

"Digital-First" Supply Chain Resilience Framework: Propositions on the Interplay between Digital Maturity, Alert Systems, and Organizational Slack

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Keywords: Supply Chain Resilience; Digital Maturity; Alert Systems; Organizational Slack; Dynamic Capabilities; Automotive Manufacturing

Abstract: Global supply chains, especially within high-tech manufacturing sectors, are confronted with unprecedented volatility. Although digitalization is broadly advocated as an effective instrument for building supply-chain resilience, existing scholarship has not sufficiently theorized the mechanisms through which digital maturity and alert systems interact with organizational resources to foster such resilience. Against this backdrop, this conceptual study constructs a “Digital-First” Supply Chain Resilience Framework. Drawing on Dynamic Capabilities Theory, Information Processing Theory and the Resource-Based View, the paper unpacks the interplay among three core dimensions: digital maturity (covering visibility, intelligence and adaptivity), alert systems (encompassing risk-detection and escalation mechanisms), and organizational slack (including physical, relational, and cognitive slack). Its key theoretical contribution lies in the Slack Transformation Hypothesis: sophisticated digital alert systems allow enterprises to strategically replace physical slack (inventory buffers) with relational slack (supplier partnerships) and cognitive slack (analytical heuristics), thereby fundamentally reshaping the well-established efficiency-resilience trade-off.

1. Introduction

The past decades have seen unprecedented global supply chain volatility, challenging the lean manufacturing and JIT assumptions that long shaped operations. The financial toll is staggering, especially for complex, multi-tiered industries like automotive manufacturing. Supply chain disruptions cost Fortune 1000 companies an estimated \$50–\$100 billion annually in lost revenues, with major events eroding shareholder value by up to 10%[1].

In response, manufacturing firms across China and globally have pursued ambitious digital transformation, investing heavily in technologies for visibility, prediction, and agility [7]. Yet a paradox persists: many firms remain vulnerable, finding their digital dashboards merely document failures rather than prevent them. The 2021 semiconductor crisis exposed this disconnect—automotive firms with costly digital platforms still failed to foresee the chip shortage, costing the industry over 9.5 million units of lost production. In China, automakers and Tier-1 suppliers faced

stoppages and delays despite rapid digitalization, showing that adoption alone does not yield resilience.

Why does this gap persist? Digitalization is often implemented as a technology-centric project—system installation, data integration, dashboard creation—rather than a strategic transformation of capabilities, decision-making, and resource allocation. Technology provides information, not resilience. Interpreting information, mobilizing resources, and learning over time are human and organizational competencies systems cannot replicate. Firms have thus acquired digital assets without digital capabilities—the hardware of visibility without the software of intelligence[2].

This paper's framework is grounded in high-mix, low-volume automotive electronics manufacturing in China—a demanding context for studying digitalization and resilience. Four interrelated features render traditional approaches inadequate and digital capabilities valuable.

First, product variety is exceptionally high: a Tier-1 intelligent cockpit supplier may support over 200 vehicle models across BYD, Geely, Great Wall, Changan, GAC, and joint ventures, each with unique specifications, multiplying planning complexity while making inventory buffers prohibitive. Second, demand volatility is extreme: OEM orders fluctuate frequently amid China's competitive market, with short-notice revisions and continuous model introductions creating "feast or famine" dynamics (Rochim et al., 2026). Third, supply lead times are long and concentrated: critical components like semiconductors and displays come from limited global suppliers, many outside China, with lead times of 20–80 weeks, compounded by US export controls. Fourth, margins are razor-thin—3–6% of revenue—making the efficiency-resilience trade-off acute: every dollar in buffers impacts profitability, yet disruptions threaten relationships and competitiveness. These features create a "perfect storm" exposing traditional resilience limits and highlighting digital potential [3].

The paper makes four theoretical contributions. First, it introduces a maturity-based perspective, moving beyond binary "digitized or not" views to conceptualize digital capability as developmental stages. Second, it deconstructs digital maturity into Visibility, Intelligence, and Adaptivity layers, offering precision to a literature treating digitalization as monolithic. Third, it develops the "Slack Transformation Hypothesis," extending slack literature via strategic slack substitution—reconciling efficiency and resilience previously seen as theoretically impossible. Fourth, it integrates Dynamic Capabilities Theory, Information Processing Theory, and the Resource-Based View into a unified explanation. The paper proceeds: Section 2 reviews literature; Section 3 develops the framework; Section 4 articulates propositions; Section 5 discusses implications; Section 6 concludes with limitations and future research.

2. Literature review

2.1. Supply Chain Resilience: From Risk Management to Resilience Engineering

As global supply chains grew more complex and volatile, this static view proved insufficient. Scholars recognized resilience involves not just bouncing back but bouncing forward—adapting and improving through disruptions. This prompted a shift toward proactive frameworks emphasizing flexibility, adaptability, and forward-looking assessment. Contemporary understanding spans the full disruption lifecycle: readiness, responsiveness, recovery, and adaptability through learning [8].

Visibility stands as perhaps the most foundational pillar, referring to the ability to access and interpret real-time information across the supply chain network. Christopher and Peck (2004) [9] conceptualised visibility as an enabler of collaboration, while subsequent research has positioned it as a driver of agility. In the context of high-mix, low-volume manufacturing, visibility enables firms to track the location and status of critical components—such as semiconductors with lead times exceeding forty weeks—and anticipate potential bottlenecks before they materialise. However, as

will be argued in this paper, visibility alone constitutes the lowest layer of digital maturity; without the analytical and adaptive capabilities to act upon visible data, it remains a necessary but insufficient condition for resilience.

Agility refers to the ability to respond rapidly to unexpected changes in supply or demand. It encompasses velocity in terms of speed of response as well as responsiveness in terms of appropriateness of response. Empirical research has demonstrated that agility is particularly critical in volatile environments, enabling firms to reconfigure operations quickly in response to disruptions. The automotive electronics industry, with its characteristic demand fluctuations and original equipment manufacturer order revisions, illustrates the premium placed on agility: a supplier's ability to expedite alternative sourcing, reroute shipments, or adjust production schedules can mean the difference between fulfilling customer commitments and incurring costly penalties.

Flexibility is closely related to agility but conceptually distinct: while agility emphasises speed and responsiveness, flexibility denotes the capacity to take different positions or adopt alternative configurations in response to abnormal situations. This distinction is important for understanding how firms build resilience pre-disruption through flexibility as a structural attribute versus how they activate resilience during disruption through agility as an operational capability. Strategies for enhancing flexibility include concurrent instead of sequential processes, flexible manufacturing systems, and adaptable logistics networks. In the Chinese automotive electronics context, flexibility might manifest as the ability to rapidly reconfigure production lines across multiple manufacturing bases to accommodate shifting demand patterns.

Collaboration encompasses the relational capabilities that enable firms to work effectively with supply chain partners, including information sharing, joint planning, and coordinated response to disruptions. Research consistently identifies collaboration as a critical resilience capability, with Christopher and Peck (2004) [9] arguing that a culture of risk management, embedded through collaborative relationships, is essential for building resilience. In the Chinese manufacturing context, where supply chain relationships often involve deep integration with original equipment manufacturer customers and strategic suppliers, collaboration takes on particular importance. Recent evidence further demonstrates that collaborative supply chain processes strengthen resilience through enhanced information exchange and coordination among firms, with timely information sharing and cooperative problem-solving improving supply chain flexibility under volatile conditions. The relational slack dimension of organisational slack—discussed later in this paper—builds directly upon collaborative capabilities [4].

Redundancy represents the most tangible and traditionally emphasised resilience capability, encompassing safety stock, multiple sourcing, back-up facilities, and surplus capacity. Redundancy operates through the logic of buffering: by maintaining resources beyond minimum requirements, firms create cushions that absorb disruption impacts. However, redundancy is also the most costly resilience capability, requiring investment regardless of whether disruptions actually occur. This cost dimension lies at the heart of the efficiency-resilience trade-off debate, to which we now turn [9].

2.2. Organizational Slack: Resource Buffers in Supply Chains

Organizational slack represents one of the most enduring and consequential constructs in management theory, yet its conceptualization and empirical application in supply chain resilience research remain surprisingly underdeveloped. This foundational definition positioned slack as a buffer that enables organizations to adapt to environmental changes, absorb performance shocks, and pursue innovation without immediate survival threat. In the decades since, organizational slack has been elaborated, refined, and empirically investigated across multiple management domains, from strategic management to organizational theory to international business, yet its integration with

supply chain resilience scholarship has been limited and fragmented [5].

A critical dimension of organizational slack that has received insufficient attention in the supply chain literature is the distinction between different types of slack. Building on the work of Bourgeois and Singh, scholars have differentiated slack along two dimensions: the degree to which it is absorbed or unabsorbed, and whether it is available, recoverable, or potential. Available slack refers to resources that are not yet committed to specific operations and can be readily redeployed, such as cash reserves or excess liquidity. Recoverable slack refers to resources that have been absorbed into operations but can be recovered through cost reduction or efficiency improvement, such as excess inventory or overstaffing. Potential slack represents resources that could be generated from the external environment, such as through borrowing or equity financing. This typology has important implications for supply chain resilience, as different types of slack have different characteristics in terms of accessibility, redeployability, and cost [10].

In the supply chain context, organizational slack manifests in multiple forms that collectively provide buffering capacity against supply and demand disruptions. The most visible and tangible form is physical slack, which includes inventory buffers, spare production capacity, backup warehousing, and redundant logistics capabilities. Physical slack is characterized by its direct availability in response to disruptions and its relatively high carrying costs. A second form, relational slack, resides in the relationships between supply chain partners and includes trust, mutual understanding, shared problem-solving capabilities, and collaborative history. Relational slack is less tangible than physical slack but can be equally valuable in responding to disruptions, as strong relationships enable partners to work together effectively under stress and to make mutual accommodations that would be impossible in transactional relationships. A third form, which we term cognitive slack, encompasses the analytical expertise, organizational learning, decision-making heuristics, and accumulated experience that enable effective responses to novel situations. Cognitive slack is perhaps the least tangible form of slack but is critical for resilience because it enables firms to interpret disruption events, evaluate response options, and learn from experience for future improvements [6].

3. Framework and Propositions

3.1. Framework

The Digital-First Supply Chain Resilience Framework centers on three sequential layers of digital maturity: Digital Visibility (capturing, integrating, and visualizing real-time data via ERP, MES, and WMS), which is necessary but insufficient alone; Digital Intelligence (analyzing data for predictive insights using analytics, AI, and machine learning), which converts visibility into actionable foresight; and Digital Adaptivity (automatically or semi-automatically reconfiguring operations through dynamic re-planning, real-time capacity allocation, and automated decision-making)—layers that are sequentially dependent, as skipping foundational layers undermines resilience benefits, with alert systems (characterized by sensitivity, accuracy, actionability, and escalation speed) bridging Intelligence and Adaptivity. Its central theoretical innovation, the Slack Transformation Hypothesis, posits that as digital maturity progresses, firms can substitute lower-value physical slack (inventory buffers, spare capacity, redundant facilities) with higher-value relational slack (trust, collaborative partnerships, shared problem-solving) and cognitive slack (analytical expertise, organizational learning, decision heuristics): enhanced Digital Intelligence improves demand and risk prediction, reducing costly physical buffers, and freed capital can be reinvested in relational and cognitive capabilities—reconciling the efficiency-resilience trade-off by enabling both cost efficiency and protective robustness, while addressing physical slack's depreciation and carrying costs by shifting toward relational and cognitive slack that appreciates through experience and yields lasting competitive advantage. The framework proposes four causal pathways: the Maturity Pathway

(environmental volatility drives sequential digital investments), the Alert System Moderation Pathway (sophisticated alerts accelerate the Intelligence-to-Adaptivity transition), the Slack Transformation Pathway (Digital Adaptivity enables physical slack reduction and reallocation, mediating digital maturity and resilience), and the Resilience Outcome Pathway (digital maturity directly enhances anticipatory and absorptive resilience, while slack transformation enhances adaptive and restorative resilience)—all reinforced by dynamic feedback loops in which resilience experiences enhance cognitive slack and Digital Intelligence, efficiency gains fund further digital investments, and improved relational slack enhances collaboration and visibility, offering a comprehensive, dynamic, and practically grounded model of building proactive supply chain resilience through synergistic digital capability development and strategic resource reallocation [7].

3.2. Propositions on Digital Maturity Development

The framework proposes that digital maturity develops sequentially through three layers, each building on prior capabilities. This dependency reflects that advanced analytics require reliable integrated data, and adaptive capabilities require predictive insights as triggers. Firms bypassing foundational layers—such as investing in predictive analytics before data integration—are unlikely to realize resilience benefits. This logic is grounded in information processing theory, which holds that processing capacity must be built incrementally, and in information systems literature documenting challenges of implementing advanced analytics without adequate data foundations.

Proposition 1 (Sequential Maturity Path): Digital maturity develops sequentially through Digital Visibility, Digital Intelligence, and Digital Adaptivity. Visibility is a prerequisite for Intelligence, and Intelligence for Adaptivity. Firms failing foundational layers will not realize resilience benefits from higher-layer investments.

The rationale lies in the hierarchical nature of information processing. Visibility establishes the data infrastructure—integrated systems, real-time capture, traceability—providing raw material for analytical intelligence. Without it, predictive models lack required data quality and timeliness. Similarly, Intelligence provides predictive insights that trigger adaptive responses; without these, adaptive systems lack decision intelligence. Practically, firms should sequence investments to build foundations before advanced analytics or automation.

Proposition 2 (Visibility-Intelligence Link): The relationship between Digital Visibility and supply chain agility is positively moderated by Digital Intelligence. High visibility alone does not improve agility without analytical capability to interpret data and generate actionable insights.

This distinguishes possessing information from using it effectively. Visibility provides data, but data alone does not enable agile responses; firms must analyze data to identify patterns, detect anomalies, and generate predictions. Firms with high visibility but low intelligence exhibit limited agility, as managers are overwhelmed with data but lack tools to extract insights. Conversely, high-intelligence firms leverage visibility to anticipate disruptions and coordinate rapid responses. This is grounded in information processing theory, which emphasizes that processing capacity depends on both data availability and analytical capability.

Proposition 3 (Intelligence-Adaptivity Link): Digital Intelligence positively influences Digital Adaptivity, moderated by alert system sophistication. More sophisticated alert systems—higher sensitivity, accuracy, actionability, and escalation speed—strengthen this relationship.

This introduces alert systems as a critical moderator in translating predictive insight into adaptive response. Intelligence generates foresight, but it must be translated into timely action. Alert systems trigger action by detecting deviations, notifying decision-makers, and providing decision support. Their sophistication determines how effectively intelligence converts to adaptivity: sensitive systems detect meaningful signals without noise; accurate systems minimize false alarms; actionable systems

provide clear guidance; fast systems enable rapid escalation. Without sophisticated alert systems, intelligence may remain unused or acted upon too slowly to prevent disruption impacts.

3.3. Propositions on Alert Systems and Resilience

Alert systems are a critical but under-researched component of digital supply chain resilience. While digitalization literature focuses on data collection and analytics, how analytical insights trigger organizational action remains underexplored. The framework positions alert systems as the bridge between Intelligence and Adaptivity, translating predictive insights into timely responses.

Proposition 4 (Alert System Sophistication and Response Effectiveness): Alert system sophistication—operationalized through sensitivity, accuracy, actionability, and escalation speed—is positively associated with the speed and effectiveness of disruption responses.

This hypothesizes a direct relationship between alert quality and response performance: firms with more sophisticated systems detect disruptions earlier, interpret them more accurately, and mobilize responses faster. Grounded in information processing theory, it implies firms should invest not only in data collection and analytics but also in the alert systems that translate insights into action.

Proposition 5 (Learning-By-Using Effect): Alert system effectiveness in preventing or mitigating disruptions increases with organizational experience, following a learning curve.

This adds a dynamic element: as managers interact with alerts, they develop heuristics for interpretation, pattern recognition, and response selection, and learn to calibrate parameters to reduce false alarms. The value of alert systems thus appreciates with experience, favoring early adopters. Grounded in organizational learning theory and experience curves.

Proposition 6 (Alert System Integration and Coordination): Integration of alert systems across supply chain partners—enabling real-time sharing and coordinated response—positively moderates the relationship between alert sophistication and resilience, such that integrated systems generate greater benefits than stand-alone systems.

This extends analysis from firm-level to supply chain-level capabilities. While firm-level systems enable individual detection and response, supply chain-wide integration enables coordinated responses addressing systemic disruptions. When partners share alerts in real time, they coordinate responses, avoid duplication, and prevent one partner's actions from harming others. Resilience benefits are thus amplified through shared awareness and coordinated response.

3.4. Propositions on Alert Systems and Resilience

The Slack Transformation Hypothesis represents the central theoretical innovation of this paper. It posits that digital maturity enables firms to strategically reconfigure their slack portfolios, substituting physical slack with relational and cognitive slack. This transformation reconciles the efficiency-resilience trade-off by enabling firms to maintain or enhance resilience while reducing the costs associated with physical buffers. The following propositions specify the relationships underlying this transformation.

Proposition 7 (Digital Adaptivity and Physical Slack Reduction): Higher levels of Digital Adaptivity are negatively associated with the level of physical slack (inventory buffers, spare capacity, redundant facilities) maintained by the firm.

This proposition hypothesizes that firms with greater adaptive capabilities require less physical slack to achieve the same level of resilience. The logic is that adaptive capabilities enable firms to respond to disruptions more quickly and effectively, reducing the need for pre-positioned physical buffers. For example, a firm that can dynamically reallocate production across multiple facilities or rapidly switch between suppliers does not need as much inventory or capacity redundancy as a firm lacking these adaptive capabilities. The proposition is grounded in the logic of substitution: adaptive

capabilities substitute for physical buffers as mechanisms for managing uncertainty. The proposition also has practical implications: firms should view digital adaptivity investments as a means of reducing the carrying costs of physical slack.

Proposition 8 (Digital Adaptivity and Relational-Cognitive Slack Investment): Higher levels of Digital Adaptivity are positively associated with investments in relational slack (supplier partnerships, collaborative capabilities) and cognitive slack (analytical expertise, organizational learning processes).

This proposition complements Proposition 7 by specifying where resources freed from physical slack reduction are reallocated. The logic is that firms achieving high Digital Adaptivity not only reduce physical slack but also invest the freed resources in building relational and cognitive capabilities. These investments generate resilience benefits that are more sustainable and less costly than physical buffers. Relational slack provides access to partner resources and coordinated response capabilities; cognitive slack provides the expertise and learning capabilities that enable continuous improvement. The proposition is grounded in the resource-based view, which suggests that firms should invest in resources that are valuable, rare, and difficult to imitate—characteristics that apply more to relational and cognitive slack than to physical slack.

Proposition 9 (The Slack Transformation Mediation): The relationship between Digital Adaptivity and supply chain resilience is partially mediated by slack transformation—that is, the reduction of physical slack and the corresponding increase in relational and cognitive slack. Firms that achieve high Digital Adaptivity but fail to transform their slack portfolio will realize lower resilience benefits than firms that combine Adaptivity with slack transformation.

This proposition specifies the mechanism through which Digital Adaptivity generates resilience benefits. It suggests that Adaptivity alone is insufficient; firms must also reconfigure their slack resources to fully realize resilience benefits. The logic is that physical slack and relational-cognitive slack provide different types of resilience benefits: physical slack provides immediate buffering capacity, while relational and cognitive slack provide adaptive and learning capabilities. Firms that reduce physical slack without building relational and cognitive slack may actually reduce their resilience, as they lose buffering capacity without developing alternative capabilities. Conversely, firms that combine Adaptivity with slack transformation achieve a more balanced and sustainable resilience portfolio. The proposition implies that slack transformation is a deliberate strategic choice, not an automatic consequence of digitalization.

Proposition 10 (The Efficiency-Resilience Reconciliation): Firms that have successfully undergone slack transformation—reducing physical slack while increasing relational and cognitive slack—achieve a superior balance between operational efficiency and supply chain resilience compared to firms that rely primarily on physical slack or lack digital capabilities.

This proposition directly addresses the efficiency-resilience trade-off debate that has dominated supply chain resilience scholarship. It hypothesizes that slack transformation enables firms to achieve both efficiency and resilience—a possibility that traditional trade-off logic would consider impossible. The logic is that physical slack imposes ongoing carrying costs without generating operational benefits, while relational and cognitive slack provide resilience benefits with lower and potentially appreciating costs. By substituting physical slack with relational and cognitive slack, firms reduce their cost base while maintaining or enhancing their resilience capabilities. The proposition suggests that the efficiency-resilience trade-off is not inherent but results from suboptimal slack configurations that can be corrected through strategic transformation enabled by digital maturity.

3.5. Propositions on Resilience Outcomes

The ultimate outcome of interest in the framework is supply chain resilience—the firm's ability to

anticipate, absorb, adapt to, and recover from disruptions. The framework proposes that resilience is a multi-dimensional construct comprising anticipatory, absorptive, adaptive, and restorative capacities, and that different digital maturity layers and slack types contribute to different dimensions of resilience. The following propositions specify these relationships.

Proposition 11 (Digital Maturity and Anticipatory Resilience): Digital Intelligence is positively associated with anticipatory resilience—the capability to foresee and prepare for potential disruptions before they occur—through enhanced sensing capabilities, predictive analytics, and risk alert systems.

This proposition specifies the mechanism through which Digital Intelligence contributes to resilience. Anticipatory resilience requires firms to detect early warning signals, assess their implications, and prepare responses before disruptions materialize. Digital Intelligence provides the analytical capabilities—predictive models, scenario simulations, risk assessments—that enable this foresight. Firms with higher Digital Intelligence can anticipate a wider range of disruption scenarios, assess their likelihood and impact more accurately, and prepare more effective response plans. The proposition is grounded in dynamic capabilities theory, specifically the sensing capability that enables firms to detect threats and opportunities in their environment.

Proposition 12 (Physical Slack and Absorptive Resilience): Physical slack is positively associated with absorptive resilience—the capability to withstand and contain disruption impacts without significant performance degradation—by providing immediate buffering capacity that absorbs supply and demand shocks.

This proposition acknowledges the continuing value of physical slack for a specific dimension of resilience. While the framework argues for reducing physical slack through digital transformation, it does not suggest eliminating it entirely. Physical slack provides immediate buffering capacity that cannot be replicated by relational or cognitive capabilities, particularly in the initial moments of a disruption when time for analysis and coordination is limited. The proposition suggests an optimal level of physical slack that balances buffering benefits against carrying costs—a level that is lower for digitally mature firms but not zero. The proposition is grounded in the traditional risk management literature, which emphasizes the value of buffers for absorbing uncertainty.

Proposition 13 (Relational-Cognitive Slack and Adaptive-Restorative Resilience): Relational slack and cognitive slack are positively associated with adaptive resilience (the capability to reconfigure operations in response to disruptions) and restorative resilience (the capability to recover and learn from disruptions), through enhanced collaboration, problem-solving, and organizational learning.

This proposition specifies the contributions of relational and cognitive slack to resilience. Unlike physical slack, which provides immediate buffering, relational and cognitive slack enable firms to adapt and recover over time. Relational slack provides access to partner resources and coordinated response capabilities; cognitive slack provides the expertise and learning capabilities that enable effective adaptation and recovery. Together, these capabilities enable firms to not only withstand disruptions but also emerge stronger from them through learning and improvement. The proposition suggests that investments in relational and cognitive slack are particularly valuable for building long-term resilience capabilities. It is grounded in the dynamic capabilities literature, specifically the seizing and transforming capabilities that enable firms to respond to and learn from disruptions.

Proposition 14 (Integrated Resilience Capability): The combination of high digital maturity (Visibility, Intelligence, Adaptivity) and a transformed slack portfolio (reduced physical slack, increased relational and cognitive slack) produces superior overall supply chain resilience—encompassing anticipatory, absorptive, adaptive, and restorative capacities—compared to configurations characterized by low digital maturity or untransformed slack portfolios.

This proposition articulates the synergistic effect of the full framework. It hypothesizes that the components of the framework—digital maturity and slack transformation—are complementary, not

additive. The full benefits of the framework are realized only when both components are present: firms with high digital maturity but untransformed slack portfolios achieve only partial resilience benefits, as do firms with transformed slack but low digital maturity. The proposition suggests a holistic approach to resilience building that addresses both digital capabilities and resource configurations. The proposition is grounded in the systems perspective, which emphasizes that system performance depends on the interaction of components, not just their individual characteristics.

4. Conclusion & implications

This paper makes four theoretical contributions to supply chain management, each addressing a significant gap and collectively offering an integrated framework for how digital maturity and organizational slack interact to build resilience.

First, it introduces a maturity-based perspective on digital resilience, moving beyond the binary view of firms as either digitized or not. The prevailing literature treats digitalization as binary or as undifferentiated investment, obscuring qualitative differences in how capabilities contribute to resilience. By conceptualizing digital maturity as progression through three layers—Visibility, Intelligence, and Adaptivity—the framework presents digital transformation as a developmental journey rather than a destination. This explains why many firms invest substantially yet fail to realize commensurate resilience benefits: they may have achieved Visibility but not Intelligence, or Intelligence but not Adaptivity. It also provides a basis for sequencing investments, suggesting firms cannot skip foundational layers. This sequential logic, grounded in information processing theory, offers a more rigorous explanation of digital transformation failures than attributions to "implementation challenges." It opens new avenues for research on how firms progress through maturity stages and how resilience benefits vary across levels.

Second, the paper deconstructs digital capability into three theoretically and empirically distinct layers, each contributing to resilience through different mechanisms. This addresses a limitation in the digital supply chain literature, which treats digitalization as monolithic—encompassing everything from data capture to advanced AI. By separating Visibility (capturing and integrating data), Intelligence (analyzing data and generating insights), and Adaptivity (reconfiguring operations based on insights), the framework enables more rigorous theorizing. Visibility contributes by providing raw information to detect disruptions; Intelligence by enabling anticipation; Adaptivity by enabling rapid response. These are fundamentally different capabilities operating through different causal pathways, and conflating them obscures understanding. The differentiation also allows researchers to develop distinct measures and test differential effects, advancing both theoretical clarity and empirical rigor while explaining why some digital investments succeed and others fail.

Third, and most innovatively, the paper proposes the Slack Transformation Hypothesis, articulating how digital maturity enables firms to reconfigure slack resources to simultaneously achieve efficiency and resilience. This addresses the long-standing trade-off between efficiency (minimizing buffers) and resilience (maintaining buffers). The hypothesis resolves this by proposing that digital maturity enables substitution of slack types: as firms develop Intelligence and Adaptivity, they can reduce costly physical slack (inventory, spare capacity) and reinvest in relational slack (trust, partnerships) and cognitive slack (analytical expertise, learning). This works because physical slack provides immediate buffering but incurs carrying costs, while relational and cognitive slack provide resilience benefits with lower costs and potential to appreciate. It thus offers a mechanism for achieving the "both/and" of efficiency and resilience rather than the "either/or" of trade-off logic. This extends organizational slack theory, which has focused on slack levels rather than composition, and provides a new lens for cost-sensitive environments like automotive electronics.

Fourth, the paper integrates Dynamic Capabilities Theory, Information Processing Theory, and the

Resource-Based View into a unified framework. Each has been applied individually, but their integration has been limited. Dynamic Capabilities Theory explains how firms sense, seize, and transform; the framework maps these to the maturity layers—Visibility enabling sensing, Intelligence enabling seizing, Adaptivity enabling transforming. Information Processing Theory explains why firms need digital capabilities to manage uncertainty; the framework articulates how each layer increases processing capacity and reduces the need for buffering. The Resource-Based View explains why some firms achieve superior resilience; the framework specifies how different slack types constitute resources with different strategic characteristics and how digital capabilities enable their reconfiguration. This integration provides a more complete explanation than any single theory, while enriching each stream. It addresses criticisms of theoretical fragmentation in the resilience literature.

The contributions extend beyond supply chain resilience to broader debates in strategic management and organization theory. The Slack Transformation Hypothesis contributes to organizational slack literature by introducing strategic slack substitution, suggesting digital capabilities alter the nature and composition of slack, enabling reconciliation of efficiency and resilience previously considered impossible under resource-based trade-off logic. The maturity perspective contributes to digital transformation literature by explaining why digital investments often fail and what conditions are necessary for success. The multi-theoretical integration demonstrates how complementary lenses can be synthesized to address complex phenomena no single theory can explain.

Finally, the framework's grounding in Chinese automotive electronics manufacturing ensures relevance to one of the most consequential supply chain environments. It addresses China-specific challenges—semiconductor dependency, OEM demand volatility, intense cost competition, rapid growth—not adequately addressed by generic Western frameworks. By anchoring in this context while articulating generalizable propositions, the paper balances contextual specificity and theoretical generality, enhancing practical relevance for Chinese firms while contributing to broader literature. It thus offers value for scholars advancing theoretical understanding of digital resilience and practitioners seeking guidance for building resilient supply chains in an increasingly volatile world.

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