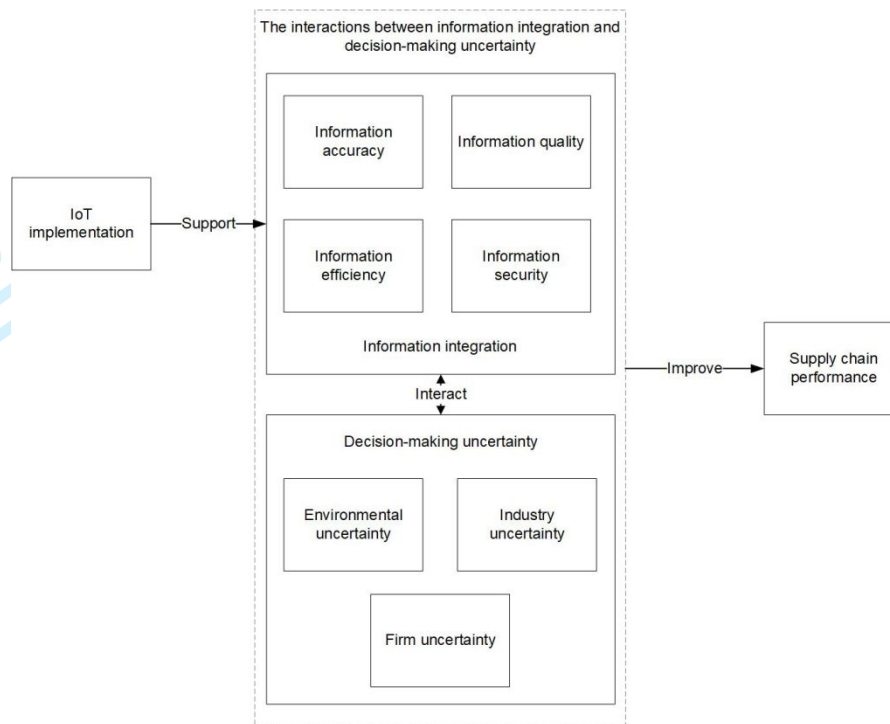


Figure 1. Information Processing theory-based relational framework of IoT implementation in supply chain management

3. Research Methodology

To investigate the proposed relationships, we conduct a theory elaboration case study. This approach allows us to gather rich and detailed data to explore the mechanisms that govern these interrelationships. Applying the theoretical lens will allow us to draw insights into the complex and dynamic nature of the phenomenon (Maestrini *et al.*, 2018). The exploratory nature of the research questions allows us to examine the nascent relationships between the key constructs highlighted in Figure 1. Qualitative research methods are well-suited for theory elaboration research, providing the depth, flexibility, contextual understanding, and participant-centred insights necessary for developing and refining complex theoretical frameworks (Livne-Tarandach *et al.*, 2015). They are also the driving force behind the modification and development of the logic of theories, allowing them to conform to a phenomenon or context (Ketokivi and Choi, 2014).

We choose a multiple case study design, which is well-suited for deriving fresh insights into emerging phenomena (Dolci *et al.*, 2017). Thus, allowing us to enrich the theoretical explanation of the phenomenon (Yin, 2009; Eisenhardt, 1989). In this research, there are several key constructs, and it is unknown a priori how they interrelate. The case study offers an ideal method in such complex instances using multiple data sources and provides the ability to capture the dynamic and interconnected nature of the processes studied (Gehman *et al.*, 2018). Moreover, using multiple cases enables a broader exploration of research

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questions and theoretical elaboration. Even a few additional cases can significantly enhance the quality of the emergent theory, leading to more robust, generalisable, and testable theoretical developments compared to single-case research (Eisenhardt and Graebner, 2007).

3.1 Case Selection

The fast fashion industry is a major contributor to the global economy and is projected to reach \$163.5 billion by 2025 (Jeszka, 2015; Ma *et al.*, 2017). Here, short product life cycles, driven by volatile and personalised demand, heighten decision-making uncertainty for supply chain stakeholders (Moyano-Fuentes and Martínez-Jurado, 2016). IoT has been adopted to strengthen information integration and mitigate such uncertainty (Sanders and Wan, 2018). Yet, despite its growing use, empirical research on how IoT-enabled information integration specifically addresses decision-making uncertainty in fast fashion supply chains remains limited (Karaosman *et al.*, 2020). Therefore, fast fashion was purposely chosen for this study.

Background research on the fast fashion industry in China identified three typical fast fashion supply chains based on market share, product volume, and IoT infrastructure: sportswear, women's casualwear, and men's fashion wear. These categories were selected because they capture the diversity of product characteristics in fast fashion: sportswear is highly functional and innovation-driven, women's casualwear is trend-sensitive and demand-volatile, and men's fashion wear balances style cycles with more stable product lines. This variation makes them particularly illustrative for examining whether product category influences IoT implementation. Other fast fashion categories, such as children's wear and fashion accessories, were excluded because they have comparatively smaller market shares, lower strategic relevance, or limited IoT implementation in China, making them less suitable to meet the study's objectives. In contrast, the three selected categories represent major segments of the fast fashion industry where IoT adoption is already visible and strategically important.

The unit of analysis is IoT-enabled information integration practices and their effects on decision-making uncertainty and supply chain performance within a focal fast-fashion supply chain network. Each "case" is therefore defined as a product-category supply chain network in China (sportswear, women's casualwear, and men's fashion wear) that includes multiple tiers and roles (brand owner/retailer, manufacturer, raw material supplier, and distributor). This definition aligns with IPT because information-processing needs and capabilities are distributed across interdependent actors, and "fit" is achieved (or constrained) through both within-firm and inter-firm integration practices.

To enable collection of rich data, each case was selected to include at least four different supply chain stakeholders, encompassing brand owners (retailers), apparel manufacturers, raw material suppliers, and distributors; ensuring a complete supply chain in each case. The geographical and industrial context is kept constant, but as product category has a known impact on supply chain characteristics (Zimmermann *et al.*, 2020), the case studies seek to investigate whether product category influences IoT implementation. Different company sizes are also considered to improve the generalisability of the cases.

The interviewees were selected based on criteria recommended by previous qualitative supply chain management case studies (Rymaszewska *et al.*, 2017; Michel *et al.*, 2023). The interviewee's level of involvement in supply chain management, their understanding of decision-making uncertainty, the company's demands for implementing IoT in their firm, and their availability and willingness to be involved in the interview process were used as selection criteria. At least one participant (e.g. the president/CEO or a senior manager) was selected in smaller companies, and two interviewees in large companies (e.g. managers directly related to supply chain management and technical support team directors). Each case comprised 10 interviewees, 8 from large companies and two from small companies. All interviewees held a management or IT-related position. Most of them have over 10 years supply chain experience. Table 1 details the roles of interviewees in each case.

3.2 Data Collection

In-depth semi-structured interviews were employed, allowing the collection of rich data, exploring a range of perspectives and ensuring that participants' experiences and views were reflected (Siddiqui *et al.*, 2020). The three-part interview protocol was developed based on extant research and Figure 1 and updated based on interviewee feedback. The interviews began with the interviewee's understanding of IoT technologies and how much they were involved in implementing them. Interviewees were then asked to describe why and how they adopted IoT to support information integration through information collection, selection, and sharing processes, and the impact on supply chain performance. The second portion of the interview focussed on changes in the measurement of decision-making uncertainty after implementing IoT. In the final part of the interview, the interviewee's opinions on the relationship between information integration and decision-making uncertainty were collected. The data collection protocol was pilot-tested with five interviewees from the sportswear supply chain to ensure the content validity, clarity, and understandability of each question. In total, 30 interviewees were interviewed (average duration 45 min.). The data was collected between September 2021 and February 2022. The original transcripts are in Chinese and were translated into English for data analysis. To ensure translation quality, a professional translator and two bilingual experts with knowledge in supply chain management terminology

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conducted the initial translation. The translated transcripts were then reviewed by two bilingual researchers, who compared them with the originals to verify accuracy, consistency, and the preservation of meaning. Any discrepancies were discussed and resolved collaboratively, ensuring that the final English transcripts accurately reflected the participants' intended meanings.

To verify the interviewee's answers, support the findings, and realise data triangulation (Glover *et al.*, 2014), additional data, including organisations' annual reports, site visits, and website materials were also collected and observations in three companies carried out (as shown in Table 2). This data is mainly qualitative. Observations were conducted in three companies. These sources were not treated as background only: they were used to verify the presence and scope of IoT systems (e.g., RFID use, platform dashboards), corroborate reported process changes (e.g., real-time inventory tracking, exception handling routines), and triangulate performance-related claims when documents contained relevant indicators (e.g., inventory accuracy reports, lead-time tracking dashboards). In the analysis, documentary and observational evidence was coded alongside interview data and linked to corresponding findings.

This study received ethical approval from Cranfield University. All interviewees provided an informed consent form before participation and were assured of confidentiality and the right to withdraw their data at any stage. The participating firms also approved the use of anonymised quotations. Interpretations of the findings were shared with key informants to ensure accuracy and confirm that the representation of their perspectives was accurate and acceptable.

3.3 Data Analysis

Template analysis is adopted in this research, which provides flexibility in data coding in theory elaboration research (King, 2012). It is suitable for studying the relationship between the factors in supply chain management research (Lusiantoro and Yates, 2021; Zubairu *et al.*, 2021). The analysis followed four steps and maintained an explicit audit trail.

Step 1: Develop a priori themes (IPT-based). We first generated a set of a priori themes from the initial IPT-based relational framework (Appendix A), which provided the higher-order structure for analysing uncertainty, information integration, and performance.

Step 2: Build the initial template through first-wave coding. Two researchers conducted the first wave of coding using the initial template (Appendix B), adding lower-order codes when data did not fit existing categories. Within case saturation was determined through tracking new lower-order codes by interview sequence, new codes diminished after between seven and nine interviews in all cases. Subsequent coding waves refined code definitions,

merged overlapping codes, and developed second-order themes that aligned with IPT “fit” logic (needs–capabilities alignment).

Step 3: Refine and enrich the template through iterative coding. We then conducted a second wave of coding to refine the template by adding, revising, and nesting lower-order codes and subcodes based on detailed transcript analysis. Each transcript was revisited using the first-wave results to ensure consistent application and to capture additional nuance not captured in the initial template.

Step 4: Reliability and the resolution of disagreements. To strengthen reliability and reduce researcher bias, both co-authors who were not involved in data collection audited the coding decisions. We first held calibration sessions to align code definitions and update the codebook. Two senior researchers independently coded 30% of the transcripts; Cohen’s Kappa was 0.76, indicating substantial agreement (Landis and Koch, 1977). Disagreements were then resolved through structured adjudication: coders documented the rationale for their coding, discussed discrepancies against code definitions and raw excerpts, and updated the codebook where needed to prevent recurrence. Where disagreement reflected genuine ambiguity, we retained alternative interpretations until triangulation evidence or cross-role corroboration supported a final categorisation. Cross-case saturation was confirmed at this stage, with no new second-order themes emerging after analysis of the third case.

Table 1. Details of cases and interviews conducted

Cases	Organisation type	Employees (Mainland China)	Interviewees	Participant No.	Years of service (current position)	Year of working in the supply chain
Case 1 - sportswear supply chain	Brand owner	618	Senior purchasing manager of a sportswear brand	15	3	11
			Senior operations manager of a sportswear brand	17	5	13
	Raw Material Supplier 1	271	General manager of a fabric supplier	21	4	16
			Senior sales manager of a fabric supplier	23	5	12
	Raw Material Supplier 2	671	Senior sales manager of a trim supplier	29	3	10
	Manufacturer 1	980	Senior sales manager of an apparel manufacturer	9	4	13
			Lean manager of an apparel manufacturer	10	3	13
	Manufacturer 2	120	Operations director of an apparel manufacturer	11	4	12
	Distributor	1285	Operations manager of a distributor	3	4	14
			Senior manager of a distributor	27	5	10
Case 2 - women's casual wear supply chain	Brand owner	5000	Senior sales manager of a women's casual wear brand	13	5	11
			Sales manager of a women's casual wear brand	14	6	9
	Raw Material Supplier 1	100	Senior sales manager of a fabric supplier	24	4	13

Case 3 - men's fashion wear supply chain			Department director of a fabric supplier	25	5	16
	Raw Material Supplier 2	70	Senior operations manager of a trim supplier	26	3	11
	Manufacturer 1	262	Sales manager of an apparel manufacturer	2	4	8
			Development director of an apparel manufacturer	12	5	13
	Manufacturer 2	54	CEO of an apparel manufacturer	16	8	26
			Operations director of an apparel manufacturer	18	6	15
	Distributor	180	Operations director of a distributor	28	4	16
	Brand owner	403	IT director of a men's fashion wear brand	4	5	10
			Department director of a men's fashion wear brand	5	3	11
	Raw Material Supplier 1	220	Sales manager of a fabric supplier	6	6	8
	Raw Material Supplier 2	134	Senior manager of a fabric supplier	19	4	12
			Development director of a fabric supplier	22	5	14
	Manufacturer 1	207	Manager of an apparel manufacturer	1	5	7
	Manufacturer 2	158	CEO of an apparel manufacturer	7	6	26
			IT director of an apparel manufacturer	8	4	11
	Distributor	46	Department manager of a distributor	20	3	9
			Senior manager of a distributor	30	5	12

Table 2. Additional data collection for data triangulation

Cases	Documentary Evidence	No. of documents
The sportswear supply chain	Company and industrial news related to IoT applications in the supply chain, supply chain issue analysis report, company performance report	12
The women's casual wear supply chain	Company presentations related to IoT applications in the supply chain, Reports related to supply chain issues, company performance report	8
The men's fashion wear supply chain	Company and industrial reports related to IoT applications in the supply chain, internal assessments about the decision-making uncertainty's impact, company performance reports, database information	17
Case	Observation Activity	Time
The sportswear supply chain	Tour of the brand's head office in Shanghai. Observation included watching the production planning activities, controlling the tower to connect different manufacturers and suppliers, and the innovation department.	2h
The women's casual wear supply chain	Tour of one manufacturer in Shanghai. Observation included watching the assembly lines as well as the package and storage management for finished goods.	1.5h
The men's fashion wear supply chain	Tour of the warehouse centre in Suzhou. Observation included watching the auto inventory management and the inbound and outbound logistics for goods.	1h

To address translation bias, we used professional translation followed by bilingual verification against the original Chinese transcripts, with discrepancies documented and resolved to preserve meaning (Liu et al., 2016). To reduce role and confirmation bias (including the risk of “forcing” data into IPT categories), we employed cross-role triangulation, independent coding audits by co-authors not involved in data collection, calibration sessions and iterative codebook refinement, member checking, and conservative interpretation of absence-of-evidence findings. (Venkatesh et al., 2020). To reduce cultural bias, we first coded culturally grounded meanings directly from the original Chinese transcripts and only then mapped these interpretations to IPT categories; we further triangulated interpretations

across stakeholder roles and supply-chain tiers to avoid relying on any single culturally situated viewpoint (Farquhar, 2020).

Rather than treating the absence of a theme as a general mechanism, we report it conservatively. For instance, “firm uncertainty” was not salient in our interview dataset; we therefore treat this as a context-specific observation in these cases rather than a universal claim, and we discuss plausible boundary explanations in the discussion section.

3.4 Within-Case and Cross-Case Analyses

Within-case and cross-case analysis is carried out to aggregate the findings (Yin, 2009; King, 2012). Within-case analysis identified the key elements of the implementation of IoT for each case by identifying the different implementation stages, their influence on information integration and decision-making uncertainty, and the impact of the relationship between information integration and decision-making uncertainty on supply chain performance. These patterns strengthen familiarity with cases and accelerate cross-case comparison (Eisenhardt, 1989). The key elements of information integration and decision-making uncertainty identified in the three cases were compared horizontally and vertically in the cross-case analysis. This comprehensive approach allows more robust theories to emerge (Eisenhardt and Graebner, 2007).

4. Findings

4.1 Impact of Implementing IoT on Information Integration

Our findings demonstrate that IoT impacts four stages of information integration: internal information collection (Stage 1), internal information selection (Stage 2), information sharing across firms (Stage 3), and decision-making support (Stage 4). This staged process is consistent across all three cases, suggesting a convergent pattern of capability development. However, the extent of technology diffusion across supply chain partners and the governance of shared data (e.g., access rights and disclosure rules) varies by case. In all cases, Stage 4 was not fully realised. Therefore, IoT enhances information processing capability, but the benefits vary by stage.

In the information collection stage, IoT implementations such as RFID chips reduce errors, speed up data acquisition, and provide more reliable information by “letting the things talk directly.” This supports extant IPT-based research, which suggests that an organisation’s information processing capability increases by both the amount and richness of available data (Kache and Seuring, 2017; Khanuja and Jain, 2019). At the same time, as data is generated by “things”, IoT also reduces reliance on human input, which minimises variability in information collection processes.

In the information selection stage, technologies such as 5G and data filtering enhance the speed and accuracy of information transfer. As a senior manager of a fabric supplier in Case 2 (Participant 24) highlighted:

"We have combined IoT with our existing system to upgrade internal information transfer, [...]. This way, the filtered information from the work floors is directly aggregated into our system with zero errors."

This enhances timeliness and quality, key elements of information processing capability. However, interviewees highlight a trade-off: faster and more accurate transmission can increase exposure to cybersecurity vulnerabilities, making risk management more salient at Stage 2.

In the information sharing stage, IoT platforms such as cloud computing facilitate the synthesis and exchange of real-time information among supply chain partners. This enables richer and timelier communication, strengthening collective information processing capability. From an IPT perspective, IoT expands the processing capacity of the supply chain by allowing firms to connect and act on a broader and more accurate set of information. A sales manager of a fabric supplier in Case 3 (Participant 6) indicated:

"The information sharing platform records the information from raw materials to final products [...], and the customers (brand owners) simply check the information they need in the system. Moreover, the system can report the information changes immediately. Thus, a quick response can be achieved."

However, there is also a negative impact on information security at this stage, increasing the risk of over-disclosure and information leakage. Brand owners, raw material manufacturers, and manufacturers all emphasised the importance of carefully screening shared information. Revealing sensitive product or process details risks reducing competitive advantage. As an operations director of an apparel manufacturer in Case 1 (Participant 11) pointed out:

"The key point is that we must think carefully about the information we put into the platform. Much product-related information needs to be kept confidential. If the information is overly disclosed, it harms the company."

Across cases, these security concerns shaped the scope of information sharing (what was shared, with whom, and at what granularity), which in turn influenced how strongly inter-firm coordination benefits were realised.

In the decision-making stage, IoT is combined with other advanced technologies, such as AI and big data analytics, to support real-time decision-making. Stage 4 was only partially

observed: one focal firm (the brand owner in Case 3) reported early use of IoT-enabled integration together with AI for replenishment decisions, while other firms had not progressed beyond Stage 3. This firm uses IoT-enabled data integration together with AI to optimise stock replenishment across stores. The director of the general manager's office (Participant 5) explained, that this allowed replenishment strategies to be tailored to sales patterns in different locations, improving the accuracy of operational decisions. Interviewees across all cases highlighted issues that limit the implementation at Stage 4. First, the high cost of IoT infrastructure and complementary technologies such as AI makes large-scale implementation difficult, especially for smaller firms. Second, firms face challenges in deciding which technologies are appropriate for their specific contexts, as IoT solutions are not off-the-shelf products but require adaptation to organisational needs. As a general manager of a fabric supplier in Case 1 (Participant 21) emphasised,

"IoT is not a simple software or hardware that someone can just buy and use [...] we transformed the IoT into our resources according to our needs. If we do not do this, the impact of IoT cannot be significant in our supply chain."

IoT, therefore, enhances the accuracy, timeliness, and reliability of information at both the firm and supply chain levels, strengthening information processing capabilities. The impact of IoT-based information integration on information security is a dilemma. On the one hand, IoT promises greater information visibility in supply chain operations; on the other, it heightens exposure to information security risks. This tension is especially significant because information systems, as the backbone of modern supply chains, are not only enablers of integration but also prime targets for information technology derived risks. The results are illustrated in Table 3

Information integration processes		IoT implementation status (number of interviewees)						Technologies applied	IoT's impact			
		Case 1		Case 2		Case 3			Information accuracy	Information quality	Information efficiency	Information security
Stage 1	Information collecting	BO	100%	BO	100%	BO	100%	RFID, Smart Cameras, Smart Meters, sensor network	-	√√	-	√
		RM	100%	RM	100%	RM	100%					
		M	100%	M	100%	M	100%					
		D	100%	D	100%	D	100%					
Stage 2	Information selecting	BO	100%	BO	100%	BO	100%	5G, Bluetooth, Data Filtering and Pre-processing Algorithms, wireless network	-	√√	-	X X
		RM	100%	RM	50%	RM	100%					
		M	100%	M	50%	M	100%					
		D	100%	D	100%	D	100%					
Stage 3	Information sharing	BO	100%	BO	100%	BO	100%	Cloud Computing Platforms, Smart Hub, information exchange network	√	-	√√	X X
		RM	100%	RM	50%	RM	100%					
		M	100%	M	50%	M	100%					
		D	100%	D	100%	D	100%					
Stage 4	Decision-making support	BO	100%	BO	100%	BO	100%	AI-support control system, Big data analysis, Block chain-based platform	-	-	√	-
		RM	50%	RM	0%	RM	50%					
		M	50%	M	0%	M	50%					
		D	0%	D	0%	D	0%					

Table 3. IoT implementation and impact on information integration BO Brand Owner, RM Raw Material Supplier, M Manufacturer, D Distributor, - no impact, √ positive impact, X negative impact, √√ or XX indicates agreement of impact across all cases)

4.2 Relationship between IoT-enabled Information Integration and Decision-Making

As no cases have completed Stage 4, this section focusses on Stages 1 – 3. Cross-case pattern matching suggests that Stages 1–2 strengthen within-firm information quality to address environmental uncertainty, whereas Stage 3 strengthens inter-firm accuracy and efficiency to mitigate industry uncertainty (e.g., demand distortion). For instance, the majority of interviewees in Cases 1 and 3 (17 out of 20) believe interactions between information integration and decision-making uncertainty increase after implementing IoT. This reflects an improved fit between IoT-enabled information integration and decision-making uncertainty.

Detailed interactions are presented in Table 4. The table shows that for all three stages, the majority of respondents in all three cases agree that implementing IoT-enabled information integration improved information quality, accuracy, and efficiency. This led to a reduction in the issues caused by the environmental and industry uncertainty aspects of decision-making uncertainty. Implementing IoT allowed the whole supply chain to achieve real-time information collection, fulfilling the need for reliable and timely information created by decision-making uncertainty.

Our findings also reveal that IoT contributes differently at each information integration stage. At the information collection and selection stages, IoT enhances information quality, aligning with environmental complexity and richness. Therefore, the fit is between IoT-enabled information collection and selection and environmental uncertainty. Specifically, IoT improved information quality by improving information reliability and meeting users' requirements for information collection and selection. IoT also enables access to a broader range of information sources, capturing all the information currently in operation and increasing the amount of usable information available in the supply chain, thereby fulfilling the information processing needs created by high environmental complexity and low environmental richness. As a development director of a fabric supplier in Case 3 (Participant 22) illustrated:

"The real-time information collected by RFID guarantees the quality of information for us to analyse. Thus, the quick adjustment ability of order scheduling, the transparency of production processing, and the reasonability of sales planning are all improved. Consequently, the resistance to unexpected business environment change is improved."

At the information sharing stage, IoT enhances information accuracy and efficiency, enabling supply chain stakeholders to reduce demand distortion. Here, the fit shifted from firm-level alignment with environmental uncertainty to supply chain-level alignment with industry uncertainty.

For instance, in Case 1, IoT enables real-time information sharing between partners for data analysis and optimising forecasts, thus mitigating demand distortion. As a senior operations manager of the brand owner in Case 1 (Participant 17) indicated:

"First of all, forecasting efficiency will be improved [...]. The second point is that if the stakeholders in the supply chain decide to implement IoT for information sharing, the relationship between them becomes closer [...], sharing key data can be achieved, making the prediction more accurate."

Similarly, in Case 3, the manufacturers indicate that IoT enhances communication through an information sharing platform. This system improves information accuracy and efficiency, deepening supply chain integration and reducing the impact of demand distortion. As a manager of an apparel manufacturer in Case 3 (Participant 1) reported:

"With the information sharing system, our customer and us achieve win-win cooperation, and the relationship with our customer becomes more stable and long-term than in the past. As a result, we can acquire more accurate demand information effectively and reduce demand distortion."

Observations made during the tours (at the brand owner's head office in Case 1 and a warehouse in Case 3) also highlighted production planning processes and inventory management procedures, indicating improvements in demand forecasting following the implementation of IoT in the information-sharing process. Connections between both the warehouse and related manufacturers and the head office and its suppliers were enhanced, optimising information accuracy and efficiency and improving demand forecasting. As a result, the impact of demand distortion was reduced.

Thus, the relationship between information integration and decision-making uncertainty can be understood using fit: IoT-enabled integration enhances information quality to match the demands of environmental complexity and richness, and it improves information accuracy and efficiency to address the information processing needs created by demand distortion.

Proportion of Interviewees who confirmed						Information integration stage	IoT's impact	Interactions with decision-making uncertainty			
								Environmental uncertainty		Industry uncertainty	Firm uncertainty
Case 1		Case 2		Case 3				Environmental complexity	Environmental richness	Demand distortion	Technology implementation willingness
BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	100% 100% 50% <i>100%</i>	BO RM M D	100% 100% 100% <i>100%</i>	Information collecting	Information quality	√	√	-	-
BO RM M D	100% 100% 100% 100%	BO RM M D	<i>100%</i> <i>100%</i> 100% <i>100%</i>	BO RM M D	100% 100% 100% 100%	Information selecting	Information quality	√	√	-	-
BO RM M D	100% <i>100%</i> 100% <i>100%</i>	BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	<i>100%</i> 100% 100% <i>100%</i>	Information sharing	Information accuracy	-	-	√	-
BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	100% 50% 50% <i>100%</i>	BO RM M D	100% 100% 100% 100%		Information efficiency				

Table 4. The interactions between information integration and decision-making uncertainty after implementing IoT in selected cases (BO Brand Owner, RM Raw Material Supplier, M Manufacturer, D Distributor, Bold – agree, italics – disagree, √ have interaction, - no interactions)

4.3 The Relationship's Resulting Impact on Supply Chain Performance

From an IPT perspective, our findings explain how performance improves when the fit between information processing needs, created by environmental and industry uncertainty, and information processing capability, enhanced by IoT-enabled information integration, is achieved. As summarised in Table 5, the relationship between IoT-enabled information integration and decision-making uncertainty influences supply chain performance along two key dimensions: production operations and cost management.

In production operations, IoT-enhanced information quality, accuracy, and efficiency improve response speed, product flexibility, and process efficiency. This represents a closer fit between the increased information demands generated by uncertainty and firms' ability to process reliable and timely data. For instance, an operations director of a supplier in Case 2 reported that this fit enhances supply chain visibility and efficiency by providing an intuitive data collection method and increasing information accuracy. Similarly, the manufacturers in Case 1 saw that this relationship helped with production management. As a lean manager of an apparel manufacturer in Case 1 (Participant 10) illustrated:

"With more accurate information we collected from supply chain management processes, the uncertainty in our decision-making process is reduced, and the production process is optimised."

Cost impacts, however, were more conditional. Although IoT replaced some manual activities (e.g., RFID-based inventory checks) and supported more accurate forecasts that improved asset utilisation, the immediate cost benefits were limited. Our cases indicate that the relationship between IoT-enabled information integration and environmental uncertainty did not translate into cost reductions. Instead, financial benefits were observed when IoT-enabled information sharing supported cross-firm coordination and mitigated industry-level uncertainty. IoT-enabled information integration addressed industry-level decision-making uncertainty. For instance, the distributor in Case 1 uses RFID to collect inventory-level information. This technology-based system not only guarantees the quality and efficiency of information collection but also reduces the time and labour required for manual information collection. Moreover, the inventory turnover ratio increases as real-time information derived forecasts reflect actual customer demand, thereby improving asset utilisation. As a senior purchasing manager of the brand owner in Case 1 (Participant 15) reported:

"For example, with demand information from consumers, we can make what they demand into our stock, which reduces our inventory level as well as our suppliers."

The distributors in Case 3 and the brand owner in Case 1 added that the benefits of IoT implementation, on return on investment (ROI), are often delayed due to the time required

for adaptation and overcoming the learning curve. Additionally, the Brand owners in Case 2 demonstrate that ongoing operational and maintenance costs, including the management of large data volumes, can be substantial.

These results extend prior conceptual work by showing that the performance effects depend on the type of relationship between IoT-enabled information integration and decision-making uncertainty. The relationship between IoT-enabled information integration and environmental uncertainty enhances operational efficiency and flexibility. In contrast, the relationship between IoT-enabled information integration and industry uncertainty leads to cost reductions. Thus, our finding is consistent with IPT, supply chain performance improvements are not directly attributed to IoT implementation, but rather to the degree to which the improved information processing capability resulting from IoT-enabled information integration aligns with the specific information processing needs generated by decision-making uncertainty.

Proportion of Interviewees who confirmed							impact on supply chain performance							
							Interactions			Production operations			Cost management	
										Response speed	Production flexibility	Process efficiency	Total cost	Asset utilisation
Case 1	Case 2	Case 3												
BO RM M D	100% 50% 50% <i>100%</i>	BO RM M D	100% <i>100%</i> 50% 100%	BO RM M D	100% 50% 75% <i>100%</i>	Environmental complexity and Information quality	√	√	√	-	-			
BO RM M D	100% 100% 75% <i>100%</i>	BO RM M D	100% 75% 100% <i>100%</i>	BO RM M D	100% 75% 75% 100%	Environmental richness and Information quality	-	√	√	-	-			
BO RM M D	100% 50% 50% 100%	BO RM M D	100% 50% <i>100%</i> <i>100%</i>	BO RM M D	100% 50% 75% 100%	Demand distortion and Information accuracy	-	√	√	√	√			
BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	100% 25% 25% 100%	BO RM M D	100% 75% 100% <i>100%</i>	Demand distortion and Information efficiency	√	-	-	√	√			

Table 5. The impact of the interactions on supply chain performance (BO Brand Owner, RM Raw Material Supplier, M Manufacturer, D Distributor, bold – agree, italics – disagree, √ have interaction, - no interactions)

5. Discussion

Our results demonstrate how IoT implementation changes the relationship between information integration and decision-making uncertainty, and how these changes, in turn, affect supply chain performance (summarised in Figure 2). Three key perspectives emerge from our empirical cases.

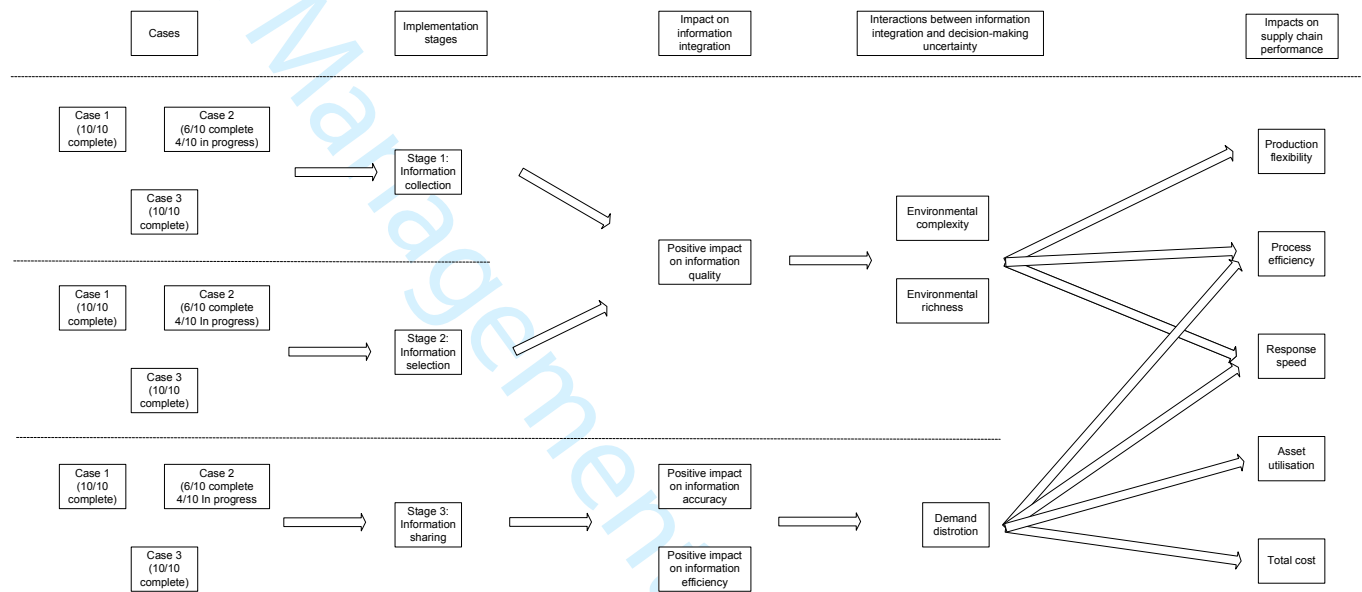


Figure 2. The relationship between different information integration processes and decision-making uncertainty

First, IoT implementation changes how information integration is achieved within firms and across supply chains. Prior to IoT, information integration relied heavily on manual processes that were often slow, error-prone, and unreliable. After IoT implementation, real-time collection and selection of data improves information quality, while supply chain-level information sharing improves accuracy and efficiency. These findings confirm earlier research on real-time data processing (Fatorachian & Kazemi, 2021) and extend it by demonstrating that IoT changes information security. Strengthening security at the firm level (collection and selection) but introducing risks at the supply chain level (sharing). This differentiation explains the shift in how firms experience the trade-offs of information integration. Thus, answering RQ1 we propose that:

Proposition 1a: IoT implementation has a more significant impact on information quality in the firm-level information collection and selection processes than on the supply chain-level information sharing process.

Proposition 1b: IoT implementation in the supply chain level information sharing process has a more significant impact on information accuracy and efficiency than in the firm level information collection and selection processes.

Proposition 1c: IoT implementation improves information security in the firm-level information collection and selection processes but has a negative impact on information security in the supply chain level information sharing process.

Secondly, building on previous research that identified the relationship between information integration and decision-making uncertainty (Yu *et al.*, 2019). Our findings illustrate that IoT changes how information integration interacts with decision-making uncertainty. Before IoT, supply chain stakeholders struggled to match information-processing needs created by environmental and industry uncertainty with their existing information processing capabilities. After IoT implementation, internal integration processes (collection and selection) allow firms to better cope with environmental complexity and richness, while supply chain-level integration (sharing) enables more accurate demand forecasts and reduces demand distortion. This explanation extends the findings of Wong *et al.* (2015), who suggest that advanced technologies help reshape the relationship between information integration and decision-making uncertainty in the supply chain. It is demonstrated that IoT helps realign “fit” by shifting the balance between information-processing needs and capabilities. Importantly, our findings also show that information security, while it helps ensure data integrity, does not directly impact the factors underpinning decision-making uncertainty. This extending our answer to RQ1 we propose that:

Proposition 2a: IoT implementation in the information collection and selection processes has a more significant impact on the relationship between information integration and decision-making uncertainty at a firm level than in the information sharing process.

Proposition 2b: IoT implementation in the information sharing process has a more significant impact on the relationship between information integration and decision-making uncertainty at the supply chain level than the information collection and selection processes.

In the case of firm uncertainty, all the supply chain stakeholders in all three cases confirm that the practical experience of managers or rules and regulations can overcome firm uncertainty. Thus, its impact on supply chain management can be managed and does not increase information processing needs. Therefore, our study finds no interaction between firm uncertainty and information integration.

Third, distinct from previous studies, we find that IoT changes the way supply chain performance outcomes are realised. Without IoT, stakeholders do not see clear financial

benefits from information integration. This explains prior studies where short-term financial benefits were not achieved after implementing IoT (Raj *et al.*, 2020). After IoT-enabled integration, operational improvements (e.g., response speed, product flexibility, efficiency) emerge at the firm level. In contrast, financial improvements (e.g., cost reduction, asset utilisation) emerge only after demand distortion is reduced by improvement in the information sharing stage. This phenomenon has been addressed previously by research at the firm level (Bravo *et al.*, 2023). This research provides empirical evidence of this phenomenon at the supply chain level. Therefore, answering RQ2 we propose the following:

Proposition 3: At the supply chain level, the degree of IoT implementation has a key influence on how the relationship between information integration and decision-making uncertainty impacts supply chain performance.

In addition to the discussion above, we found no evidence that different product categories or company sizes affect the implementation of IoT applications. The analysis results did not show an exact relationship between product category and decision-making uncertainty.

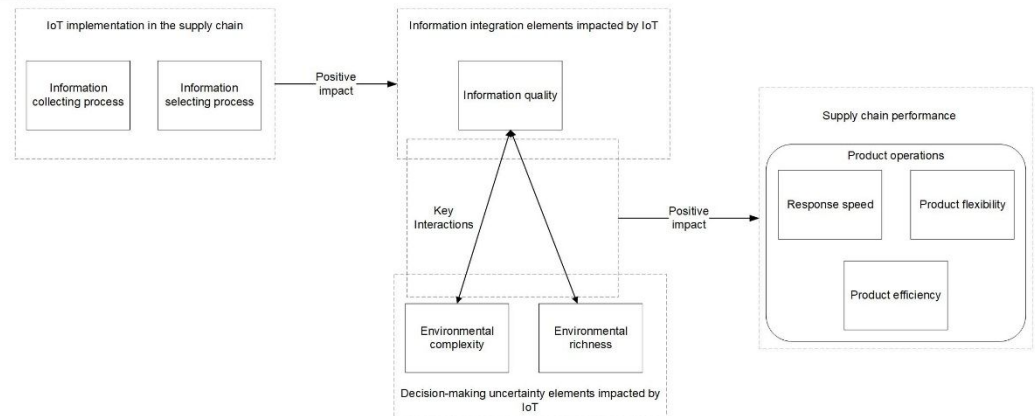
Building on IPT, we propose an extended relational framework (Figure 3) to capture these dynamics.

6. Conclusions

6.1 Theoretical Implications

This study makes theoretical contributions through the elaboration of our IPT-based framework. Specifically, we propose three propositions that highlight the key elements of the interactions between information integration and decision-making uncertainty during IoT implementation. We then illustrate the key differences between these interactions at the firm and supply chain levels, before explaining the link to supply chain performance and thus answering our research questions.

Framework I: After implementing IoT in the information collection and selection processes of information integration



Framework II: After implementing IoT in the information sharing process of information integration

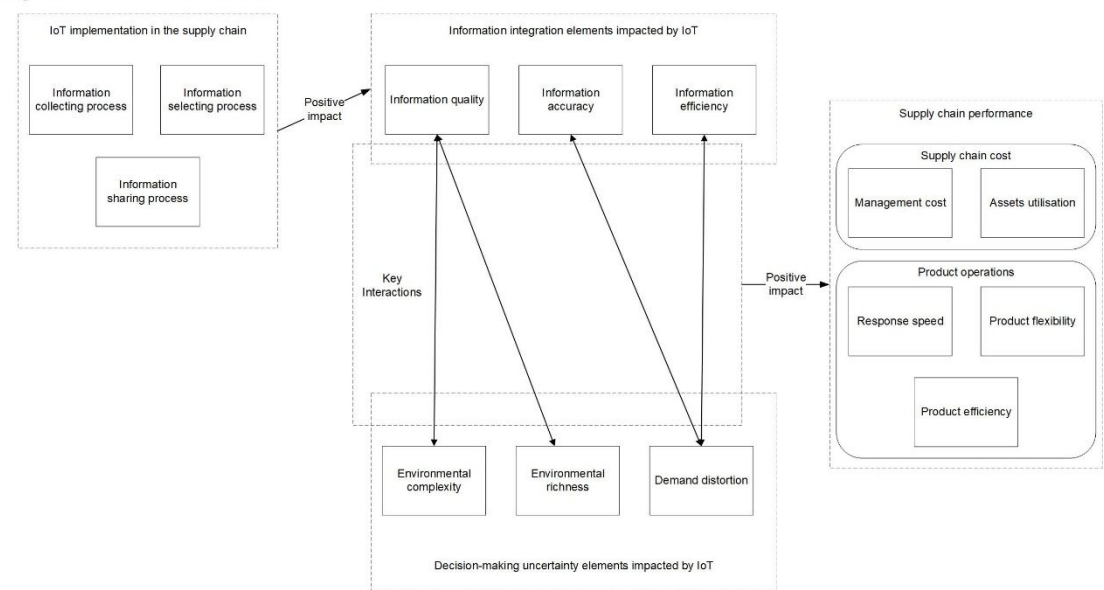


Figure 3. The relationship between IoT-enabled information integration and decision-making uncertainty and the resulting impact on supply chain performance

First, while previous studies associated IoT implementation with overall supply chain improvements at a global level (e.g., Singh & Garg, 2015), our cross-case patterns suggest that the relationship between IoT and performance depends on the context in which IoT is implemented. This differentiation helps explain why operational benefits were reported earlier, while cost-related outcomes were reported most clearly once inter-firm sharing and coordination mechanisms were established. Second, the study provides boundary conditions for digital integration research by highlighting the benefits of IoT implementation. While earlier models (e.g. Yu et al., 2019) often positioned uncertainty as a moderator or mediator between integration and performance. Our framework advances this perspective highlighting the fundamental differences between the mechanisms governing firm-level and supply chain-level IoT implementation processes (Figure 3). Finally, we translate these patterns into empirically grounded propositions that support extant conceptual research (e.g., Birkel and

Hartmann, 2019). While acknowledging that our claims are bound to three Chinese fast-fashion supply chains, we provide a holistic view of how supply chain stakeholders implement IoT in information integration processes.

6.2 Managerial Implications

This study offers several practical insights for managers seeking to implement IoT in supply chain management. A key implication is the need to separate operational and financial outcomes. Early IoT implementation, in information collection and selection, improves response speed, flexibility, and information quality but does not immediately reduce management costs. Managers should therefore set realistic expectations and view these stages as capability-building steps rather than expect direct cost-savings.

The research also highlights that financial benefits emerge only after IoT supports information sharing across the supply chain. Investments in shared platforms such as cloud systems or smart hubs are essential for enabling accurate, timely information exchange among stakeholders, which in turn reduce management costs and improve asset utilisation. Managers are encouraged to implement IoT as a step-by-step process: first, strengthening internal information quality and accuracy at the firm level, and then scaling to supply chain-level integration focused on information efficiency.

Finally, managers should align IoT implementation with the areas of decision-making uncertainty where interactions have the biggest impact on supply chain performance, such as demand forecasting or inventory management. By recognising the progression from operational improvements to financial returns, managers can better justify IoT investments and foster agile, resilient, and cost-effective supply chains.

6.3 Societal and policy implications.

At a societal level, our findings highlight that digital integration can improve operational stability and reduce waste (through improved forecasting and inventory management), but it also intensifies information security and workforce capability requirements as supply chains become more connected. Policy support may therefore be needed in three areas:

1. Cybersecurity and data governance guidance for inter-firm sharing, including templates for access control and minimum security practices;
2. Support for digital infrastructure diffusion across tiers, since uneven readiness constrains end-to-end benefits; and

3. Workforce upskilling programmes (data literacy, system monitoring, response protocols) so that IoT adoption improves decision quality rather than increasing dependence on technology without organisational readiness.

6.4 Limitations and Future Directions

This research is limited to studying the implementation of IoT and its impact on the interactions between information integration and decision-making uncertainty across cases in the fast-fashion supply chain. In addition, the use of multiple qualitative case studies limits the generalisability of the findings to theory (Yin, 2009). Although with care the findings can help explain similar situations in other study contexts, such as similar supply chains in the fast-fashion industry or other consumer goods industries, the research findings lack statistical generalisability.

The study results, motivate several promising future research directions. This paper identifies elements of information integration, decision-making uncertainty, and supply chain performance and illustrates the interaction between them. Future studies could evaluate the degree of interaction between these factors and assess the extent to which the interactions impact supply chain performance. Quantitative studies (e.g., large-scale surveys or simulations) would be suitable to validate the hypotheses developed from these interactions.

Second, in response to the limitations of this research, future studies could explore the applicability, adaptability, and effectiveness of the proposed model across diverse industries such as manufacturing, healthcare, and logistics to enhance its generalisability. This includes conducting comparative studies to assess industry-specific factors that may influence outcomes, evaluating scalability at different operational levels, and identifying necessary modifications for sector-specific needs. By pursuing these directions, future research can refine the theoretical foundations while ensuring practical applicability across multiple sectors. In addition, such a study could investigate the implications of IoT implementation in the Stage 4 Decision Making Support process which was not completed in any of our case studies. A large scale survey based study could be used to test the propositions proposed in this study providing further generalisability.

Third, future studies could explore the social impacts of implementing IoT. When replying to the impact on supply chain costs, some participants (14/30) mentioned that machines replace humans after implementing IoT in the supply chain. Therefore, future research is encouraged to focus on the impact of IoT on corporate social responsibility, including the relationship between machines and workers, health and safety in the workplace, and stakeholder engagement. In addition, this study does not explicitly address the public policy relevance of IoT-enabled information integration. Important regulatory and ethical

issues, such as standards for data sharing, privacy protection, and responsible use of IoT technologies, remain underexplored. Future research could investigate how policy frameworks influence the implementation of IoT, how firms balance the trade-offs between efficiency and ethical responsibility, and how regulation might mediate the balance between innovation and data protection.

Fourth, given the final goal of implementing IoT is to develop a decision-making system, it is suggested that future research views other advanced technologies and investigates how IoT can integrate with technologies, such as Blockchain, digital twins and artificial intelligence and their resulting impact on supply chain management.

Finally, although this paper provides valuable insights into supply chain management, it does not consider the technological and cultural limitations of IoT implementation. For instance, reliance on legacy systems continues to constrain technological progress. Cultural barriers such as resistance to organisational change and workforce skill gaps reduce acceptance, trust, and collaboration related to IoT implementation. Future research may therefore examine how these technological and cultural constraints influence IoT implementation and explore strategies to facilitate the implementation in a range of diverse contexts.

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Appendices

Appendix A: The a priori themes for the coding system

Theoretical dimension	Priori themes	Secondary themes
1 Tool that improves information processing capability	IoT	
2 Information processing capability (IPT)	Information integration	Information accuracy Information quality Information efficiency Information security
3 Information processing needs (IPT)	Decision-making uncertainty	Environmental uncertainty Industry uncertainty Firm uncertainty
4 The concept of fit (IPT)	Relationship between information integration and decision-making uncertainty	

Theoretical dimension	Priori themes	Secondary themes
1 Tool that improves information processing capability	IoT	
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4 The concept of fit (IPT)	Relationship between information integration and decision-making uncertainty	

Appendix B: The framework of the initial template

Higher-order codes	Lower-order codes	Sub-codes
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3	IoT in supply chain management	Impact related to information integration	Information sharing
4			Information collection
5			Information selection
6			
7		Impact irrelevant to information integration	Decision-making support
8			
9			
10	Information integration in supply chain management	Measurement	Information accuracy
11			Information quality
12			Information efficiency
13		Positive impact	Information security
14			Transparency
15			Flexibility
16		Negative impact	Specialisation
17			Traceability
18			
19		Environmental uncertainty measurement	Higher cost
20			Invalid investment
21			
22	Decision-making uncertainties in supply chain management	Industry uncertainty measurement	The complexity of the business environment
23			The availability of resources or information in the business environment
24			Supply chain structure
25			
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36	Relationship between information integration and decision-making uncertainty	Impact of IoT	Exacerbate
37		Important	Remission
38		The goal of supply chain stakeholders	
39		Not important	The goal of supply chain stakeholders
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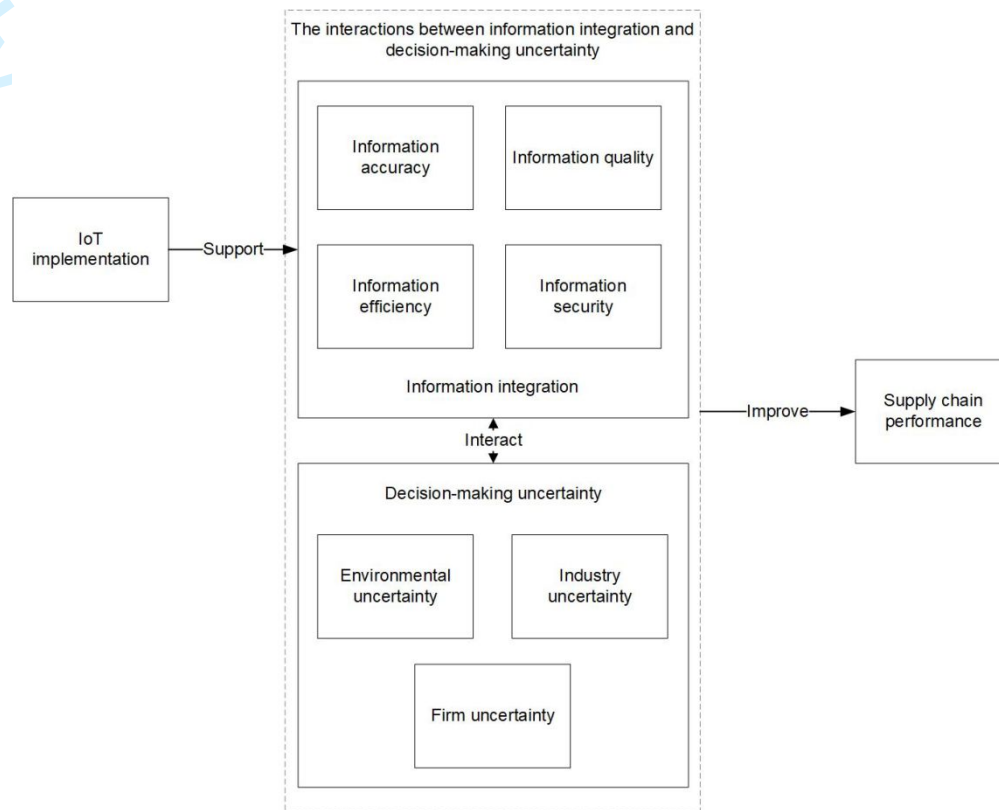


Figure 1. Information Processing theory-based relational framework of IoT implementation in supply chain management

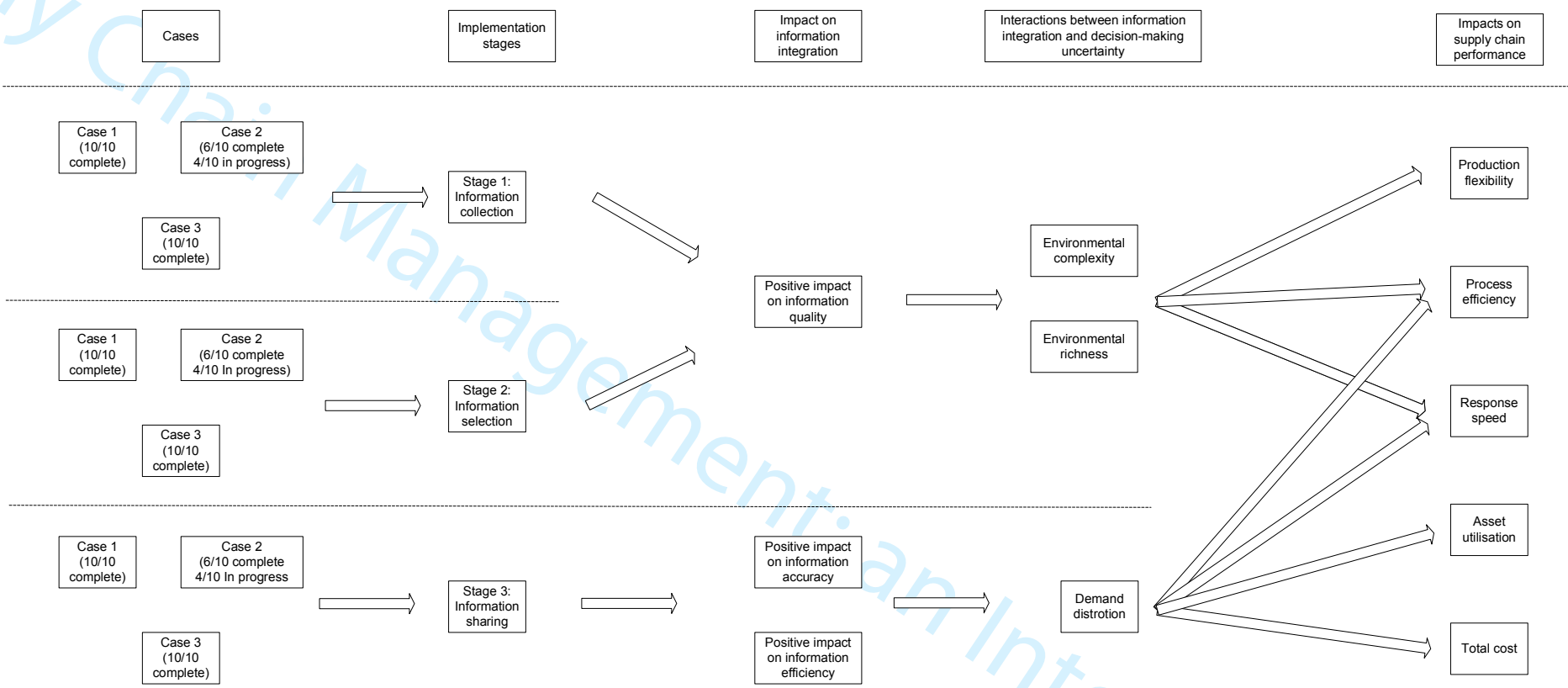
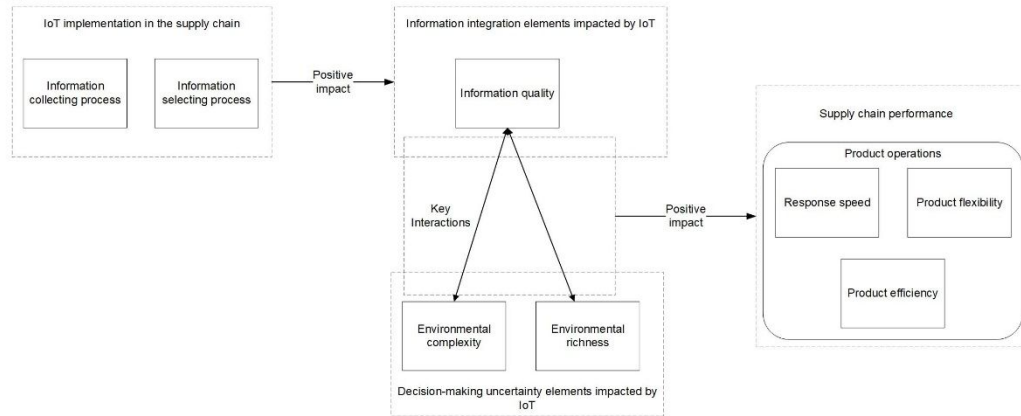


Figure 2. The relationship between different information

Framework I: After implementing IoT in the information collection and selection processes of information integration



Framework II: After implementing IoT in the information sharing process of information integration

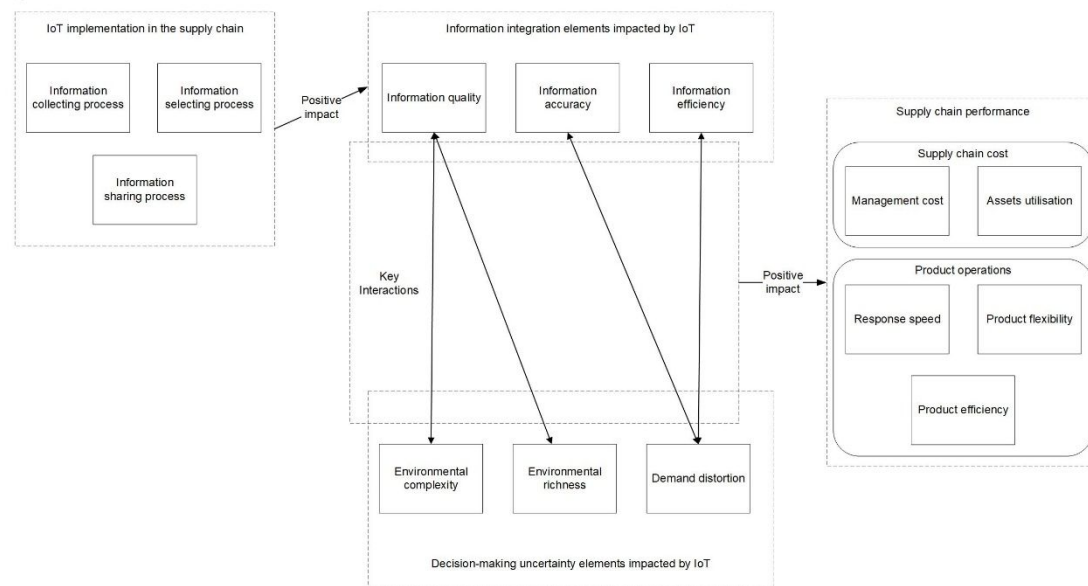


Figure 3. The relationship between IoT-enabled information integration and decision-making uncertainty and the resulting impact on supply chain performance

Table 1. Details of cases and interviews conducted

Cases	Organisation type	Employees (Mainland China)	Interviewees	Participant No.	Years of service (current position)	Year of working in the supply chain
Case 1 - sportswear supply chain	Brand owner	618	Senior purchasing manager of a sportswear brand	15	3	11
			Senior operations manager of a sportswear brand	17	5	13
	Raw Material Supplier 1	271	General manager of a fabric supplier	21	4	16
			Senior sales manager of a fabric supplier	23	5	12
	Raw Material Supplier 2	671	Senior sales manager of a trim supplier	29	3	10
	Manufacturer 1	980	Senior sales manager of an apparel manufacturer	9	4	13
			Lean manager of an apparel manufacturer	10	3	13
	Manufacturer 2	120	Operations director of an apparel manufacturer	11	4	12
	Distributor	1285	Operations manager of a distributor	3	4	14
			Senior manager of a distributor	27	5	10
Case 2 - women's casual wear supply chain	Brand owner	5000	Senior sales manager of a women's casual wear brand	13	5	11
			Sales manager of a women's casual wear brand	14	6	9
	Raw Material Supplier 1	100	Senior sales manager of a fabric supplier	24	4	13

Case 3 - men's fashion supply chain			Department director of a fabric supplier	25	5	16
	Raw Material Supplier 2	70	Senior operations manager of a trim supplier	26	3	11
	Manufacturer 1	262	Sales manager of an apparel manufacturer	2	4	8
			Development director of an apparel manufacturer	12	5	13
	Manufacturer 2	54	CEO of an apparel manufacturer	16	8	26
			Operations director of an apparel manufacturer	18	6	15
	Distributor	180	Operations director of a distributor	28	4	16
	Brand owner	403	IT director of a men's fashion wear brand	4	5	10
			Department director of a men's fashion wear brand	5	3	11
	Raw Material Supplier 1	220	Sales manager of a fabric supplier	6	6	8
	Raw Material Supplier 2	134	Senior manager of a fabric supplier	19	4	12
			Development director of a fabric supplier	22	5	14
	Manufacturer 1	207	Manager of an apparel manufacturer	1	5	7
	Manufacturer 2	158	CEO of an apparel manufacturer	7	6	26
			IT director of an apparel manufacturer	8	4	11
	Distributor	46	Department manager of a distributor	20	3	9
			Senior manager of a distributor	30	5	12

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Table 2. Additional data collection for data triangulation

Cases	Documentary Evidence	No. of documents
The sportswear supply chain	Company and industrial news related to IoT applications in the supply chain, supply chain issue analysis report, company performance report	12
The women's casual wear supply chain	Company presentations related to IoT applications in the supply chain, Reports related to supply chain issues, company performance report	8
The men's fashion wear supply chain	Company and industrial reports related to IoT applications in the supply chain, internal assessments about the decision-making uncertainty's impact, company performance reports, database information	17
Case	Observation Activity	Time
The sportswear supply chain	Tour of the brand's head office in Shanghai. Observation included watching the production planning activities, controlling the tower to connect different manufacturers and suppliers, and the innovation department.	2h
The women's casual wear supply chain	Tour of one manufacturer in Shanghai. Observation included watching the assembly lines as well as the package and storage management for finished goods.	1.5h
The men's fashion wear supply chain	Tour of the warehouse centre in Suzhou. Observation included watching the auto inventory management and the inbound and outbound logistics for goods.	1h

Information integration processes		IoT implementation status (number of interviewees)						Technologies applied	IoT's impact			
		Case 1		Case 2		Case 3			Information accuracy	Information quality	Information efficiency	Information security
Stage 1	Information collecting	BO	100%	BO	100%	BO	100%	RFID, Smart Cameras, Smart Meters, sensor network	-	√√	-	√
		RM	100%	RM	100%	RM	100%					
		M	100%	M	100%	M	100%					
		D	100%	D	100%	D	100%					
Stage 2	Information selecting	BO	100%	BO	100%	BO	100%	5G, Bluetooth, Data Filtering and Pre-processing Algorithms, wireless network	-	√√	-	X X
		RM	100%	RM	50%	RM	100%					
		M	100%	M	50%	M	100%					
		D	100%	D	100%	D	100%					
Stage 3	Information sharing	BO	100%	BO	100%	BO	100%	Cloud Computing Platforms, Smart Hub, information exchange network	√	-	√√	X X
		RM	100%	RM	50%	RM	100%					
		M	100%	M	50%	M	100%					
		D	100%	D	100%	D	100%					
Stage 4	Decision-making support	BO	100%	BO	100%	BO	100%	AI-support control system, Big data analysis, Block chain-based platform	-	-	√	-
		RM	50%	RM	0%	RM	50%					
		M	50%	M	0%	M	50%					
		D	0%	D	0%	D	0%					

Table 3. IoT implementation and impact on information integration BO Brand Owner, RM Raw Material Supplier, M Manufacturer, D Distributor, - no impact, √ positive impact, X negative impact, √√ or XX indicates agreement of impact across all cases)

Proportion of Interviewees who confirmed						Information integration stage	IoT's impact	Interactions with decision-making uncertainty			
								Environmental uncertainty		Industry uncertainty	Firm uncertainty
Case 1		Case 2		Case 3				Environmental complexity	Environmental richness	Demand distortion	Technology implementation willingness
BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	100% 100% 50% <i>100%</i>	BO RM M D	100% 100% 100% <i>100%</i>	Information collecting	Information quality	√	√	-	-
BO RM M D	100% 100% 100% 100%	BO RM M D	<i>100%</i> <i>100%</i> 100% <i>100%</i>	BO RM M D	100% 100% 100% 100%	Information selecting	Information quality	√	√	-	-
BO RM M D	100% <i>100%</i> 100% <i>100%</i>	BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	<i>100%</i> 100% 100% <i>100%</i>	Information sharing	Information accuracy	-	-	√	-
BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	100% 50% 50% <i>100%</i>	BO RM M D	100% 100% 100% 100%		Information efficiency				

Table 4. The interactions between information integration and decision-making uncertainty after implementing IoT in selected cases (BO Brand Owner, RM Raw Material Supplier, M Manufacturer, D Distributor, Bold – agree, italics – disagree, √ have interaction, - no interactions)

Proportion of Interviewees who confirmed							impact on supply chain performance							
							Interactions			Production operations			Cost management	
										Response speed	Production flexibility	Process efficiency	Total cost	Asset utilisation
Case 1		Case 2		Case 3										
BO RM M D	100% 50% 50% <i>100%</i>	BO RM M D	100% <i>100%</i> 50% 100%	BO RM M D	100% 50% 75% <i>100%</i>	Environmental complexity and Information quality	√	√	√	- - - -				
BO RM M D	100% 100% 75% <i>100%</i>	BO RM M D	100% 75% 100% <i>100%</i>	BO RM M D	100% 75% 75% 100%	Environmental richness and Information quality	-	√	√	- - - -				
BO RM M D	100% 50% 50% 100%	BO RM M D	100% 50% <i>100%</i> <i>100%</i>	BO RM M D	100% 50% 75% 100%	Demand distortion and Information accuracy	-	√	√	√ √ √ √				
BO RM M D	100% 100% 100% <i>100%</i>	BO RM M D	100% 25% 25% 100%	BO RM M D	100% 75% 100% <i>100%</i>	Demand distortion and Information efficiency	√	-	-	√ √ √ √				

Table 5. The impact of the interactions on supply chain performance (BO Brand Owner, RM Raw Material Supplier, M Manufacturer, D Distributor, bold – agree, italics – disagree, √ have interaction, - no interactions)



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