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Digitalization as a Systemic Enabler: Expanding the Geographic Scope of Global Supplier Networks in Chinese Firms

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Abstract

Geographically dispersed supplier networks represent a crucial strategy for firms to mitigate supply chain dependencies. This study investigates how the digitalization of enterprises enables firms to expand their global supplier base. Grounded in resource dependence theory, we argue that digitalization helps firms identify suitable suppliers worldwide and manage complex multinational networks. We utilize a multidimensional digitalization index covering six dimensions: strategic leadership, digital outputs, technology drive, organizational enablement, digital application, and environmental support. Using data on Chinese listed companies from 2011 to 2023, our findings reveal that digitalization significantly expands suppliers' geographic scope, especially under high economic policy uncertainty, world trade uncertainty, and geopolitical risks. Further analyses indicate that process and technological innovations are the primary drivers within digitalization, and that geographic expansion occurs mainly into Asia, Europe, and America. These findings position digitalization as a systemic enabler for building global supplier networks and a strategic response to external uncertainty. Our study extends resource dependence theory by demonstrating how digitalization facilitates the management of dependencies at the network level.

Keywords: digitalization of enterprises; geographic dispersion of suppliers; resource dependence theory; external uncertainty; Chinese firms

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1. Introduction

The ongoing global bifurcation makes global supply chain design critically important [1]. In configuring their supplier networks, firms face a key trade-off. Global sourcing improves efficiency by accessing more suppliers [2]. However, geographical dispersion introduces coordination complexity and exposure to risks [3]. These risks are amplified by heightened external environmental uncertainty [4].

Existing literature has primarily explored the "why" behind global sourcing. For example, it shows how geopolitical pressures drive firms to find new partner locations [5,6]. However, the question of "how" firms implement global supplier network remains underexplored. Internal capabilities enable firms to pursue geographic expansion, particularly in volatile conditions. This study argues that digitalization is one such essential capability. Prior research confirms that digitalization of enterprises strengthens dyadic buyer-supplier relationships. For instance, it helps control partner opportunism [7]. Yet, it remains unclear

whether digitalization enables firms to manage a geographically dispersed network. It is also unclear how external environmental uncertainty influences this process.

To address this gap, our study has two main objectives. First, we investigate how the digitalization of enterprises influences the geographic scope of their global supplier networks. Second, we examine how external environmental uncertainty moderates this relationship. By answering these questions, we shift the focus from why firms globalize to how they achieve it. We also expand digitalization's role from managing single relationships to designing entire networks.

From the perspective of resource dependence theory (RDT) [8], firms face internal resource constraints and must engage in external exchanges to acquire critical resources. This requires them to manage their dependence on external resource providers [9,10]. In global supply chains, where firms transact with suppliers across the world, the configuration of a global supplier network serves as a key strategic response to such dependency.

Guided by this logic, we argue that the digitalization of enterprises strengthens their ability to manage external dependencies, thereby facilitating the development of a more geographically dispersed global supplier network. This occurs through two main mechanisms. First, improved digitalization helps firms identify and evaluate potential suppliers worldwide with lower search costs and less information asymmetry [11]. By reducing these traditional barriers, firms gain access to a broader range of viable partners. This alleviates the risks of relying heavily on any single external entity. In effect, digitalization enables firms to build a broader and more diversified dependency portfolio, which helps mitigate power imbalances with individual suppliers [12].

Second, digitalization enhances a firm's ability to govern and monitor [13] a geographically scattered supplier network. It increases supply chain transparency [14], lowers oversight costs, and accelerates response to disruptions [15]. By reducing the risks and complexities of managing distant partners, digitalization provides the confidence for firms to manage a wider array of external dependencies across more countries. This strengthened governance turns the theoretical benefits of global sourcing into a manageable reality.

This study empirically examines how digitalization shapes the geographic scope of global supplier networks, using a sample of Chinese listed companies. Our sample selection is guided by three key considerations. First, Chinese firms are deeply embedded in global supply chains and serve as pivotal nodes within them [16]. Their strategic decisions are therefore critical to understanding the evolution of global production networks. Second, the digitalization of Chinese listed companies remains ongoing and highly heterogeneous. The substantial variation in adoption levels and progress across firms offers rich, natural variation for robust hypothesis testing [17,18]. Third, Chinese firms currently operate in an environment marked by significant external uncertainties, such as geopolitical tensions and supply chain disruptions [19,20]. This context offers a unique opportunity to examine how digitalization helps firms manage global supplier networks precisely under such challenging conditions.

Using panel data from 2510 Chinese listed companies spanning 2011 to 2023, our analysis confirms a positive relationship between the digitalization of enterprises and the geographic scope of their global suppliers. We further show that this effect is stronger in contexts of higher external environmental uncertainty. A nuanced finding reveals that process-technology-oriented digitalization is the primary driver behind this strategic reconfiguration of supplier networks.

This study proposes a new geographic and network perspective for digital supply chain management. We innovatively demonstrate how digitalization allows firms to design their supplier network's geographic distribution. This approach moves beyond traditional dyadic relationship management. We also examine how these capabilities enhance strategic

resilience amid external uncertainties. This reveals the critical role of digitalization in managing global supply chain risks.

This study makes several key contributions to the literature. First, it shows that digitalization does more than improve dyadic buyer-supplier relationships [12,18]; it fundamentally shapes the geographic scope of a firm's global supplier network. This shifts scholarly attention from operational efficiency at the relationship level to strategic design at the network level. Second, the study conceptualizes the geographic diversification of supplier networks as a distinct strategy for managing external dependencies. While traditional RDT applications focus on structural strategies such as mergers or partnerships [21,22], we demonstrate that digitalization offers firms a viable alternative: using geographic dispersion to mitigate dependence and build resilience. Third, in an era of growing geopolitical tensions and supply chain disruptions [23,24], this study highlights digitalization as a key mechanism that helps firms balance the classic trade-off between efficiency and security. It shows that digitalization supports sophisticated management of dispersed networks, enabling firms to pursue optimal global supplier configurations even in highly volatile environments.

This paper proceeds in five sequential sections. Following this introduction, we systematically develop our theoretical framework and research hypotheses. Next, we detail the research design, including data sources, variable measurement, and empirical models. We then present and interpret the empirical findings. The final section synthesizes the core contributions, discusses theoretical and practical implications, acknowledges limitations, and proposes directions for further scholarly inquiry.

2. Theoretical Background and Hypotheses Development

2.1. Resource Dependence and the Global Supplier Network

Rooted in the seminal work of Pfeffer and Salancik [8], RDT posits a fundamental premise: no organization is self-sufficient. To survive and thrive, firms must obtain essential resources from their external environment [22], including physical inputs, financial capital, and informational assets, which are not available internally. This necessary reliance on external resources creates interdependence and power asymmetries [10,25]. Since the behavior and interests of external actors may not align with those of the focal firm, such dependencies introduce substantial uncertainty and risk [8]. Therefore, according to RDT, a firm's core strategic challenge lies in effectively managing and mitigating the constraints and uncertainties that stem from these external resource dependencies [26,27].

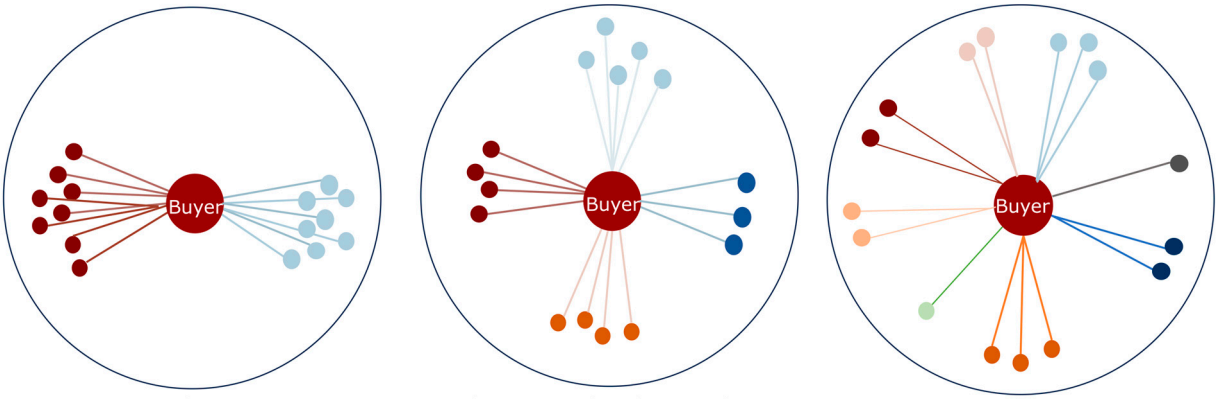
Suppliers serve as a primary source of external resources [28,29], delivering essential raw materials, components, technologies, and services. As a result, the supplier-buyer relationship represents a critical domain for strategic management [30,31]. When the resources provided by suppliers are critical and difficult to replace, firms become dependent on them.

Prior research has identified various strategies for managing partner dependence. These approaches can be broadly categorized into two types. The first involves absorbing constraints by adapting and restructuring existing relationships [32,33]. For example, firms may establish long-term strategic alliances, exercise control through equity ownership or board interlocks, or pursue vertical integration by acquiring suppliers. The second type focuses on distributing dependence risks through developing alternative relationships [34]. Rather than relying on a single source, firms can proactively cultivate new partnerships to strengthen supply chain resilience.

While valuable, these traditional strategies primarily address specific, dyadic relationships. They often overlook the broader, network-level perspective through which a firm can design its overall supplier portfolio.

This study examines a distinct, geography-based strategy for managing external dependence in a globalized context. We argue that beyond modifying relationships with individual suppliers, firms can manage dependence by strategically designing the geographic distribution of their supplier network [35]. This approach is unique in two main aspects. First, it represents a shift from dyadic to network-level management. Instead of focusing solely on individual supplier relationships, firms can view external suppliers as nodes within a global network and manage the configuration of the network as a whole. Second, it introduces a geographic dimension to dependence management. Firms can leverage geographic dispersion to mitigate systemic risks. Suppliers from different countries or regions often offer diverse comparative advantages, allowing firms to access a broader range of heterogeneous resources [36]. At the same time, maintaining alternative suppliers across different locations enhances resilience against region-specific disruptions, such as geopolitical tensions [6]. Thus, a geographically dispersed supplier network serves as a key strategic tool for managing external resource dependence and strengthening strategic autonomy.

Existing research has extensively examined the motivations for supplier diversification, but has given less attention to the organizational capabilities needed to implement a geographically dispersed strategy. As shown in Figure 1, where the central node represents the focal firm and surrounding nodes represent suppliers (with colors indicating geographic regions), the progression from panel (a) to (c) illustrates a trend toward greater geographic dispersion.



(a) Geographic scope - 2 (b) Geographic dispersed - 4 (c) Geographic scope - 8

Figure 1. A continuum of supplier network geographic dispersion, illustrating: (**a**) a buyer with suppliers from two countries; (**b**) a buyer with suppliers from four countries; (**c**) a buyer with suppliers from 8 countries. (Source: Original work by the authors).

This expansion, however, raises coordination, monitoring, and governance costs in transnational management. Although geographically complex networks bring clear benefits [37], a firm's ability to manage such complexity is critical. This study contends that digitalization serves as a key enabler, allowing firms to effectively govern broader and more complex global supplier networks and thereby supporting expansion into more countries and regions.

2.2. The Impact of Digitalization on Global Supplier Geographic Scope

Digitalization has been defined from multiple perspectives in existing literature. Some studies focus on technology adoption, viewing it as the implementation of digital tools like blockchain, AI, and cloud computing [38]. Others emphasize business process transformation, considering it as the use of digital technologies to improve efficiency and reshape operations [13,39]. Stage models further clarify this concept by differentiating three levels:

digitization (converting analog to digital), digitalization (enhancing processes digitally), and digital transformation (fundamentally changing business models) [40].

Building on these views, this study defines the digitalization of enterprises as their overall capability to acquire, integrate, and use digital technologies. This capability helps firms optimize internal operations and strengthen external collaboration, forming the foundation for managing complex global supplier networks.

Existing research has widely explored how digitalization strengthens dyadic supply chain relationships. Two primary mechanisms explain this effect: improved operational efficiency and enhanced relational governance [13,14]. Studies indicate that technologies such as IoT, big data, and blockchain help firms share information more effectively, adjust production plans in a timely manner, and monitor partner behavior with greater accuracy. These improvements contribute to increased supply chain flexibility. Additionally, digitalization has been shown to reduce opportunistic behavior and foster closer collaboration between firms and their established partners [7,31].

However, this predominant focus on dyadic relationships has overlooked a key strategic aspect: how digitalization shapes the macro-configuration of entire supplier networks. While prior research effectively shows how digitalization optimizes existing one-to-one relationships, it rarely examines how it enables firms to strategically redesign their one-to-many network architecture. We argue that the strategic value of digitalization lies not only in optimizing operations, but also in empowering firms to reshape their global footprint. This capability allows firms to better manage external dependencies through structural reconfiguration rather than relational adjustment alone.

The impact of digitalization on the geographic distribution of global suppliers operates through two key mechanisms. First, digitalization enhances a firm's ability to identify and connect with suitable resource providers worldwide [41]. While firms may theoretically seek optimal suppliers globally, this requires effective search capabilities. Digital tools enable firms to locate and engage more distant partners. For example, using big data analytics and AI-driven procurement platforms, firms can efficiently identify, evaluate, and authenticate potential suppliers across borders, overcoming traditional geographic constraints. By setting parameters for cost, technical capability, and quality, firms can achieve optimal matches and build more geographically dispersed supplier networks. Thus, digitalization reduces information asymmetry [11] and expands the firm's ability to establish supply relationships across broader geographic areas.

Second, digitalization strengthens a firm's ability to manage geographically dispersed resource dependencies. Establishing a global supplier network exposes firms to more complex environments, requiring adaptation to diverse geographic and institutional contexts [42]. Digitalization helps reduce the costs of coordinating geographically scattered suppliers. For example, digital collaboration platforms [43] standardize communication processes between upstream and downstream partners, enabling efficient daily coordination across regions. Moreover, digital technologies enhance supply chain transparency [14]. Technologies such as IoT, ERP, and blockchain enable real-time visibility into order status, inventory levels, and logistics trajectories, effectively overcoming the supervisory challenges posed by distance. Finally, digital tools help firms respond better to region-specific risks. Predictive analytics and monitoring systems can identify potential disruptions, offering early warnings to support global supplier decision-making [44].

In summary, digitalization enhances a firm's capacity to establish more advantageous resource dependencies while simultaneously improving its ability to manage complex, long-distance dependencies. This means it enables firms to operate geographically dispersed global supplier networks more effectively, encouraging expansion into wider geographic regions. Hence, we hypothesize:

H1. *The digitalization of enterprises is positively associated with the geographic scope of their global supplier networks.*

2.3. The Moderating Role of External Environmental Uncertainty

The preceding arguments establish that digitalization empowers firms to manage the complexities of a geographically dispersed supplier network. Building on this foundation, we introduce a crucial contingency: external environmental uncertainty. We contend that the strategic value of digitalization in enabling global sourcing becomes more evident under high volatility.

Accordingly, we examine three salient types of uncertainty: global economic policy uncertainty, world trade uncertainty, and geopolitical risk. We propose that each of these factors strengthens the relationship between digitalization and supplier geographic dispersion by enhancing the value of digital capabilities.

As shown in Table 1, these three dimensions of uncertainty operate through distinct mechanisms. Economic policy uncertainty affects operational costs through policy-induced volatility [45,46]. World trade uncertainty influences market access through disruptions in trade flows [4]. Geopolitical risk threatens supply continuity via physical and political disruptions [24,47]. Together, these interrelated dimensions illustrate how digitalization becomes especially vital in helping firms navigate uncertain external environments.

Table 1. External environmental uncertainty (Source: Original work by the authors.).

Dimension	Economic Policy Uncertainty	World Trade Uncertainty	Geopolitical Risk
Definition	Uncertainty about the future direction of countries' domestic fiscal, monetary, and regulatory policies.	Uncertainties about the rules and conditions governing the flow of information, goods, and capital between countries.	The risk associated with political, military, or diplomatic conflicts between states.
Sources	Elections; Central bank policy shifts; Changes in laws	Trade wars; Breakdown of trade agreements; Anti-dumping investigations	Wars and armed conflicts; Territorial disputes; Strategic resource competition
Supply Chain Impact	Demand volatility; Investment delay; Cost fluctuations	Increased costs; Market access risk; Shift in sourcing and manufacturing locations	Physical disruption; Forced decoupling; Asset stranding
Temporal Dimension	Often cyclical	Event-driven	Sudden and acute; Chronic and structural
Relevant References	[45,46,48]	[20,49,50]	[1,47]

2.3.1. Global Economic Policy Uncertainty

Global economic policy uncertainty (GEPU) refers to ambiguities in future fiscal, regulatory, and monetary policies across major economies [45,48]. This uncertainty can suddenly reduce the efficiency of established supply routes. In such an environment, characterized by unpredictable tax regimes and volatile exchange rates, the ability to digitally search for and evaluate a broad range of suppliers becomes crucial.

Firms can use data analytics to continuously scan for suppliers in countries with more stable policies and shift sourcing accordingly. This digital agility allows them to treat their global supplier network as a dynamic portfolio, strategically reducing dependence on regions with high policy volatility [4,51]. As a result, the value of digital search capabilities increases significantly when firms face frequent policy shocks.

Furthermore, heightened economic policy uncertainty amplifies the value of digital governance mechanisms in managing global supplier relationships. While digital search helps identify alternative suppliers, effective coordination becomes crucial when policies become volatile. Digitalization facilitates real-time information sharing [52] and collaborative planning with suppliers [53] across different jurisdictions. This allows firms to quickly adjust production schedules and inventory management in response to policy changes. Such coordination ensures that geographic dispersion does not become a disadvantage during periods of policy instability. Hence, we hypothesize:

H2. *Global economic policy uncertainty positively moderates the relationship between digitalization and the geographic scope of global suppliers, strengthening this relationship when GEPU is higher.*

2.3.2. World Trade Uncertainty

World Trade Uncertainty (WTU) refers to volatility in international trade flows caused by tariff changes, shipping disruptions, and evolving trade policies [20,50]. Strategically, such uncertainty can directly disrupt established buyer-supplier relationships. For example, new trade policies may force firms to cut existing international supply links and consider reshoring production [4,54].

In response, firms often turn to strategies such as friendshoring to balance efficiency and security [6]. In this context, digitalization plays a critical role. They help firms efficiently identify, evaluate, and match with suitable suppliers in new regions, while also assessing local trade policies and potential risks. When WTU is low, firms have little incentive to expand their supplier networks geographically, as disruption risks remain limited. However, as WTU increases, the motivation to use digital tools for supplier diversification grows significantly.

At the operational level, WTU can disrupt the cross-border flow of information, goods, and capital. This increases the complexity of managing a geographically dispersed supplier network. In such situations, digital technologies become vital tools for maintaining coordination and operational continuity [31,55]. For example, cloud-based platforms and IoT-enabled systems help firms sustain real-time communication and collaborative planning with suppliers across regions. These tools facilitate logistics rerouting, production adjustments, and delay mitigation, without requiring firms to reshore operations or reduce geographic presence.

Therefore, under high WTU, digitalization delivers a dual benefit: it enables strategic reconfiguration of the supplier network while strengthening operational resilience. We thus hypothesize:

H3. *World trade uncertainty positively moderates the relationship between digitalization and the geographic scope of global suppliers, such that the relationship is stronger when WTU is higher.*

2.3.3. Geopolitical Risk

Geopolitical risk (GPR) refers to the potential for international conflicts, diplomatic tensions, or territorial disputes to disrupt global economic activities [24,47]. Unlike other forms of uncertainty, GPR often entails direct governmental intervention, mandatory decoupling policies, or even complete severance of supply relationships between specific countries.

In this context, firms face strong pressure to geographically diversify their supplier base away from high-risk regions. Digital capabilities become crucial in enabling firms to rapidly identify, evaluate, and qualify alternative suppliers in politically stable regions [56]. When GPR is low, firms may lack sufficient motivation to expand their global supplier network. However, as GPR intensifies to moderate levels, the strategic value of digital search

and matching capabilities grows significantly. In such cases, geographic dispersion becomes a vital risk mitigation strategy, rather than simply a means to improve efficiency [57].

Furthermore, digitalization help maintain operational continuity during geopolitical disruptions. Tools such as cloud-based collaboration platforms, encrypted communication systems, and blockchain-enabled tracking [58,59] allow firms to sustain real-time coordination with globally dispersed suppliers, even when political tensions restrict traditional communication channels. This digital connectivity ensures that geographic diversification does not compromise coordination efficiency. As a result, firms can effectively respond to geopolitical disruptions without having to localize their supply chains entirely.

However, digitalization may not be effective under all levels of geopolitical risk. In extreme cases, such as economic sanctions [60] or war, digital capabilities can be overridden. Governments may force companies to decouple their supply chains. In these situations, firms must restructure regardless of their digital strength. This means that at very high levels of GPR, the effect of digitalization may be attenuated as its role is superseded by political mandates. We therefore suggest a more precise view: GPR strengthens the link between digitalization and geographic dispersion only up to a point. Beyond that point, the effect may fade. Thus, we hypothesize:

H4. *Geopolitical Risk positively moderates the relationship between digitalization and the geographic scope of global suppliers within moderate ranges of GPR; however, this moderating effect may attenuate under high GPR conditions.*

In summary, the three types of uncertainty examined—GEPU, WTU, and GPR—each strengthen the value of digitalization. This makes the creation and management of a globally dispersed supplier network both more feasible and strategically necessary. The overall conceptual framework of this study is shown in Figure 2.

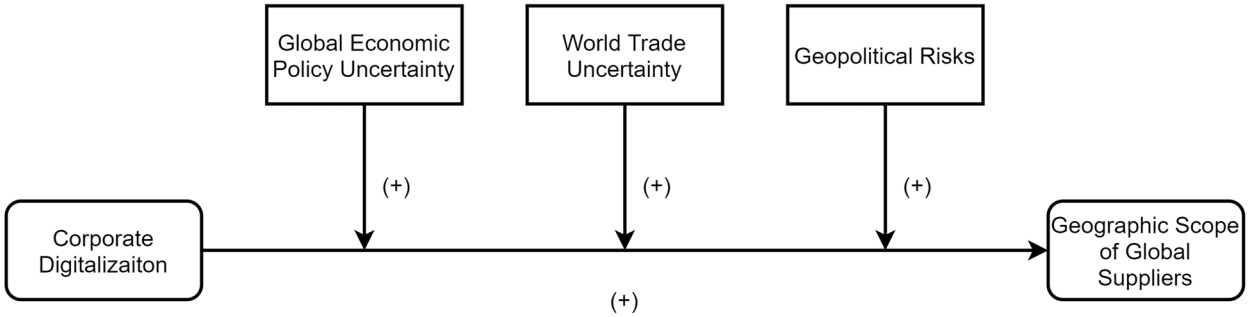


Figure 2. Conceptual framework (Source: Original work by the authors).

3. Methods

3.1. Data and Sample

This study investigates the impact of digitalization on the geographical dispersion of global suppliers using a comprehensive sample of Chinese A-share listed companies from 2011 to 2023. This starting point aligns with two important trends. First, the adoption of digital technologies by Chinese listed companies accelerated significantly in 2011, with the digital penetration rate exceeding one-third for the first time [61]. Second, the disclosure of supplier information improved markedly, as evidenced by the substantial increase in supplier observations in our dataset beginning in 2011.

Our focus on listed companies is justified by their prominent role in global supply chains and the superior data availability regarding their digitalization [62,63]. Our baseline sample includes all listed companies during this period to ensure broad representativeness. To construct the final sample, we excluded firm-year observations with missing data for key

variables. We also removed firms under special treatment (ST/*ST) due to their atypical financial or operational status, which may lead to fundamentally different global sourcing behaviors. We further validate the robustness of our findings through additional sample configurations in the sensitivity analysis section.

This study integrates data from three primary sources. Supply chain relationship data are sourced from FactSet Supply Chain Relationships, a database extensively used in academic research [64,65]. It provides detailed information on buyer-supplier linkages, including relationship start and end dates, enabling the analysis of annual variations in firms' global supplier networks. It should be noted that, as FactSet relies on corporate disclosures, it may underreport relationships involving private firms or those not publicly documented. This limitation is explicitly acknowledged in Section 5.3 of our study.

Firm-level financial and digitalization data come from the CSMAR database. This database has been extensively used in prior research on Chinese listed companies [66,67]. The digitalization measure incorporates both textual analysis of corporate disclosures and objective outputs such as digital-related patents, offering broader coverage than annual-report-only alternatives. However, as with any firm-level digitalization metric, it may be subject to corporate self-reporting biases. We conduct additional robustness checks by replacing and decomposing this independent variable in subsequent analyses.

Macro-level uncertainty measures, including the GEPU, WTU, and GPR, were collected from the "policy uncertainty" website[1] [45,47,68]. These indices provide quarterly country-level data on external uncertainty. However, as aggregate measures, they do not reflect firm-specific exposure. To overcome this limitation, we construct a firm-specific uncertainty measure in our subsequent calculations by multiplying each firm's proportion of overseas suppliers by the corresponding country-level uncertainty index.

We bounded the influence of anomalous observations by winsorizing all continuous variables at the 1st and 99th percentiles. The final dataset represents an unbalanced panel of 12,506 firm-year observations across 2510 unique Chinese listed companies. In all regression analyses, we cluster standard errors at the firm level to account for potential serial correlation within firms over time. This research design ensures robust estimation of the proposed relationships while addressing common econometric concerns in panel data analysis.

3.2. Variables

3.2.1. Dependent Variable

The dependent variable in this study is the geographic scope of a firm's global supplier network. Following prior studies [69], we use the number of countries where a firm has suppliers as our main measure. Counting countries shows how widely a firm spreads its suppliers across the world. This measure captures the extensive margin of geographic diversification, emphasizing the firm's ability to enter and manage relationships across diverse national contexts. More countries mean greater geographic diversification. Fewer countries mean more concentration.

This measure captures geographic breadth effectively, though it does not represent the distribution of supplier counts across countries. To ensure robustness, we supplement it with three alternative metrics: an entropy-based index, an inverse Herfindahl–Hirschman Index (HHI), and a total geographic distance measure. Detailed discussion of these alternatives appears in Section 4.3.

3.2.2. Independent Variable

The digitalization of enterprises is measured using the comprehensive Digitalization Index from the CSMAR database. This sophisticated metric integrates six strategically weighted dimensions to capture the multifaceted nature of organizational digitalization.

The framework emphasizes Strategic Leadership (34.72%), which reflects top management's commitment to digital priorities, and Digital Outputs (27.13%), representing measurable innovation achievements. It further incorporates Technology Drive (16.20%), capturing the adoption of core digital technologies; Organizational Enablement (9.69%), assessing resource allocation for digital infrastructure; Digital Application (8.84%), evaluating the integration of digital capabilities into business operations; and Environmental Support (3.42%), gauging the digital maturity of the firm's external operating context. This carefully calibrated structure ensures the index captures both strategic inputs and performance outputs, providing a holistic assessment of corporate digital maturity that reflects the complex interplay between strategic direction, technological implementation, and innovation outcomes.

We utilized the comprehensive index as it effectively reflects how its constituent dimensions work together to lower search costs and strengthen governance capabilities. Strategic leadership supports both mechanisms by directing resources toward digital tools. The technology drive cuts search costs via AI and big data analytics, while cloud computing and blockchain improve oversight and coordination. Organization enablement establishes the foundational infrastructure required for efficient supplier discovery and management. Environmental support increases search effectiveness through greater data accessibility and enables more seamless governance via improved information flows. Digital output attracts potential partners and streamlines governance through standardized protocols. Meanwhile, digital application opens up new avenues for supplier identification and institutes more robust processes for managing external partners. Together, these integrated dimensions allow digitalization to simultaneously overcome the hurdles of locating new suppliers and administering a geographically dispersed network.

3.2.3. Moderating Variables

This study investigates how three types of external uncertainty moderate the link between digitalization and the geographic scope of supplier network. A central premise is that the same level of global uncertainty may affect firms differently, based on their exposure to international markets.

Prior research demonstrates that the adverse effects of external uncertainty are more pronounced for firms with extensive outsourcing [70]. We propose that a firm's reliance on its global supplier network shapes its vulnerability and reaction to external uncertainty. Firms with more overseas suppliers face higher strategic exposure [6]. As global uncertainty increases, these firms pay greater managerial attention and have stronger motivation to reconfigure their supplier networks. In contrast, firms with mostly domestic suppliers are more insulated. They feel less urgency to change their global footprint under the same uncertainty. To measure this firm-level exposure, we weight established global uncertainty indices by each firm's share of overseas suppliers. This method captures the idea that uncertainty's impact corresponds to a firm's existing global sourcing dependence.

Specifically, we measure a firm's exposure to GEPU by multiplying its proportion of overseas suppliers by the GEPU index [45]. This index combines policy uncertainty measures from 18 major economies, based on the frequency of newspaper articles discussing economic policy uncertainty [45].

For WTU, we construct a firm-specific measure by interacting the overseas supplier ratio with the WTU Index. This index uses textual analysis of Economist Intelligence Unit country reports to track mentions of uncertainty in trade-related contexts [68].

Finally, we measure exposure to geopolitical risk by multiplying the overseas supplier ratio with the GPR index, which systematically identifies articles related to adverse geopolitical events in major international newspapers [47].

These firm-specific interaction terms offer a nuanced view of how digitalization shape global supplier dispersion strategies, depending on a firm's existing international exposure and the uncertainty conditions it faces.

3.2.4. Control Variables

To isolate the effect of digitalization on supplier geographic scope, we include a comprehensive set of control variables that may influence global sourcing strategies. All firm-level controls are measured annually and obtained from the CSMAR database.

Firm Ownership and Characteristics: We control for state ownership with a binary indicator (SOE), coded 1 for state-controlled firms, as these may exhibit different global sourcing patterns due to political considerations and resource access [71]. Firm size is measured as the natural logarithm of total assets, since larger firms typically have more resources for international expansion [72]. We also control for profitability using return on assets (ROA), calculated as net income divided by total assets, as more profitable firms may be better able to sustain diverse global networks.

Financial Structure and Efficiency: We include the asset–liability ratio (leverage) to capture financial constraints that could limit international expansion. The management expense ratio (administrative expenses to total assets) controls for operational efficiency differences. The book-to-market ratio proxies for growth opportunities and market valuation [73], which can influence strategic investments in global sourcing.

Corporate Governance: The proportion of independent directors on the board accounts for governance quality and monitoring effectiveness [74], which may affect strategic decisions about global supplier networks. Ownership concentration is measured by the proportion of shares held by the largest shareholder, as this structure can influence a firm's risk appetite in global strategic decisions.

Financial Resources: We control for cash flow from operations (the difference between operating cash inflows and outflows), as firms with stronger cash positions are better equipped to manage the costs of geographically dispersed suppliers.

These controls help ensure that the estimated relationship between digitalization and supplier geographic scope is not confounded by other firm-specific factors known to affect internationalization decisions. Although our baseline model includes firm and year fixed effects, we have further incorporated industry and province fixed effects in subsequent analyses. This adjustment accounts for the possibility that some firms may change their industry classification or physical location during the study period.

3.3. Empirical Models

This study examines how corporate digitalization influences the geographic scope of global suppliers. We also examine how external environmental uncertainty moderates this relationship. Our baseline regression model is specified as follows:

$$Supplier\ Country\ Scope_{it} = \beta_0 + \beta_1 Digitalization_{it} + \beta_2 Controls_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In this model, the dependent variable $Supplier\ Country\ Scope_{it}$ measures the geographic dispersion of firm i's global suppliers in year t, calculated as the number of countries where the firm operates with suppliers. The main independent variable $Digitalization_{it}$ represents

firm i's level of digitalization in year t. The term $Controls_{it}$ includes all firm-level control variables described previously.

We incorporate firm fixed effects (α_i) to account for time-invariant firm characteristics that might influence global sourcing decisions. These effects control for unobserved factors such as corporate culture and management philosophy. We also include year fixed effects (λ_t) to capture common temporal shocks and trends that affect all firms simultaneously. The error term ε_{it} captures remaining unobserved factors. The coefficient β_1 represents the core relationship of interest: the effect of digitalization on the geographic distribution of suppliers, after controlling for firm-specific and time-specific factors.

To address potential endogeneity concerns, we conduct robustness checks using lagged independent and control variables:

$$Supplier\ Country\ Scope_{it} = \gamma_0 + \gamma_1 Digitalization_{i,t-1} + \gamma_2 Controls_{i,t-1} + \alpha_i + \lambda_t + \mu_{it} \quad (2)$$

For testing moderation effects, we extend our baseline model by incorporating interaction terms between digitalization and uncertainty measures: In Equation (3), $Uncertainty_{i,t-1}$ encompasses the three firm-specific uncertainty exposure measures—GEPU, WTU, and GPR. The coefficient δ_3 captures the moderating effect of each uncertainty dimension on the relationship between digitalization and supplier geographic dispersion. We estimate these models separately for each uncertainty measure to isolate their distinct moderating effects.

$$\begin{aligned} Supplier\ Country\ Scope_{it} &= \delta_0 + \delta_1 Digitalization_{it} + \delta_2 Uncertainty_{i,t-1} \\ &+\delta_3 Digitalization_{it} * Uncertainty_{i,t-1} + \delta_4 Controls_{it} + \alpha_i + \lambda_t + v_{it} \end{aligned} \quad (3)$$

4. Results

Table 2 presents the descriptive statistics for the key variables. On average, the firms in our sample maintain suppliers in 1.94 countries. The digitalization index shoes considerable variation, with values ranging from 21.98 to 64.95, indicating substantial heterogeneity in digital maturity across firms. The three moderating variables—GEPU, WTU, and GPR—have minimum values of zero. By construction, these values correspond to firms that source exclusively from domestic suppliers and therefore have no exposure to international uncertainty.

Table 2. Descriptive statistics of key variables.

Variables	Obs	Mean	Sd	Min	Max
Global Supplier Geographic Scope	12,506	1.9414	1.7170	1.0000	12.0000
Digitalization	12,506	37.7307	10.3480	21.9829	64.9535
SOE	12,506	0.3998	0.4899	0.0000	1.0000
Size	12,506	22.8401	1.2884	20.0142	27.2693
ROA	12,506	0.0300	0.0731	−0.3823	0.2080
Asset–liability ratio	12,506	0.4660	0.1983	0.0691	0.9279
Management expense ratio	12,506	0.0731	0.0629	0.0054	0.4675
Book to market ratio	12,506	0.3332	0.1621	0.0147	0.8183
Independent director ratio	12,506	37.6732	5.4305	33.3300	57.1400
Ownership concentration	12,506	34.0447	15.0579	7.8569	74.8237
Cash flow	12,506	0.0534	0.0675	−0.1620	0.2542
GEPU	12,506	86.4002	90.3596	0.0000	308.7665
WTU	12,506	8.3141	22.9993	0.0000	119.0658
GPR	12,506	42.8242	43.7654	0.0000	157.5800

Table 3 reports the correlation matrix. As expected, GEPU and GPR show a relatively high correlation, consistent with the frequent co-occurrence of geopolitical risks and economic policy uncertainty. However, since these variables are included into separate regression models, this correlation does not raise multicollinearity concerns in our estimations. To mitigate concerns regarding multicollinearity, we calculated the Variance Inflation Factor (VIF). The maximum VIF observed in our models is below 7, and the mean VIF is 2.12. As all values are well below the conventional threshold of 10, multicollinearity does not significantly affect our results.

Table 3. Correlation matrix of key variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Global Supplier Geographic Scope	1.0000													
Digitalization	0.1512	1.0000												
SOE	−0.0020	−0.0885	1.0000											
Size	0.2262	0.0569	0.3066	1.0000										
ROA	−0.0088	−0.0445	−0.0234	0.1009	1.0000									
Asset–liability ratio	0.0886	−0.0256	0.2290	0.4487	−0.3424	1.0000								
Management expense ratio	−0.0998	0.1000	−0.1043	−0.3600	−0.2829	−0.2047	1.0000							
Book to market ratio	−0.0171	−0.0561	0.0389	0.0598	0.0950	−0.4737	−0.0637	1.0000						
Independent director ratio	0.0255	0.0852	−0.0436	0.0078	−0.0316	0.0019	0.0236	−0.0466	1.0000					
Ownership concentration	0.0176	−0.1600	0.2611	0.2340	0.1537	0.0503	−0.1443	0.0694	0.0354	1.0000				
Cash flow	0.0098	−0.0600	−0.0270	0.0830	0.4473	−0.1849	−0.1760	0.0333	−0.0112	0.1178	1.0000			
GEPU	0.2410	0.0912	−0.1474	−0.0959	−0.0047	−0.1234	0.0224	0.0316	0.0238	−0.0617	0.0325	1.0000		
WTU	0.0932	0.0932	−0.0717	−0.0231	−0.0086	−0.0503	−0.0064	0.0062	0.0073	−0.0423	0.0523	0.4600	1.0000	
GPR	0.2379	0.0626	−0.1245	−0.1028	−0.0012	−0.1195	0.0565	0.0261	0.0148	−0.0411	0.0242	0.8821	0.2656	1.0000

4.1. Main Effects of Digitalization

Table 4 presents the baseline regression results examining the relationship between digitalization and supplier geographic scope. Column (1) reports a positive and statistically significant coefficient for digitalization alone (coef. = 0.0251, $p < 0.01$), providing initial support for Hypothesis 1.

Column (2) introduces control variables to strengthen the model specification. Column (3) adds year fixed effects to control for common temporal shocks. Column (4) includes both firm and year fixed effects, representing our most rigorous specification that accounts for unobserved time-invariant firm characteristics and aggregate time trends.

The digitalization coefficient remains positive and statistically significant across all specifications, demonstrating robust support for Hypothesis 1. This consistent pattern confirms that greater digitalization is associated with wider geographic dispersion of suppliers.

The model's explanatory power shows a notable progression. The Adjusted R^2 increases substantially from 0.0810 in Column (3) to 0.6849 in Column (4). This significant improvement occurs because the firm fixed effects effectively account for time-invariant firm characteristics that shape supplier network decisions. These characteristics encompass a range of inherent organizational traits such as corporate culture and management philosophy. Such traits systematically influence how firms configure their global supply base.

Regarding the control variables, the results reveal several notable patterns consistent with theoretical expectations. The significantly negative coefficient for state ownership indicates that state-owned enterprises tend to maintain more geographically concentrated supplier networks. This aligns with the view that SOEs often prioritize domestic supply chain security and are more deeply embedded in local institutional environments, reducing their incentive for global diversification. In contrast, firm size shows a positive and significant relationship with geographic dispersion. This suggests that larger firms, with

their greater resources and organizational capabilities, are better equipped to manage the complexities of extensive global supplier networks.

Table 4. Baseline regression results.

	(1)	(2)	(3)	(4)
Digitalization	0.0251 ***	0.0216 ***	0.0206 ***	0.0133 **
	(0.0037)	(0.0036)	(0.0037)	(0.0053)
SOE		−0.2063 ***	−0.1793 **	−0.2457 **
		(0.0779)	(0.0790)	(0.1117)
Size		0.3396 ***	0.3335 ***	0.1954 ***
		(0.0441)	(0.0449)	(0.0642)
ROA		−1.6122 ***	−1.4591 ***	−0.4635
		(0.3963)	(0.4080)	(0.2888)
Asset–liability ratio		−0.6101 ***	−0.5710 ***	−0.1348
		(0.2132)	(0.2208)	(0.2686)
Management expense ratio		−1.7418 ***	−1.5767 ***	0.0001
		(0.4969)	(0.5209)	(0.4567)
Book to market ratio		−0.5677 ***	−0.6358 ***	−0.5861 ***
		(0.2074)	(0.2293)	(0.2023)
Independent director ratio		0.0022	0.0015	0.0030
		(0.0059)	(0.0059)	(0.0050)
Ownership concentration		0.0002	0.0009	−0.0027
		(0.0027)	(0.0028)	(0.0038)
Cash flow		0.0732	−0.0073	0.0077
		(0.4235)	(0.4278)	(0.2176)
_cons	0.9950 ***	−5.9903 ***	−5.8312 ***	−2.6734 *
	(0.1311)	(1.0218)	(1.0366)	(1.4230)
Year FE	No	No	Yes	Yes
Firm FE	No	No	No	Yes
N	12,506	12,506	12,506	12,506
Adjusted R^2	0.0228	0.0786	0.0810	0.6849

Note: Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The same convention applies to all subsequent tables.

4.2. Analysis of Endogeneity Issues

We address potential endogeneity concerns through three identification strategies: first, we employ an instrumental variable approach to mitigate reverse causality; second, we include additional control variables to alleviate omitted variable bias; and third, we implement propensity score matching to account for sample selection bias.

4.2.1. Instrumental Variable Approach

This section addresses potential endogeneity concerns, particularly reverse causality. One possible issue is that firms with more globally dispersed supplier networks might have greater opportunities to develop digital capabilities. To mitigate this concern, we employ two identification strategies.

First, we lag all independent and control variables by one period to reduce simultaneity bias. As shown in Column (1) of Table 5, the coefficient on the lagged digitalization variable remains positive and statistically significant, consistent with our baseline results.

Table 5. Endogeneity Tests.

	(1)	(2)	(3)	(4)	(5)	(6)
Digitalization			0.0278 **	0.0116 **	0.0117 **	0.0135 **
			(0.0130)	(0.0053)	(0.0052)	(0.0053)
Digitalization_1	0.0098 **	0.3706 ***				
	(0.0050)	(0.0144)				
IV_distance*city		−0.0057 ***				
		(0.0017)				
R&D				0.0128 *		
				(0.0073)		
KZ				0.0338 **		
				(0.0165)		
_cons	−3.3857 **	2.2498		−3.0965 *	−3.0473 **	−2.5857 *
	(1.6565)	(3.5292)		(1.6317)	(1.4808)	(1.4236)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	No	No	No	No	Yes	No
Province FE	No	No	No	No	Yes	No
N	11,431	12,349	12,349	10,908	12,498	12,496
Adjusted R^2	0.7038	0.9088	0.0059	0.6934	0.6871	0.6851

Notes: Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Control variables consistent with the baseline model are included in all specifications. The same applies hereafter.

Second, we use an instrumental variable (IV) approach to strengthen causal inference. We construct two instruments to address potential endogeneity. The first instrument is the one-period lagged digitalization measure (digitalization_1). The second instrument, IV_distance*city, draws on Babina et al. [75], who argue that access to digital talent drives digital capability development. We calculate the geographic distance between a firm's headquarters and top-tier Chinese science and engineering universities, identified through official disciplinary assessments. This distance is then multiplied by the number of other firms in the same city.

The logic is that greater distance from talent sources, combined with stronger local competition for skilled workers, limits a firm's ability to hire digital specialists. This constraint negatively correlates with the firm's digitalization level.

The IV_distance*city instrument satisfies the exclusion restriction due to the exogenous nature of its components and their theorized channel of influence. The spatial distribution of universities is historically predetermined and unrelated to contemporary firm decisions, while city-wide firm count reflects general economic activity rather than supply chain-specific factors. Although these geographic and economic conditions might indirectly correlate with firm performance, their primary theoretical pathway to influencing supplier geographic dispersion is through constraining digital talent supply. It is this developed digitalization, not the instrument itself, that directly enables firms to identify, manage, and coordinate with geographically dispersed suppliers.

The IV estimation results appear in Columns (2) and (3) of Table 5. The first-stage results in Column (2) show a statistically significant positive relationship between lagged digitalization and current digitalization, and a significant negative relationship between IV_distance*city and digitalization. Both findings align with theoretical expectations. In the second stage (Column 3), the instrumented digitalization measure continues to show a positive and significant effect on the geographic scope of global suppliers. This supports our main hypothesis.

Post-estimation tests confirm the strength of our instruments. The Kleibergen–Paap rk LM statistic (p = 0.0000) rejects under identification, and the Wald F statistic of 337.062—well above the 10% Stock-Yogo critical value of 19.93—rules out weak instrument concerns. The nonsignificant Hansen J statistic (p = 0.2159) supports the validity of the overidentifying restrictions.

Together, these results validate the strength and exogeneity of our instruments. They provide credible evidence that digitalization promotes geographic dispersion in global supplier networks.

4.2.2. Controlling for Omitted Variables

We perform two robustness checks to address potential omitted variable bias. First, we introduce additional control variables that could affect global sourcing strategies. Specifically, we account for a firm's innovation intensity and financial health, as these factors may directly influence its capacity to reconfigure global supplier networks. These include a firm's innovation intensity, measured as R&D expenditure divided by operating revenue, and its financial constraints, captured by the Kaplan–Zingales (KZ) index. Firms with greater R&D commitment may possess stronger technological capabilities that facilitate managing dispersed partners, while financially constrained firms likely face greater challenges in undertaking the upfront investments required for global supply chain expansion. After including these controls, the digitalization coefficient remains positive and statistically significant, as shown in Column (4) of Table 5.

Second, we include both industry and province fixed effects. This approach controls for unobserved factors related to a firm's industry and regional context. Industry needs determine the strategic imperative for geographic dispersion, while regional conditions determine its practical feasibility. This interaction between sectoral requirements and locational constraints collectively shapes firms' supplier configuration decisions. As Column (5) of Table 5 shows, the positive relationship between digitalization and supplier geographic dispersion remains significant, confirming our main finding.

Across both tests, the digitalization coefficient shows remarkable stability in both magnitude and statistical significance. This consistency reinforces our main finding that digitalization promotes geographic dispersion of suppliers, while demonstrating the robustness of this relationship to alternative model specifications.

4.2.3. Propensity Score Matching Analysis

We address potential sample selection bias using Propensity Score Matching (PSM). Firms with above-median digitalization form the treatment group; those below-median form the control group. We estimate propensity scores through kernel matching, using our core control variables. The matching variables include state ownership, firm size, profitability, leverage, management expense ratio, growth opportunities, corporate governance, ownership concentration, and cash flow. These variables capture the key firm characteristics that may jointly influence digitalization adoption and global supplier configuration.

We rigorously assess matching quality through multiple balance checks. Multiple tests verify the matching quality. As Figure 3 shows, standardized differences for all covariates are below 2% after matching. t-tests in Table 6 show no significant inter-group differences. The Pseudo R^2 decreases to 0.000, and the joint significance test yields an insignificant result (p = 0.949). We re-estimate our model on this matched sample. As Column (6) of Table 5 shows, the effect of digitalization remains positive and statistically significant. This confirms our main finding is robust to sample selection concerns.

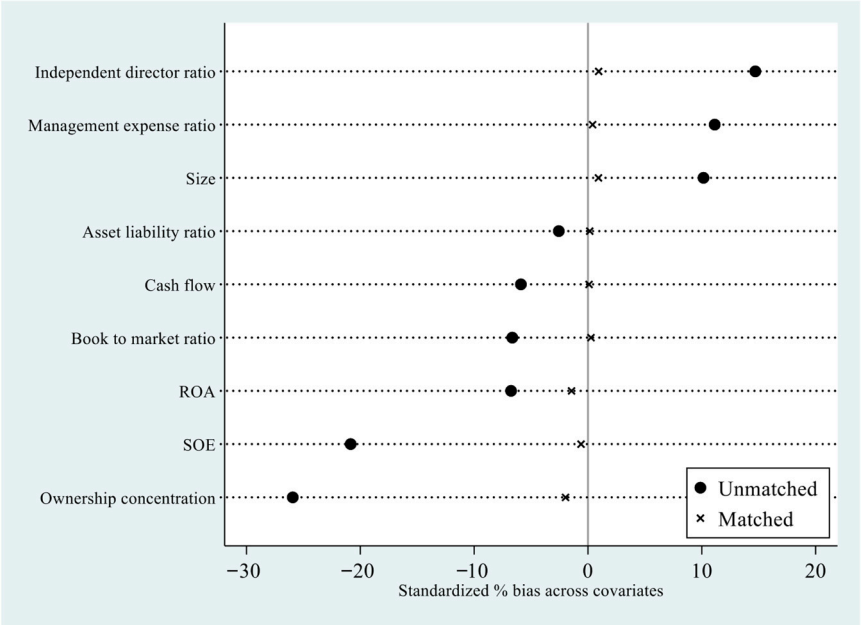


Figure 3. Standardized bias across covariates.

Table 6. *t*-tests of PSM.

Variables	Unmatched Matched	Mean			*t*-Test	
		Treated	Control	Bias %	*t*	$p > \|t\|$
SOE	U	0.3490	0.4506	−20.8	−11.66	0.000
	M	0.3494	0.3524	−0.6	−0.35	0.725
Size	U	22.905	22.7750	10.1	5.67	0.000
	M	22.903	22.8910	0.9	0.50	0.618
ROA	U	0.0275	0.0325	−6.8	−3.78	0.000
	M	0.0276	0.0286	−1.5	−0.77	0.443
Asset–liability ratio	U	0.4635	0.4686	−2.6	−1.43	0.152
	M	0.4634	0.4631	0.2	0.08	0.933
Management expense ratio	U	0.0766	0.0696	11.1	6.23	0.000
	M	0.0765	0.0763	0.4	0.21	0.835
Book to market ratio	U	0.3278	0.3386	−6.6	−3.72	0.000
	M	0.3280	0.3276	0.3	0.14	0.885
Independent director ratio	U	38.0710	37.2750	14.7	8.22	0.000
	M	38.0600	38.0100	0.9	0.50	0.616
Ownership concentration	U	32.1080	35.9810	−25.9	−14.50	0.000
	M	32.1230	32.4190	−2.0	−1.14	0.255
Cash flow	U	0.0514	0.0554	−5.9	−3.29	0.001
	M	0.0514	0.0514	0.1	0.05	0.962

4.3. Robustness of the Main Findings

We perform a series of robustness checks to validate our main findings. These tests use different model specifications, variable measurements, and sample compositions. Results appear in Table 7.

Table 7. Robustness Checks.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Poisson	Independent Variable	Dependent Variables			Sub-Samples		
Digitalization	0.0032 *		0.0058 ***	0.0024 ***	62.5400 *	0.0184 **	0.0162 ***	0.0208 **
	(0.0018)		(0.0013)	(0.0007)	(36.9896)	(0.0076)	(0.0060)	(0.0090)
Digitalization_alt		0.0031 **						
		(0.0015)						
_cons	−1.0822 *	−2.3103	−2.8273 ***	−1.3113 ***	-1.81×10^4	−0.4238	−3.0464 **	−1.2749
	(0.5676)	(1.4230)	(0.3634)	(0.1985)	(1.18×10^4)	(1.9530)	(1.5272)	(2.7215)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	12,506	12,502	12,506	12,506	12,307	7291	10,488	4615
Adjusted R^2	0.2398	0.6848	0.5641	0.5008	0.6358	0.7071	0.6931	0.6371

Note: Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

First, we estimate a Poisson model. This approach better suits the count-based nature of our dependent variable. As Column (1) shows, the digitalization effect remains positive and significant. This confirms our finding is robust to the choice of model.

Second, we test an alternative measure of digitalization. This check addresses potential measurement bias. We follow Wu et al. [76], and create a new index based on digital-related terms textual analysis in annual reports. As Column (2) shows, the positive effect remains significant. This confirms our result is not tied to one specific measurement method.

Third, we employ three alternative measures of supplier geographic scope.

The first measure is the entropy-based geographic dispersion index. Following established methodology [77], we calculate this index as:

$$Entropy_{index} = -\sum (p_i \times \ln p_i) \tag{4}$$

where p_i represents the proportion of a firm's suppliers located in country i. This metric captures the uniformity of supplier distribution across locations. A higher value indicates greater dispersion. Results in Column 3 of Table 7 remain consistent with our main findings.

The second measure is the inverse HHI. We compute this measure as:

$$HHI_{inverse} = 1 - \sum (p_i)^2 \tag{5}$$

where p_i again denotes the proportion of suppliers in country i. This metric reflects the degree of dispersion across countries. The result, shown in Column 4 of Table 7, continues to support our hypothesis.

The third measure is the total geographic distance. This measure sums the distances from China to each country where the firm maintains suppliers. It directly captures the spatial spread of the supplier network. As shown in Column 5 of Table 7, the significant positive effect persists, confirming the robustness of our findings across different dispersion metrics.

Finally, we test our results using different sample compositions. In Column (6), we remove firms with suppliers in only one country. This ensures our findings are not driven by firms with no geographic variation in their supply base. In Column (7), we exclude firms in the financial industry and the computer, communication, and other electronic equipment manufacturing sector. Financial firms often follow different location strategies, while tech firms typically have different digitalization patterns. Removing them addresses

this concern. In Column (8), we drop post-2019 data. This reduces potential bias from COVID-19 impacts on global supply chains.

Across all these samples, digitalization maintains a positive and significant link with supplier dispersion. This confirms our finding holds under various sample conditions.

4.4. The Moderating Role of External Uncertainty

This section presents the empirical tests for Hypotheses 2–4, which posit that external environmental uncertainty amplifies the positive effect of digitalization. The regression results are reported in Table 8.

Table 8. Moderating Effects.

	(1)	(2)	(3)	(4)	(5)
Digitalization	0.0087	0.0127 **	0.0078	0.0102	−0.0004
	(0.0055)	(0.0054)	(0.0054)	(0.0091)	(0.0044)
GEPU	0.0278				
	(0.0910)				
Digitalization*GEPU	0.0076 ***				
	(0.0023)				
WTU		0.0191			
		(0.1922)			
Digitalization*WTU		0.0093 **			
		(0.0046)			
GPR			0.0611	−0.4577	0.3962
			(0.1656)	(0.2951)	(0.1821)
Digitalization*GPR			0.0134 ***	0.0238 ***	0.0050
			(0.0043)	(0.0078)	(0.0047)
_cons	−2.9513 **	−2.6401 *	−2.8585 **	−0.9010	−3.7770 **
	(1.3894)	(1.4176)	(1.3936)	(2.6742)	(1.7980)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
N	12,506	12,506	12,506	4615	7441
Adjusted R^2	0.6966	0.6863	0.6944	0.6419	0.8383

Note: Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8 presents the moderating effect estimates for GEPU, WTU, and GPR in columns (1) through (3), respectively. Across all three models, the interaction terms between digitalization and uncertainty measures are positive and statistically significant. This consistent pattern strongly supports our hypotheses, indicating that the positive effect of digitalization on supplier geographic dispersion intensifies under heightened external uncertainty. These findings align with our theoretical argument: digitalization becomes particularly valuable for managing external resource dependencies when firms operate in volatile and unpredictable environments.

To further examine the moderating role of GPR, we split the sample into two periods based on its intensity. As shown in Columns (4) and (5), the average GPR index is significantly lower in 2011–2018 than in 2019–2023. The moderating effect of GPR is positive and significant in the earlier period (Column 4), but becomes insignificant in the later period (Column 5). This divergence supports a more nuanced view: the enabling role of digitalization is effective within a certain range of GPR, yet may diminish when geopolitical risk escalates to higher levels.

To help interpret these interaction effects, we plot the predictive margins in Figures 4–6. In these figures, the red line shows the relationship between digitalization and supplier

dispersion under high environmental uncertainty, while the blue line shows the relationship under low uncertainty.

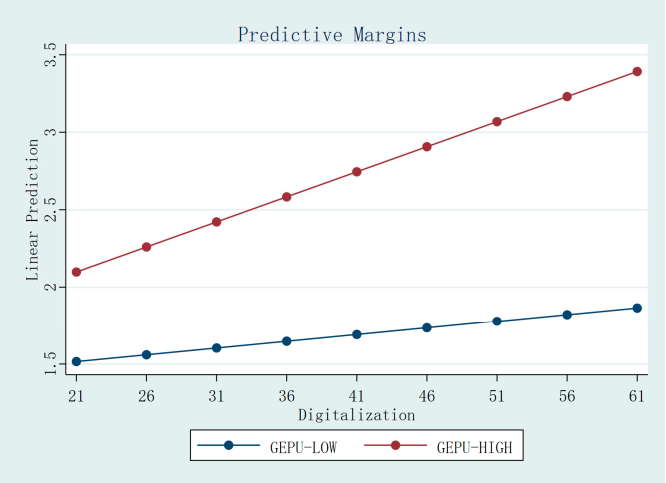


Figure 4. Moderating effects of GEPU.

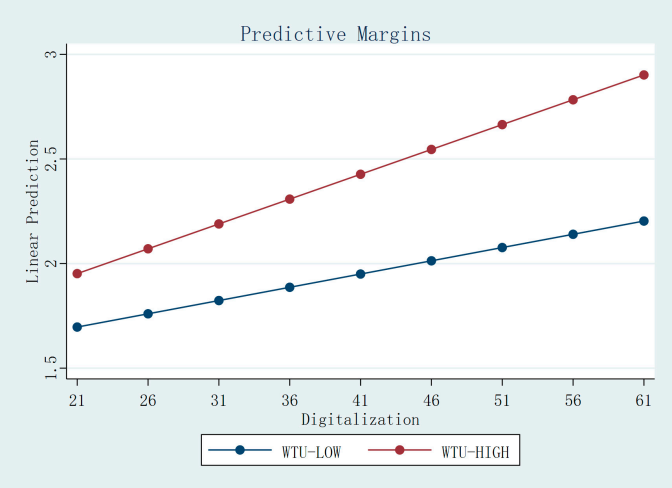


Figure 5. Moderating effects of WTU.

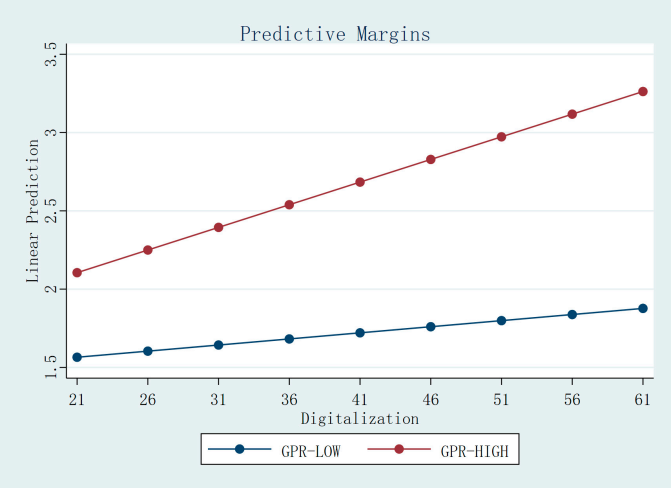


Figure 6. Moderating effects of GPR.

A clear pattern emerges across all three figures: the red line has a noticeably steeper slope than the blue line. This visual evidence confirms that the effect of digitalization on geographic dispersion is stronger when uncertainty is high. These graphs provide intuitive support for the moderating role of external uncertainty.

4.5. Extending the Research: Dimensions of Digitalization and Directions of Expansion

4.5.1. Heterogeneous Effects Across Digitalization Dimensions

Our study proposes that digitalization promotes global supplier dispersion by enhancing a firm's ability to manage external resource dependencies. To examine this mechanism, we analyze three distinct dimensions of digital application captured in a composite index: (1) Process innovation, reflected in automated workflows such as smart manufacturing; (2) Technological innovation, involving the adoption of foundational technologies such as 5G and digital twins; (3) Business model innovation, manifested through digital-driven products, services, or value propositions.

These indices are constructed using data from the CSMAR database, which calculates the frequency of relevant keywords in corporate annual reports. Example keywords include "digital twin" and "5G" for technological innovation, "smart manufacturing" for process innovation, and "smart healthcare" for business model innovation. We hypothesize that among these dimensions, supplier search and governance capabilities are most directly enhanced through innovations in process and technology.

The empirical results in Table 9 reveal an informative pattern. While process innovation demonstrates a significant positive effect on geographic scope, technological and business model innovations show statistically insignificant impacts when examined separately. However, the combined effect of technological and process innovation emerges as positive and significant. The significance of process innovation, particularly when coupled with technological infrastructure, aligns with its direct role in revolutionizing supply chain operations.

Table 9. Further Analysis.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Technology	0.0217								
	(0.0133)								
Process		0.0102 *							
		(0.0060)							
Business model			0.0024						
			(0.0061)						
Technology + Process				0.0138 **					
				(0.0067)					
Digitalization					−0.0001	0.0902 **	0.0070 **	0.0209 **	0.0005
					(0.0001)	(0.0437)	(0.0035)	(0.0086)	(0.0007)
_cons	−2.4201 *	−2.5754 *	−2.5888 *	−2.4428 *	−0.0124	−18.6818 **	−0.4388	−2.4927	0.0434
	(1.4181)	(1.4251)	(1.4267)	(1.4178)	(0.0247)	(8.5571)	(0.7373)	(1.8825)	(0.2516)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	12,506	12,506	12,506	12,506	12,506	12,506	12,506	12,506	12,506
Adjusted R^2	0.6848	0.6844	0.6842	0.6849	0.0068	0.6301	0.7147	0.6895	0.4717

Note: Standard errors are shown in parentheses. * and ** denote statistical significance at the 10% and 5% levels, respectively.

Digitized processes, such as automated supplier screening and integrated logistics platforms, directly lower the costs and complexities of identifying potential suppliers across

regions and managing ongoing relationships across distances. Technologies like cloud computing and big data analytics provide the essential infrastructure that enables these process improvements, creating a synergistic effect that makes global supplier networks operationally feasible and economically viable.

In contrast, the non-significance of business model innovation reinforces that the mechanism operates primarily through operational efficiencies rather than strategic repositioning. Business model innovation may redefine how a firm creates value but does not inherently provide the operational tools needed to identify and manage suppliers across diverse geographic locations. While potentially transformative in other strategic dimensions, these innovations lack the direct operational linkage required to overcome the tangible challenges of managing physical distance and coordinating across global supply bases.

4.5.2. Geographic Composition of the Supplier Network

Our main analysis shows that digitalization broadens the overall geographic scope of supplier networks. This subsection examines where that expansion occurs. We use the CEPII geographic classification to analyze supplier distribution across five regions: Africa, Asia, Europe, America, and the Pacific. Results in Table 8 (Columns 5–9) show a clear pattern. Digitalization significantly increases supplier counts in Asia, Europe, and America. It does not significantly affect counts in Africa or the Pacific.

This pattern refines our main hypothesis. Asia, Europe, and America represent the world's most established manufacturing and consumer markets. Entering these regions demands advanced digital capabilities. Firms must navigate complex ecosystems, meet high standards, and manage sophisticated logistics. In contrast, Africa and the Pacific often present different sourcing opportunities such as resource extraction and lower-cost labor. In such contexts, the specific search and coordination capabilities enhanced by digitalization are less critical. Overall, digitalization helps firms build presence in complex, established markets rather than uniformly scattering suppliers worldwide.

5. Discussion

This study examines how corporate digitalization influences the geographic scope of firms' global supplier networks. While RDT has traditionally emphasized structural responses like merges and joint ventures to manage dependencies [10], our findings reveal digitalization as a fundamentally different type of organizational capability. This study shifts the theoretical focus from structural solutions to include operational capabilities as core means of dependence management.

Empirical evidence from Chinese listed companies strongly supports this view. We find digitalization significantly expands supplier network geographic scope, with this relationship being systematically moderated by external uncertainty. Specifically, when economic policy uncertainty, trade uncertainty, or geopolitical risk increases, firms demonstrate stronger motivation to manage their supplier relationships through digital means. This finding connects two distinct types of dependence in RDT, demonstrating how environmental dependence directly strengthens partner dependence management.

Our analysis further reveals that process and technological innovations drive this geographic expansion. This suggests digital capabilities prove most valuable in core operational activities that underpin supplier management.

Finally, we introduce a network-level perspective to dependence management. While traditional RDT research typically examines single dyadic relationships, our findings show firms can manage their entire supplier portfolio as an integrated system. By strategically configuring the geographic composition of their supplier network—particularly through expansion into established markets like Asia, Europe, and America—firms gain more

effective control over their external dependencies. This redefines the unit of analysis in dependence management from individual relationships to the overall network structure.

5.1. Theoretical Contribution

This study makes several key theoretical contributions that extend the boundaries of RDT, supply chain management, and digitalization literature.

First, our findings advance resource dependence theory by revealing a new strategic approach to dependency management [8]. While traditional RDT applications in supply chains emphasize dyadic relationships [10,78], we demonstrate how digitalization enables firms to manage dependencies through supplier network architecture. Specifically, we conceptualize the geographic scope of a firm's entire supplier network as a proactive mechanism for managing external dependence. Our empirical results confirm that digitalization helps firms disperse suppliers across multiple countries. We also find that external uncertainty strengthens this motivation, thereby linking environmental dependence with partner dependence in RDT. Together, these insights provide a more systemic understanding of how modern firms manage dependencies through digital capabilities.

Second, our study shifts the focus of global supplier network research from consequences to antecedents. While existing work extensively documents outcomes—such as effects on innovation and performance [37,64]—less is known about the capabilities that enable firms to configure these networks in the first place. We identify digitalization as a key enabler, demonstrating its role through a dual mechanism: it reduces the costs and information barriers of global supplier search, while simultaneously enhancing the firm's ability to manage dispersed networks by lowering coordination and monitoring costs. In this way, we reframe digitalization not as a mere optimization tool, but as a foundational capability that unlocks the strategic option of geographic dispersion.

Third, our study broadens the understanding of digitalization. While prior research has compellingly demonstrated how digitalization improves internal outcomes such as innovation and ESG performance [79], and enhances bilateral supply chain relationships [7], we extend this perspective to a macro-strategic level. Specifically, we show that digitalization enables firms to expand the geographic scope of their overall supplier network and this effect intensifies under uncertain conditions. This finding reveals a more strategic and systemic role for digitalization: it empowers firms not merely to operate efficiently within existing networks, but to proactively reconfigure their global resource dependence landscape.

5.2. Practical Implications

Our findings provide practical guidance for managers.

First, digitalization is a key investment for global supply chain development. Firms seeking global expansion can use digital tools to find and connect with suitable suppliers worldwide. This helps them build strategic supplier networks beyond geographic limits. For firms already in global networks, digitalization improves transparency and coordination across their supplier base [7,80]. This turns a widespread network from a challenge into a manageable advantage.

Second, managers should adopt a network-level perspective in supply chain design. While individual supplier relationships are important, executives must also consider the overall architecture of their supplier network [28,37]. Our findings show that building a geographically diversified network helps reduce concentration risk and decreases over-reliance on specific regions or suppliers. This approach strengthens a firm's strategic independence.

Finally, digitalization offers a way to manage uncertainty. As geopolitical tensions and supply chain disruptions increase, firms are turning to strategies like friend-shoring and diversification [6]. These transitions can be costly. However, our research shows that

digitalization helps reduce these costs. Developing digital capabilities is therefore not just about operational improvement but also a strategic necessity. It allows firms to adapt their global supplier networks with greater agility and confidence in a volatile environment.

5.3. Limitations and Future Research

This study has several limitations that suggest valuable directions for future research.

First, our sample focuses on Chinese listed companies. While important in global supply chains, their strategic choices may not represent all firms. Companies in developed markets or those less globalized may show different patterns due to varying institutional environments. Future studies could examine firms from different countries to build a more universal theory.

Second, our data may not capture all supplier relationships. Although we focus on geographic distribution, this could still affect results. Future research could use detailed case studies of firms that fully disclose their supplier lists to better understand network structures.

Third, our analysis is largely static. We study the scope of supplier networks but not how they change over time. Future work could use longitudinal or case methods to trace how firms actually build their global networks, including the sequence, timing, and reasons behind each expansion step. This would shed light on the real strategic choices firms face.

In summary, this study shows how digitalization helps firms expand their global supplier networks. Theoretically, it extends resource dependence theory by highlighting network-level strategies; advances supply chain research by identifying digitalization as a key driver; and broadens digitalization studies by showing its role in shaping global networks. For managers, it offers guidance on using digitalization to build resilient supply chains in an uncertain world.

6. Conclusions

This study confirms that digitalization significantly expands the geographic dispersion of suppliers, with stronger effects in highly uncertain environments. Theoretically, we advance resource dependence theory by introducing a network perspective and establishing digitalization as a key mechanism for dependency management. By showing how digital capabilities enable firms to reconfigure supplier networks amid external constraints, this research reframes digitalization from a technical tool into a strategic asset for navigating global dependency challenges.

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Abbreviations

The following abbreviations are used in this manuscript:

CEPII	Centre d'Études Prospectives et d'Informations Internationales
CSMAR	China Stock Market & Accounting Research Database
GEPU	Global Economic Policy Uncertainty
GPR	Geopolitical Risk
RDT	Resource Dependence Theory
WTU	World Trade Uncertainty

Notes

[1] Data obtained from www.policyuncertainty.com (accessed on 8 November 2025).

References

1. Vertinsky, I.; Kuang, Y.Q.; Zhou, D.S.; Cui, V.C. The Political Economy and Dynamics of Bifurcated World Governance and the Decoupling of Value Chains: An Alternative Perspective. *J. Int. Bus. Stud.* **2023**, *54*, 1351–1377. [CrossRef]
2. Verwaal, E. Global Outsourcing, Explorative Innovation and Firm Financial Performance: A Knowledge-Exchange Based Perspective. *J. World Bus.* **2017**, *52*, 17–27. [CrossRef]
3. Zhang, D.J.; Dabadghao, S.S.; Udenio, M. Global Sourcing under Tariffs: A Perspective of Time Series Analysis. *Int. J. Prod. Econ.* **2025**, *280*, 109473. [CrossRef]
4. Ben, C.; Han, M.Z.; Wu, J. Trade and Foreign Economic Policy Uncertainty in Supply Chain Networks: Who Comes Home? *MSOM-Manuf. Serv. Oper. Manag.* **2023**, *25*, 126–147. [CrossRef]
5. Deng, Z.L.; Wang, Y.H.; Xu, H.J. Supplier Response to Apple's Friendshoring. *J. Bus. Res.* **2025**, *200*, 115614. [CrossRef]
6. Charpin, R.; Cousineau, M. Friendshoring: How Geopolitical Tensions Affect Foreign Sourcing, Supply Base Complexity, and Sub-Tier Supplier Sharing. *Int. J. Oper. Prod. Manag.* **2025**, *45*, 1006–1031. [CrossRef]
7. Li, L.X.; Chen, L.J.; Liu, Y.Q. Digital Governance for Supplier Opportunism: The Mediating Role of Supplier Transparency. *Int. J. Prod. Econ.* **2024**, *275*, 109351. [CrossRef]
8. Pfeffer, J.; Salancik, G.R. The External Control of Organizations: A Resource Dependency Perspective. *Econ. J.* **1979**, *89*, 969–970. [CrossRef]
9. Hillman, A.J.; Withers, M.C.; Collins, B.J. Resource Dependence Theory: A Review. *J. Manag.* **2009**, *35*, 1404–1427. [CrossRef]
10. Casciaro, T.; Piskorski, M.J. Power Imbalance, Mutual Dependence, and Constraint, Absorption: A Close Look at Resource Dependence Theory. *Adm. Sci. Q.* **2005**, *50*, 167–199. [CrossRef]
11. Yu, Z.P.; Cao, X.N.; Tang, L.; Yan, T.H.; Wang, Z.Y. Does Digitalization Improve Supply Chain Efficiency? *Financ. Res. Lett.* **2024**, *67*, 105822. [CrossRef]
12. Son, B.G.; Kim, H.; Hur, D.; Subramanian, N. The Dark Side of Supply Chain Digitalisation: Supplier-Perceived Digital Capability Asymmetry, Buyer Opportunism and Governance. *Int. J. Oper. Prod. Manag.* **2021**, *41*, 1220–1247. [CrossRef]
13. Wang, L.; Zhang, C.; Huang, Y. Can Digitalization Transform Conventional Governance to Curb Supplier Opportunism in Emerging Markets? *Int. J. Oper. Prod. Manag.* **2025**, 1–34. [CrossRef]
14. An, J.; Li, S.C.; Qiao, J.Q. How Does Supply Chain Digitalization Affect Supply Chain Transparency? The Roles of Supply Chain Collaboration and Cross-Organizational Governance. *Bus. Process. Manag. J.* **2025**. [CrossRef]
15. Zhao, N.Y.; Hong, J.T.; Lau, K.H. Impact of Supply Chain Digitalization on Supply Chain Resilience and Performance: A Multi-Mediation Model. *Int. J. Prod. Econ.* **2023**, *259*, 108817. [CrossRef]
16. Chor, D.; Manova, K.; Yu, Z.H. Growing Like China: Firm Performance and Global Production Line Position. *J. Int. Econ.* **2021**, *130*, 103445. [CrossRef]
17. Hu, S.M.; Chen, M.H.; Liu, X.J.; Wang, H. Winner-Takes-All or Inclusive Growth? The Impact of Digitalization on Inter-Firm Wage Inequality: Evidence from China. *Appl. Econ.* **2025**, *57*, 5777–5792. [CrossRef]
18. Xiong, S.; Paulraj, A.; Dai, J.; Irawan, C.A. Digital Integration Capability Asymmetry and Buyer Product Innovation: The Contingent Roles of Environmental Dynamism and Innovative Climate. *Int. J. Oper. Prod. Manag.* **2025**, *45*, 756–782. [CrossRef]
19. Jiang, Q.; Wang, N.M.; Jiang, B.; Bu, F. Relationship between Supply Chain Disruption Orientation and Firm's Resilience in China: The Dynamic Capabilities Perspective. *Asia Pac. Bus. Rev.* **2024**, 1–28. [CrossRef]
20. Alessandria, G.; Khan, S.Y.; Khederlarian, A.; Ruhl, K.J.; Steinberg, J.B. Trade War and Peace: Us-China Trade and Tariff Risk from 2015-2050. *J. Int. Econ.* **2025**, *155*, 104066. [CrossRef]
21. Xia, J.; Li, S. The Divestiture of Acquired Subunits: A Resource Dependence Approach. *Strateg. Manag. J.* **2013**, *34*, 131–148. [CrossRef]

22. Drees, J.M.; Heugens, P. Synthesizing and Extending Resource Dependence Theory: A Meta-Analysis. *J. Manag.* **2013**, *39*, 1666–1698. [CrossRef]
23. Nikookar, E.; Stevenson, M.; Varsei, M. Building an Antifragile Supply Chain: A Capability Blueprint for Resilience and Post-Disruption Growth. *J. Supply Chain Manag.* **2024**, *60*, 13–31. [CrossRef]
24. Fan, D.; Ma, P.C.; Cui, L.; Yiu, D.W. Locking in Overseas Buyers Amid Geopolitical Conflicts. *J. Oper. Manag.* **2024**, *70*, 756–792. [CrossRef]
25. Gulati, R.; Sytch, M. Dependence Asymmetry and Joint Dependence in Interorganizational Relationships: Effects of Embeddedness on a Manufacturer's Performance in Procurement Relationships. *Adm. Sci. Q.* **2007**, *52*, 32–69. [CrossRef]
26. Zona, F.; Gomez-Mejia, L.R.; Withers, M.C. Board Interlocks and Firm Performance: Toward a Combined Agency-Resource Dependence Perspective. *J. Manag.* **2018**, *44*, 589–618. [CrossRef]
27. Xia, J.; Ma, X.F.; Lu, J.W.; Yiu, D.W. Outward Foreign Direct Investment by Emerging Market Firms: A Resource Dependence Logic. *Strateg. Manag. J.* **2014**, *35*, 1343–1363. [CrossRef]
28. Jiang, S.Y.; Yeung, A.C.L.; Han, Z.J.; Huo, B.F. The Effect of Customer and Supplier Concentrations on Firm Resilience During the COVID-19 Pandemic: Resource Dependence and Power Balancing. *J. Oper. Manag.* **2023**, *69*, 497–518. [CrossRef]
29. Jajja, M.S.S.; Kannan, V.R.; Brah, S.A.; Hassan, S.Z. Linkages between Firm Innovation Strategy, Suppliers, Product Innovation, and Business Performance Insights from Resource Dependence Theory. *Int. J. Oper. Prod. Manag.* **2017**, *37*, 1054–1075. [CrossRef]
30. Palit, S.; Hora, M.; Ghosh, S. Global Buyer-Supplier Networks and Innovation: The Role of Technological Distance and Technological Breadth. *J. Oper. Manag.* **2022**, *68*, 755–774. [CrossRef]
31. Obal, M.; Lancioni, R.A. Maximizing Buyer-Supplier Relationships in the Digital Era: Concept and Research Agenda. *Ind. Mark. Manag.* **2013**, *42*, 851–854. [CrossRef]
32. Prajogo, D.; Chowdhury, M.; Nair, A.; Cheng, T.C.E. Mitigating the Performance Implications of Buyer's Dependence on Supplier: The Role of Absorptive Capacity and Long-Term Relationship. *Supply Chain Manag.* **2020**, *25*, 693–707. [CrossRef]
33. Wang, Y.G.; Wang, N.; Jiang, L.; Yang, Z.L.; Cui, V. Managing Relationships with Power Advantage Buyers: The Role of Supplier Initiated Bonding Tactics in Long-Term Buyer-Supplier Collaborations. *J. Bus. Res.* **2016**, *69*, 5587–5596. [CrossRef]
34. Berenguer, G.; Lorenzo, N.C.; Cuenca, A.S.D. The State of Supplier Diversity Initiatives by Large Corporations: The New Sustainable Supply Chain? *Prod. Oper. Manag.* **2025**, *34*, 541–551. [CrossRef]
35. Zhao, J.Y.; He, T.; Xi, X.; Li, W.H.; Liu, W. Geographic Proximity and Supply Chain Resilience: Unravelling Their Complex Dynamics in the Digital Age. *Technovation* **2025**, *148*, 103328. [CrossRef]
36. Richard, O.C.; Su, W.C.; Peng, M.W.; Miller, C.D. Do External Diversity Practices Boost Focal Firm Performance? The Case of Supplier Diversity. *Int. J. Hum. Resour. Manag.* **2015**, *26*, 2227–2247. [CrossRef]
37. Sharma, A.; Kumar, V.; Borah, S.B.; Adhikary, A. Complexity in a Multinational Enterprise's Global Supply Chain and Its International Business Performance: A Bane or a Boon? *J. Int. Bus. Stud.* **2022**, *53*, 850–878. [CrossRef]
38. Benzidia, S.; Makaoui, N.; Bentahar, O. The Impact of Big Data Analytics and Artificial Intelligence on Green Supply Chain Process Integration and Hospital Environmental Performance. *Technol. Forecast. Soc. Change* **2021**, *165*, 120557. [CrossRef]
39. Pagani, M.; Pardo, C. The Impact of Digital Technology on Relationships in a Business Network. *Ind. Mark. Manag.* **2017**, *67*, 185–192. [CrossRef]
40. Verhoef, P.C.; Broekhuizen, T.; Bart, Y.; Bhattacharya, A.; Dong, J.Q.; Fabian, N.; Haenlein, M. Digital Transformation: A Multidisciplinary Reflection and Research Agenda. *J. Bus. Res.* **2021**, *122*, 889–901. [CrossRef]
41. Benabdellah, G.C.; Zekhnini, K.; Benabdellah, A.C.; Lu, Q.; Wu, J.; Khan, Z. Building Dynamic Capabilities in Supplier Selection in Industry 4.0 Era: A Literature Review. *J. Gen. Manag.* **2024**, *50*, 53–64. [CrossRef]
42. Davis-Sramek, B.; Omar, A.; Germain, R. Leveraging Supply Chain Orientation for Global Supplier Responsiveness: The Impact of Institutional Distance. *Int. J. Logist. Manag.* **2019**, *30*, 39–56. [CrossRef]
43. Culotta, C.; Blome, C.; Henke, M. Theories of Digital Platforms for Supply Chain Management: A Systematic Literature Review. *Int. J. Phys. Distrib. Logist. Manag.* **2024**, *54*, 449–475. [CrossRef]
44. Su, C.J.; Chen, Y.A. Risk Assessment for Global Supplier Selection Using Text Mining. *Comput. Electr. Eng.* **2018**, *68*, 140–155. [CrossRef]
45. Baker, S.R.; Bloom, N.; Davis, S.J. Measuring Economic Policy Uncertainty. *Q. J. Econ.* **2016**, *131*, 1593–1636. [CrossRef]
46. Avsar, V.; Hudgins, D. Measuring the Effects of Economic Policy Uncertainty on Trade Credit Financing. *Appl. Econ. Lett.* **2022**, *29*, 249–252. [CrossRef]
47. Caldara, D.; Iacoviello, M. Measuring Geopolitical Risk. *Am. Econ. Rev.* **2022**, *112*, 1194–1225. [CrossRef]
48. Huang, Y.; Luk, P. Measuring Economic Policy Uncertainty in China. *China Econ. Rev.* **2020**, *59*, 101367. [CrossRef]
49. Bandura, W.N. Trade Uncertainty in Us and China on Trade Openness in Sub-Sanaran Africa. *China Econ. J.* **2022**, *15*, 49–59. [CrossRef]
50. Handfield, R.B.; Graham, G.; Burns, L. Corona Virus, Tariffs, Trade Wars and Supply Chain Evolutionary Design. *Int. J. Oper. Prod. Manag.* **2020**, *40*, 1649–1660. [CrossRef]

51. Saghiri, S.; Mohammadipour, M.; Mirzabeiki, V. Revisiting Operations Agility and Formalizing Digitalization in Response to Varying Levels of Uncertainty and Customization. *Prod. Plan. Control* **2025**, *36*, 925–949. [CrossRef]
52. Chen, Z.Y.; Huang, L.Z. Digital Twins for Information-Sharing in Remanufacturing Supply Chain: A Review. *Energy* **2021**, *220*, 119712. [CrossRef]
53. Ding, Q.; Chen, J.Y. How Does Supplier Digitalization Improve Customer Resource Allocation Efficiency? The Role of Supply Chain Entrainment. *Int. J. Oper. Prod. Manag.* **2025**, *45*, 1336–1362. [CrossRef]
54. Freund, C.; Mattoo, A.; Mulabdic, A.; Ruta, M. Is Us Trade Policy Reshaping Global Supply Chains? *J. Int. Econ.* **2024**, *152*, 104011. [CrossRef]
55. Nasiri, M.; Ukko, J.; Saunila, M.; Rantala, T. Managing the Digital Supply Chain: The Role of Smart Technologies. *Technovation* **2020**, *96–97*, 102121. [CrossRef]
56. Ivanov, D.; Dolgui, A.; Sokolov, B. The Impact of Digital Technology and Industry 4.0 on the Ripple Effect and Supply Chain Risk Analytics. *Int. J. Prod. Res.* **2019**, *57*, 829–846. [CrossRef]
57. Lee, H.; Baek, S. South Korea's Supply Chain Diversification in Response to Geopolitical Risk: Evidence from Change Point Detection Approach to Battery Industry. *Asia Pac. Bus. Rev.* **2025**, 1–25. [CrossRef]
58. Saberi, S.; Kouhizadeh, M.; Sarkis, J.; Shen, L.J. Blockchain Technology and Its Relationships to Sustainable Supply Chain Management. *Int. J. Prod. Res.* **2019**, *57*, 2117–2135. [CrossRef]
59. Wu, D.Z.; Rosen, D.W.; Wang, L.H.; Schaefer, D. Cloud-Based Design and Manufacturing: A New Paradigm in Digital Manufacturing and Design Innovation. *Comput.-Aided Des.* **2015**, *59*, 1–14. [CrossRef]
60. Ha, T.M.; Thang, D.N. Economic Sanction and Global Sourcing Complexity: A Cross-Country Analysis. *World Econ.* **2023**, *46*, 1017–1050. [CrossRef]
61. Jin, X.Y.; Zuo, C.J.; Fang, M.Y.; Li, T.; Nie, H.H. Measurement Problem of Enterprise Digital Transformation:New Methods and Findings Based on Large Language Models. *Econ. Res. J.* **2024**, *59*, 34–53.
62. Fang, L.T.; Li, Z.H. Corporate Digitalization and Green Innovation: Evidence from Textual Analysis of Firm Annual Reports and Corporate Green Patent Data in China. *Bus. Strateg. Environ.* **2024**, *33*, 3936–3964. [CrossRef]
63. Wu, Y.; Li, Z. Digital Transformation, Entrepreneurship, and Disruptive Innovation: Evidence of Corporate Digitalization in China from 2010 to 2021. *Hum. Soc. Sci. Commun.* **2024**, *11*, 163. [CrossRef]
64. Guo, B.; Li, X.; Liu, T.; Wu, D. Supplier–Supplier Coopetition and Buyer Innovation: A Perspective of Learning and Competitive Tension within the Focal Buyer's Supplier Network. *Int. J. Oper. Prod. Manag.* **2023**, *43*, 1409–1433. [CrossRef]
65. Ding, H.Y.; Hu, Y.C.; Jiang, H.; Wu, J.; Zhang, Y. Social Embeddedness and Supply Chains: Doing Business with Friends Versus Making Friends in Business. *Prod. Oper. Manag.* **2023**, *32*, 2154–2172. [CrossRef]
66. Yang, Y.; Jiang, Y.; Chen, X.W. Does Buyers' Financial Slack Promote or Inhibit Suppliers' Circular Economy Performance? *Ind. Mark. Manag.* **2021**, *99*, 111–122. [CrossRef]
67. Guo, S.J.; Zan, B.T.; Sun, Y.; Zhang, M.L. Effects of Top Managers' Military Experience on Technological Innovation in the Transition Economies of China. *Technol. Forecast. Soc. Change* **2020**, *153*, 119909. [CrossRef]
68. Ahir, H.; Bloom, N.; Furceri, D. The World Uncertainty Index. In *National Bureau of Economic Research Working Paper Series*; National Bureau of Economic Research: Cambridge, MA, USA, 2022.
69. Kim, M. Geographic Scope, Isolating Mechanisms, and Value Appropriation. *Strateg. Manag. J.* **2016**, *37*, 695–713. [CrossRef]
70. Fan, D.; Zhou, Y.; Yeung, A.C.L.; Lo, C.K.Y.; Tang, C. Impact of the Us-China Trade War on the Operating Performance of Us Firms: The Role of Outsourcing and Supply Base Complexity. *J. Oper. Manag.* **2022**, *68*, 928–962. [CrossRef]
71. Cuervo-Cazurra, A.; Inkpen, A.; Musacchio, A.; Ramaswamy, K. Governments as Owners: State-Owned Multinational Companies. *J. Int. Bus. Stud.* **2014**, *45*, 919–942. [CrossRef]
72. Li, Y.; Zhang, Y.A.; Shi, W. Navigating Geographic and Cultural Distances in International Expansion: The Paradoxical Roles of Firm Size, Age, and Ownership. *Strateg. Manag. J.* **2020**, *41*, 921–949. [CrossRef]
73. Pontiff, J.; Schall, L.D. Book-to-Market Ratios as Predictors of Market Returns. *J. Financ. Econ.* **1998**, *49*, 141–160. [CrossRef]
74. Byrd, J.W.; Hickman, K.A. Do Outside Directors Monitor Managers—Evidence from Tender Offer Bids. *J. Financ. Econ.* **1992**, *32*, 195–221. [CrossRef]
75. Babina, T.; Fedyk, A.; He, A.L.; Hodson, J. Artificial Intelligence, Firm Growth, and Product Innovation. *J. Financ. Econ.* **2024**, *151*, 103745. [CrossRef]
76. Wu, F.; Hu, H.; Lin, H.; Ren, X. Enterprise Digital Transformation and Capital Market Performance: Empirical Evidence from Stock Liquidity. *J. Manag. World* **2021**, *37*, 130–144+10. [CrossRef]
77. Phillips, S.J.; Anderson, R.P.; Schapire, R.E. Maximum Entropy Modeling of Species Geographic Distributions. *Ecol. Model.* **2006**, *190*, 231–259. [CrossRef]
78. Yin, Y.; Wang, Q. The Influence of Supplier Dependence on Exploitation and Exploration in Innovation: Evidence from a Resource Dependence Perspective. *Int. J. Oper. Prod. Manag.* **2025**, *45*, 1721–1751. [CrossRef]

79. Kong, J.Y.; Goh, M.; Cao, Y. Can Digital Economy Development Facilitate Corporate Esg Performance? *Sustainability* **2024**, *16*, 3956. [CrossRef]
80. Li, Q.; Tian, W.J.; Zhang, H. Digital Transformation for Sustainability in Industry 4.0: Alleviating the Corporate Digital Divide and Enhancing Supply Chain Collaboration. *Systems* **2025**, *13*, 123. [CrossRef]

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