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# Navigating through geopolitical risk: The role of supply chain concentration

**Abstract**

**Purpose:** This study aims to investigate the impact of geopolitical risk (GPR) on supply chain concentration (SCC) and the roles of operational capabilities and resources in this relationship.

**Design/methodology/approach:** Secondary longitudinal data from multiple sources are collected and combined to test for a direct impact of GPR on SCC. We further examine the moderating effects of firms' operational capabilities and resources (i.e., firm resilience, operational slack, and cash holding). Fixed-effect regression models are applied to test the hypotheses, followed by a series of robustness tests to check the consistency of the results.

**Findings:** Consistent with the tenets of resource dependence theory, our analysis reveals a significant negative impact of GPR on SCC. Moreover, we find that this adverse effect is attenuated for firms with higher levels of resilience, more operational slack, and greater cash holdings. Further analysis suggests that maintaining a diversified supply chain base during heightened GPR is associated with a firm's improved financial performance.

**Originality/value:** This study contributes to the supply chain management (SCM) literature by integrating GPR into the supply chain risk management framework. Additionally, it demonstrates the roles of diversification and operational resources in addressing GPR-induced challenges.

**Keywords:** Geopolitical risk, Supply chain concentration, Operational resources, Resource dependence theory, China

**Paper type:** Research paper

## 1. Introduction

A world that had been ordered for decades primarily by globalization and geoeconomics has swiftly transformed into one increasingly grounded in geopolitical risk (GPR) (S&P, 2024). This transformation has been catalyzed by a series of accumulating shocks, including Brexit, the COVID-19 pandemic, the strategic competition between the U.S. and China, and the Russia-Ukraine conflict, all of which have significantly reorganized global structures and relationships (Bednarski *et al*., 2024). According to a client survey released by Goldman Sachs in January 2024, 54% of respondents identified geopolitics as the top risk to markets and the global economy this year (Gledhill, 2024). As GPR intensifies, supply chain management (SCM) faces several interconnected challenges, including disruptions in the flow of goods and services across borders, difficulties in supply chain planning and forecasting, and the erosion of trust and cooperation along the supply chain (Moradlou *et al*., 2024; Roscoe *et al*., 2020; Sheth and Uslay, 2023). Clearly, it is imperative for both academics and practitioners to broaden the scope of supply chain risk management (SCRM) to include GPR and explore potential operations and supply chain strategies that can effectively mitigate such risks (Tang, 2006).

Buyer-supplier relationships (BSRs) are essential to firm success due to their critical roles in helping firms gain competitive advantages (Revilla and Knoppen, 2015; Whipple *et al*., 2015). One key aspect of BSRs that has recently garnered scholarly attention is supply chain concentration (SCC). This concept has been examined across various fields, including finance, accounting, strategic management, and SCM (Ak and Patatoukas, 2016; Cohen and Li, 2020; Dhaliwal *et al*., 2016). A concentrated supply chain occurs when a customer heavily relies on a small number of suppliers for essential inputs or when a supplier derives a significant portion of its revenue from a few key customers (Jiang *et al*., 2023; Patatoukas, 2012). Resource dependence theory (RDT) addresses how organizations manage external uncertainties by strategically navigating dependencies on critical external resources, such as key suppliers and customers, which are central to SCC. Some studies suggest that an increase in SCC can foster long-term and stable trading relationships, facilitate resource integration, and reduce transaction costs, thereby enhancing firm performance (Lanier *et al.*, 2010; Patatoukas, 2012). However, others argue that heightened SCC may diminish a firm's bargaining power, crowd out operational resources, and dampen the incentive for information disclosure, ultimately leading to a decline in firm performance (Dhaliwal *et al*., 2016; Huang *et al*., 2016; Leung and Sun, 2021; Zhu *et al*., 2021). Given the inconsistent findings on the impact of SCC on firm performance and the fact that a firm's decision-making is subject to uncertainties in the economic environment that are closely linked to GPR (Caldara and Iacoviello, 2022), a crucial question for managers is whether they should diversify their supply chain base or strengthen their ties with existing supply chain partners in anticipation of significant GPR.

In addition, prior resource-related operations and SCM studies argue that firms can leverage both external and internal resources to achieve their operational objectives (Chahal *et al*., 2020; Hitt *et al*., 2016). While firms may adjust their supply chain base to obtain external resources from trading partners in response to the negative impacts of rising GPR, the role of internal operational capabilities and resources, such as resilience, slack, and cash, remains underexplored. Moreover, although existing research has shown that these internal resources can effectively mitigate firm-specific, endogenous operational disruptions, such as equipment failure, inventory shortages, order changes, quality control issues, cybersecurity breaches, and labor strikes (Braunscheidel and Suresh, 2009; Kleindorfer and Saad, 2005), it is unclear whether they are still effective in coping with exogenous, major shocks like GPR.

Collectively, the motivation for conducting this study is twofold. From a literature perspective, while prior research in economics and finance has examined the impacts of GPR on the macro economy and firm-level financial outcomes, demonstrating that GPR could elevate financing costs, reduce sales and revenues, trigger market declines, and increase volatility in commodity prices and exchange rates (Ahmed *et al*., 2023; Baur and Smales, 2020; Caldara and Iacoviello, 2022), the SCRM literature has yet to fully address how GPR shapes supply chain dynamics. Much of the existing SCRM research focuses on internal risks, such as supplier failures and demand variability (Aral *et al*., 2022; Sting and Huchzermeier, 2014), leaving external risks, particularly those related to GPR, relatively underexplored (Fan and Xiao, 2023). This oversight is significant, given the growing importance of GPR in today's globalized economy and the uncertainties it introduces to global supply chains. Our study seeks to address this gap by investigating how GPR influences supply chain concentration and geographical distance, examining how firms navigate the trade-offs between flexibility, efficiency, and risk mitigation in response to geopolitical uncertainties. From a practical perspective, understanding the impact of GPR on supply chain structures is especially pertinent for Chinese firms, which operate within a unique geopolitical and economic context. As key players in global trade, Chinese firms are highly exposed to geopolitical fluctuations, such as trade disputes, diplomatic tensions, and regional instability (Jiang *et al*., 2023). These factors, combined with China's geopolitical complexities, place significant pressure on firms to adapt their supply chain strategies. By examining how Chinese firms respond to GPR through adjustments in SCC and geographical distance, this study provides valuable insights into navigating the uncertainties of an increasingly volatile geopolitical landscape. Furthermore, focusing on China offers a context where state influence, regulatory conditions, and market dynamics differ significantly from those in developed economies, allowing for a nuanced understanding of how supply chain strategies may vary across geopolitical environments. Although region-specific, this focus offers broader implications for firms operating in other geopolitical contexts.

Taken together, this study aims to address the following research questions:

*RQ*1. How does GPR influence firms' supply chain base decisions in terms of SCC?

*RQ*2. How do various firms' operational capabilities and resources impact the relationship between GPR and SCC?

To address these questions, we collect and combine longitudinal secondary data from multiple sources to construct a panel dataset comprising 2,408 unique Chinese listed firms with 11,807 firm-year observations between 2018 and 2022. We apply fixed-effects regression models to test the proposed hypotheses. Our findings reveal a significant negative impact of GPR on SCC. Additionally, we observe that this negative effect is mitigated for firms with higher resilience levels, more operational slack, and greater cash holdings. Post-hoc analysis further indicates that a diversified supply chain base during increasing GPR benefits firms' financial and sales performance. In addition, firms opt for geographically closer supply chain partners as GPR increases.

This study makes several contributions to SCM research. First, there is limited empirical research that investigates the implications of GPR for SCM to date. This study responds to the call to incorporate socio-political risks into the scope of SCRM (Fan *et al*., 2022; Manhart *et al*., 2020), thereby offering valuable insights into how supply chain structures adapt in response to GPR within the Chinese context, based on rigorous empirical analysis. Second, this study extends the application of RDT to the SCM field, particularly within the context of GPR. By examining how firms' dependence on external resources influences their supply chain strategies under geopolitical pressures, we contribute to a deeper understanding of RDT's relevance beyond traditional organizational settings. Third, while prior studies suggest that firms' internal resources and capabilities are effective in addressing firm-specific endogenous issues such as parts shortages, order changes, or production problems, little is known about their effectiveness in stabilizing supply chains when facing exogenous socio-political shocks with broad impacts, such as GPR. Our study provides empirical evidence of the value of these internal capabilities and resources in enabling firms to respond more resiliently to GPR. Finally, we revisit the relationship between SCC and firm performance in the context of GPR. Previous research on the impact of SCC on financial performance has produced inconsistent results, partly due to varying research contexts. Our findings suggest that firms may benefit more from a diversified supply chain base when confronted with geopolitical shocks.

## 2. Literature review and hypothesis development

### *2.1 RDT and SCRM*

Resource Dependence Theory (RDT), as articulated by Pfeffer and Salancik in their seminal work *The External Control of Organizations: A Resource Dependence Perspective* (1978), posits that organizations are not self-sufficient and rely on external actors and resources to achieve their goals and sustain operations. The theory emphasizes that an organization's survival and success depend on its ability to acquire and control essential resources, often sourced from other organizations. This dependence fosters power dynamics, prompting organizations to strategically influence or adapt to their external environment in order to manage and mitigate vulnerabilities (Hillman *et al*., 2009).

In the realm of GPR and SCRM, RDT offers a pertinent theoretical perspective. GPR introduces significant uncertainties and disruptions into global supply chains, making it crucial for firms to understand and manage their dependencies on external resources controlled by other entities. RDT provides a framework for examining how organizations navigate these dependencies and the power dynamics they create. For example, firms may employ inward-focused buffering strategies, such as enhancing manufacturing flexibility, maintaining slack resources, and holding cash reserves, to protect themselves from external pressures. Alternatively, they may adopt outward-focused bridging strategies, such as mergers and acquisitions, alliances, joint ventures, and vertical integration, to strengthen external relationships and create boundary-spanning linkages (Jiang *et al*., 2023; Manhart *et al*., 2020).

In the context of SCRM, RDT underscores the importance of strategic adaptation to environmental changes, such as geopolitical shifts or economic instability. Firms should continuously assess and adjust their supply chain strategies to mitigate risks arising from external factors. For instance, Darby *et al*. (2020) examine how firms stockpile inventory as a precaution against potential government policy shifts, reflecting the significant influence of government actions on firm decision-making. This aligns with RDT's emphasis on managing dependencies and adapting to external changes. Moreover, RDT complements the extensive SCM literature that explores resource flows and risk management within supply chains (e.g., Dhingra and Krishnan, 2021; Kim and Wagner, 2021). By focusing on risks originating from outside the chain, particularly GPR, RDT offers insights into how firms can manage and adapt to external risks by adjusting their supply chain strategies. This theoretical lens provides a deeper understanding of the complexities involved in managing dependencies and power dynamics in the face of global political risks.

### *2.2 GPR*

A growing body of literature has begun to investigate the implications of GPR, particularly in a time marked by increasing criticism and doubts about globalization (Fan and Xiao, 2023). A recent systematic literature review from Bednarski *et al*. (2024) comprehensively analyzed 50 SCM papers related to geopolitical disruptions between 1995 and 2022. The findings reveal that approximately 78% of them were published in 2020 or later, indicating that the exploration of the influence of GPR on SCM is a relatively new area of research. While a universal definition of GPR is lacking, the concept generally refers to potential challenges and uncertainties arising from political, economic, social, and environmental factors that may negatively affect firms' operations, strategies, and overall business environment. For instance, in their seminal article, Caldara and Iacoviello (2022) define GPR as "the threat, realization, and escalation of adverse events associated with wars, terrorism, and any tensions among states and political factors that affect the peaceful course of international relations." From SCM perspective, Bednarski *et al*. (2024) describe this term as "conflicts or disputes between nation-states that interfere with the smooth flow of goods and services in global supply chains."

One research stream relevant to our study focuses on measuring GPR. Bremer (1996) assesses GPR along two dimensions, political risk, and economic risk, outlining potential risk events. Business Monitor International advances quantitative research on GPR by developing a Country Risk Index. This index is constructed by collecting and processing extensive macroeconomic, political, and operational risk data over an extended period for more than 200 markets globally and regionally. Importantly, Caldara and Iacoviello (2022), drawing on the quantitative methodology for economic policy uncertainty proposed by Baker *et al*. (2016), quantify a monthly GPR index. They employ a dictionary-based method to compute the frequency of articles related to GPR in ten leading English-language newspapers from the US, UK, and Canada. This index has been widely adopted within academic communities as an appropriate metric for measuring GPR for specific countries or regions.

Another research stream, more relevant to the focus of this study, examines the outcomes of GPR. Most research in this area concentrates on the macroeconomic impacts of GPR, such as energy market volatility, exchange rate fluctuations, and the increase in trade barriers (e.g., Caldara and Iacoviello, 2022; Qin *et al*., 2020; Yang *et al*., 2021). At the firm level, some studies find that GPR significantly elevates firms' financial constraints (Lee and Wang, 2021) and the risk of stock price crashes (Fiorillo *et al*., 2024), resulting in reduced corporate investment (Caldara and Iacoviello, 2022) and poor financial performance (Ahmed *et al*., 2023). In response, firms may strategically increase their cash holdings and utilize Bitcoin or precious metals to partially hedge against the negative effects of GPR on their operations (Baur and

Smales, 2020; Su *et al*., 2020). In SCM, studies focus on how geopolitical disruptions impact global supply chain configuration, flow, and management (Bednarski *et al*., 2024). For instance, Roscoe *et al*. (2020) collect longitudinal data between June 23, 2016 (the pro-Brexit vote) and January 31, 2020 (the UK's departure from the EU) to investigate how firms of various sizes formulate and implement strategies to cope with supply chain uncertainties arising from geopolitical events such as Brexit. Building on an institutional logic perspective, Roscoe *et al*. (2022) develop a theoretical construct (i.e., supply chain logic) to analyze three different environmental ecosystem conditions that may constrain managerial decision-making when redesigning global supply chains during compounding geopolitical disruptions. Several studies also suggest that the impact of geopolitical disruptions on supply chains could be mitigated through supply chain redesign, including back-shoring and regionalization, as well as improvements in supply chain transparency and modularized manufacturing stemming from the adoption of emerging technologies such as 3D printing, big data analytics, blockchain, and AI (Handfield *et al*., 2020; Moradlou *et al*., 2021; Xu *et al*., 2020). Thus, our study is positioned within the research stream that aims to investigate the supply chain implications of GPR and potential mitigation strategies.

### *2.3 SCC*

The concept of SCC has been extensively studied across diverse scholarly disciplines and from various theoretical perspectives, with most studies in this research stream focusing on its outcomes (Kim and Fortado, 2021). For example, transaction cost economics contends that a concentrated supplier/customer base may enhance supply chain efficiency by reducing complexity and increasing information-sharing intensity (Huo *et al*., 2017; Lanier Jr *et al*., 2010). Drawing on RDT, a few studies find that a supplier/customer's resource dependence positively impacts a focal firm's financial performance (Elking *et al*., 2017; Kim and

Henderson, 2015). However, some recent literature suggests that a concentrated supply chain base could lead to unintended consequences for the focal firm, including reduced R&D intensity (Kim and Zhu, 2018), decreased corporate social responsibility performance (Zhang *et al*., 2022; Zhu *et al*., 2021), and a perceived lack of justice in dispute resolution (Cheng *et al*., 2020). We summarize the relationship between SCC and firm-level outcomes in Table 1.

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Regarding the antecedents of SCC, while several OM studies have examined the moderating role of diversification strategy in mitigating the negative impacts of supply chain disruptions derived from operational glitches, supply or demand uncertainty, and natural disasters on firms' SCM (e.g., Hendricks *et al*., 2009; Jain *et al*., 2022; Whitney *et al*., 2014), limited efforts have been devoted to investigating how firms strategically adjust their supply chain bases to proactively deal with external shocks (Fan and Xiao, 2023; Leung and Sun, 2021). This gap provides avenues for this study to explore how firms diversify or concentrate their supply chain bases to navigate GPR.

*2.4 Hypothesis development*

Our first hypothesis examines the direct impact of GPR on SCC. Although previous operations and SCM studies have shown that a concentrated supply chain offers numerous advantages, such as reducing supply and demand uncertainty, enabling effective inventory management, maintaining stable supply chains, lowering communication costs, achieving economies of scale, and minimizing discretionary expenses like administrative and sales costs (Ak and Patatoukas, 2016; Lanier *et al*., 2010; Lanier *et al*., 2019), these benefits are highly contingent on a stable external environment (Chen *et al*., 2023; Jiang *et al*., 2023; Polyviou *et al*., 2023). In such stable conditions, firms can fully capitalize on the advantages of a concentrated supply chain, as they can reliably access market information, make informed decisions, and maintain consistent operational performance (Patatoukas, 2012).

However, when GPR increases, the external environment becomes more volatile, potentially undermining the benefits of SCC. One alternative perspective suggests that in response to GPR, firms might opt to increase their SCC by solidifying long-term relationships with a limited number of suppliers and customers to ensure stability and reliability. While this strategy could offer short-term stability, it also heightens the risk of overdependence (Ni *et al*., 2023). Should these key suppliers or customers be located in geopolitically unstable regions, firms face amplified risks such as supply disruptions, increased costs, or revenue fluctuations due to political unrest, trade disputes, or other geopolitical events (Caldara and Iacoviello, 2022; Roscoe *et al*., 2020). Thus, what might seem like a strategy to enhance stability could, in fact, increase vulnerability to external shocks.

RDT provides valuable insight into how firms manage these dependencies through power balancing (Drees and Heugens, 2013; Manhart *et al*., 2020). Under rising GPR, power dynamics within the supply chain can shift, granting suppliers or customers greater bargaining power. To mitigate these risks and maintain operational autonomy, firms may diversify their supply chains, thereby reducing their reliance on a limited number of partners. This approach aligns with RDT's emphasis on reducing external dependencies to minimize risks. For example, in response to the pandemic and ongoing trade tensions between the U.S. and China, Apple initiated efforts to diversify its manufacturing base away from China. This move highlights the risks associated with overconcentration in geopolitically sensitive regions and demonstrates the potential benefits of a diversified supply chain.

To sum up, while increasing SCC might initially appear as a logical response to GPR for ensuring stability, the heightened uncertainties and disruptions in such environments often prompt firms to view overconcentration as a significant risk. As a result, they are inclined to reduce their SCC to mitigate the adverse effects of GPR.

*H1*. GPR has a negative impact on SCC.

Next, we explore the role of firms' internal operational capabilities and resources in moderating the impact of GPR on SCC. Existing resource-related OSCM literature emphasizes the importance of integrating both external and internal resources to achieve production objectives (Chahal *et al*., 2020; Hitt *et al*., 2016). While external resources outside a firm's direct control can significantly influence supply chain dynamics, internal capabilities, such as resilience, slack resources, and cash holdings, are crucial in shaping how firms respond to GPR. RDT underscores the importance of power dynamics and interdependencies between firms and external entities, suggesting that firms may strategically leverage their internal capabilities to buffer against dependencies on external partners, particularly in the context of heightened GPR. Studying the role of internal capabilities also reveals potential sources of competitive advantage or vulnerability in the face of GPR, aligning with RDT's focus on managing power imbalances and strategic adaptation.

Our second hypothesis considers the moderating effect of firm resilience. Firms with heightened resilience possess a strong capacity to withstand and navigate turbulent environments, including those characterized by GPR (Ambulkar *et al*., 2015; Cohen and Kouvelis, 2021). Resilience, at its core, refers to a firm's ability to anticipate, absorb, respond to, and recover from disruptions while maintaining essential functions and operations (Ge *et al*., 2023; Kim *et al*., 2015). When confronted with increasing GPR, firms with robust resilience frameworks are better equipped to mitigate its negative effects on SCC. First, resilient firms exhibit superior adaptability and agility, enabling them to quickly recalibrate their operations and strategies in response to changing geopolitical conditions (Vega *et al*., 2023). They can proactively identify vulnerabilities in their supply chains, diversify their supplier and customer bases preemptively, and establish alternative sourcing or distribution channels to avoid potential disruptions (Hendricks *et al*., 2009). Second, resilience enhances a firm's risk management capabilities, allowing it to develop proactive contingency plans specifically tailored to address geopolitical uncertainties (Ambulkar *et al*., 2015). By systematically assessing and mitigating risks across their supply networks, resilient firms can effectively protect themselves against the adverse effects of GPR, thereby reducing the need for immediate supply chain restructuring.

Furthermore, the organizational culture in resilient firms promotes continuous improvement and learning, which encourages proactive risk identification and mitigation (Ortiz-de-Mandojana and Bansal, 2016). Through ongoing monitoring, evaluation, and refinement of their supply chain strategies, these firms adeptly adapt to emerging geopolitical challenges, ensuring the stability and resilience of their supply chains. Additionally, resilient firms often build strong relationships and collaborations with their supply chain partners, facilitating collective responses to geopolitical complexities and the collaborative development of adaptive strategies (Scholten and Schilder, 2015). In sum, the intrinsic characteristics of firm resilience empower firms to effectively manage and mitigate the negative impact of GPR on SCC, highlighting resilience's pivotal role in fostering supply chain stability and continuity amid geopolitical uncertainties.

*H2*. The impact of GPR on SCC is less negative for firms with higher resilience.

Our third hypothesis explores the moderating effect of operational slack on the relationship between geopolitical risk (GPR) and supply chain concentration (SCC). Operational slack refers to the surplus capacity, extra time, excess labor, or spare physical inventory available within specific organizational functions or departments (Azadegan *et al*., 2013; Hendricks and Singhal, 2009). This surplus enables firms to absorb shocks and adapt to changing market conditions without the need for immediate supply chain restructuring. For example, excess production capacity allows firms to manage demand fluctuations, ensuring operational continuity even in the face of external disruptions (Kovach *et al*., 2015; Vanacker *et al*., 2017). Similarly, idle resources in marketing or distribution can be redeployed to alternative channels or regions, helping to maintain customer service levels and market reach (Sok and O'Cass, 2015). Operational slack also provides firms with the flexibility to respond to geopolitical uncertainties by adjusting operational strategies and reallocating resources. This flexibility can be critical in exploring new sourcing options, diversifying supplier portfolios, or investing in technology and innovation to enhance supply chain adaptability (Yousefi *et al*., 2023). By effectively leveraging operational slack, firms can mitigate the disruptive effects of GPR on SCC, maintaining strategic flexibility in their sourcing and distribution decisions.

*H3*. The impact of GPR on SCC is less negative for firms with more operational slack.

Our fourth hypothesis examines the moderating effect of cash holding. Firms with substantial cash reserves have a significant advantage in mitigating the negative impact of GPR due to their immediate financial flexibility. According to RDT, firms with ample cash can more effectively manage their external environment by reducing their dependency on external entities. When faced with escalating GPR, these firms can strategically deploy their financial resources to absorb shocks and maintain operational resilience (Rapp *et al*., 2014). Unlike operational resources or capabilities, which may require time to develop or mobilize, cash reserves provide firms with the ability to quickly adapt to shifting market conditions and unforeseen disruptions. Rather than solely relying on diversifying their supply chain base, firms with higher cash reserves can leverage their financial strength to negotiate better terms with existing partners, invest in alternative sourcing strategies, or acquire new suppliers or customers. Additionally, greater cash reserves enhance a firm's bargaining power and control within the supply chain, enabling it to navigate GPR with greater confidence (Elking *et al*., 2017; Kim and Henderson, 2015). By strategically deploying their financial resources, firms can reduce their dependence on external entities and mitigate the adverse effects of GPR without needing significant structural changes to their supply chain. Thus, while firm resilience and operational slack provide valuable buffers against disruptions, higher cash reserves offer a distinct and immediate advantage in addressing the challenges posed by GPR.

*H4*. The impact of GPR on SCC is less negative for firms with greater cash holding.

## 3. Methodology

### *3.1. Data and sample*

To investigate the impact of GPR on SCC, we constructed a dataset spanning from 2018 to 2022 for Chinese listed firms. Initially, we collected basic information and financial data from the China Stock Market and Accounting Research Database (CSMAR). Subsequently, we matched the data with the GPR index developed by Caldara and Iacoviello (2022). Data cleaning procedures were then implemented, involving: (I) focusing on manufacturing firms categorized with industry codes ranging from C13 to C41, (II) excluding firms labeled as special treatment (ST), and (III) removing observations with missing values. Additionally, all continuous variables were winsorized at the 1st and 99th percentiles. The final sample comprised 2,408 unique firms with 11,807 firm-year observations. The detailed definitions for all variables in our research and the data structure snippet are provided in Tables 2 and 3, respectively. Table 4 presents the distribution of sample firms across industries, while Table 5 provides the summary statistics and correlation matrix. The regression's VIF scores are below 5, which indicates that multicollinearity is not a major concern in this study.

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### *3.2. Measures*

*Supply Chain Concentration*. Following Dong *et al*. (2020), Jiang *et al*. (2023), and Yang *et al*. (2024), customer concentration is calculated by dividing the total sales of the top five customers by the total sales every year. Supplier concentration is measured by the ratio of the total purchases of the top five suppliers to the full purchase amount each year.

$$Customer\ Concentration_{it} = \sum_{1}^{5} Sales_{ist}/Sales_{it}$$

$$Supplier\ Concentration_{it} = \sum_{1}^{5} Purchases_{ist}/Purchases_{it}$$

$$SCC_{it} = \frac{1}{2}(Customer\ Concentration_{it} + Supplier\ Concentration_{it})$$

$$Supply\ Chain\ HHI_{i,t} = \frac{1}{2}\left(\sum_{1}^{5}(Sales_{ist}/Sales_{it})^2 + \sum_{1}^{5}\left(\frac{Purchases_{ist}}{Purchases_{it}}\right)^2\right)$$

where $Sales_{ist}$ is firm *i*'s sales to major customer *s* in year *t*, $Sales_{it}$ indicates the total sales of firm *i* in year *t*, $Purchases_{ist}$ refers to firm *i*'s purchases from major supplier *s* in year *t*, and $Purchases_{it}$ represents the total purchases of firm *i* in year *t*. $SCC_{it}$ is thus calculated as the arithmetic mean of $Customer\ Concentration_{it}$ and $Supplier\ Concentration_{it}$. $Supply\ Chain\ HHI_{i,t}$ indicates the supply chain's HHI index, which is the arithmetic mean of the supplier's HHI and the customer's HHI.

*Geopolitical Risk*. The measurement of GPR is based on the GPR index developed by Caldara and Iacoviello (2022). Initially, they conducted the automated text search in the digital archives of ten newspapers, including *Chicago Tribune*, *The Daily Telegraph*, *Financial Times*, *The Globe and Mail*, *The Guardian*, *The Los Angeles Times*, *The New York Times*, *USA Today*, *The Wall Street Journal*, and *The Washington Post*. Then, they compute the index based on the results by counting the quantity of articles about adverse geopolitical incidents in each newspaper every month as a proportion of the total count of news articles. China's GPR index is determined by calculating the monthly proportion of all newspaper articles that both (1) qualify for inclusion in the GPR index and (2) consist of the country or its major cities. Each index is represented as a monthly proportion of newspaper articles. The monthly indices are transformed into annual indices by arithmetic averaging (Adra *et al*., 2023). Figure 1 demonstrates the global GPR index from 2001 to 2023.

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*Firm Resilience*. Following Dormady *et al*. (2019), we use the production function to measure firm resilience over our observation period. This function provides insight into how firms operate, including the arrangement of inputs and their corresponding productivity levels and how input-output relationships change with scale. The production function contains intermediate inputs, labor inputs, and capital investment. Following the approach developed by Giannetti *et al*. (2015), we employ the classic Cobb-Douglas production function for estimation:

$$\ln(VA_{it}) = \alpha lnK_{it} + \beta lnL_{it} + \gamma lnM_{it} + \delta + \epsilon_{it}$$

where $VA_{it}$ represents the total sales revenue of firm *i* in year *t*, $K_{it}$ denotes the logarithm of the total assets of firm *i* in year *t*, $L_{it}$ refers to the logarithm of the total number of employees of firm *i* in year *t*, and $M_{it}$ indicates the logarithm of the expense for raw materials and other inputs of firm *i* in year *t*. We also include $\delta$ (year dummies) as control variables to account for yearly effects. The coefficients of each item indicate a firm's output elasticity for a given input, that is, the percentage change in $VA_{it}$ caused by a 1% change in the given input value. Firm *i*'s total factor productivity (TFP) in year *t* is computed as the residual of the above firm-level regression (Jiang *et al*., 2023). Finally, we use changes in productivity as the measure of resilience, with the degree of change in current period productivity relative to the previous period serving as a proxy for firm resilience (Ambulkar *et al*., 2015; Jiang *et al*., 2023).

$$Resilience_{it} = TFP_{it} - TFP_{it-1}$$

*Operational Slack*. The measurement of operational slack is determined by a firm's cash-to-cash cycle in the current year (Jia *et al*., 2023). This cycle is calculated as the days of inventory plus days of accounts receivables minus days of accounts payables for firm *i* in year *t* as follows (Kovach *et al*., 2015):

$$Operational\ Slack_{i,t} = (\frac{INV_t}{COGS_t})_i + \left(\frac{accountsreceivable_t}{Sales_t}\right)_i - \left(\frac{accountspayable_t}{COGS_t}\right)_i$$

*Cash Holding*. Following Chu (2020) and Nason and Patel (2016), cash holding is calculated as the cash and cash equivalents divided by total assets net of cash and cash equivalents.

*Control Variables*. To rule out potential confounding effects, we introduce a range of variables that might affect SCC as control variables (Li *et al*., 2022; Yiu *et al*., 2020; Zhu *et al*., 2022). Specifically, we control for *firm size*, the natural logarithm of the number of employees; *firm age*, the number of years since a firm was established; *Tobin's q*, market value of equity plus total assets minus book value of equity, then divided by total assets; *book-to-market ratio*, subtract total liabilities, preferred shares, and intangible assets from the total assets; *asset tangibility*, property, plant, and equipment scaled by total assets.

## 4. Identification strategy and empirical results

To examine the relationship between GPR and SCC, we use fixed effect (FE) models to conduct regression analysis. In addition, we use the generalized moments method (GMM) to address potential endogeneity concerns.

### *4.1. Baseline results*

In the baseline analysis, we use FE models to identify how GPR influences SCC. We construct the following model with firm-year-level panel data:

$$SCC_{i,t} = \beta_0 + \beta_1 GPR_{t-1} + \beta_2 GPR_{t-1} * Firm\ Resilience_{t-1} + \beta_3 GPR_{t-1} * Operational\ Slack_{t-1}$$
$$+ \beta_4 GPR_{t-1} * Cash\ Holding_{t-1} + \delta \times X_{i,t-1} + Industry\ FE + \varepsilon_{i,t}$$

where $i$ denotes firm $i$ and $t$ denotes year $t$. $GPR_{t-1}$ is the lagged GPR index constructed by Caldara and Iacoviello (2022), which has been explained in Section 3.2. GPR measured at the end of fiscal year $t-1$ is used to explain SCC in fiscal year $t$; $X_{i,t-1}$ is a vector of lagged firm-level control variables illustrated in Section 3.2. A one-year lag between the dependent and independent variables is to ensure unbiased estimations.

Table 6 denotes the regression results of the baseline model. We include industry-fixed effects in all the models. Following Gulen and Ion (2015), because not all firms' fiscal quarters align with the same month for each calendar quarter, some cross-sectional fluctuations exist in $GPR_{i,t}$ for each $t$. Nevertheless, this fluctuation is minimal, as most firms have fiscal quarters ending in the last month of the calendar quarter. Consequently, we cannot include time-fixed effects in our specifications since doing so would automatically absorb the independent variable's explanatory power.

Column 1 shows the baseline results. The coefficient of GPR is significantly negative at the 1% level. Columns 2-4 show the moderating results respectively, and Column 5 shows the moderating results together. The empirical findings in these columns support our H1-H4. GPR has a negative impact on SCC ($p<0.1$). The impact of GPR on SCC is less negative for firms with higher resilience ($p<0.1$), more operational slack ($p<0.01$), and greater cash holding ($p<0.1$).

---Please insert Table 6 about here---

*4.2. Robustness checks and endogeneity issues*

Using different evaluation strategies and alternative measurement methods, we conducted a series of tests to evaluate the robustness of our results. Tables 7-11 present the robustness check results, and we discuss the steps below. The robustness checks offer further support and rule out some alternative explanations of our research findings.

*4.2.1. Different lengths of lagged years*

We set the lagged year for all variables except dependent variables (GPR) as two years. As shown in Table 7, the main effect and moderating effects in Column 1 remain consistent with the results of the previous analysis. Second, we replace industry-fixed effects with firm-fixed effects in rows *X* and *Y*. Results in Column 2 confirm the consistency with the previous analysis.

---Please insert Table 7 about here---

*4.2.2. Alternative measurements for key variables*

(1) Dependent variable (SCC)

First, we adopt alternative measures for our dependent variable (SCC). To replicate our empirical analysis, we include the dummy concentration indicator as an alternative measure. We categorize our observations into the high SCC group and the low SCC group based on whether the value of SCC is above or below the median value during our research period. The SCC dummy is assigned a value of one if firm *i* in year *t* exceeds the median value of SCC. In Table 7, the results shown in Column 3 are aligned with our main analysis. Then, we adopt another measurement for SCC (*Supply chain's HHI index*), which is the arithmetic mean of the supplier's HHI and the customer's HHI. In Table 8, Column 1 shows the results are aligned with our main analysis.

(2) Independent variable (GPR)

In Table 7 Column 4, we use the natural logarithm form of GPR to repeat our analysis in the baseline tests, finding that our results are consistent.

(3) Moderator (Firm resilience)

Following existing studies (DesJardine *et al*., 2019; Ortiz-de-Mandojana and Bansal, 2016; Ran *et al*., 2024), we alternatively measure firm resilience by including the growth and volatility dimensions. The growth rates of sales revenue and operating income are used to measure performance growth; monthly stock volatility, earnings volatility, and cash flow volatility are used to measure volatility. The growth rate of sales revenue is the ratio of the current year's sales revenue to that of the previous year. The growth rate of the firm's operating income is obtained from the difference between the current year's operating income and the previous operating income divided by the previous operating income. The monthly stock volatility is the standard deviation of monthly stock returns. Earnings volatility is obtained by multiplying the ratio of earnings before interest, taxes, depreciation, and amortization to the total assets by the volatility of the previous three years. Cash flow volatility is obtained by multiplying the ratio of cash flows to assets by the volatility of the previous three years. The entropy weight method was used to calculate firm resilience, and the specific calculation steps are in Appendix A1. In Table 8, Column 2 shows the results are consistent with our main analysis.

(4) Moderator (Operational slack)

Referring to Chen *et al*. (2023) and Jia *et al*. (2023), we consider three alternative measurements to capture operational slack: quick ratio, receivable turnover ratio, operating cycle, and inventory turnover ratio. The quick ratio (QR) is calculated as quick assets divided by current liabilities, where quick assets is measured by current assets minus net inventory balance (Bortolotti *et al*., 2015; Chen *et al*., 2023; Jia *et al*., 2023). The receivables turnover ratio (RTR), which is the net sales divided by the average accounts receivable, measures the firm's efficiency in using its current assets and receiving its accounts receivable (Chen *et al*., 2023; Wood *et al*., 2017). The inventory turnover ratio (ITR) is calculated as sales divided by average inventory (Azadegan *et al*., 2013; Chen *et al*., 2023). The specific measures are as follows. In Table 8, Columns 3-5 show the results by using QR, RTR, and ITR as alternative measurements for operational slack, respectively. Results are aligned with previous analysis.

$$QR_{i,t} = \frac{Quick\ Assets}{Current\ Liabilities_{i,t}}$$

$$RTR_{i,t} = \frac{Net\ Sales}{Average\ Accounts\ Receivable_{i,t}}$$

$$ITR_{i,t} = \frac{Sales}{Average\ Inventory_{i,t}}$$

---Please insert Table 8 about here---

*4.2.3 Sensitivity of GMM models*

Because firms' SCC could be persistent over time depending on past performance (Lam *et al*., 2016), we construct a Dynamic Panel Data (DPD) model to test hypotheses as follows:

$$SCC_{i,t} = \beta_0 + \beta_1 SCC_{i,t-1} + \beta_2 GPR_{i,t-1} + \beta_3 GPR_{i,t-1} * Firm\ Resilience_{i,t-1} + \beta_4 GPR_{i,t-1} * Operational\ Slack_{i,t-1} + \beta_5 GPR_{i,t-1} * Cash\ Holding_{i,t-1} + \sum \beta_6 x_{it} + \mu_i + \varepsilon_{it}$$

where *i* and *t* are firm and year indices, respectively. $x_{i,t-1}$ represents a series of other control variables, which are described in Section 3.4. $\mu_i$ denotes the industry dummies. $\varepsilon_{it}$ is the error term, which follows the normal distribution and is not correlated with $\mu_i$ and $\lambda_i$. The addition of a lagged dependent variable makes our model "dynamic" across the years by considering the continuous impact of past concentration patterns. A one-year lag between the dependent variable and other variables is also set to ensure unbiased estimations.

We test the sensitivity of our results to the modeling choices in the system GMM model in Table 9. In Column 1, we use all available lagged values beginning with *t-2*, i.e. (*t-2*, *t-maximum*). As instruments for the difference equation, we then instead constrained the maximum period of lags to *t-5* by choosing a smaller set of instruments, i.e., (*t-2*, *t-3*), (*t-2*, *t-4*), and (*t-2*, *t-5*) in Column 2-4. All Hansen and AR2 test results are insignificant ($p > 0.1$), demonstrating the validity of these instruments employed in our system GMM estimation. All estimation results from the alternative models agree with our system GMM model findings.

---Please insert Table 9 about here---

*4.2.4. Difference-in-differences method (DiD)*

(1) DiD Model

To effectively reduce potential endogeneity problems caused by reverse causality and omitted variables and identify the true impact of GPR on Chinese manufacturing firms' SCC, we further consider the impact of the U.S.-China trade war (started in 2018) on SCC as a quasi-natural experiment of empirical estimation based on the DiD. The model is set up as follows:

$$SCC_{it} = \beta_0 + \beta_1 Treat_i * Post_t + \theta X_{it} + Industry\ FE + \varepsilon_{it}$$

where $i$ and $t$ are firm and year indices, respectively. $SCC_{it}$ indicates firm $i$'s supply chain concentration in year $t$. $Treat_i$ is equal to one for firms affected by the U.S.-China trade war in the treatment group and zero for those not affected in the control group. $Post_t$ equals 1 for firms in the post-regulation period (2018-2022) and 0 in the pre-regulation period (2014-2017). $Treat_i * Post_t$ is the interaction item and if coefficient $\beta_1$ is greater than 0, it refers that the U.S.-China trade war improved the SCC of Chinese manufacturing firms. Otherwise, it makes the supply chain less concentrated. $X_{it}$ includes a list of control variables; $\varepsilon_{it}$ is the error term.

(2) Identification strategy

Following existing research (Chen *et al*., 2023; Vig, 2013), we choose appropriate treatment and control groups based on the degree to which samples are affected. In the U.S.-China trade war, the U.S. mainly imposed high tariffs on Chinese firms to limit their exports. It is clear that there are significant differences in the impact of firms' different levels of export dependence on their risk of being sanctioned. Based on this, we use the proportion of exports in sales revenues to measure each firm's export dependence and calculate the median. Firms with export dependence above the median are categorized in the treatment group and vice versa in the control group. The firm's export dependence is calculated based on 2017 data to avoid possible effects of related events in the U.S.-China trade war. This approach allows us to distinguish the impact of the trade war from other confounding factors as much as possible.

(3) Empirical results

In this research, we use Ordinary Least Squares (OLS) and Negative Binomial Regression (NB) to study the impact of the U.S.-China trade war on Chinese manufacturing firms' SCC. Before the regression, we conducted a white test to control for possible heteroskedasticity, and the results show that there is no heteroskedasticity in the model. Then we use the Hausman test to check the appropriateness of the fixed-effects model selection in OLS estimation and NB estimation, and the results validate the fixed-effects model. Finally, in order to examine the validity of the NB regression model, we conducted the LR test, and the $p$-value is less than 0.01.

In Table 10, Columns 1 and 4 display the results without control variables and fixed effects. Negative coefficients for the interaction treatment indicators are statistically significant at the 1% level. Columns 2 and 5 report results with control variables. Columns 3 and 6 control for industry fixed effect with control variables. The coefficients of the interaction terms are -0.028 and -0.031 for the two estimation methods and are significant at the 1% level. This shows that the U.S.-China trade war reduces Chinese manufacturing firms' SCC and results are significantly consistent.

---Please insert Table 10 about here---

*4.3. Post-hoc analysis: GPR, SCC, and firm performance*

During the surging GPR, what is the role of a diversified supply chain? Does it bolster or hinder the firm performance? To address this concern, we employ the Fama-MacBeth approach (Fama and MacBeth, 1973) to discover the potential relationship between SCC and firm performance. We also examine whether this relationship changes between rising and falling GPR. We develop the following model:

$$Firm\ Performance_{i,t} = \beta_0 + \beta_1 Supply\ Chain\ Concentration_{i,t-1} + \delta \times X_{i,t-1} + Industry\ FE + \varepsilon_t$$

$$Investment_{i,t} = \frac{Fixed\ Assets - Net\ Value_{i,t} + Construction\ in\ Progress_{i,t} + Intangible\ Assets_{i,t} + Long\ Term\ Investment_{i,t}}{Total\ Assets_{i,t}}$$

where *Supply Chain Concentration*$_{i,t-1}$ is the concentration of major suppliers and customers of firm $i$ in year $t$-$1$, which refers to $SCC_{i,t-1}$ or $Supply\ Chain\ HHI_{i,t-1}$. We examine *Firm*

*Performance*$_{i,t}$ in three perspectives: *ROA, Investment* and *Operating Cost*. We exclude *ROA* in the same group of lagged control variables $X_{i,t-1}$. By using the Fama-MacBeth approach (Leung and Sun, 2021), we conduct the cross-sectional regression.

Table 11 (a) presents the estimation results for *ROA*. As depicted in Columns 1 and 2, firms with higher SCC exhibit notably lower ROA. In Columns 3-6, we segment our samples into two groups based on whether the previous year witnessed an escalation in GPR, that is, whether the lagged changes (from *t-2* to *t-1*) in GPR are positive. To put it another way, in Columns 3 and 4 (5 and 6), the estimated coefficients are derived from averaged values from cross-sectional regressions across the years when the lagged changes in GPR are positive (negative). As indicated in these columns, the average negative coefficients for SCC are substantially more pronounced and only statistically significant in the subset of firms encountering an upsurge in GPR.

Similarly, Table 11 (b) and (c) present the estimation results for *Investment* and *Cost*. In Columns 1 and 2, firms with lower SCC witness their investments going down and have their costs go up. In Columns 3-6, we also separate samples based on whether the previous year witnessed an escalation in GPR, that is, whether the lagged changes (from *t-2* to *t-1*) in GPR are positive. As shown in the columns, the average coefficients for SCC are substantially more pronounced and only statistically significant in the subset of firms encountering an upsurge in GPR.

Overall, our findings suggest that diversifying the supply chain base during periods of rising geopolitical risk is likely to enhance ROA. On the other hand, firms witness a decline in investments and an increase in costs.

---Please insert Table 11 about here---

*4.4. Additional analysis: GPR, SCC (customer concentration and supplier concentration), and* *geographical distance*

*4.4.1 The impact of GPR on customer concentration and supplier concentration*

In Table 12, we first test the impact of *GPR* on customer concentration (Columns 1 and 2) and supplier concentration (Columns 3 and 4). We use all available lagged values beginning with *t*-2, i.e. (*t*-2, *t*-maximum) in Columns 1 and 3. As instruments for the difference equation, we then instead constrained the maximum period of lags to *t*-5 by choosing a smaller set of instruments, i.e., (*t*-2, *t*-3), (*t*-2, *t*-4), and (*t*-2, *t*-5) in Columns 2 and 4. All models' Hansen and AR2 test results are insignificant ($p > 0.1$), demonstrating the validity of these instruments employed in our system GMM estimation. Estimation results reveal that when GPR rises, firms' customer base and supplier base become more diversified.

---Please insert Table 12 about here---

*4.4.2 The impact of GPR on supply chain geographical distance*

In this section, we develop supply chain geographical distance as the arithmetic mean of the top five customers' geographical distance and suppliers' geographical distance to the focal firm as follows.

$$Supply\ Chain\ Geographical\ Distance_{it} = \frac{1}{2}\left(\sum_{i=1}^{5} Customer\ Geographical\ Distance_i + \sum_{j=1}^{5} Supplier\ Geographical\ Distance_j\right)$$

In Table 13, Columns 1 and 2 are regression results with the geographical distance lagged for 1 year and 2 years, respectively. Results demonstrate that with the increase of GPR, firms not only diversify their supply chains, but also choose closer supply chain partners.

---Please insert Table 13 about here---

## 5. Summary, discussion, and future research

In recent years, GPR has garnered increasing attention within the field of SCM (Bednarski *et al*., 2024; Pavlínek, 2024). In the realm of firms' global operations, widely distributed supply chain partners serve as both critical assets for gaining a competitive edge and potential vulnerabilities that may trigger failure (Eckerd *et al*., 2022). Consequently, the buyer-supplier relationship emerges as a central concern for many firms, with SCC serving as a determinant of this relationship (Shen *et al*., 2023). However, it remains unclear how GPR influences firms and whether it impacts their SCC. To address this pivotal question, our findings indicate that firms generally reduce SCC in response to increasing GPR, providing empirical support for H1.

Furthermore, we explored potential moderators affecting this relationship, specifically examining the roles of firm resilience (H2), operational slack (H3), and cash holding (H4). Our results demonstrate that these factors can mitigate the aforementioned negative impact, suggesting that firms with higher operational capabilities and resources exhibit greater adaptability to effectively respond to changing external conditions, thereby reducing the urgency to enact significant changes in their supply chain structures. Within the framework of RDT, diversification aims to diminish reliance on specific customers or suppliers and acquire additional resources from a diverse array of stakeholders to navigate GPR. While acknowledging the benefits of supply chain diversification in addressing GPR, it is important to recognize the associated costs, such as increased complexity, additional investment, and reduced economies of scale. In this context, operational capabilities and resources play a crucial role in stabilizing supply chains without necessitating substantial changes. Further, we also find that more diversified supply chains can lead to better firm performance, as shown in the post-hoc analysis. In this case, operational resources may have a "dark side" in the GPR context, as they may constrain firms' motivation to pursue diversification strategies.

Finally, our research examines the effect of GPR on supply chain geographical distance.

Previous studies suggest that firms tend to reduce the geographic span of their networks in response to heightened external risks (Kano and Oh, 2020; Rugman *et al.*, 2009). Our findings align with this research, demonstrating that as GPR increases, firms opt for geographically closer supply chain partners. This preference for proximity may be attributed to the higher similarity between these partners and the focal firm in terms of economic, political, and social norms (Rugman *et al*., 2009; Verbeke, 2020). Such similarity, coupled with geographic proximity, not only offers substantial opportunities for collaboration but also mitigates the risks inherent in managing distant and complex supply chain relationships. In the context of rising GPR, selecting closer partners becomes a more secure and pragmatic strategy for firms.

Overall, our research contributes valuable insights into how firms respond to GPR and emphasizes the importance of considering both external and internal factors in supply chain decision-making. These findings advance theoretical understanding and offer practical implications for SCM, as discussed below.

### *5.1. Research implications*

This research contributes to SCM literature in several ways. First, it extends the boundaries of existing SCM studies by incorporating GPR into the supply chain risk management framework. While previous studies have mainly focused on the macro-level outcomes of GPR (Caldara and Iacoviello, 2022; Yang *et al*., 2021), only a few have delved into its impact on SCM. Through empirical investigation, we have illuminated firms' nuanced responses to such risks, particularly their strategic diversification of the supply chain base in response to GPR-induced uncertainties. By delving into these responses, we have enriched our comprehension of the intricate dynamics and interactions between firms and their supply chain partners, broadening our understanding of how firms navigate and adapt to complex external environments.

Second, our research contributes to the application of RDT within the SCM domain, particularly in mitigation strategies for GPR. Previous literature (e.g., Kleindorfer and Saad, 2005) has mainly focused on solutions for internal operational glitches, leaving a gap in understanding whether these strategies apply to exogenous major shocks such as GPR. By examining how firms' reliance on external resources influences their supply chain strategies amidst GPR, we have extended the theoretical underpinnings of RDT beyond traditional organizational contexts. Through this extension, our findings enhance the understanding of how firms strategically manage their supply chains to mitigate the adverse effects of external risks, highlighting the dynamic nature of resource dependencies in contemporary SCM practices.

Furthermore, our research underscores the significance of internal operational capabilities and resources in addressing GPR-induced challenges. By emphasizing the importance of firm resilience, operational slack, and cash holding, we have shed light on the buffering role of internal resources in stabilizing the supply chain during periods of heightened geopolitical uncertainty. We provide solid evidence about how these internal capabilities bolster firms' ability to weather GPR-induced disruptions and mitigate supply chain vulnerabilities (the bright side), thereby emphasizing the need for a balanced approach that integrates both internal and external resources in supply chain risk management strategies, aligning with previous resource-related OM studies (Chahal *et al*., 2020; Hitt *et al*., 2016). Nonetheless, we also acknowledge the "dark side" of operational resources in the GPR context, as they may limit firms' adoption of diversification strategies.

Finally, our research reexamines the relationship between SCC and firm performance within the context of GPR. While previous research has yielded inconsistent findings regarding the impact of SCC on financial performance (Ahmed *et al*., 2023; Hitt *et al*., 2016), our study suggests that firms may derive greater benefits from a diversified supply chain base when confronted with GPR. By elucidating this relationship, we contribute valuable insights for firms seeking to enhance their resilience and performance in today's volatile geopolitical landscape.

### *5.2. Practical implications*

GPR is increasingly becoming a focal point in global operations. Our findings offer clear implications for firms seeking to manage their supply chain base in today's volatile global trade environment. First, our research suggests that firms facing GPR can derive benefits from strategically diversifying their supply chain base. By reducing reliance on a limited number of suppliers or customers, firms can alleviate the negative impact of GPR on their supply chains. Specifically, this entails the need for firms to regularly assess their supply chain partners and consider diversification as a fundamental risk management strategy.

Second, our study underscores the importance of integrating GPR into supply chain risk management frameworks. Firms should take proactive measures to evaluate GPR factors and develop contingency plans to address potential disruptions. This may involve scenario planning, conducting comprehensive supply chain mapping, and establishing alternative sourcing options.

Furthermore, our research highlights the critical role of internal operational capabilities and resources, such as firm resilience, operational slack, and cash holding, in mitigating the impact of GPR. Firms should carefully evaluate their resource portfolio and strategic objectives to invest in strengthening these internal resources to counteract external shocks. This could entail implementing robust risk management practices, maintaining adequate financial reserves, and fostering a culture of adaptability and innovation. However, firms should focus not only on the bright side of internal resources but also on the dark side in the GPR context, as they may serve as restrictions for firms' adoption of diversification strategies. When equipped with ample internal operational resources, firms may find it unnecessary to pursue extensive supply chain diversification to cope with GPR. Instead, they may opt for complementary strategies, such as enhancing internal operational resources and adopting supply chain diversification, to bolster resilience and flexibility in the face of external shocks.

*5.3. Limitations and future directions*

Our research has certain limitations that future studies could address. First, this study focuses exclusively on listed firms in China affected by GPR in recent years. Future research could expand the scope by incorporating a more internationally diverse sample to assess whether the findings are generalizable across different contexts (Peng *et al*., 2024). Additionally, the impact of GPR on small and medium-sized enterprises (SMEs) remains unexplored, presenting an opportunity for further investigation that could yield valuable insights for business development and stakeholders.

Second, our analysis of the relationship between GPR and SCC is constrained by data availability, limiting the scope to the top five major suppliers and customers (Zhu *et al*., 2021). Future research could build upon these findings by utilizing more comprehensive datasets that include a wider array of suppliers and customers. It would also be valuable to explore the specifics of supply chain diversification prompted by GPR. For example, future studies could investigate the direction of supply chain diversification: Is it oriented toward greater internationalization, or are firms increasingly relying on domestic suppliers within China? Alternatively, is diversification concentrated in specific regions within China?

Finally, our analysis is conducted at the firm level, which may overlook the complex dynamics within industries where firms operate extensive production networks across multiple countries. Future research could benefit from a plant-level analysis to capture additional factors, such as order entry points and plant size, providing a more nuanced understanding of the relationship between GPR and SCC. One example of plant-level analysis is Ball *et al*. (2017), in which the authors examine the impact of plant inspections on future product quality and the role of investigator experience. Incorporating order entry points could offer further insights into the operational complexities and supply chain dynamics within industries.

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**Table 1 A summary of SCC's firm-level implications**

| Articles | Independent variable | Specific outcome | Key findings | Direction |
|---|---|---|---|---|
| Lanier Jr *et al*. (2010) | Supply chain concentration | Supply chains' financial performance (ROA, profit margin, asset turnover, and cash cycle) | A concentrated supply chain can reduce the transaction costs, thereby enhancing financial performance across the supply chain | Positive |
| Patatoukas (2012) | Customer concentration | Supplier firms' fundamentals and stock market valuation | Customer-base concentration improves supplier firm performance by increasing operational efficiencies. | Positive |
| Kim & Henderson (2015) | Supplier and customer embeddedness | Focal firm's financial performance (ROA and return on sales) | Both supplier and customer embeddedness contribute to the enhanced accounting-based performance of the focal firm. | Positive |
| Ak & Patatoukas (2016) | Customer concentration | Supplier's inventory efficiency | Manufacturers with more concentrated customer bases are less likely to encounter inventory surpluses and typically experience shorter inventory holding periods. The enhanced inventory efficiency in turn contributes to higher valuation premiums for the company. | Positive |
| Dhaliwal *et al*. (2016) | Customer concentration | Supplier's cost of equity capital | A concentrated customer base is positively correlated with the supplier's cost of equity by increasing its systematic risk. | Positive |
| Saboo *et al*. (2017) | Customer concentration | Supplier's profitability | Customer-base concentration undermines a supplier's profitability by reducing its bargaining power relative to its customers. | Negative |
| Kim & Zhu (2018) | Supplier's dependence on customers | Supplier's R&D intensity | Supplier dependence on major customers is negatively associated with the supplier's R&D intensity. | Negative |
| Cohen & Li (2020) | Concentration of major government clients | Supplier's profitability | Firms contracting with major government customers exhibit better profitability due to the stability of government procurement. | Positive |
| Dong *et al*. (2021) | Target firm's customer concentration | Merger performance of acquirers | Acquirers purchasing firms with higher customer concentration experience significantly lower stock market announcement returns and weaker long-term performance post-acquisition. | Negative |
| Leung & Sun (2021) | Policy uncertainty | Focal firm's customer concentration | Policy uncertainty has a significant negative impact on customer concentration, prompting the focal firms to diversify their customer base to mitigate increasing uncertainty. This diversification strategy positively affects firm performance. | Negative |
| Zhong *et al*. (2021) | Customer concentration | Supplier's search depth and search breadth | Firms with higher customer concentration demonstrate enhanced proficiency in managing major customer demands, which increases their propensity for conducting in-depth searches and decreases their likelihood of engaging in broad searches. | Positive<br>Negative |
| Zhu *et al*. (2021) | Customer concentration | Supplier's corporate social responsibility | The relationship between customer concentration and suppliers' corporate social responsibility performance is significantly negative. | Negative |
| Chen *et al*. (2022) | Concentrated supplier portfolios | Customer's innovation capability | There is a U-shape relationship between supplier portfolio concentration and firm innovation. | U-shape |
| Jiang *et al*. (2023) | Customer and supplier concentrations | Focal firm's resilience | Customer concentration is negatively associated with firm resilience during the pandemic stage but shows no significant impact during the restoration stage. In contrast, supplier concentration positively | Mixed |

| | | | | |
|---|---|---|---|---|
| | | | influences firm resilience during the pandemic stage but diminishes firm resilience in the restoration stage. | |
| Lin & Deng (2024) | Supplier concentration | Customer's digital innovation | A concentrated supplier base negatively affects the focal firm's digital innovation, primarily due to the absence of heterogeneous knowledge bases necessary for fostering innovation. | Negative |

**Source(s):** Authors' own creation

**Table 2 Variable definition**

| Variable | Definition | Source / Reference |
|---|---|---|
| **Independent variable** | | |
| *Geopolitical Risk (GPR)* | China's GPR index is determined by calculating the monthly proportion of all newspaper articles that both (1) qualify for inclusion in the GPR index and (2) consist of the country or its major cities. The monthly indices are transformed into annual indices by arithmetic averaging. | Geopolitical Risk (GPR) Index (matteoiacoviello.com) Caldara and Iacoviello (2022), Adra *et al*. (2023) |
| **Dependent variable** | | |
| *Supply Chain Concentration (SCC)* | $SCC_{it}$ is calculated as the arithmetic mean of $Customer\ Concentration_{it}$ and $Supplier\ Concentration_{it}$. $$Customer\ Concentration_{it} = \sum_{1}^{5} Sales_{ist}/Sales_{it}$$ $$Supplier\ Concentration_{it} = \sum_{1}^{5} Purchases_{ist}/Purchases_{it}$$ where $Sales_{ist}$ is firm *i*'s sales to major customer *s* in year *t*, $Sales_{it}$ indicates the total sales of firm *i* in year *t*, $Purchases_{ist}$ refers to firm *i*'s purchases from major supplier *s* in year *t*, and $Purchases_{it}$ represents the total purchases of firm *i* in year *t*. $$SCC_{it} = \frac{1}{2}(Customer\ Concentration_{it} + Supplier\ Concentration_{it})$$ | CSMAR Dong *et al*. (2020), Jiang *et al*. (2023), Yang *et al*. (2024) |
| *Supply Chain HHI* (Alternative measurement for *SCC*) | It is the arithmetic mean of the supplier's HHI and the customer's HHI. $$Supply\ Chain\ HHI_{i,t} = \frac{1}{2}(\sum_{1}^{5}(Sales_{ist}/Sales_{it})^2 + \sum_{1}^{5}\left(\frac{Purchases_{ist}}{Purchases_{it}}\right)^2)$$ | CSMAR Yang *et al*. (2024), Giannetti *et al*. (2015) |
| **Moderating variables** | | |
| *Firm Resilience* | Firm *i*'s total factor productivity (TFP) in year *t* is computed | CSMAR |

| | | |
|---|---|---|
| | as the residual of the following classic Cobb-Douglas production function: $$\ln(VA_{it}) = \alpha lnK_{it} + \beta lnL_{it} + \gamma lnM_{it} + \delta + \epsilon_{it}$$ Then, Firm Resilience is as calculated as follows: $$Resilience_{it} = TFP_{it} - TFP_{it-1}$$ | Dormady *et al*. (2019), Giannetti *et al*. (2015), Jiang *et al*. (2023), Ambulkar *et al*. (2015) |
| *Operational Slack* | It is determined by a firm's cash-to-cash cycle in the current year. This cycle is calculated as the days of inventory plus days of accounts receivables minus days of accounts payables for firm *i* in year *t* as follows: $$Operational\ Slack_{i,t} = (\frac{INV_t}{COGS_t})_i + \left(\frac{accountsreceivable_t}{Sales_t}\right)_i - \left(\frac{accountspayable_t}{COGS_t}\right)_i$$ | CSMAR Jia *et al*. (2023), Kovach *et al*. (2015) |
| *Cash Holding* | The cash and cash equivalents are divided by the total assets net of cash and cash equivalents. | CSMAR Chu (2020), Nason and Patel (2016) |
| **Control variables** | | |
| *Firm Size* | The natural logarithm of the number of employees | |
| *Firm Age* | The number of years since a firm was established | |
| *Tobin's Q* | The market value of equity plus total assets minus the book value of equity, all divided by total assets. Market value of equity is calculated by multiplying the year-end closing price by the number of shares outstanding | CSMAR Li *et al*., 2022; Yiu *et al*., 2020; Zhu *et al*., 2022 |
| *Book-to-Market Ratio* | Subtract total liabilities, preferred shares, and intangible assets from the total assets | |
| *Asset Tangibility* | Plant, property, and equipment divided by total assets | |

**Source(s):** Authors' own creation

**Table 3 Raw data snippet**

| Firm name | Year | SCC (in %) | Customer Concentration (in %) | Supplier Concentration (in %) | GPR |
|---|---|---|---|---|---|
| BYD | 2021 | 30.71 | 33.00 | 28.41 | 0.75 |
| BYD | 2022 | 20.47 | 18.86 | 22.08 | 1.21 |
| CATL | 2021 | 23.37 | 31.32 | 15.42 | 0.75 |
| CATL | 2022 | 28.30 | 35.33 | 21.26 | 1.21 |
| GREE | 2021 | 25.66 | 16.25 | 35.07 | 0.75 |
| GREE | 2022 | 20.20 | 15.96 | 24.43 | 1.21 |

**Source(s):** Authors' own creation

**Table 4 Sample distribution across the industry**

| Industry Code | Industry name | Percentage | Accumulated Percentage |
|---|---|---|---|
| C13 | Agricultural and sideline food processing industry | 1.70 | 1.70 |
| C14 | Food manufacturing | 2.28 | 3.98 |
| C15 | Wine, Beverage and Refined Tea Manufacturing | 1.52 | 5.50 |
| C16 | Tobacco Manufacturing | 0.00 | 5.50 |
| C17 | Textile Manufacturing | 1.50 | 7.00 |
| C18 | Textile and apparel industry | 1.17 | 8.17 |
| C19 | Leather, fur, feathers and their products and footwear | 0.25 | 8.42 |
| C20 | Wood Processing and Wood, Bamboo, Rattan, Palm and Grass Products Industry | 0.27 | 8.70 |
| C21 | Furniture manufacturing | 0.98 | 9.67 |
| C22 | Paper and paper products industry | 1.29 | 10.96 |
| C23 | Printing and recording media reproduction industry | 0.53 | 11.50 |
| C24 | Cultural and educational, industrial beauty, sports and entertainment products manufacturing | 0.52 | 12.02 |
| C25 | Petroleum, coal and other fuel processing industries | 0.51 | 12.53 |
| C26 | Chemical raw materials and chemical products manufacturing | 10.64 | 23.17 |
| C27 | Pharmaceutical manufacturing | 9.41 | 32.57 |
| C28 | Chemical fiber manufacturing | 0.98 | 33.55 |
| C29 | Rubber and plastic products industry | 3.77 | 37.32 |
| C30 | Non-metallic mineral products industry | 3.36 | 40.68 |
| C31 | Ferrous metal smelting and rolling industry | 1.18 | 41.86 |
| C32 | Non-ferrous metal smelting and calendaring industry | 2.75 | 44.61 |
| C33 | Metal products industry | 2.95 | 47.57 |
| C34 | General equipment manufacturing | 5.91 | 53.48 |
| C35 | Special equipment manufacturing | 10.05 | 63.53 |
| C36 | Automotive manufacturing | 5.39 | 68.92 |
| C37 | Railway, marine, aerospace and other transportation equipment manufacturing | 2.17 | 71.09 |
| C38 | Electrical machinery and equipment manufacturing | 9.80 | 80.89 |
| C39 | Computer, communications and other electronic equipment manufacturing | 15.80 | 96.69 |
| C40 | Instrumentation manufacturing | 2.65 | 99.35 |
| C41 | Other manufacturing | 0.65 | 100.00 |

**Source(s):** Authors' own creation

**Table 5 Summary statistics and correlation matrix**

| **Variable** | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) F. SCC | 1.000 | | | | | | | | | |
| (2) GPR | -0.046*** | 1.000 | | | | | | | | |
| (3) Firm Resilience | 0.015* | -0.085*** | 1.000 | | | | | | | |
| (4) Operational Slack | 0.115*** | -0.005 | -0.094*** | 1.000 | | | | | | |
| (5) Cash Holding | -0.058*** | -0.039*** | 0.094*** | 0.194*** | 1.000 | | | | | |
| (6) Firm Size | -0.386*** | -0.004 | 0.060*** | 0.019*** | 0.200*** | 1.000 | | | | |
| (7) Firm Age | -0.138*** | -0.051*** | 0.011 | 0.039*** | 0.129*** | 0.191*** | 1.000 | | | |
| (8) Tobin's *q* | 0.082*** | -0.097*** | 0.068*** | -0.085*** | -0.142*** | -0.155*** | -0.034*** | 1.000 | | |
| (9) Book to Market Ratio | -0.116*** | 0.118*** | -0.060*** | 0.140*** | 0.187*** | 0.322*** | 0.101*** | -0.736*** | 1.000 | |
| (10) Asset Tangibility | 0.109*** | 0.043*** | -0.045*** | 0.024*** | -0.189*** | -0.061*** | -0.073*** | 0.037*** | -0.047*** | 1.000 |
| Mean | 0.346 | 0.891 | 0.037 | 0.434 | 0.172 | 7.589 | 23.642 | 1.980 | 0.634 | 0.927 |
| SD | 0.155 | 0.166 | 0.245 | 0.595 | 0.0132 | 1.266 | 5.782 | 1.428 | 0.244 | 0.089 |
| Min | 0.120 | 0.754 | -3.650 | 0.001 | 0.001 | 0.693 | 7.000 | 0.625 | 0.030 | 0.064 |
| Max | 0.666 | 1.208 | 2.770 | 17.633 | 0.911 | 13.254 | 66.000 | 33.872 | 1.600 | 1.000 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

**Source(s):** Authors' own creation

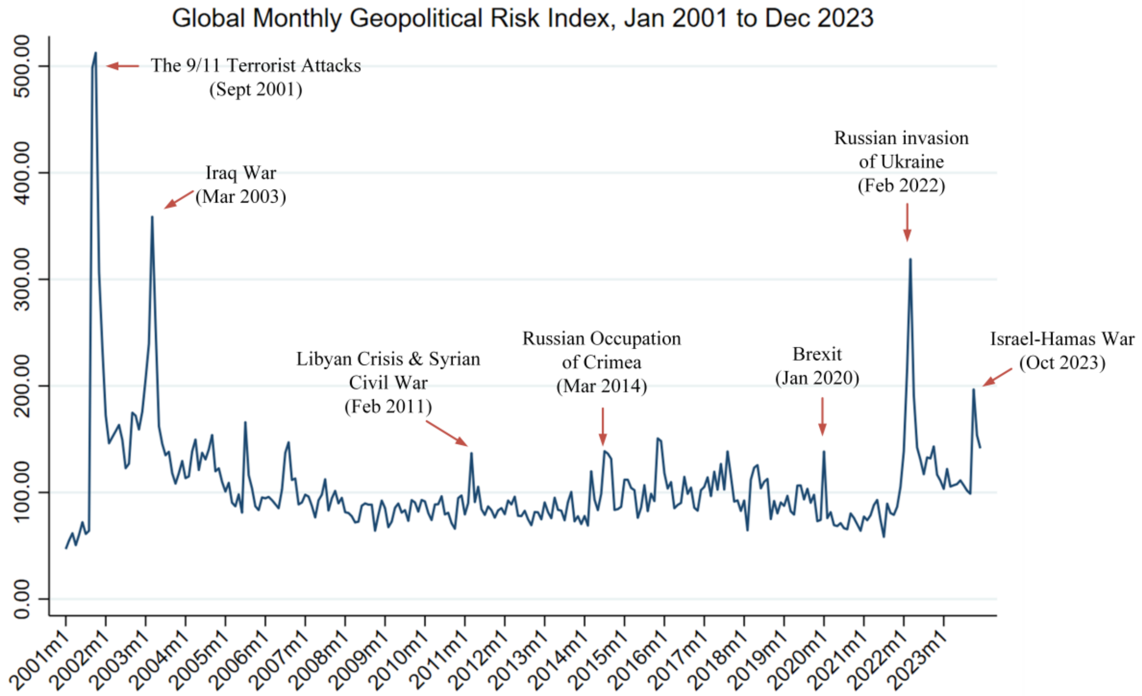


**Figure 1 Global monthly GPR index from 2001 to 2023**

**Source(s):** Authors' own creation

**Table 6 Baseline results and moderating effects**

| Dependent Variable: SCC | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| GPR | -0.033*** | -0.017*** | -0.014** | -0.035*** | -0.095* |
| | (0.006) | (0.005) | (0.006) | (0.002) | (0.054) |
| Firm Resilience | 0.879*** | 0.630*** | 0.897*** | 0.893*** | 0.277 |
| | (0.242) | (0.022) | (0.241) | (0.241) | (0.223) |
| Operational Slack | 0.332*** | 0.334*** | 0.322** | 0.194 | 0.038 |
| | (0.015) | (0.015) | (0.138) | (0.140) | (0.129) |
| Cash Holding | -0.178 | -0.168*** | -0.173 | -0.183 | -0.183 |
| | (0.125) | (0.053) | (0.125) | (0.097) | (0.097) |
| GPR × | | 0.883*** | | | 0.453* |
| Firm Resilience | | (0.272) | | | (0.273) |
| GPR × | | | 0.821*** | | 0.455*** |
| Operational Slack | | | (0.172) | | (0.162) |
| GPR × | | | | 0.383*** | 0.202* |
| Cash Holding | | | | (0.115) | (0.118) |
| Cons | Included | Included | Included | Included | Included |
| Control | Included | Included | Included | Included | Included |
| Industry FE | YES | YES | YES | YES | YES |
| Observations | 11,807 | 11,807 | 11,807 | 11,807 | 11,807 |
| R-squared | 0.371 | 0.372 | 0.367 | 0.379 | 0.368 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.

**Source(s):** Authors' own creation

**Table 7 Robustness check results for fixed effect models**

| Dependent Variable: SCC | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| GPR | -0.015** | -0.015** | -0.235*** | -0.142*** |

| | | | | |
|---|---|---|---|---|
| | (0.006) | (0.007) | (0.020) | (0.010) |
| Firm Resilience | -0.512 | -0.519 | 0.005 | 0.291 |
| | (0.328) | (0.328) | (0.004) | (0.353) |
| Operational Slack | 0.082 | 0.085 | 0.008 | 0.377** |
| | (0.166) | (0.166) | (0.013) | (0.188) |
| Cash Holding | -0.111 | -0.111 | -0.024 | -0.172 |
| | (0.139) | (0.139) | (0.020) | (0.146) |
| GPR × | 0.703* | 0.713* | 0.119*** | 0.828* |
| Firm Resilience | (0.391) | (0.391) | (0.010) | (0.498) |
| GPR × | 0.503** | 0.507** | 0.017*** | 0.122*** |
| Operational Slack | (0.203) | (0.202) | (0.005) | (0.032) |
| GPR × | 0.403*** | 0.125** | 0.010** | 0.706*** |
| Cash Holding | (0.139) | (0.054) | (0.004) | (0.211) |
| Cons | Included | Included | Included | Included |
| Control | Included | Included | Included | Included |
| Industry FE | YES | NO | YES | YES |
| Firm FE | NO | YES | NO | NO |
| Observations | 8,917 | 11,807 | 11,807 | 11,807 |
| R-squared | 0.345 | 0.358 | 0.237 | 0.378 |

Notes: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. Standard errors are in parentheses.

**Source(s):** Authors' own creation

**Table 8 Robustness check results for alternative measurements**

| **Dependent Variable: SCC** | **(1) SC HHI** | **(2) Resilience** | **(3) QR** | **(4) RTR** | **(5) ITR** |
|---|---|---|---|---|---|
| GPR | -0.499*** | -0.462*** | -0.079*** | -0.090** | -0.104*** |
| | (0.182) | (0.117) | (0.030) | (0.040) | (0.032) |
| Firm Resilience | 0.039*** | / | 0.038*** | 0.072*** | 0.041*** |
| | (0.015) | / | (0.008) | (0.009) | (0.007) |
| *Alternative Firm Resilience* | / | 0.200*** | / | / | / |
| | / | (0.021) | / | / | / |
| Operational Slack | 0.017 | 0.020** | / | / | / |
| | (0.015) | (0.010) | / | / | / |
| *Alternative Operational Slack* | | | | | |
| QR | / | / | 0.072*** | / | / |
| | / | / | (0.006) | / | / |
| RTR | / | / | / | 0.100*** | / |
| | / | / | / | (0.007) | / |
| ITR | / | / | / | / | 0.031*** |
| | / | / | / | / | (0.003) |
| Cash Holding | -0.004 | 0.287*** | 0.204*** | 0.173*** | 0.177*** |
| | (0.005) | (0.037) | (0.014) | (0.018) | (0.013) |
| GPR × | 0.250*** | 0.228*** | 0.054*** | 0.087*** | 0.055*** |
| Firm Resilience | (0.091) | (0.059) | (0.009) | (0.011) | (0.009) |
| GPR × | 0.064** | 0.964*** | 0.829*** | 0.711*** | 0.325*** |
| Operational Slack | (0.025) | (0.157) | (0.193) | (0.172) | (0.021) |
| GPR × | 0.013*** | 0.173** | 0.249** | 0.213* | 0.214* |
| Cash Holding | (0.001) | (0.074) | (0.121) | (0.117) | (0.122) |
| Cons | Included | Included | Included | Included | Included |
| Control | Included | Included | Included | Included | Included |
| Industry FE | YES | YES | YES | YES | YES |
| Observations | 11,807 | 11,807 | 11,807 | 11,807 | 11,807 |
| R-squared | 0.349 | 0.327 | 0.316 | 0.395 | 0.386 |

Notes: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. Standard errors are in parentheses.

**Source(s):** Authors' own creation

**Table 9 Robustness check results for DPD models**

| Dependent Variable: SCC | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| L. SCC | 0.659*** | 0.664*** | 0.672*** | 0.669*** |
| | (0.025) | (0.023) | (0.023) | (0.023) |
| GPR | -0.287** | -0.241* | -0.241* | -0.244* |
| | (0.136) | (0.129) | (0.128) | (0.128) |
| Firm Resilience | 0.019 | 0.027 | 0.020 | 0.017 |
| | (0.067) | (0.060) | (0.063) | (0.063) |
| Operational Slack | 0.011*** | 0.018*** | 0.015*** | 0.017*** |
| | (0.003) | (0.002) | (0.001) | (0.002) |
| Cash Holding | -0.002** | -0.010** | -0.178 | -0.235 |
| | (0.001) | (0.004) | (0.125) | (0.203) |
| GPR × | 0.140** | 0.117* | 0.116* | 0.119* |
| Firm Resilience | (0.068) | (0.065) | (0.064) | (0.065) |
| GPR × | 0.100*** | 0.110*** | 0.120*** | 0.180*** |
| Operational Slack | (0.027) | (0.026) | (0.027) | (0.027) |
| GPR × | 0.079*** | 0.049*** | 0.049*** | 0.050*** |
| Cash Holding | (0.020) | (0.012) | (0.010) | (0.013) |
| Industry Dummies | Included | Included | Included | Included |
| Cons | Included | Included | Included | Included |
| Control | Included | Included | Included | Included |
| Arellano-Bond Test for AR (2) | 0.413 | 0.397 | 0.413 | 0.702 |
| Instrument Validity Test | 0.437 | 0.451 | 0.466 | 0.462 |
| Observations | 11,807 | 11,807 | 11,807 | 11,807 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.

**Source(s):** Authors' own creation

**Table 10 Robustness check results for DiD analysis**

| Dependent Variable: SCC | OLS (1) | (2) | (3) | NB (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| *Treat*Post* | -0.027*** | -0.021*** | -0.028*** | -0.029*** | -0.020*** | -0.031*** |
| | (0.003) | (0.004) | (0.005) | (0.008) | (0.007) | (0.010) |
| Firm Resilience | / | 0.032*** | 0.028*** | / | 0.098*** | 0.094*** |
| | / | (0.006) | (0.005) | / | (0.019) | (0.014) |
| Operational Slack | / | 0.030*** | 0.030*** | / | 0.086*** | 0.088*** |
| | / | (0.003) | (0.003) | / | (0.010) | (0.024) |
| Cash Holding | / | -0.067* | -0.032* | / | -0.023 | -0.022 |
| | / | (0.035) | (0.018) | / | (0.044) | (0.103) |
| Cons | Included | Included | Included | Included | Included | Included |
| Control | Not Included | Included | Included | Not Included | Included | Included |
| Industry FE | NO | NO | YES | NO | NO | YES |
| Observations | 18,365 | 18,365 | 18,365 | 18,365 | 18,365 | 18,365 |
| R-squared | 0.350 | 0.348 | 0.392 | 0.324 | 0.310 | 0.331 |
| Log likelihood | / | / | / | -7088.73 | -6608.97 | -6008.91 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.

**Source(s):** Authors' own creation

**Table 11 GPR, SCC, and firm performance**

**(a) ROA**

| Dependent Variable | $ROA_t$ | | | | | |
|---|---|---|---|---|---|---|
| | Full sample | | $+\Delta GPR_{t-1}$ | | $-\Delta GPR_{t-1}$ | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $SCC_{t-1}$ | -0.041* | / | -0.036*** | / | -0.038 | / |
| | (0.021) | / | (0.013) | / | (0.170) | / |

| | | | | | | |
|---|---|---|---|---|---|---|
| $Supply\ Chain\ HHI_{t-1}$ | / | -0.049** | / | -0.063** | / | -0.018 |
| | / | (0.023) | / | (0.030) | / | (0.042) |
| Controls | YES | YES | YES | YES | YES | YES |
| Industry FE | YES | YES | YES | YES | YES | YES |
| Observations | 11,807 | 11,807 | 6,932 | 6,932 | 4,875 | 4,875 |
| Average R Squared | 0.246 | 0.275 | 0.316 | 0.385 | 0.348 | 0.347 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.
**Source(s):** Authors' own creation

**(b) Investment**

| **Dependent Variable** | $Investment_t$ | | | | | |
|---|---|---|---|---|---|---|
| | **Full sample** | | $+\Delta GPR_{t-1}$ | | $-\Delta GPR_{t-1}$ | |
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| $SCC_{t-1}$ | 0.029*** | / | 0.032*** | / | 0.031 | / |
| | (0.008) | / | (0.006) | / | (0.043) | / |
| $Supply\ Chain\ HHI_{t-1}$ | / | 0.019** | / | 0.038*** | / | 0.029 |
| | / | (0.009) | / | (0.007) | / | (0.033) |
| Controls | YES | YES | YES | YES | YES | YES |
| Industry FE | YES | YES | YES | YES | YES | YES |
| Observations | 11,807 | 11,807 | 6,932 | 6,932 | 4,875 | 4,875 |
| Average R Squared | 0.290 | 0.315 | 0.348 | 0.390 | 0.394 | 0.345 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.
**Source(s):** Authors' own creation

**(c) Operating Cost**

| **Dependent Variable** | $Operating\ Cost_t$ | | | | | |
|---|---|---|---|---|---|---|
| | **Full sample** | | $+\Delta GPR_{t-1}$ | | $-\Delta GPR_{t-1}$ | |
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| $SCC_{t-1}$ | -0.033** | / | -0.098** | / | 0.010 | |
| | (0.014) | / | (0.041) | / | (0.140) | |
| $Supply\ Chain\ HHI_{t-1}$ | / | -0.020** | / | -0.062** | | 0.012 |
| | / | (0.010) | / | (0.028) | | (0.047) |
| Controls | YES | YES | YES | YES | YES | YES |
| Industry FE | YES | YES | YES | YES | YES | YES |
| Observations | 11,807 | 11,807 | 6,932 | 6,932 | 4,875 | 4,875 |
| Average R Squared | 0.256 | 0.278 | 0.373 | 0.356 | 0.361 | 0.319 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.
**Source(s):** Authors' own creation

**Table 12 Robustness check results for customer concentration and supplier concentration**

| **DV: Customer Concentration** | **(1)** | **(2)** | | |
|---|---|---|---|---|
| **DV: Supplier concentration** | | | **(3)** | **(4)** |
| L. Customer Concentration | 0.747*** | 0.756*** | / | / |
| | (0.030) | (0.027) | / | / |
| L. Supplier Concentration | / | / | 0.562*** | 0.568*** |
| | / | / | (0.030) | (0.026) |
| GPR | -0.276* | -0.223* | -0.834*** | -0.723*** |
| | (0.143) | (0.124) | (0.176) | (0.156) |
| Firm Resilience | 0.037** | 0.032** | 0.201 | 0.375 |
| | (0.015) | (0.014) | (0.156) | (0.241) |
| Operational Slack | 0.015 | 0.013 | 0.013 | 0.067 |
| | (0.012) | (0.011) | (0.012) | (0.080) |
| Cash Holding | -0.006 | -0.004 | 0.037 | 0.034 |
| | (0.004) | (0.004) | (0.049) | (0.042) |
| GPR × | 0.135* | 0.109* | 0.425*** | 0.371*** |
| Firm Resilience | (0.072) | (0.062) | (0.088) | (0.078) |
| GPR × | 0.114*** | 0.109*** | 0.057** | 0.051** |

| | | | | |
|---|---|---|---|---|
| Operational Slack | (0.023) | (0.022) | (0.024) | (0.023) |
| GPR × | 0.020** | 0.018** | 0.067*** | 0.145*** |
| Cash Holding | (0.009) | (0.008) | (0.010) | (0.020) |
| Industry Dummies | Included | Included | Included | Included |
| Cons | Included | Included | Included | Included |
| Control | Included | Included | Included | Included |
| Arellano-Bond Test for AR (2) | 0.416 | 0.415 | 0.713 | 0.488 |
| Instrument Validity Test | 0.445 | 0.437 | 0.406 | 0.408 |
| Observations | 11,807 | 11,807 | 11,807 | 11,807 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.
**Source(s):** Authors' own creation

**Table 13 Additional test results for geographical distance**

| Dependent Variable: Supply Chain Geographical Distance | (1) Lagged for 1 year | (2) Lagged for 2 years |
|---|---|---|
| GPR | -0.026** | -0.038** |
| | (0.012) | (0.025) |
| Firm Resilience | 0.167*** | 0.258*** |
| | (0.020) | (0.028) |
| Operational Slack | 0.178*** | 0.123*** |
| | (0.066) | (0.009) |
| Cash Holding | 0.813** | 0.716 |
| | (0.393) | (0.510) |
| GPR × | 0.499*** | 0.311*** |
| Firm Resilience | (0.025) | (0.042) |
| GPR × | 0.218*** | 0.170* |
| Operational Slack | (0.078) | (0.101) |
| GPR × | 0.838* | 0.732** |
| Cash Holding | (0.477) | (0.311) |
| Cons | Included | Included |
| Control | Included | Included |
| Industry FE | YES | YES |
| Observations | 11,807 | 8,917 |
| R-squared | 0.377 | 0.403 |

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard errors are in parentheses.
**Source(s):** Authors' own creation

**Appendix A1. The detailed steps for the calculation of firm resilience**

**(1) Data standardization (extreme variance method)**

$$y_{r,s,t} = \begin{cases} \dfrac{x_{r,s,t} - \min(x_s)}{\max(x_s) - \min(x_s)}, x_{r,s,t} \text{ } is\ the\ positive\ indicator \\ \dfrac{\max(x_s) - x_{r,s,t}}{\max(x_s) - \min(x_s)}, x_{r,s,t} \text{ } is\ the\ negative\ indicator \end{cases}$$

*r*, *s*, and *t* denote firms, measurement indicators of the growth and volatility dimensions in firm resilience, and year, respectively; $x_{r,s,t}$ and $y_{r,s,t}$ denote the original and normalized values of each measurement, respectively; $\max(x_s)$ and $\min(x_s)$ denote the maximum and minimum values of the *s-th* measure, respectively.

**(2) Determination of indicator weights (entropy value method)**

$$p_{rst} = \frac{y_{rst}}{\sum_{r=1}^{n} y_{rst}}$$

$p_{rst}$ represents the weight of firm *r* on the *s-th* measure in year *t*, and *n* is the total number of firms.

Calculate the information entropy of the *s-th* measure:

$$k = 1/\ln(n)$$

$$e_s = -k \sum_{r=1}^{n} p_{rst} \ln(p_{rst})$$

$e_s$ is the entropy value of the *s-th* measure, $0 \leq e_s \leq 1,\ k > 0$.

Calculate the coefficient of variation for the *s-th* indicator:

$$g_s = 1 - e_s$$

$g_s$ is the coefficient of variation for the *s-th* indicator.

Calculate the weight of the *s-th* indicator:

$$w_s = g_s / \sum_{s=1}^{n} g_s$$

$w_s$ is the weight of the *s-th* indicator.

**(3) Calculation of firm resilience (linear weighting approach)**

$$Firm\ resilience_r = \sum_{s=1}^{q} w_s\, y_{rst}$$

$Firm\ resilience_r$ is the result value of firm resilience assessment for firm *r*, and $q$ is the total number of all indicators measuring firm resilience.