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Operations locked-in amid geopolitical conflicts: A study of the 2022 Russo–Ukrainian war☆

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ABSTRACT

The rise in geopolitical conflicts has created unprecedented risks for firms, particularly in their operations and supply chains. In the wake of the 2022 Russo–Ukrainian War, many multinational enterprises have faced significant challenges in managing these risks, with some becoming "locked-in" to such high-risk regions as Russia. This study explores how firms manage operations under geopolitical conflict, with a focus on those unable to fully exit risky markets. Using a sample of U.S.-listed firms maintaining operations in Russia following the invasion, our propensity score matching and difference-in-differences analysis demonstrates that these firms have experienced undermined profitability. However, we find mixed moderating effects of different types of market dependencies. Firms with subsidiaries and suppliers in Russia experienced a more severe decline in profitability, while having customers in Russia served to mitigate this impact. Moreover, we explore the role of slack resources in alleviating the adverse effects, showing that firms with more operating and unborrowed slacks better maintained their financial performance. The findings contribute to the operations and supply chain management literature on geopolitical risks and resource dependence theory, while offering managerial implications for navigating operations under geopolitical conflicts.

1. Introduction

Firms today are facing increasing operational and supply chain risks due to the rise in geopolitical conflicts across the globe. Operations and supply chain management (OSCM) scholars have begun to investigate the effects of these conflicts, such as the US–China trade war and Brexit, on firms. Studies have examined various impacts, including firm performance (Fan et al., 2022a), sourcing decisions (Charpin & Cousineau, 2024; Fan et al., 2024), international research collaborations (Charpin et al., 2024), and supply chain reconfigurations (Moradlou et al., 2021; Moradlou et al., 2024).

When confronted with heightened geopolitical risks, firms typically reduce or suspend operations in the affected regions to mitigate exposure. For example, U.S. firms have reduced transactions with Chinese suppliers following the outbreak of the U.S.–China trade war in 2018 (Fan et al., 2024). Similarly, after Russia's invasion of Ukraine in February 2022, many multinational enterprises (MNEs), particularly those headquartered in Western countries, either suspended or scaled back their operations in Russia (The New York

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Times, 2022). This move not only aligned with the West's political stance against Russia's military action, but also served to reduce operational risks in an increasingly unstable environment.

However, some firms have found themselves unable to fully exit the conflict zone, becoming *locked into* the region while bearing significant geopolitical risks. In this context, "locked-in" refers to firms having subsidiaries, suppliers, or customers in Russia, which prevent them from easily withdrawing from the market. This concept differs from the notion of "locked-in" used by Fan et al. (2024), which focuses on suppliers' superior attributes that lock in foreign buyers. Our operationalization of "locked-in operations" emphasizes deployed resources, such as physical assets, human capital, and established supply chain relationships in a specific region. For instance, such companies as Pepsi and AstraZeneca did not withdraw from the Russian market due to the substantial assets and market shares they held there (Doherty, 2023).

These locked-in companies have critical resources tied to high-risk regions, making redeployment to more stable areas challenging. For instance, Russia has implemented regulations preventing Western firms from repatriating their assets to countries it considers "unfriendly" (Stognei, 2023). As such, these firms must manage elevated risks and resource shortages while continuing to operate in volatile markets.

However, this challenging situation also presents a potential trade-off for firms. With fewer players in the market, firms that remain could potentially strengthen their position and increase their profitability (Grullon et al, 2019). On the other hand, operating in a high-risk environment, firms may face increased operating costs, reputational risks, and potential sanctions—all of which can negatively impact their performance (Alam et al., 2023; Jungblut & Johnen, 2022). This paradox leads to our first research question (RQ1): *Do firms with locked-in operations in high-risk geopolitical settings suffer undermined profitability*?

From a resource dependence theory (RDT) perspective, firms operating in uncertain environments have a greater need to control external resources to mitigate instability (Pfeffer & Salancik, 1978). In the case of geopolitical conflicts, such as the Russo–Ukrainian War, firms with assets locked into high-risk regions face even greater uncertainty. RDT suggests that firms' performance is largely determined by their ability to manage dependencies on critical resources (Hillman et al., 2009). However, firms' abilities to manage uncertainty and secure resources vary. Indeed, those with higher resource dependence on a particular market or region may be more vulnerable to geopolitical shocks in that area (Lo et al., 2022). However, firms with greater organizational slack, or a buffer of excess resources, may be more able to absorb environmental shocks (Bourgeois, 1981). These heterogeneities among firms in this context lead to the second research question (RQ2): *Under what conditions can firms effectively mitigate the undermined profitability, despite being locked into high-risk geopolitical settings?*

To address these questions, we analyze a sample of U.S.-listed firms with operations locked in Russia following the 2022 Russo–Ukrainian War. Using propensity score matching and difference-in-differences (PSM-DID) analysis, our findings show that these firms experience reduced profitability. However, we also find mixed moderating effects of different types of market dependencies. Firms with subsidiaries and suppliers in Russia experienced a more severe decline in profitability, while having customers in Russia mitigated the negative impact. Moreover, we explore the role of slack resources in alleviating the adverse effects, showing that firms with more operating and unborrowed slacks better maintained their financial performance.

We also discuss our theoretical contributions to the OSCM literature on geopolitical issues, supply chain risk management, and RDT. This study provides a fresh perspective by focusing on firms with "locked-in operations", going beyond the recommendation to simply move away from conflict areas. Our study also identifies market dependency as a critical factor shaping firms' ability to respond to geopolitical conflicts. Lastly, we outline the managerial implications of our findings, providing managers with actionable ways to navigate potential geopolitical disruptions.

2. Literature review and hypotheses development

This section begins by providing a broad overview of the existing literature on geopolitical conflicts in OSCM, before proceeding to discuss the locked-in effect during geopolitical conflicts. Next, from the theoretical lens of RDT, we examine the direct impacts of the Russo–Ukrainian conflict on firms maintaining operations in Russia, with a focus on profitability. Finally, we explore the potential moderating roles of two key factors: dependency and organizational slack.

2.1. Geopolitical conflicts in OSCM

Geopolitical risks, such as armed conflicts, pandemics, terrorism, inter-state tensions, and territorial disputes, have brought instability and uncertainty to international economic activities (Adabor & Ayesu, 2024). As geopolitical conflicts become more frequent and impactful worldwide in the era of de-globalization, MNEs are adjusting their operational strategies based on the level of risk and their risk perceptions (Witt, 2019; Moradlou et al., 2024). Unlike other disruptions, such as natural disasters or market fluctuations, geopolitical conflicts pose complex and multidimensional challenges for firms due to their inherently political nature and potential for escalation and spread (Handley & Limão, 2022). These conflicts disrupt the institutional foundations of cross-border economic activity by altering the formal and informal rules and expectations that govern cross-border exchanges (Petricevic & Teece, 2019; Charpin & Cousineau, 2024), creating an unstable and unpredictable business environment.

The recent escalation in geopolitical conflicts has attracted scholarly interest in their impacts on firms' operations, supply chains, and performance outcomes. Research contexts include Brexit (Roscoe et al., 2020; Moradlou et al., 2021), the COVID-19 pandemic (Jiang et al., 2023; Shen & Sun, 2023), trade wars (Fan et al., 2022a; Fan et al., 2024), the Russo–Ukrainian War (Belhadi et al., 2024; El Baz et al., 2025), and broad geopolitical risk (Roscoe et al., 2022; Zhu et al., 2024). These conflicts can disrupt cross-border flows of goods and materials, creating bottlenecks, delays, and uncertainties in supply chains, thus undermining their ability to maintain

smooth and efficient operations (Bednarski et al., 2024). Such disruptions significantly impact firms' financial performance (Fan et al., 2022a), largely due to the increased operational costs and risks in politically unstable environments, along with the potential reputational damage and stakeholder backlash (Darendeli & Hill, 2016). Ultimately, these various impacts can severely undermine firms' competitiveness and resilience in the face of geopolitical turbulence.

To combat these impacts, scholars have suggested various ways to build resilience. Supply chain reconfiguration strategies, such as reshoring (Cheng et al., 2024) and friend-shoring (Charpin & Cousineau, 2024), have been proposed to reduce exposure to geopolitical risks and improve overall network efficiency. Flexibility in supply chain design and operations is also crucial for improved adaptation (Lin et al., 2021; Moradlou et al., 2024). Moreover, digital technologies and enhanced supply chain visibility provide firms with predictive capabilities to anticipate and respond to geopolitical risks (Belhadi et al., 2024).

2.2. Locked-in operations during geopolitical conflicts

A dominant perspective in the literature suggests that firms tend to reduce their exposure to geopolitical risk by reducing or relocating operations in conflict-prone regions (Dai et al., 2013; Srai et al., 2023). The "flight" response occurs, as political instability undermines the appropriability of returns on investment, making continuation commercially unviable. Empirical evidence supports this view. For example, Fan et al. (2024) found that, during the U.S.–China trade war, firms reduced sourcing from conflict zones to mitigate risks. Similarly, Oh and Oetzel (2017) revealed that MNEs often divest subsidiaries after terrorist attacks and natural disasters to mitigate operational disruptions. Srai et al. (2023) suggested that firms began to "unhook" their supply chains from conflict zones after the Russo–Ukrainian War.

However, some firms are unable to exit conflict zones. In particular, the Russo–Ukrainian War has highlighted the challenges faced by firms "locked in" to geopolitically unstable regions, unable to easily exit or reduce their risk exposure (Evenett & Pisani, 2023). High sunk costs and asset specificity are primary factors, as firms invest heavily in specialized infrastructure and equipment that cannot be easily redeployed or recovered, making exit financially prohibitive (Dai et al., 2013; Dai et al., 2017). Additionally, strategic market considerations are key, as some firms remain to retain access to valuable resources or protect their market positions (Lieberman et al., 2017). Institutional constraints, such as binding contracts or legal restrictions imposed by host governments, can further limit exit options (Darendeli & Hill, 2016).

The locked-in phenomenon can arise from dependency but represents a more static state. Dependency is more dynamic, as it evolves from the firm's ongoing reliance on external factors. In contrast, lock-in is the result of accumulated dependencies and past decisions that create significant exit barriers, leaving the firm unable to adapt or relocate despite changing geopolitical conditions (Jiang et al., 2023). Researchers have argued that these dependencies can create inertia and limit firms' ability to adapt to shifting geopolitical circumstances (Darendeli & Hill, 2016). Consequently, firms operating in conflict zones may face unique challenges in balancing risk management imperatives with the need to maintain competitiveness and financial performance (Hiatt & Sine, 2014).

Prior research has explored the lock-in effects within buyer–supplier relationships during geopolitical conflicts. For instance, Fan et al. (2024), studying the U.S.–China trade war, found that U.S. firms often focused on the superior attributes of suppliers, becoming locked in with innovative and socially responsible Chinese suppliers. However, there is a limited understanding of how firms that are locked in during such conflicts are affected and react. This study aims to fill this gap by focusing on the firms that are locked in amid geopolitical conflicts.

2.3. Impacts of the 2022 Russo–Ukrainian war

The Russo–Ukrainian War has become the largest geopolitical conflict in Europe since World War II (D'Anieri, 2023). This crisis has significantly increased systemic risks, with spillover effects felt across the globe (Qureshi et al., 2022). According to the Federal Reserve, as of May 2022, the escalating conflict was expected to cause a 1.7 % reduction in global output, underscoring the profound impact of geopolitical risks on the world economy (Alam et al., 2023; Liadze et al., 2023). Although OSCM scholars have not extensively focused on the Russo–Ukrainian War (Srai et al., 2023; Belhadi et al., 2024), its impacts have been broadly studied in other disciplines, including quantifying the economic losses to countries worldwide (Qureshi et al., 2022; Liadze et al., 2023) and launching war-related sociopolitical activism to gain legitimacy from stakeholders (Ganesan & Mallapragada, 2025; Kipnis et al., 2025).

In response to the invasion, numerous MNEs announced plans to suspend or cease operations in Russia (Srai et al., 2023). However, some firms faced significant challenges in exiting Russia due to complex dilemmas and processes, including dismantling extensive

Table 1
Pre-and post-war comparison of firms operating in Russia.

Aspect	Before Russo–Ukrainian War	After Russo–Ukrainian War
Operating costs	Manageable operating costs, primarily driven by business strategy.	Rising operating costs due to inflation, regulatory challenges, and logistics.
Operational flexibility	Higher flexibility; less constrained by asset specificity.	Reduced flexibility; "locked-in" due to high asset specificity.
Supply chain stability	Relatively stable supply chains with minor disruptions.	High instability; disruptions and delays in logistics.
Regulatory environment	Standard regulatory requirements; freedom to repatriate assets.	Challenging environment; regulatory restrictions on asset repatriation.
Reputational risk	Low reputational risk; no political pressures affecting reputation.	High reputational risk; political pressures and potential boycotts.

supply chains and accepting substantial financial losses. Additionally, legal and regulatory obstacles, such as restrictions on selling assets and contractual challenges, made withdrawal difficult. For example, Philip Morris aimed to scale down operations and explore exit options, but cited challenges related to the regulatory environment and difficulty in finding buyers for its Russian assets (Barnes, 2023). Table 1 illustrates the challenges for firms operating in Russia after the war.

RDT provides a suitable framework for understanding the heightened uncertainty faced by firms with locked-in operations amidst the current geopolitical tensions. According to RDT, organizations are constrained by their environment and depend on external entities for critical resources (Pfeffer & Salancik, 1978). In times of heightened uncertainty, firms may face significant challenges in accessing these critical resources, potentially threatening their ability to maintain operations (Darby et al., 2020).

Firms currently operating in Russia face significant supply chain disruptions, increased operating costs, and reputational risks—all of which negatively impact their revenues and profitability (Alam et al., 2023). Additionally, with the rise of political consumerism, consumers and other stakeholders increasingly pressure firms to publicly take a stance on political issues; those failing to meet these expectations may face boycotts (Jungblut & Johnen, 2022). As argued by Ganesan & Mallapragada (2025), firms choosing to remain in Russia may suffer from negative consumer perceptions and decreased purchase intentions. Consequently, the heightened uncertainty and volatility make it all the more difficult for firms to generate the cash flows needed to service their increasing operating costs. Accordingly, we propose the following hypothesis:

H1: Firms maintaining operations in Russia after the Russo–Ukrainian War experience a decrease in profitability.

2.4. The moderating effects of market dependency

RDT posits that an organization's dependence on external entities for critical resources determines the extent to which those entities can influence the focal organization's behavior and outcomes (Pfeffer & Salancik, 1978). It is important to manage external dependencies and reduce environmental uncertainty (Hillman et al., 2009). MNEs' dependence on a foreign market can take various forms, including dependence on subsidiaries, suppliers, and the market's customers (Gereffi et al., 2005). Subsidiaries represent a company's direct investment and operational presence in a foreign market, while suppliers and customers reflect the company's reliance on the market for critical inputs and revenue streams, respectively.

Firms that depend heavily on the Russian market for critical resources face greater challenges in managing the risks and disruptions associated with the current geopolitical conflict (Lo et al., 2022). These firms are more vulnerable to changes in the market's conditions, as they are less able to adapt to changing circumstances due to their reliance on market-specific resources and relationships (Darby et al., 2020). They have fewer opportunities to optimize their cost structures or pursue alternative growth opportunities in other markets (Hillman et al., 2009; Ivanov et al., 2014). Moreover, a company that derives its revenue in a country that has invaded its neighbor may face reputational risks (Ganesan & Mallapragada, 2025) and a sharp decline in demand. Therefore, we propose:

H2: For firms maintaining operations in Russia after the Russo–Ukrainian War, the negative impact on profitability is stronger when they have a higher, rather than lower, dependency on the Russian market.

2.5. The moderating effects of organizational slack

Organizational slack allows firms to accumulate slack resources as a buffer against environmental uncertainties and facilitate adaptive behavior (Bourgeois, 1981). Accordingly, its examination can yield valuable insights into how firms locked into high-risk geopolitical settings can effectively secure external resources while maintaining profitability. We discuss the role of two types of slack: operating and unborrowed.

Operating slack provides firms with internal flexibility to respond to adverse conditions without requiring significant external adjustments by using such resources as excess inventory, underused production capacity, and surplus human resources (Kovach et al., 2015). These resources can be quickly deployed to address operational challenges (Shi et al., 2025). Firms with high levels of operating slack have a great capacity to absorb the shocks and disruptions associated with geopolitical uncertainties (Azadegan et al., 2013). By leveraging their operating slack, firms can minimize the negative impacts on their revenues and profit margins. Based on the above, we propose the following hypothesis:

H3: For firms maintaining operations in Russia after the Russo–Ukrainian War, the negative impact on profitability is less pronounced for firms with more, rather than less, operating slack.

Unborrowed slack represents a firm's potential to access external financial resources, such as its borrowing capacity or ability to raise additional capital (Cheng & Kesner, 1997). Aligned with RDT, which posits that firms facing higher environmental uncertainty have a greater need to obtain external resources (Pfeffer & Salancik, 1978), we argue that firms with operations locked in Russia have a more urgent need to raise financing resources as a buffer against future production disruptions (Alam et al., 2023).

Under geopolitical uncertainty and constraint, debt financing can be vital for absorbing financial resources from external parties, and thus thereby enhance firm liquidity and financial flexibility. By raising debt capital, firms can maintain operations, invest in new opportunities, or respond to unforeseen challenges (Demerjian, 2017). This aligns with RDT's premise that firms take actions to minimize the impact of external constraints (Pfeffer & Salancik, 1978). Prior research has supported the notion that firms increase financial resources during times of mounting uncertainty (Alfaro et al., 2021; Graham & Harvey, 2001). By leveraging their unborrowed slack, firms can secure the necessary capital to maintain operations. Therefore, we propose:

H4: For firms maintaining operations in Russia after the Russo–Ukrainian war, the negative impact on profitability is less pronounced for firms with more, rather than less, unborrowed slack.

Fig. 1 summarizes the theoretical framework.

3. Data

3.1. Data sources

To test our hypotheses, we drew upon a combination of data sources, including the KSE Institute, Orbis, FactSet Reverse, and the Compustat database. The KSE Institute, an independent research institution based in Ukraine, was the primary source for identifying firms still operating in Russia. In the aftermath of the war, it launched a project to track international companies' business decisions on Russia during the war and publicly shared data on a website called "Leave Russia". Further to these data, we used the Orbis database to cross-validate the information. Orbis, a global database containing detailed financial and ownership information on private and public companies, allowed us to verify the accuracy and consistency of the KSE Institute's data. Supply chain relationship data were sourced from FactSet Reverse. Compustat is a widely recognized database of financial information for publicly listed firms, providing the necessary quarterly financial data for our analysis. We focused on U.S.-listed firms because of the political animosity between the U.S. and Russia, making these firms face a higher risk for maintaining operations in Russia.

3.2. Data collection

Table 2 outlines the data collection and preparation process. The data collection process began with clear criteria for identifying the "locked-in" firms. We defined a firm as "operations locked-in Russia" if it is a U.S.-listed multinational corporation that had active operations in Russia prior to the war (i.e., having subsidiaries, suppliers, or customers in Russia), continued its operations in the country after the war began, and had not announced a suspension or withdrawal from the Russian market by the end of 2023.

To identify these firms, we relied on the data from the KSE Institute, which was collected from various sources to assess firms with confirmed operations in Russia. These sources include official company statements, press releases, reputable news agencies, international media publishers, company blogs, and official social media channels. The institute collaborates with the Ukrainian Ministries of Economy, Foreign Affairs, and Digital Transformation to examine and verify the collected data, ensuring its accuracy and reliability. We also manually checked the firms' status, eliminating those that had previously announced intentions to suspend or exit operations in Russia, despite their actual status indicating continued operations. By removing these firms, we reduced the likelihood of including firms whose stated intentions were misaligned with their actual practices. To further ensure the accuracy of this identification process, we cross-validated the data collected from the KSE Institute with the Orbis database where we obtained U.S. firms' subsidiaries operating in Russia. Then, we identified the parent companies of these entities. Subsequently, we used the Compustat database to confirm that the companies in our sample, or their parent companies, are publicly listed in the United States. We identified a total of 366 U.S.-listed firms with operations locked-in Russia after the 2022 Russo–Ukrainian War. We employed the remaining U.S.-listed firms as a potential control pool.

After finalizing the list of firms, we collected quarterly financial data for these firms from the Compustat database, covering 2021Q1 to 2023Q3. To focus on the war's impact, we intentionally excluded the year 2020 to avoid confounding effects from the COVID-19 pandemic, thereby ensuring a more reliable identification of war-related impacts. The dataset included 11 observation periods (quarters), using the official start of the war (February 24, 2022) as the threshold between pre- and post-treatment periods. During these periods, 132 treated firms were removed due to unavailable financial data coverage. Then, we removed firms with missing data on key variables (i.e., total asset, return on assets (ROA), quick ratio, debt to asset ratio, and inventory data), leaving a total of 216 treated firms. We also included the other 3,080 firms from Compustat as industrial potential control firms for subsequent estimations.

4. Methods

4.1. Empirical design

Our empirical framework relied on the comparison between the treated and control groups. The treated groups were the 216 U.S.-

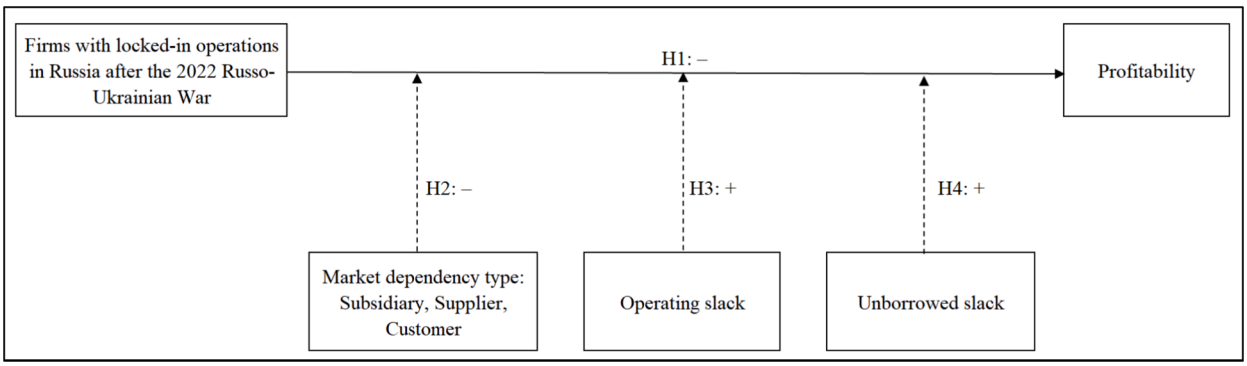

Fig. 1. Theoretical framework.

Table 2
Data collection and preparation process.

Panel A: Data collection				
	Data screening	No. of treated firms removed	No. of firms remained	Data source
1	Collected firms with locked-in operations in Russia	/	2,214	KSE Institute
2	Identified that firms are listed in the U.S.	1,848	366 (treated firms)	Compustat
3	Removed firms with unavailable quarterly financial data from 2021 to 2023	132	234 (treated firms)4,103 (control firms in industries)	Compustat
4	Removed firms without total asset, return on asset, quick ratio, inventory, and debt to asset ratio data	18	216 (treated firms)3,080 (control firms in the same industries)	Compustat
Panel B: PSM procedures				
	Data screening	No. of treated firms removed	No. of treated firms	No. of control firms
5	Continued with the 216 treated firms	/	216	3,080
6	Removed treated firms that could not be matched with any corresponding control firms	8	208	555
Panel C: Develop data for DID analysis				
	Data screening	No. of observations removed	No. of observation remained	No. of firms remained
7	Continued with the matched dataset	/	7,516	763
8	Removed observations without necessary variables in DID regression	2,018	5,435	542

listed firms identified as having operations locked-in Russia after the outbreak of the war. The control firms were selected based on their similarity to the treated firms in terms of industry classification and key firm characteristics. To further strengthen the validity of our experiment, we used a difference-in-differences (DID) estimation approach (Bertrand et al., 2004). By comparing the changes in outcomes of the treated firms to those of the control firms before and after the treatment period, we could more accurately isolate the causal impact of being locked-in Russia on firm performance.

4.2. PSM

The purpose of employing matching methods is to address the issue of heterogeneity among firms, which could have confounded our estimation of the causal effect of being locked-in Russia on firm performance. To address this, we adopted propensity score matching (PSM) to control for observable firm characteristics, such as industry, size, and performance. By matching these dimensions, we sought to achieve a balanced distribution of covariates between the treated and control groups. This balance reduced the selection bias stemming from firm heterogeneity.

The PSM calculated the probability that a firm would choose to leave or stay in Russia after the war began. We used nearest neighbor matching, ensuring that control and treated firms shared exact Standard Industry Classification (SIC) codes, meaning that they operate in highly similar business sectors. We used the following estimation model to match treated firms with potential controlled firms:

$$Status_{i,t} = P(X_{i,t_{-1}\&t_{-2}\&t_{-3}\&t_{-4}}, Industry_i) \quad (1)$$

where $P(.)$ is a probit function used to calculate the probability that firm i would choose to leave or stay in Russia. X is a vector of averaged pre-trend variables from four periods before the war (i.e., 2021Q1 to 2021Q4) as matching covariates. The 4-quarter lagged variable could mitigate the potential influence of short-term fluctuations or outliers (Levine & Toffel, 2010). In cases where data were missing for a particular period, we averaged only the available periods, with 82.69 % of companies having data for all four periods and 93.84 % having data for at least three. All had at least one period available. Additionally, $Industry_i$ is a four-digit SIC code of industry dummies to ensure that matched pairs are from the same industry.

4.3. Matching covariates in PSM

We incorporated several covariates to calculate the probability of a firm's status in Russia. First, we used the 4-quarter lagged average total asset to control firm size, as it is one of the key confounding factors leading to heterogeneity issues (Barber & Lyon, 1996). We controlled pre-trend average ROA as a proxy for profitability. Profitable firms may have a higher risk tolerance and be more willing to bear the costs and uncertainties associated with operating in a conflict zone (Dai et al., 2017). Additionally, we included several covariates to capture other factors potentially influencing a firm's decision to exit. The high inventory level creates a buffer for firms to deal with risk (Shu & Fan, 2024); firms with higher inventories may be less sensitive to geopolitical risk and choose to continue operations in conflict zones. The average quick ratio was incorporated as a measure of liquidity, reflecting a company's ability to meet

short-term obligations and serving as a proxy for the strength of its supply chain. The average debt-to-asset ratio was used to control for a firm's risk tolerance and investment preferences—firms with higher pre-war risk exposure may have been more inclined to exit rather than stay.

We also included industry dummies because, while the war may be considered a systematic shock, its impact varies across industries. For instance, although both the natural gas and water supply industries share the first two digits of their SIC codes (49), the effect of Russia's invasion differs significantly—Russia is a major natural gas supplier but less relevant to water supply. Therefore, we ensured that each of the four digits of an SIC code would match so as to guarantee that the matched firms were in the same industry.

After calculating the propensity scores, we matched each treated firm with three control firms. A sensitivity analysis (see Section 5.1.3) demonstrated that the chosen matching ratio did not introduce any distortion into our analysis. We employed the nearest neighbor matching method, using the closest distance and exact SIC codes without replacement, ensuring no overlap between the treated and control firms. However, due to limitations in the screened dataset, not all firms were matched with three control firms, meaning that the caliper was not crucial in this case. Finally, 555 control firms were matched with 208 treated firms, while 8 treated firms that could not be matched with any controls were excluded.

4.4. DID regression

We created a 3-year, 11-period panel dataset consisting of 208 matched pairs (555 control firms and 208 treated firms) covering the period 2021Q1 to 2023Q3. To avoid any confounding effects from COVID-19, we excluded data prior to 2021. Due to the war having begun in late February 2022, we treated 2022Q1—whose financial reports extend through March—as the first post-treatment period. As our analysis relied on quarterly data, we conducted seasonality tests on the dependent variables to ensure the validity of our estimation. The ANOVA results revealed no significant differences in the means of financial performance measures across different quarters ($p > 0.1$), indicating that seasonal fluctuation was not a significant concern in our dataset. Table 3 shows the distribution of treated firms in our sample by industry.

We conducted a DID analysis with two-way fixed effects to examine differences in profitability (H1) before and after the war, comparing the treated and control firms. The baseline model for analysis is the following:

$$Profitability_{i,t} = \alpha + \beta Status_i \times Post_t + \gamma X_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t} \quad (2)$$

where the dependent variable $Profitability_{i,t}$ represents the ROA of firm i at time t,. $Status_i$ is coded as 1 for companies with operations in Russia, and 0 otherwise. The variable $Post_t$ takes a value of 1 if the quarter t falls after 2022Q1, marking the financial reports after the war's outbreak in February 2022, and 0 otherwise. The vector $X_{i,t}$ represents a set of control variables that account for firm characteristics that could affect our interpretation of the war's impact, ensuring the validity of the results. These variables include the logarithmic transformation of quarterly total assets and net income, the accounts receivable ratio, and the inventory turnover ratio. Firm size (identified by total assets) is a key source of heterogeneity (Corbett et al., 2005). Net income captures the scale of profits from core business operations (Barber & Lyon, 1996). The accounts receivable ratio reflects a company's financial health; during times of war, a lower ratio can indicate reduced operational efficiency or liquidity issues (Deloof, 2003). The inventory turnover ratio serves as a proxy for a firm's inventory management efficiency in response to adverse events (Fan et al., 2022a). μ_i and τ_t represent firm fixed effects and time fixed effects, respectively. $\varepsilon_{i,t}$ accounts for the error term. Table 4 presents the descriptions of variables in regression analysis.

4.5. Analysis for moderating effects

For H2 to H4, we employed the model in equation (3) to investigate the moderating effects of market dependency and organizational slacks on the baseline effects.

$$Profitability_{i,t} = \alpha + \beta_1 Status_i \times Post_t \times Moderator_{i,t} + \beta_2 Status_i \times Post_t + \beta_3 Moderator_{i,t} + \gamma X_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t} \quad (3)$$

where $Moderator_{i,t}$ is the degree of market dependency or organizational slack of firm i in time t. We used three indicators to measure a

Table 3
The distribution of treated firms by industry.

Two-digit SIC	Percentage	Two-digit SIC	Percentage	Two-digit SIC	Percentage
13	0.65 %	29	1.94 %	49	0.65 %
16	0.65 %	30	2.58 %	50	1.94 %
17	0.65 %	32	0.65 %	51	1.94 %
20	3.87 %	33	0.65 %	53	0.65 %
21	0.65 %	34	2.58 %	56	1.29 %
22	0.65 %	35	11.61 %	58	0.65 %
23	1.94 %	36	13.55 %	73	1.94 %
24	0.65 %	37	5.16 %	78	0.65 %
25	0.65 %	38	14.19 %	79	0.65 %
26	1.94 %	39	0.65 %		
28	21.94 %	48	1.94 %		

Table 4
Variable descriptions.

Variable	Description	Source	Reference
Profitability	ROA: the ratio of operating income to total assets	Compustat	Corbett et al. (2005)
Ru_proportion	The number of a firm's subsidiaries in Russia to the total number of subsidiaries	Subsidiary Data by WRDS	/
Supplier	Equals 1 if a firm has suppliers identified in Russia; 0 otherwise	FactSet Revere	/
Customer	Equals 1 if a firm has suppliers identified in Russia; 0 otherwise	FactSet Revere	/
Operating Slack	The ratio of PPE to sales, standardized by three-digit SIC	Compustat	Hendricks et al. (2009)
Unborrowed Slack	1 – total debt/total assets	Compustat	Wiengarten et al. (2017)
Total Assets	Logged total assets.	Compustat	Fan et al. (2022b)
Net Income	Logged net income	Compustat	Dewenter and Malatesta (2001)
Accounts Receivable Turnover	Net Credit Sales / Average Accounts Receivable	Compustat	Deloof (2003)
Inventory Turnover	The ratio of cost of goods sold to average inventories	Compustat	Fan et al. (2022a)

firm's market dependency on Russia: *Ru_proportion*, *Supplier*, and *Customer*. Organizational slacks are measured by *Operating Slack* and *Unborrowed Slack*.

Ru_proportion is the ratio of a firm's number of subsidiaries in Russia to its total number of subsidiaries worldwide. *Supplier* and *Customer* are binary variables that take a value of 1 if a firm has identified suppliers or customers in Russia, respectively, and 0 otherwise. These three variables were chosen to measure dependency because they capture different dimensions of a firm's reliance on Russia for its operations, supply chain, and customer base.

Operating Slack, computed as the ratio of a firm's fixed assets (property, plant, and equipment (PPE)) to its sales and standardized by a three-digit SIC code, indicates a company's ability to adjust production levels in response to environmental changes (Hendricks et al., 2009). Firms with a higher level of production slack have greater flexibility to scale their operations up or down, enabling them to adapt more effectively to market disruptions (Kovach et al., 2015).

Unborrowed Slack is calculated as 1 minus the leverage ratio (Tan & Peng, 2003). A higher *Unborrowed Slack* indicates a firm's greater ability to secure external funding when needed, providing financial flexibility and liquidity (Tan & Peng, 2003), whereas *Operating Slack* is an internally focused measure that assesses a firm's operating flexibility derived from its existing resources.

5. Results

We present the correlation and descriptive statistics of variables in Table 5, and the results of the DID regression in Table 6. The largest variation inflation factor in our regressions was 1.42, suggesting that multicollinearity was not a big concern in our analysis. As for the results of the baseline effect in Table 6, the coefficient of *Status* × *Post* was significantly negative ($\beta = -0.0189$, $p < 0.01$), indicating that companies with locked-in operations in Russia experience a significant drop in ROA, approximately 1.89 % lower than industrial control firms. Thus, H1 is supported.

Tables 7 and 8 provide the results of the moderating effects of market dependency and organizational slack, respectively. To test H2, we examined how market dependency, measured by *Ru_proportion*, *Supplier*, and *Customer*, moderated the relationship between *Status* × *Post* and profitability. The results in models (2) and (3) in Table 7 show that *Ru_proportion* ($\beta_1 = -0.0953$, $p < 0.1$) and *Supplier* ($\beta_1 = -0.0119$, $p < 0.1$) significantly worsened the negative baseline effect on profitability. However, the interaction term *Status* × *Post* × *Customer* was significantly positive for profitability ($\beta_1 = 0.0172$, $p < 0.01$). These results reveal the mixed outcomes of the moderating role of market dependency. A higher proportion of subsidiaries in Russia implies a greater exposure to the direct impact of sanctions, operational disruptions, and asset impairment in the Russian market (Srai et al., 2023). Additionally, reliance on Russian suppliers during the war can lead to supply chain disruptions, input shortages, and increased costs (Bode et al., 2011). However, the withdrawal of competitors directly reduces the number of players in the market, allowing locked-in firms to capture a larger share of the remaining demand, thus possibly explaining the positive moderating effect.

For H3 and H4, we used *Operating Slack* and *Unborrowed Slack* as indicators. Model (5) shows that the coefficient of the interaction term *Status* × *Post* × *Operating Slack* was significantly positive for profitability ($\beta_1 = 0.0099$, $p < 0.05$), which could suggest that the availability of unused production capacity can buffer the negative impact of being stuck in Russia. *Unborrowed Slack* also significantly moderated the baseline models on profitability (model (6), $\beta_1 = 0.0529$, $p < 0.01$). Overall, these findings support H3 and H4, demonstrating that both forms of slack can help firms locked in Russia effectively maintain profitability, with *Unborrowed Slack* having a stronger effect.

5.1. Robustness checks

5.1.1. Parallel trend test on DID analysis

The parallel trend assumption is a critical prerequisite for the validity of the DID analysis. This assumption requires that, in the absence of the treatment, the dependent variables (ROA) would have followed similar trends over time for both the control and treated groups (Angrist & Pischke, 2009). Violating this assumption could have led to biased estimates of the treatment effect, as the observed differences between the groups could be attributed to pre-existing differences rather than the treatment itself. To assess whether our

Table 5
Correlations and descriptive statistics of variables ($N = 5{,}435$).

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10
1	*Profitability*	0.079	0.169										
2	*Status* × *Post*	0.185	0.388	0.126***	1								
3	*Ru_Proportion*	0.006	0.026	−0.015	0.129***	1							
4	*Supplier*	0.026	0.158	0.068***	0.124***	0.006	1						
5	*Customer*	0.353	0.478	0.218***	0.430***	0.159***	−0.120***	1					
6	*Operating Slack*	−0.012	0.86	−0.152***	−0.024*	0.012	−0.016	−0.048***	1				
7	*Unborrowed Slack*	0.675	0.211	0.011	−0.052***	−0.003	−0.031**	−0.032**	−0.034**				
8	*Net Income*	1.92	3.449	0.548***	0.110***	0.001	0.080***	0.221***	−0.115***	0.038***			
9	*Total Assets*	6.747	2.604	0.320***	0.019	0.004	0.057***	0.201***	−0.006	−0.095***	0.498***		
10	*Accounts Receivable Turnover*	11.359	22.066	0.094***	−0.027**	−0.045***	−0.005	−0.034**	−0.032**	−0.035***	0.052***	−0.005	
11	*Inventory Turnover*	7.385	11.933	−0.062***	−0.036***	−0.017	−0.023*	−0.039***	0.021	−0.099***	−0.063***	0.039***	0.061***

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

Table 6
Results of baseline analysis.

Variables	(1)	
	Estimate	SE
Status × Post	–0.0189***	0.0048
Net Income	0.0021***	0.0007
Total Assets	–0.0013	0.0034
Accounts Receivable Turnover	0.0016***	0.0006
Inventory Turnover	0.0014	0.0010
Constant	0.0564**	0.0256
Firm fixed effect	Yes	
Time fixed effect	Yes	
N	5,435	
F	11.4957***	
R-Squared (within)	0.0184	

Note: *** $p < 0.01$, ** $p < 0.05$.

Table 7
Results of the moderating effects of dependency.

Variables	(2)		(3)		(4)	
	Estimate	SE	Estimate	SE	Estimate	SE
Status × Post	–0.0098***	0.0036	–0.0083**	0.0034	–0.0226***	0.0050
Net Income	0.0025***	0.0004	0.0026***	0.0004	0.0025***	–0.0004
Total Assets	–0.0029	0.0024	–0.003	0.0022	–0.0029	–0.0022
Accounts Receivable Turnover	0.0016***	0.0006	0.0016***	0.0006	0.0016**	–0.0006
Inventory Turnover	0.0014	0.0008	0.0015*	0.0008	0.0015	–0.0008
Ru_Proportion	0.2124*	0.1166				
Status × Post × Ru_Proportion	–0.0953*	0.0548				
Supplier			/	/		
Status × Post × Supplier			–0.0119*	0.0068		
Customer					/	/
Status × Post × Customer					0.0172***	0.0054
Constant	0.0650***	0.0195	0.0669***	0.0179	0.0665***	0.0179
Firm fixed effect	Yes		Yes		Yes	
Time fixed effect	Yes		Yes		Yes	
N	5,435		5,435		5,435	
F	9.4595***		11.8121***		13.2862***	
R-Squared (within)	0.0318		0.0367		0.0377	

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

Table 8
Results of the moderating effects of organizational slack.

Variables	(5)		(6)	
	Estimate	SE	Estimate	SE
Status × Post	–0.0086***	0.0033	–0.0435***	0.0120
Net Income	0.0026***	0.0004	0.0026***	0.0004
Total Assets	–0.0029	0.0022	0.0001	0.0022
Accounts Receivable Turnover	0.0016***	0.0006	0.0014***	0.0005
Inventory Turnover	0.0014*	0.0008	0.0011	0.0008
Operating Slack	–0.0016	0.0021		
Status × Post × Operating Slack	0.0099**	0.0045		
Unborrowed Slack			0.1695***	0.0200
Status × Post × Unborrowed Slack			0.0529***	0.0165
Constant	0.0670***	0.0178	–0.0631***	0.0235
Firm fixed effect	Yes		Yes	
Time fixed effect	Yes		Yes	
N	5,435		5,435	
F	10.8423***		19.5168***	
R-Squared (within)	0.0384		0.0874	

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

parallel trend assumption held, we conducted a parallel trend analysis using the following model:

$$Profitability_{i,t} = \sum_{2021q1}^{2023q3} \beta_t \times Status_i \times D_t + \gamma X_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t} \quad (4)$$

where D_t represents the dummy variable of each quarter (2021Q1 to 2023Q3) of our timeframe of interest. The interaction term at 2021Q4 was excluded as the reference group. The control variables were identical to those used in the DID analysis.

The results of this test are displayed in Appendix Table A1, which shows the estimated coefficients and the confidence intervals. The coefficients for the pre-treatment period, from 2021Q1 to 2021Q3, were not statistically significant for ROA ($p > 0.1$), indicating no significant differences on the outcomes between the control and treated groups during these periods. These observations are further supported by the trend plot provided in Fig. 2. The absence of significant differences in the pre-treatment period suggests that the parallel trend assumption is satisfied.

5.1.2. Placebo test on DID analysis

To further validate the robustness of our DID estimates and ensure that the observed treatment effects were not artifacts of random chance, we conducted a placebo test by randomly assigning the treatment status to firms and re-estimating the DID model 500 times (Abadie, 2005). We plotted the density of the coefficients of the interaction term (*Status* × *Post*) and their *p*-values in Fig. 3. The red vertical dashed line indicates the position of the original coefficient obtained from the actual treatment effect estimation. For profitability, 90.2 % of the placebo DID estimates had *p*-values that were not statistically significant at the 10 % level. Additionally, the original estimate of the treatment effect lay at the far tail of the placebo effect distribution, indicating that the estimated treatment effects substantially differed from the placebo effects. These results suggest that the probability of observing our original treatment effects due to random chance is low, providing strong support for the causal interpretation of our findings and reinforcing the robustness of our conclusions.

5.1.3. Sensitivity check on matching ratio

In the PSM process, we employed a 1:3 matching ratio, allowing each treated firm to be matched with up to three control firms based on identical SIC codes. To validate this choice, we conducted a sensitivity analysis by comparing the results obtained using ratios ranging from 1:1 to 1:10 against our selected ratio. Using the same DID model, we estimated the treatment effect for each ratio and recorded the coefficients and their confidence intervals. We then compared these results with those obtained using the 1:3 ratio, checking for significant differences. The results are shown in Fig. 4. Notably, the confidence intervals of the DID coefficients covered zero for all matching ratios, indicating no significant differences in the estimated results across different ratios.

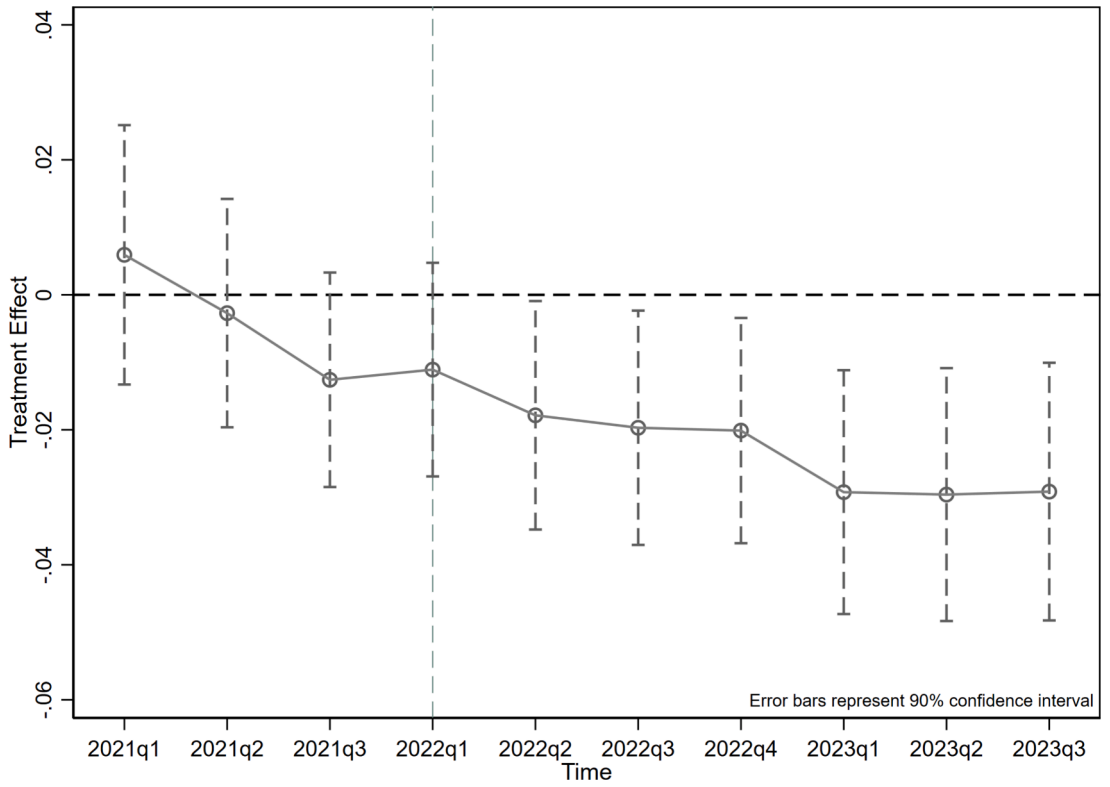

Fig. 2. Parallel trend test on profitability (2021Q4 as the benchmark).

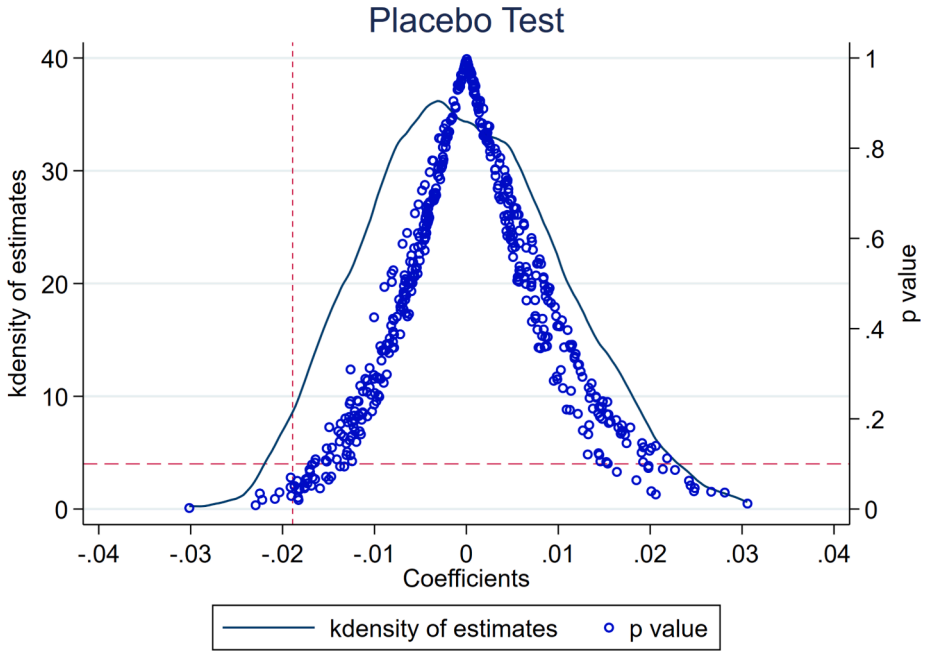

Fig. 3. Placebo test on profitability.

6. Conclusion and discussion

This study examined the operations of firms trapped in geopolitical turmoil, focusing on those unable to exit Russia amid the 2022 Russo–Ukrainian War. Our findings reveal that these firms have faced a decreased level of profitability during this challenging period. Additionally, we discovered that firms with more operating and unborrowed slack were more effectively able to alleviate profitability reduction by leveraging internal resources and accessing external financing. However, the moderating role of market dependency proved to be mixed. Firms with subsidiaries or suppliers in Russia experienced a worsening reduction in profitability due to operational rigidity and supply chain disruptions. In contrast, firms with customer dependency in Russia were able to mitigate the negative impact on profitability, likely benefiting from retained revenue streams. These results highlight the complex dynamics of resource use and market dependency in navigating geopolitical crises. In this section, we discuss the theoretical and practical implications of these findings.

6.2. *Theoretical contributions*

In the current era of de-globalization, geopolitical risks have become a prominent concern for firms, urging scholars to consider political factors in OSCM (Witt, 2019; Fan et al., 2022b). Geopolitical conflicts disrupt the physical flow of goods and services in supply chains, presenting a significant source of risk (Roscoe et al., 2022). Accordingly, many scholars have advocated for firms to de-risk their supply chains by decoupling themselves from conflict zones (Freund et al., 2024).

However, this recommendation overlooks the reality that some firms may be unable to reconfigure their operations and supply chains when geopolitical conflicts arise. Firms with significant investments, asset specificity, or institutional entanglements in these regions may face exiting barriers, resulting in what we term “locked-in operations”. This study provides a fresh perspective by focusing on such firms and exploring how the 2022 Russo–Ukrainian War has negatively impacted their profitability. This insight broadens the scope of OSCM research, which traditionally focuses on strategies for avoiding or mitigating risks, by examining the conditions under which firms must adapt and manage sustained exposure to geopolitical turmoil.

Furthermore, existing research (e.g., Fan et al., 2024) has shown that dependency can limit a firm’s response to geopolitical risks. Our study extends previous research by disentangling the effects of different types of market dependency (i.e., upstream, downstream, and operational) in the context of geopolitical disruptions. However, the findings challenge the conventional view of market dependency as a liability during crises. Our mixed results highlight the double-edged role of dependency, suggesting that it can act as both a liability and an asset during geopolitical disruptions. On the one hand, a higher proportion of subsidiaries and reliance on suppliers in the affected market can amplify the negative impact on profitability, as firms face operational disruptions, asset impairment, and supply chain challenges (Bode et al., 2011). As competitors exit due to heightened geopolitical risks, sanctions, or public pressure (Alam et al., 2023; Srai et al., 2023), firms locked in Russia may be able to capture a larger market share as customers seek alternative suppliers. This increased demand can help offset some of the negative impact of the geopolitical disruption on the firm’s profitability. The study offers a more balanced perspective on the role of market dependency in firm resilience. These findings

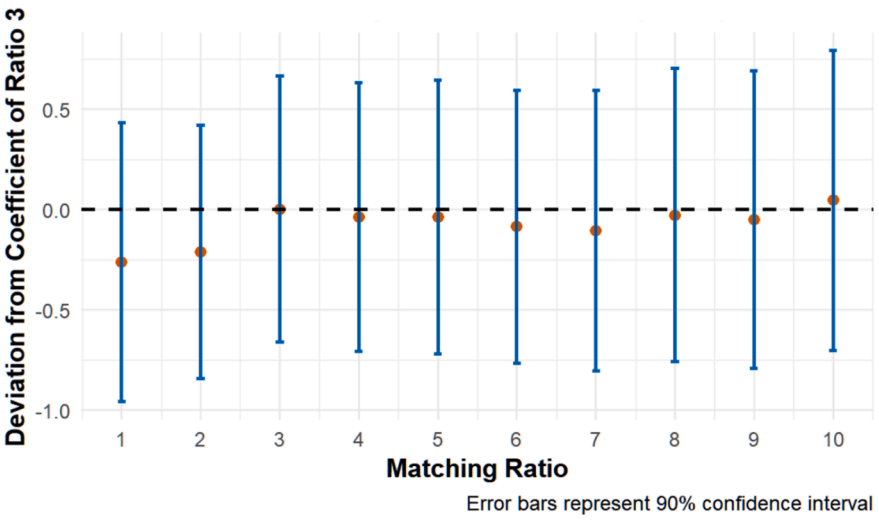

Fig. 4. Coefficient estimates relative to matching ratio = 3 on profitability.

add depth to the OSCM literature on geopolitical risks by identifying market dependency as a critical factor shaping firms' ability to respond to geopolitical conflicts.

Furthermore, prior studies have pointed to the merits of operating slack in mitigating supply chain risks (Kovach et al., 2015; Wiengarten et al., 2017). We find that operating slack continues to be valuable in helping firms alleviate the negative impact of geopolitical conflicts on their profitability, especially amid limited options to reconfigure global operations. This finding is consistent with the notion that lean firms are vulnerable in uncertain environments (Hendricks & Singhal, 2003; Obermaier & Donhauser, 2012). In addition, we add new understanding to the literature that firms can leverage unborrowed slack to obtain external financing resources during a crisis. Creditors may have more confidence in a firm's future cash flow when they have more unborrowed slack amid the uncertainty (Bendig et al., 2017). These findings highlight unborrowed slack's additional merit of helping firms obtain external resources to sustain operations during a crisis.

Our study contributes to RDT by extending its application to the context of firms operating under severe geopolitical risks. RDT posits that organizations are dependent on external resources and must manage these dependencies to mitigate uncertainty and ensure survival (Pfeffer & Salancik, 1978). Traditionally, RDT has focused on how firms proactively manage resource dependencies to reduce uncertainty and gain control over critical resources. However, our research introduces the concept of "locked-in operations" during geopolitical conflicts, highlighting a scenario where firms face significant external constraints that limit their ability to manage resource dependencies effectively. By examining firms with locked-in operations in Russia during the Russo–Ukrainian War, we reveal that these firms can leverage both internal production resources and potential external financial resources to sustain their operations.

6.2. *Managerial implications*

The findings carry significant implications for managers operating in or considering entry into high-risk geopolitical regions. First, managers should carefully assess their firm's market dependency on regions prone to geopolitical conflicts. High dependency on operations and supply bases in conflicting zones can severely limit a firm's flexibility and exacerbate financial vulnerabilities during crises. Therefore, managers should develop strategies to reduce over-reliance on any single high-risk market. This could involve diversifying their geographical presence or developing adaptable parallel supply chains that can be reoriented as geopolitical landscapes shift. However, it must be noted that the benefits of remaining in the market when competitors exit are not guaranteed. Firms must carefully weigh the potential gains against the risks and challenges associated with operating in a geopolitically unstable environment. A pertinent example here is how AstraZeneca continues operating in Russia and integrates its Russian production into its global supply chain. AstraZeneca's approach hinges on the ethical justification of its continued operations. The company emphasizes the essential nature of the pharmaceutical products it provides, many of which are critical to the maintenance of human life. This framing allows AstraZeneca to navigate the reputational and political pressures associated with remaining active in the Russian market (Jungblut & Johnen, 2022). Beyond ethical considerations, AstraZeneca has strategically transformed its Moscow production site into a key component of its global supply chain—a decision that reflects a sophisticated application of RDT principles, where dependency on a single market is mitigated by expanding the scope of resource use.

Secondly, the study highlights the critical role of slack as a buffer against geopolitical uncertainties. Managers should consider building and maintaining adequate levels of organizational slack to enhance their firm's resilience. Firms with greater operating slack were found to be better able to mitigate the negative impacts on profitability when locked into high-risk regions. However, maintaining such slack requires a delicate balance, as its excess can lead to inefficiencies. Managers should conduct thorough risk assessments to determine the optimal level of slack needed to navigate potential geopolitical disruptions without compromising

operational efficiency.

Lastly, managers should proactively manage their firm's leverage levels, as maintaining a healthy financial structure is essential for accessing external financing and ensuring the firm's resilience during crises. This is especially important during geopolitical crises, as firms with high levels of leverage, which leads to low unborrowed slack, may find it harder to secure additional financing when faced with unexpected shocks or disruptions (Phan et al., 2019). By keeping leverage levels in check, managers can ensure that their firms have the financial flexibility needed to weather the storm and adapt to changing circumstances.

6.3. Limitations

This study has several limitations that could be addressed by future research. First, we focused specifically on the 2022 Russo-–Ukrainian War—a military-driven geopolitical conflict. It remains unclear whether our findings are applicable to other types of geopolitical conflicts, such as economic or cultural conflicts, which may unfold over longer periods and in more gradual ways. Second, our sample consists solely of U.S.-listed firms, whose country is in a heightened state of political tension with Russia. Future research could examine firms from countries with less political animosity toward Russia, such as China or India, to determine whether these dynamics differ in less adversarial contexts. Moreover, this study relied on secondary data, which may not capture certain unobservable aspects of the decision-making processes behind firms' choices to remain in Russia. Future studies could employ interviews or text analyses to gain deeper insights into these decision-making processes and motivations. Lastly, this study compared the treated firms (i.e., those with locked-in operations in geopolitical areas) with similar industrial pairs as control firms, without taking into account whether the control firms were operating in Russia before the war. Future studies could further refine the empirical design.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT to edit the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

CRediT authorship contribution statement

Wenjun Shu: Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Di Fan:** Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization. **Xiao Zhang:** Writing – original draft, Supervision, Resources, Funding acquisition, Conceptualization. **Guanlin Li:** Writing – original draft, Visualization, Validation, Methodology, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A1
DID regression on quarter.

Variables	(A1)	
	Estimate	SE
Status × *2021Q1*	0.0059	0.0117
Status × *2021Q2*	–0.0027	0.0103
Status × *2021Q3*	–0.0126	0.0097
Status × *2022Q1*	–0.0111	0.0096
Status × *2022Q2*	–0.0178*	0.0103
Status × *2022Q3*	–0.0197*	0.0106
Status × *2022Q4*	–0.0201**	0.0101
Status × *2023Q1*	–0.0292***	0.0110
Status × *2023Q2*	–0.0296***	0.0114
Status × *2023Q3*	–0.0292**	0.0116
Net Income	0.0021***	0.0007
Total Assets	–0.0025	0.0035

(*continued on next page*)

Table A1 (*continued*)

Variables	(A1)	
	Estimate	SE
Accounts Receivable Turnover	0.0016***	0.0006
Inventory Turnover	0.0014	0.0010
Constant	0.0651**	0.0259
Firm fixed effect	Yes	
Time fixed effect	Yes	
N	5,435	
F	4.9917***	
R-Squared (within)	0.0200	

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

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