▪ Journal of Competitiveness

Navigating Geopolitical Risk: Internal Reconfiguration, Innovation-led Quality Productivity, and Firm Competitiveness

Dan Luo, Yiran Wang, Yong Chen*

Abstract

This study examines how geopolitical risk affects firms' innovation-led quality productivity (IQP) and how digital transformation moderates this relationship. It focuses on how firms adjust their productivity structures under external uncertainty shocks. Using monthly panel data on digital economy firms in the Yangtze River Delta, the study reports three main findings. First, geopolitical shocks exert a significant lagged negative impact on firms' IQP. These external shocks do not immediately suppress innovation activities themselves; instead, they weaken innovation-led productivity by constraining market demand and the commercialization of innovative outputs. Second, in response to heightened geopolitical uncertainty, firms tend to strengthen internal restructuring, such as reallocating resources and increasing innovation investment. This creates a short-term defensive innovation response. Third, digital transformation provides only limited and heterogeneous buffering effects, which are insufficient to systematically offset the adverse impact of geopolitical risk on IQP. Building on the dynamic chain of "geopolitical risk → internal restructuring → innovation-led quality productivity → corporate competitiveness," this study elucidates how external shocks reshape the transformation from innovation to productivity and, ultimately, to competitiveness through firms' internal adjustment mechanisms.

Keywords: *Geopolitical risk, Innovation-led quality productivity, Digitalization*

JEL Classification: F50, L25

Article history: Received: January 2025; Accepted: March 2026; Published: July 2026

1 INTRODUCTION

In an era marked by escalating geopolitical tensions, ranging from trade wars and economic sanctions to regional conflicts, firms are increasingly exposed to external uncertainty. Caldara & Iacoviello (2022) developed a news-based Geopolitical Risk (GPR) Index and showed that surges in geopolitical risk foreshadow declines in corporate investment and employment. Consistent with this finding, a large body of research shows that adverse geopolitical events can depress economic activity, constrain credit, and disrupt global supply chains (Khatib et al., 2025). Heightened uncertainty raises the "option value" of waiting, leading firms to postpone or scale down investments in new projects (Bernanke, 1983; Gulen & Ion, 2016). In short, geopolitical risk is emerging as a critical external threat to firm performance and long-term growth. This issue is particularly salient for China. Amid rising global uncertainties, China has placed strategic emphasis on achieving high-quality development. A key component of this strategy is the development of innovation-led quality productivity (IQP), which encompasses innovation-driven, high value-added growth engines (Zheng, 2024; Miao & Hu, 2025). Also known as new-quality productivity in Chinese, IQP refers to the productive forces that enhance the technological content and value-added of output through innovation, advanced skills, and digital transformation (Zheng, 2024). It is viewed as the "new engine" for sustaining economic

https://doi.org/10.7441/joc.2026.02.01

upgrading and competitiveness in the digital economy (Miao & Hu, 2025). However, the extent to which external geopolitical shocks might undermine firms' IQP remains an open and pressing question.

Existing research on the effects of geopolitical risk on firm-level outcomes provides mixed insights. A growing body of work warns that geopolitical uncertainty can stifle corporate innovation and productivity growth. An increase in perceived external risk can tighten financing conditions and dampen executives' risk appetite, thereby curbing R&D investment and other innovation activities (Lee et al., 2023). For example, a recent study of Chinese listed companies found that higher geopolitical risk significantly reduces firms' patent innovations, largely by raising external financing costs and lowering managers' willingness to invest. The negative impact is most pronounced for highly innovative and export-oriented firms (Lee et al., 2023). This is consistent with the broader uncertainty literature, which argues that firms tend to pull back on long-term innovative projects in unpredictable environments (Bloom, 2009; Julio & Yook, 2012). In contrast, some studies suggest a more nuanced or positive effect in certain contexts. Jia et al. (2022) found that geopolitical risk can spur corporate innovation in China, especially for state-owned or government-subsidized firms. Geopolitical threats may induce such firms to pursue "catch-up" innovation and technological self-sufficiency as a form of defensive R&D investment to mitigate external shocks (Jia et al., 2022). This growth-option perspective echoes the real options theory, which posits that when competition and future opportunities are at stake, higher uncertainty can incentivize some firms to invest in innovation to preempt rivals or substitute risky inputs (Perotti & Kulatilaka, 1998; Rumokoy et al., 2023). Some evidence shows that Chinese companies have responded to trade and geopolitical tensions by accelerating certain R&D and substitution efforts (e.g. developing domestic technologies amid tech sanctions) (Jia et al., 2022; Guo et al., 2024). These contrasting viewpoints highlight that the net impact of geopolitical risk on firms' IQP is an empirical question.

Against this backdrop, our study examines how geopolitical risk influences firms' IQP and whether digital transformation capabilities alter this impact. We focus on China's digital economy firms, which are at the forefront of innovation but also highly exposed to external uncertainties in the current global environment. We leverage a novel firm-level Innovation-led Quality Productivity Index (IQPI) that captures innovation-driven productivity improvements across multiple dimensions (expectations, creation, market demand, output, diffusion, and organizational efficiency). This composite index, developed by Chinese researchers, reflects the quality of growth rather than sheer quantity, aligning with China's strategic goal of upgrading industrial productivity (Miao & Hu, 2025). By using IQPI and its sub-indices, we can observe overall productivity effects and which aspects of productivity (e.g. innovation output vs. market realization) are most sensitive to geopolitical shocks.

Furthermore, we incorporate digital transformation as a potential moderating factor. Digitalization has been widely recognized to enhance agility and resilience during disruptions. Firms with advanced digital capabilities (data analytics, automation, platform-based operations, etc.) are better equipped to absorb shocks, reconfigure resources, and maintain productivity during turbulent times (Ayadi & Jahmane, 2025; Ivanov & Dolgui, 2021). For instance, digital supply chain integration can improve real-time responsiveness, helping firms avoid severe demand-supply mismatches under uncertainty (Ivanov & Dolgui, 2021). An IMF study by Nose et al. (2023) found that digitally advanced firms "weather shocks better," experiencing significantly smaller declines in sales and profits during uncertainty spikes compared to less-

https://doi.org/10.7441/joc.2026.02.01

digitalized peers. However, digitalization could also introduce new vulnerabilities. Highly interconnected information systems might propagate shocks quickly or expose firms to cyber-risks, and tightly coupled production networks might amplify immediate reactions (Ivanov & Dolgui, 2021; Ayadi & Jahmane, 2025). Whether digital transformation mitigates or exacerbates the impact of external risk remains an important empirical issue. By exploring the interaction between geopolitical risk and firms' digitalization level, this study provides insights into the role of technology and organizational preparedness in managing external uncertainty.

This study addresses two key gaps in the existing literature. First, while geopolitical risk has been studied mostly in macro-financial contexts (e.g. its effects on stock markets, investment, or trade flows), we provide a firm-level perspective on how it affects the quality of productive activities within companies. We link the GPR index to a granular measure of innovation-led productivity, thereby bridging macro-level risk analysis with micro-level productivity outcomes. Second, we test a moderating mechanism (digital transformation) that has not been thoroughly examined in prior studies. This offers a novel look at how internal firm capabilities can buffer or modify the transmission of global risks to operational performance. Our analysis is built on a unique panel dataset of monthly observations from digital economy firms in China's Yangtze River Delta, spanning January 2020 to June 2025. By leveraging time variation in an exogenous risk index and detailed firm productivity metrics, we can identify both the contemporaneous and lagged effects of geopolitical shocks on different facets of IQP.

2 THEORETICAL BACKGROUND

2.1. Geopolitical Risk and Firm Performance

Geopolitical risk represents the uncertainty and potential losses stemming from adverse international events such as wars, terrorist attacks, diplomatic conflicts, or sanctions (Caldara & Iacoviello, 2022). A growing consensus indicates that high geopolitical risk can negatively affect both macroeconomic and firm-level performance. At the macro level, spikes in geopolitical risk are associated with depressed investment, higher volatility, and slower growth. Using historical data, Caldara & Iacoviello (2022) show that surges in their GPR Index precede declines in aggregate capital investment and employment, as firms adopt a wait-and-see stance. Similarly, Khatib et al. (2025) conclude that rising GPR leads to "severe economic repercussions," including reduced industrial production, constrained domestic credit, and disrupted trade and supply chains. These outcomes mirror those observed with other forms of uncertainty (such as economic policy uncertainty), but geopolitical risk is often more exogenous and can materialize abruptly (e.g., geopolitical conflicts or sanctions shocks), leaving firms little time to prepare.

From a theoretical standpoint, the negative impact of geopolitical risk on firms can be explained by real options and investment irreversibility theories. When uncertainty about the future business environment increases, firms gain option value from delaying irreversible investments (like building new capacity or entering new markets) until uncertainty is resolved (Bernanke, 1983; Bloom, 2014). Delaying investment or hiring helps firms avoid costly mistakes if adverse geopolitical outcomes occur. However, this defensive strategy implies forgone growth opportunities and slower accumulation of productive capital and innovation. Empirical evidence supports this mechanism. Uncertainty shocks cause immediate drops in investment and output, amplifying economic downturns (Bloom, 2009; Baker et al., 2016). For example, Handley & Limao (2017) showed that the prospect of trade policy conflict significantly deterred

https://doi.org/10.7441/joc.2026.02.01

export investments by firms, until a stable agreement was reached. Similarly, Julio & Yook (2012) documented that corporate capital expenditures contract in periods of heightened political uncertainty (e.g., before national elections), consistent with a precautionary delay in spending. As a form of extreme political uncertainty, geopolitical risk is expected to generate similar cautious behavior among firms.

At the firm level, geopolitical risk can increase financial and market risks. Uncertainty about international relations and stability can lead to higher risk premiums demanded by investors and creditors. Hassan et al. (2019) found that firms with greater exposure to political risks faced higher financing costs and volatility in stock prices, reflecting investors' concerns about those firms' future cash flows. In China, geopolitical risk has been shown to explain changes in firms' idiosyncratic volatility, indicating that geopolitical tensions introduce firm-specific risk and heighten uncertainty in capital markets (Ren et al., 2023). Higher volatility and financing costs, in turn, can impair a firm's operational performance by raising the cost of capital and complicating planning (Kim, 2019). Another important channel operates through global supply chains. Geopolitical conflicts such as trade wars or sanctions can disrupt supply chains and export markets, directly hitting firms' sales and productivity. For example, sudden sanctions or export restrictions force firms to scramble for alternative suppliers or lose foreign customers, reducing efficiency and productivity in the short run. Recent evidence also shows that geopolitical risk reshapes firms' supply-chain structures. For example, Yang et al. (2025) show that U.S. firms adjust their supplier networks in China in response to U.S.-China geopolitical rivalry, while Bai et al. (2025) document the dual effects of geopolitical risk on MNCs' first-tier supply base. These findings suggest that geopolitical tensions can disrupt firms' supply-chain configuration and market exposure, thereby weakening short-run productivity performance. These mechanisms illustrate why geopolitical risk is generally viewed as a negative shock to firms' productive performance.

Despite this generally negative relationship, recent studies highlight heterogeneous responses across firms. Firms with certain characteristics or strategic orientations may react differently. For instance, Jia et al. (2022) found that Chinese firms with strong state support or those operating in strategically critical sectors (e.g., defense, energy) increased R&D investment in response to higher geopolitical risk. These firms anticipate government backing or market opportunities in periods of geopolitical tension, treating geopolitical uncertainty as a signal to intensify innovation efforts. This finding aligns with the real options strategy under uncertainty (Perotti & Kulatilaka, 1998). If the firm perceives an opportunity to gain competitive advantage or fulfill a strategic need, like technological self-reliance, amid external turmoil, it may accelerate investment despite uncertainty. Such behavior might be more common in state-influenced economies or strategic industries, where firms expect geopolitical crises to translate into supportive policies or captive domestic demand. Jia et al. (2022) observed this positive innovation effect mainly in state-owned enterprises and firms receiving more government subsidies, implying the government's role in cushioning risk. In contrast, purely private and financially constrained firms did not show this positive response; they likely cut back, as predicted by the uncertainty-discourages-innovation hypothesis.

In summary, the existing literature suggests that geopolitical risk tends to be detrimental and causes firms to retrench, thereby dampening growth and innovation. Yet, exceptional cases exist where risk can act as a catalyst for innovation, often under special conditions (state support, strategic imperatives). This duality motivates a closer investigation of Chinese digital economy firms. While these firms are generally innovation-driven and crucial to the country's

https://doi.org/10.7441/joc.2026.02.01

high-tech ambitions, they also face intense geopolitical pressures (e.g. US-China tech frictions). Understanding whether GPR shocks mostly hinder their productivity (via demand declines, investment pullbacks, etc.) or perhaps spur some adaptive innovations remains an empirical question. Overall, we anticipate the dominant effect to be negative, consistent with the mainstream theory: heightened geopolitical risk will undermine innovation-led quality productivity.

2.2. Innovation-led Quality Productivity: Concept and Importance

IQP has gained prominence in the Chinese academic and policy discourse as a linchpin of high-quality development. While traditional productivity analysis often focuses on quantitative growth (e.g., output per worker or TFP growth from factor accumulation), IQP emphasizes qualitative growth, notably through technological innovation, human capital, and better institutional efficiency (Zheng, 2024). According to Zheng (2024), IQP can be defined as "all economic activities that enhance the technological content and value-added of products based on technological progress." It reflects the idea that, in the new development stage, economic growth should rely less on input expansion and more on innovation, knowledge, and higher value creation. In practice, IQP involves the emergence of new industries, the transformation and upgrading of traditional industries through advanced technologies, and the diffusion of innovations across the economy (Sun, 2024). As such, IQP aligns with China's goals of industrial upgrading, self-reliance in key technologies, and sustainable growth.

Recent studies have attempted to measure and quantify IQP at various levels. For instance, Miao & Hu (2025) constructed a provincial-level index of IQP development in China and found that IQP drives regional economic convergence and high-quality growth. They note that provinces with higher IQP levels tend to have stronger innovation capacity (e.g., more R&D personnel and patents), more dynamic new industries, and better resource allocation efficiency. Furthermore, Yue et al. (2024) highlighted the role of IQP in promoting sustainable development outcomes. Their firm-level analysis shows that IQP is positively linked to corporate green innovation. Firms with higher IQP are more likely to engage in environmental innovation, suggesting that IQP fosters greener growth. This reinforces the view that IQP captures a broad-based improvement in economic activity, including a shift toward innovation with social benefits (like lower pollution technologies).

In the corporate context, Sun (2024) examined the impact of IQP on firm innovation performance. Using data on Chinese A-share companies, Sun found that firms operating in regions or industries with higher IQP tend to have significantly greater innovation output (measured by patent counts and new product revenues). IQP appears to stimulate corporate innovation by enhancing innovation incentives and improving the business environment. This includes the agglomeration of high-tech industries and R&D collaboration. Additionally, Sun found that a supportive institutional environment (better governance and openness) amplifies IQP's positive effect on innovation, indicating that policy and institutional quality complement productive forces. These findings echo the broader narrative that IQP is crucial for sustaining firm-level innovation and competitiveness in the long run. It shifts the concept of productivity from pure efficiency to capability-building, including the development of new industries, skills, and infrastructure that drive future growth.

Our study employs a specific firm-level measure called the IQPI, which reflects multiple dimensions of a firm's innovation-driven productivity. This measure was inspired by the

https://doi.org/10.7441/joc.2026.02.01

framework of Xu et al. (2014) and subsequent refinements by Chinese economists, aiming to make the concept of IQP operational at the micro level. The IQPI used in our analysis includes six modules: Expectation, Creation, Demand, Output, Sharing, and Configuration. These correspond to forward-looking innovation inputs (expectation of innovation, actual creation of new technology), market realization (demand for new products, output generated), and diffusion/organization (sharing of knowledge, configuration of resources). Such a structure captures the full lifecycle of innovation and its integration into production. By examining sub-indices (e.g., an Expectation-Creation index, Demand-Output index, etc.), imbalances or gaps can be revealed. For example, a gap between creation and market demand might indicate that innovations are not being fully commercialized. This rich measurement approach to IQP is relatively novel, allowing analysis of not only "how much" productivity changes, but "how" it changes in terms of underlying innovation dynamics.

In sum, IQP represents a paradigm shift in growth: from quantity to quality. It recognizes that, in mature and transitioning economies, future competitiveness depends on raising the knowledge and technology content of production. For firms, this means developing new products, embracing digital transformation, and achieving more with advanced methods (rather than just expanding scale). A strong IQP implies that a firm is adept in innovation and agile in meeting market needs, which typically correlates with higher total factor productivity (TFP) and sustainable profitability. Because our study examines how an external shock (geopolitical risk) affects this quality-oriented productivity, it sits at the intersection of external risk management and internal innovation processes. Any significant deterioration in IQP due to geopolitical risk would be alarming, as it could hinder long-term growth and competitiveness. Conversely, resilience of IQP in the face of external shocks would support sustained high-quality development. The existing literature has not explicitly connected geopolitical risk with IQP, a gap our study addresses. By doing so, we also contribute to the understanding of what factors can derail or foster high-quality growth at the firm level.

2.3. Digital Transformation and Resilience to Shocks

Digital transformation refers to the integration of digital technologies into business processes, products, and models, fundamentally changing how firms operate and deliver value. Over the past decade, firms across industries have invested heavily in technologies like big data analytics, cloud computing, artificial intelligence (AI), and the Internet of Things (IoT) to increase efficiency and agility. The impact of digitalization on a firm's resilience and competitive performance under volatile conditions is increasingly being researched. Digital capabilities can act as a buffer against external shocks, enabling firms to respond more flexibly and maintain performance amid disruptions. For example, Ayadi & Jahmane (2025) found that European companies with higher digital integration mitigate the adverse effects of economic policy uncertainty on their operations, effectively sustaining better ESG and financial performance even as uncertainty rises. The study shows that digital tools, such as advanced data systems and online platforms, help firms adapt quickly to changing conditions, thereby fostering long-term sustainability and resilience.

In the supply chain and operations literature, digitalization is often linked to greater supply chain agility and visibility, which are key for shock absorption. Ivanov & Dolgui (2021) illustrated that digital supply chain management allows firms to detect disruptions early and reconfigure production or sourcing accordingly. Digital supply chain uses tools like real-time monitoring, digital twins, and AI-driven analytics. This agility reduces the impact of shocks

https://doi.org/10.7441/joc.2026.02.01

like sudden demand swings or supply interruptions, as firms can pivot more rapidly than those with analog systems. During the COVID-19 pandemic, firms with digitalized processes sustained operations and gained market share, whereas less digitalized competitors struggled (Ivanov, 2022). These examples underscore a “bright side” of digital transformation: it builds dynamic capabilities that enhance a firm’s ability to withstand and recover from unforeseen events (Teece, 2018). In essence, digitalization can make firms more shock-resilient by improving information flow, decision speed, and process adaptability.

Researchers caution about potential “dark sides” or limitations of digitalization. Highly digitalized systems can create tight interdependencies and new failure points. For instance, a cyber-attack or IT system failure during a geopolitical conflict could cripple a firm relying on integrated digital platforms. Additionally, complex algorithms and just-in-time systems might propagate local disruptions globally if not properly managed (Ivanov & Dolgui, 2021). Digital transformation can also introduce strategic risks. Jiang et al. (2025) found that while corporate digitalization generally improves performance, it can exacerbate exposure to data security and privacy risks. Furthermore, managers might underestimate rare-event risks if they rely on data-driven models. Despite these caveats, the prevailing view is that digital transformation is largely beneficial for firm competitiveness and robustness (Verhoef et al., 2021; Nambisan et al., 2019). An IMF working paper by Nose et al. (2023) analyzing over a million firms across countries found that digitalized firms experienced significantly smaller drops in revenue, employment, and profit during major uncertainty shocks compared to their less-digital peers. The authors concluded that digitalization creates a “resilience dividend,” an insurance-like benefit that cushions firms against adverse shocks.

In China, the measurement of firm digital transformation has been advanced by scholars like Zhang et al. (2021) and Wu et al. (2021), who developed indices based on textual analysis of annual reports and various innovation indicators. These indices show that digital transformation boosts firms’ innovation output and operational efficiency. For instance, Zhang et al. (2021) found that firms with higher digitalization scores see greater improvements in innovation (patent counts) and tend to entail lower operating costs, suggesting enhanced productivity. Digitalized firms can better leverage e-commerce, digital marketing, and intelligent manufacturing, which contribute to both top-line growth and bottom-line savings. Such competitive gains could theoretically translate into better shock resistance. For example, a firm with robust e-commerce channels can continue selling during a physical disruption, while those with digitally optimized inventory can prevent overstocking when demand falters. This is particularly relevant under geopolitical shocks that might suddenly dampen demand. Similarly, Wu et al. (2021) constructed a digital transformation index and confirmed its positive effects on firm performance metrics in China. In our research, we include a firm-level digitalization measure to investigate how it interacts with geopolitical risk.

Summarizing the literature, digital transformation is a strategic enabler that can strengthen a firm’s competitiveness and stability. It is not a panacea, but a higher level of digital maturity that provides firms more tools to deal with uncertainty. This motivates our interest in the moderating role of digitalization. We aim to test whether digitalized firms experience a different intensity of impact from geopolitical risk shocks compared to less-digitalized firms. If digital capabilities truly enhance resilience, highly digital firms may suffer a smaller drop in IQP when geopolitical risk rises, perhaps by quickly reallocating resources or finding alternative markets. Some specific mechanisms in our context could include data analytics helping firms forecast and cushion the impact on demand (mitigating output losses), or digital platforms enabling

https://doi.org/10.7441/joc.2026.02.01

collaboration that maintains innovation momentum despite external turmoil. Our analysis will contribute empirical evidence to this contemporary debate on the risk-mitigating value of digital transformation.

2.4 Theoretical Analysis

In order to explain the chain from geopolitical risk to IQP and ultimately competitiveness, we draw on Porter's competitive advantage theory, the resource-based view (RBV), and dynamic capabilities theory. Porter's framework emphasizes that sustained competitive advantage is derived from creating greater value for customers than competitors do, either through lower cost or differentiated products (Porter, 1985). This implies that firms must continuously upgrade the technological content and value-added of their outputs (i.e. improve IQP) to offer superior value and outcompete rivals. The RBV complements this by positing that firm-specific, valuable and hard-to-imitate resources underpin persistent performance advantages, especially when external conditions deteriorate (Barney, 2001).

RBV traditionally assumes a relatively static environment. The dynamic capabilities theory extends RBV by addressing how firms adapt and reconfigure resources under rapidly changing conditions. Dynamic capability is defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments." In our framework, internal reconfiguration in response to geopolitical risk is a prime example of a dynamic capability at work. A firm senses an external threat and reconfigures or redeploys its internal resources to mitigate that threat and seize any arising opportunities. This process might include reallocating R&D efforts, securing alternative supply inputs, reorganizing teams, or shifting strategic focus to resilient markets. Such internal adjustments echo Teece's notion that firms must "enhance, combine, protect, and when necessary, reconfigure" their asset base to maintain competitiveness amid threats (Teece, 2007). Amid geopolitical turmoil, firms with strong dynamic capabilities can pivot internally to uphold or strengthen their innovation-driven productivity. This internal reconfiguration mechanism leverages firms' resource base and strategic agility as well as links an external shock and the firm's productivity outcomes.

By intensifying internal capability-building under threats, firms aim to sustain their IQP. From Porter's perspective, this equates to continually upgrading one's value proposition, delivering products or services with superior quality or innovation that rivals cannot match, thereby achieving competitive differentiation. Miao & Hu (2025) found that firms with higher IQP enjoy stronger innovation performance and drive high-quality growth. Thus, if a firm can preserve or enhance its IQP despite geopolitical headwinds (through effective reconfiguration of resources), it can protect its trajectory toward sustainable competitive advantage. Theoretically, firm competitiveness is the eventual outcome of high IQP. A firm adept at innovation and agility will likely outperform competitors in the market, consistent with Porter's idea that superior value creation underpins competitive success. Although our empirical analysis does not directly test competitiveness as an outcome, we include it conceptually to highlight that maintaining productivity and innovation in turbulence is crucial for long-run competitive positioning.

Importantly, we incorporate digital transformation as a moderator in this framework, recognizing it as a double-edged factor that can bolster or hinder the above processes. Digital transformation endows firms with enhanced agility, information processing, and connectivity, which can reinforce their dynamic capabilities. A digitally advanced firm can more quickly

https://doi.org/10.7441/joc.2026.02.01

sense changes (through data analytics, real-time monitoring) and execute internal adjustments (via automation, digital platforms). Furthermore, they can absorb shocks better and reconfigure operations, mitigating the negative impact of geopolitical risk on IQP. For example, digital supply chain systems enable rapid rerouting of materials or substitution of suppliers when trade routes are disrupted. Thus, a firm with strong digital infrastructure can sustain innovation and production more effectively amid external shocks (smaller decline in IQP). Digital assets and competencies can strengthen firms' adaptive response and reconfiguration capacity.

Digital transformation can also introduce negative channels or new vulnerabilities. Highly digitalized systems can be tightly coupled; they might propagate disturbances faster or expose the firm to cyber-attacks and IT failures, especially during geopolitical conflicts. Additionally, heavy reliance on data-driven algorithms could backfire if those algorithms are not equipped to handle unprecedented geopolitical disruptions (managers might be blindsided by risks not in the model). Thus, a firm with extensive digital operations might experience amplified immediate reactions to shocks or face security risks that partially offset the agility benefits. In short, digitalization improves a firm's capacity to adapt, but it can also create fragility if not managed prudently.

By integrating these perspectives, we form a holistic theory. Geopolitical risk acts as a disruptive force pushing firms into a defensive stance. Firms with strong internal resources and dynamic capabilities respond via internal reconfiguration, reallocating and reshuffling assets to maintain their innovation drive, which is consistent with our capability-based framework. This internal mechanism links the external shock to changes in IQP. If reconfiguration is successful, the firm can sustain higher value-added output and mitigate the drop in IQP. However, IQP falters if the firm is rigid. Digital transformation conditions the effectiveness of this response. It strengthens the firm's adaptive capacity, but we remain cognizant of the complexity. Ultimately, the extent to which IQP is preserved or impaired will influence the firm's long-term competitiveness. A stable or growing IQP in spite of geopolitical turmoil would mean the firm continues to innovate and improve productivity, giving it a competitive edge. In contrast, a sharp decline in IQP would jeopardize the firm's competitive advantage in the marketplace.

Empirical evidence lends support to this pathway. During recent geopolitical shocks, firms first ramp up internal efforts, such as securing supply chains, boosting in-house R&D, and stockpiling key inputs. They would also scale back external expansion or partnerships, effectively creating an "internal-external gap." Khatib et al. (2025) note that internal reallocation tends to happen earlier, with external engagement suffering later, leading to structural imbalances in firms' operations. Such findings align with our argument that internal reconfiguration is a primary coping mechanism. At the same time, digital-ready firms have shown more resilience. Ayadi & Jahmane (2025) found that European companies with higher digital integration maintained better performance under policy uncertainty. Similarly, Nose et al. (2023) document that digitalized firms "weather shocks better" in terms of revenue declines. Case evidence also highlights the caveats, as highly networked systems can transmit shocks (Ivanov & Dolgui, 2021) and over-digitization may increase cyber exposure (Jiang et al., 2025). We incorporate all these nuances into our theoretical expectations.

In summary, we explain the chain: Geopolitical Risk → Internal Reconfiguration → Innovation-led quality productivity → Firm Competitiveness. Geopolitical risk is theorized to negatively affect innovation-led quality productivity on average, and this effect is associated with the firm's internal reconfiguration response. Digital transformation might moderate this process, helping firms cushion the blow (due to agility and real-time adjustments). The theoretical framework thus yields a set of testable hypotheses about each link in this chain, as detailed next.

3 RESEARCH OBJECTIVE, METHODOLOGY, AND DATA

3.1 Hypotheses Development

Our study develops a theoretical framework from an internal reconfiguration mechanism perspective, integrating classical competitive strategy theory with modern capability-based views. We focus on how firms adjust their internal resources and capabilities to counteract the impact of external geopolitical risk on IQP, and the role of digital transformation in this process. Our theoretical logic comprises the following links: (1) Geopolitical risk, as an external shock, pressures firms to undertake internal reconfiguration, such as redeploying and readjusting internal resources and processes in response; (2) this internal reconfiguration is expected to shape the firm's IQP, where successful reconfiguration helps the firm sustain or enhance its innovation output and production efficiency, whereas failure to adapt may lead to productivity declines; (3) the firm's degree of digital transformation moderates the above process. A high level of digitalization is expected to improve the efficiency and outcomes of internal reconfiguration, though it may also introduce new challenges. We elaborate each variable and linkage and then present the corresponding hypotheses.

Geopolitical risk creates an uncertain and adverse external environment that is likely to undermine innovation-driven productivity at the firm level. When geopolitical risk spikes, indicating rising tensions or potential conflicts, firms face greater downside risk in their markets and operations. The real options theory and uncertainty-aversion behavior suggest that, under such conditions, firms will scale back or delay activities that contribute to IQP. These include investments in R&D, new product development, and capacity expansion, all of which are critical for sustaining innovation and productivity growth (Bernanke, 1983; Bloom, 2009). Moreover, geopolitical turmoil often leads to demand declines (especially in export markets), supply chain disruptions, and tighter financial constraints (Caldara & Iacoviello, 2022; Hassan et al., 2019). For a firm's IQP, which relies on successful innovation and market realization of that innovation, such conditions are detrimental. We expect higher geopolitical risk to manifest in lower overall IQPI for firms. This also means that the firm's TFP improvements driven by new innovations will slow down or reverse. Specifically, components related to demand and output realization, and potentially innovation creation, may be negatively affected. Although some defensive innovation spurts may occur, we hypothesize that these are outweighed by the prevailing negative forces. Thus, a negative relationship is anticipated between geopolitical risk and firm's IQP. This hypothesis is consistent with empirical evidence of uncertainty shocks lowering firm productivity and innovation output (Lee et al., 2023; Zheng et al., 2020). Accordingly, rising geopolitical tensions are likely to act as a headwind to firms' high-quality growth.

Hypothesis 1. Geopolitical risk has a negative impact on a firm's innovation-led quality productivity.

The degree and nature of a firm's digital transformation shape how geopolitical risk affects IQP. Digital transformation does not operate as a uniformly protective force. Instead, its moderating role depends on how digital technologies are embedded in organizational processes and how effectively they are translated into reconfiguration capabilities.

https://doi.org/10.7441/joc.2026.02.01

Application-oriented and intelligence-driven digitalization can enhance firms' dynamic capabilities, thereby strengthening their ability to respond to external shocks. Digital technologies such as big data analytics, AI, and real-time monitoring systems improve firms' information-processing speed and decision accuracy, allowing managers to identify disruptions earlier and reallocate internal resources more efficiently. For example, digitally enabled firms can detect supply chain interruptions or sudden demand shifts in real time and adjust production plans, inventory allocation, or R&D priorities accordingly. These capabilities reduce the adjustment costs and time delays associated with internal reconfiguration, helping firms conduct innovation activities and operational continuity under geopolitical stress. Nose et al. (2023) showed that highly digitalized firms experience significantly smaller declines in sales and profits during uncertainty shocks, while Ayadi and Jahmane (2025) found that digital integration improves firms' resilience under policy uncertainty.

However, digital transformation may also introduce structural frictions and short-term inefficiencies that weaken its buffering role. Highly digitalized firms often operate through tightly coupled information systems and algorithm-driven decision processes, which can amplify coordination complexity and increase vulnerability to cyber risks or system failures during periods of geopolitical tension. Moreover, when firms accelerate innovation investment or expectation formation under risk, digital tools may widen the gap between innovation creation and market realization if complementary demand conditions or institutional support are insufficient. In such cases, digitalization may intensify internal imbalances rather than stabilizing productivity performance immediately, particularly in the short run.

Taken together, these arguments suggest that digital transformation exerts a conditional and heterogeneous moderating effect on the relationship between geopolitical risk and IQP. Digitalization is more likely to mitigate the adverse impact of geopolitical shocks when it enhances firms' sensing, seizing, and reconfiguring capabilities through effective application and organizational integration. Conversely, excessive digital dependence or misalignment between innovation efforts and market absorption may limit or offset its buffering role.

Hypothesis 2. Digital transformation conditionally moderates the impact of geopolitical risk on innovation-led quality productivity.

The impact of geopolitical risk on firms is not limited to a direct shock. Severe external turbulence often requires internal adjustments by firms. Firms facing market uncertainty and constrained external resources must scrutinize and reorganize their own resource deployments, consistent with internal reconfiguration. This argument aligns with the dynamic capabilities view, which emphasizes firms' capacity to sense threats and decisively redeploy and reconfigure resources to maintain competitiveness (Teece et al., 2016; Schulze & Brusoni, 2022). In periods of high geopolitical risk, firms may reprioritize strategic activities, reallocate funds and personnel, redesign supply-chain arrangements, and modify operational routines to cope with disruptions and reduce exposure to external dependence (Caldara & Iacoviello, 2022; Barbieri et al., 2026). For example, if trade frictions disrupt cross-border sourcing, firms may backshore key inputs or strengthen domestic supplier networks; alternatively, they may channel more resources into in-house R&D to reduce reliance on external technologies (Barbieri et al., 2026). Consistent with the RBV, such adjustments reflect firms' efforts to activate and recombine internal resources when external opportunities shrink and uncertainty rises (Barney, 1991).

https://doi.org/10.7441/joc.2026.02.01

Internal reconfiguration seeks to preserve and potentially enhance the firm's IQP, ensuring that critical R&D projects are sustained and resources are redirected toward more promising innovation domains even under external turbulence (Bloom, 2009; Schulze & Brusoni, 2022). It can improve organizational efficiency and allocation effectiveness by re-engineering routines and optimizing assignments, helping firms achieve more with less resources and maintain productive performance (El Baz et al., 2023). Internal reconfiguration represents the renewal and upgrading of ordinary capabilities, which can underpin longer-run productivity advantages (Schulze & Brusoni, 2022). Importantly, we treat it as an interpretive mechanism rather than an empirically validated mediation path given data-frequency constraints. Accordingly, we interpret the IQPI sub-index and gap patterns as mechanism-consistent evidence of how firms may adjust internal resources under heightened geopolitical risk (Caldara & Iacoviello, 2022).

Hypothesis 3. Geopolitical risk is expected to intensify firms' internal reconfiguration, which is theorized to support innovation-led quality productivity.

The research framework of this paper is presented in Fig. 1 below. Next, we empirically test these hypotheses using panel data on Chinese digital economy firms.

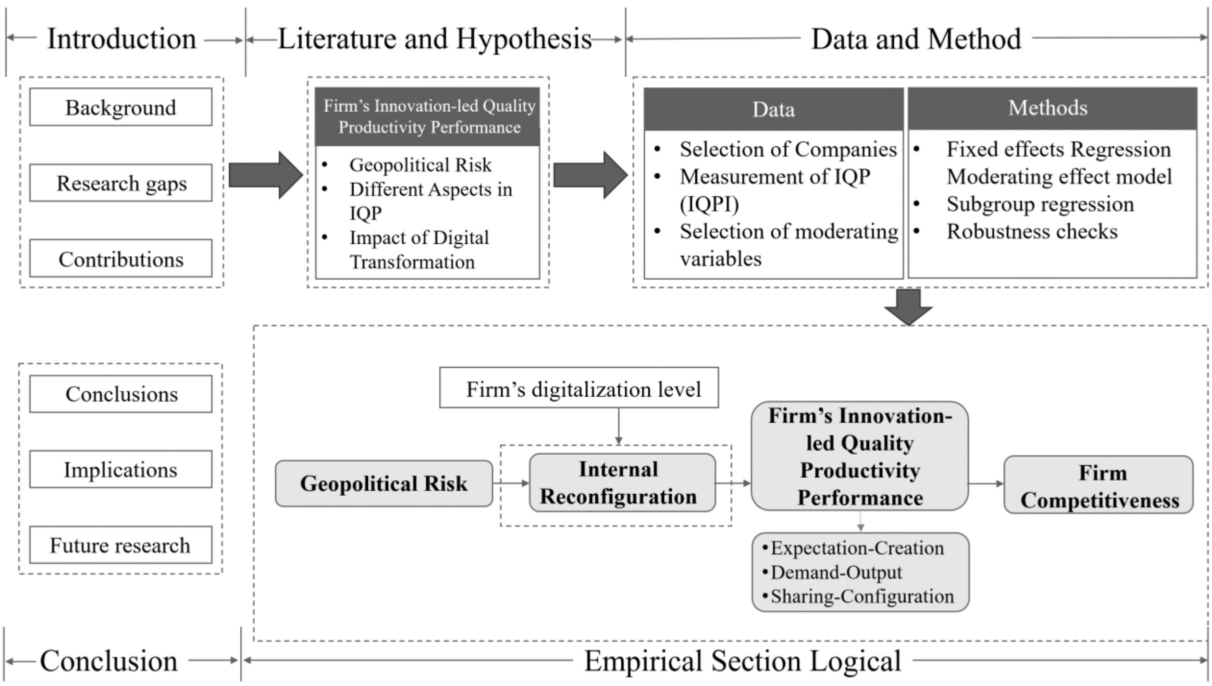

Fig. 1 – Research framework of this study. Source: own research

https://doi.org/10.7441/joc.2026.02.01

3.2 Data and Variables

In this section, we introduce the definition and measurement of dependent variables, independent variables, moderating variables, and control variables as shown in Tab. 1.

Tab. 1 – Variable List. Source: own research

Type	Variable Name	Variables	Description
Dependent variables	IQPI	*Y_IQPI*	Innovation-led Quality Productivity Index (composite).
	Expectation-Creation Index	*Y_exp-cre*	Second-order index capturing innovation prospects and efforts.
	Demand-Output Index	*Y_dem-out*	Second-order index capturing market realization via orders and production.
	Sharing-Configuration Index	*Y_sha-cfg*	Second-order index capturing diffusion and organizational/allocative efficiency.
	Output-Demand gap	*Out_minus_Dem*	Structural gap: Output minus Demand.
	Configuration-Sharing gap	*Cfg_minus_Sha*	Structural gap: Configuration minus Sharing.
	Creation-Expectation gap	*Cre_minus_Exp*	Structural gap: Creation minus Expectation.
Independent variables	GPR_t	GPR_t	Geopolitical Risk Index at month t.
	GPR_{t-1}	GPR_{t-1}	One-month lag of the China-specific GPR series.
Moderating variables	Digitalization	*Digital*	Digitalization index (firm-level digitalization measure).
	DIGI (in robustness tests)	*DIGI*	Wu et al. digitalization index (firm-level).
Control variables	PPI_industry	*ppi_industry*	Producer Price Index at the industry level.
	USD_CNY	*usd_cny*	USD-CNY exchange rate (RMB per USD).
	NEER (in robustness tests)	*NEER*	Nominal Effective Exchange Rate Index.
	Export_share	*Export*	The ratio of overseas revenue to total revenue.
	TariffRatio	*TariffRatio*	Tariff revenue to imports ratio.
	PMI	*PMI*	Purchasing Managers' Index.
	LPR	*LPR*	Loan Prime Rate (benchmark interest rate).
	IIP	*IIP*	National industrial value added (YoY).

(1) **Dependent variables**. The core premise of IQP is the substantial enhancement of TFP. We measure firm-level IQP using a composite IQPI constructed following the non-parametric identification technique (Xu et al., 2014). A nonparametric path-converged technique is employed to aggregate bottom-up from basic indicators into first-order indices, while a joint structural design connects and organizes the aggregated first-order indices top-down to generate higher-order indices. This approach avoids ad hoc or subjective weight assignment and allows the data structure itself to determine the relative importance of different components. The underlying basic indicators are constructed from firm-level operational, innovation, and market-related data, including R&D activity, production realization, order and demand dynamics, collaboration and diffusion intensity, and internal resource allocation. Building on this measurement system, we estimate a time-varying partially linear model and derive a key

https://doi.org/10.7441/joc.2026.02.01

inferential metric, Total Output Productivity, which serves as a direct indicator of the IQP-driven progress in improving TFP.

Using monthly data for digital-economy firms in the Yangtze River Delta, we construct six basic indicators: expectation rate, creation rate, demand rate, output rate, sharing rate and configuration rate. These are aggregated bottom-up to form first-order indices. The index system is then structured top-down: the first-order indices are combined into three second-order indices (the Expectation-Creation Index, the Demand-Output Index, and the Sharing-Configuration Index), which are further connected to the corresponding third-order indices (Expectation Index, Creation Index, Demand Index, Output Index, Sharing Index, Configuration Index). The base period is June 2020, which serves as a normalization benchmark for tracking relative monthly dynamics rather than absolute productivity levels. The framework of the index system is shown in Table A of Appendix A. The detailed construction procedure of the index, including the calculation of fourth-order rates and aggregation weights, is reported in the remainder of Appendix A.

The IQPI is organized to mirror the three canonical sources of TFP in modern growth and firm dynamics literature (innovation, market realization, and diffusion/organization) and make their short-run imbalances observable. Concretely, the second-order indices map these channels one-to-one: the Expectation-Creation Index captures innovation prospects and effort; the Demand-Output Index captures market realization of innovations via orders and production; and the Sharing-Configuration Index captures diffusion and organizational/allocative efficiency. The third-order indices (Expectation, Creation, Demand, Output, Sharing, Configuration) further disentangle each channel, while “Output-Demand gap” and “Configuration-Sharing gap” measure transitory disequilibria between supply and demand, and between reconfiguration and diffusion. This architecture is motivated by the observation that firms typically adjust expectations and configuration ahead of demand and output after macro shocks. Making the gaps explicit lets us quantify such sequencing and interpret the lagged effects.

The index was launched by Hangzhou City University and the Zhejiang Society of Quantitative Economics. The underlying data primarily cover the constituents of the CSI Yangtze River Delta Digital Economy Thematic Index (932423). For this study, we use the Zhejiang subset of that index from January 2020 to June 2025, comprising 12 firms across core industries including integrated circuits, AI, and the industrial internet. The firm list is shown in Appendix B.

(2) **Independent Variables**. Following Caldara & Iacoviello (2022), we use the monthly China-specific GPR index as the main explanatory variable to capture exogenous variation in geopolitical risk. The GPR index is constructed from automated text searches of leading international newspapers and equals the share of articles that discuss geopolitical tensions, wars, and related threats in total published articles over a given period.

(3) **Moderating Variables**. We measure firms’ digital transformation and examine its moderating role in the transmission of geopolitical risk. To align with Chinese practice, our baseline measure follows the widely used computation proposed by Zhang et al. (2021), which constructs a firm-level digitalization index based on textual analysis of annual reports to capture firms’ intangible digital assets, digital strategy orientation, and technology adoption intensity. We adopt the digital-transformation measure of Wu et al. (2021) as an alternative in robustness checks, allowing us to further distinguish between digital technologies and digital application dimensions and explore heterogeneous moderating effects across digitalization types.

https://doi.org/10.7441/joc.2026.02.01

(4) **Control Variables**. This study controls for a series of firm and industry characteristic variables. These variables include the industry-level Producer Price Index (PPI), the USD/CNY exchange rate, the firm's share of overseas revenue, the national industrial value added (year-on-year, current month), the tariff-revenue-to-imports ratio, and the Loan Prime Rate (LPR). These monthly macroeconomic variables are included to capture time-varying nationwide shocks related to business cycles, price dynamics, external financial conditions, and policy environments, thereby mitigating potential omitted-variable bias arising from common macro shocks. Data sources include CSMAR database and Wind database. Tab. 1 presents the specific definition of all variables.

3.3. Methods

We estimate firm-month panel models to study the effect of geopolitical risk on the IQPI and its components. All specifications include firm fixed effects and firm-specific linear trends. We do not include month fixed effects to avoid absorbing nationwide monthly series; instead, macro time variation is controlled explicitly and standard errors are clustered by month.

$$Y_{i,t} = \alpha_i + \beta_0 + \beta_1 GPR_t + \beta_2 GPR_{t-1} + \gamma'_1 Controls_t + \theta_i t + \varepsilon_{i,t} \tag{1}$$

$$\begin{aligned} Y_{i,t} = \alpha_i + \beta_0 + \beta_1 GPR_t + \beta_2 GPR_{t-1} + \beta_3 (GPR_t \times D_i) + \beta_4 (GPR_{t-1} \times D_i) \\ + \gamma'_1 Controls_t + \theta_i t + \varepsilon_{i,t} \end{aligned} \tag{2}$$

where $Y_{i,t}$ denotes the composite IQPI, second-order indices (the Expectation-Creation Index, the Demand-Output Index, the Sharing-Configuration Index), third-order indices (Expectation, Creation, Demand, Output, Sharing, Configuration), or structural gaps. GPR_t and GPR_{t-1} denote contemporaneous and lagged China-specific GPR, respectively. D_i is the standardized digital-transformation measure. $Controls_t$ denotes a vector of firm- and macro-level controls (industry PPI, USD/CNY, the ratio of overseas revenue to total revenue, national industrial value added, tariff-revenue-to-imports ratio, LPR). α_i denotes firm fixed effects and $\theta_i t$ denotes firm-specific linear trends.

4 RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Tab. 2 reports the descriptive statistics of the variables used in the baseline and extended specifications. The dependent variables, as the IQPI and its third-order components (Expectation Index, Creation Index, Demand Index, Output Index, Sharing Index, Configuration Index) are standardized around a common scale. This narrow dispersion reflects the index construction and helps comparability across outcomes. The two structural gaps exhibit richer variation: the Demand-Output gap averages -0.028 with a standard deviation of 1.676, while the Configuration-Sharing gap averages -0.689 with a larger dispersion (s.d.=2.659). The slightly negative means indicate that, in tranquil periods, demand and sharing tend to marginally outpace output and configuration, respectively. The wider spread of Configuration-Sharing gap anticipates our later finding that reconfiguration responds more strongly than sharing following shocks, producing a widening gap as the effects of geopolitical risk materialize with a lag.

https://doi.org/10.7441/joc.2026.02.01

Tab. 2 – Descriptive statistics. Source: own research

Variables	Mean	Standard deviation	Min	Max
Y_IQPI	59.98	0.614	58.58	61.68
Y_exp-cre	59.55	0.458	57.92	60.84
Y_dem-out	60.11	1.049	57.33	62.33
Y_sha-cfg	60.27	1.179	56.82	63.66
Cre_minus_Exp	-1.642	3.739	-11.62	7.721
Out_minus_Dem	-0.0283	1.676	-5.932	4.920
Cfg_minus_Sha	-0.689	2.659	-9.169	6.550
Y_expect	60.37	2.018	54.84	66.12
Y_create	58.73	1.828	53.44	63.25
Y_demand	60.13	1.508	56.41	63.81
Y_output	60.10	1.163	55.73	62.82
Y_share	60.61	1.806	55.22	65.79
Y_config	59.92	1.749	55.02	65.36
GPR	0.904	0.304	0	2.475
ppi_industry	-0.392	3.117	-4.900	11
usd_cny	6.880	0.277	6.346	7.203
NEER	104.5	3.890	97.12	112.3
Export	0.238	0.241	0	0.791
IIP	5.779	8.909	-25.87	52.34
TariffRatio	0.0161	0.00297	0.0110	0.0255
LPR	3.709	0.345	3	4.300
PMI	49.82	1.893	35.70	52.60
Digital	0.128	0.162	0	0.795
DIGI	3.796	1.526	0	5.624

Notes: Tab. 2 reports the descriptive statistics of main variables. The four columns are the mean value, standard deviation, minimum value, and maximum value, respectively.

Turning to the principal regressor, the GPR index exhibits substantial time-series variation, ensuring adequate identifying movement once we use the one-month lag in the regressions. Macroeconomic controls display economically meaningful swings. These magnitudes motivate our choice to model common time shocks explicitly rather than absorb them with month fixed effects. Firm-level openness and financing conditions are heterogeneous. The export share has a mean of 0.238, supporting the interaction design with exchange-rate measures to proxy price-openness channels. Measures of digital transformation show ample cross-sectional spread, which is essential for moderation tests.

Finally, the number of observations varies across blocks because of missing values. In the empirical sections, we keep the panel as balanced as possible and confirm that the conclusions are unchanged in robustness checks. Overall, the descriptive statistics reveal negative baseline gaps with sizeable dispersion, substantial variation in GPR and macro controls, and rich heterogeneity in digitalization and openness.

Additionally, we report a Pearson correlation matrix for the main variables in Appendix C. Overall, pairwise correlations among regressors are moderate and do not indicate severe multicollinearity. Notably, the lagged GPR measure is more strongly negatively correlated with the composite index than the contemporaneous GPR, consistent with a more pronounced lagged effect.

https://doi.org/10.7441/joc.2026.02.01

4.2. Baseline Regression Results

Tab. 3 presents the baseline regression results examining the impact of geopolitical risk on the firm's IQPI. Each column corresponds to a separate regression where the dependent variable is one dimension of IQP (Column 1 is the overall composite index, Columns 2-4 are the three paired sub-index composites, and Columns 5-7 are the gap measures between sub-index pairs). Consistent patterns emerge from these baseline results.

Notably, lagged geopolitical risk (GPR_{t-1}) has a significantly negative effect on the overall IQPI as shown in Column 1 of Tab. 3 ($p < 0.01$). This indicates that an increase in geopolitical risk is associated with a decline in firms' innovation-driven productivity in the subsequent period. In particular, GPR shocks appear to suppress the Demand-Output dimension of IQPI: the coefficient on GPR_{t-1} is significantly negative for the Demand-Output composite ($p < 0.01$, Column 3), and lagged GPR widens the Output-Demand gap, as evidenced by a positive effect on Out_minus_Dem, Column 5. In contrast, GPR_{t-1} shows a positive and significant impact on the Configuration-Sharing gap (Cfg_minus_Sha, $p < 0.01$), suggesting that geopolitical risk triggers firms to reallocate or reconfigure internal resources. This "reconfiguration" response is also reflected in the positive effect of GPR_{t-1} on the Configuration sub-index, indicating that amid geopolitical turmoil, firms intensify internal capacity-building, such as securing supply chains and searching for domestic substitutions, while external collaboration or market-sharing efforts fall behind. This will be discussed in greater detail using Chinese firms' cases in 4.5.2.

Tab. 3 – Baseline regression results: Effect of geopolitical risk on innovation-led quality productivity. Source: own research

	(1) *Y_IQPI*	(2) *Y_exp-cre*	(3) *Y_dem-out*	(4) *Y_sha-cfg*	(5) *Out_minus _Dem*	(6) *Cre_minus _Exp*	(7) *Cfg_minus _Sha*
GPR_t	0.113	0.131	0.157	0.050	0.123	0.902^{**}	-0.143
	(0.637)	(0.916)	(0.367)	(0.299)	(0.425)	(2.193)	(-0.134)
GPR_{t-1}	-0.514^{***}	-0.330	-1.084^{***}	-0.127	1.437^{***}	0.149	3.166^{***}
	(-4.181)	(-1.231)	(-4.014)	(-0.611)	(5.144)	(0.372)	(5.079)
Usd_cny×export	1.398^{***}	-0.094	0.891^{**}	3.408^{***}	-1.821^{***}	-3.422^{***}	-1.494^{**}
	(8.232)	(-0.641)	(2.068)	(11.651)	(-3.455)	(-3.294)	(-2.144)
Obs.	792	792	792	792	792	792	792
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.374	0.135	0.299	0.469	0.601	0.771	0.388

Notes: All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. Standard errors are clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Current-period GPR_t on its own does not have a strong immediate effect on most IQP outcomes, as the coefficients on GPR_t are positive but statistically insignificant in the first four columns. The only exception is that GPR_t has a positive and statistically significant effect on the Creation-Expectation gap (Cre_minus_Exp) in the baseline model ($p < 0.05$ in Column 6). This implies that in the same month of a geopolitical risk spike, firms' actual innovation output ("creation") exceeds their prior expectations, widening the Creation-Expectation gap. A plausible interpretation is that firms may undertake defensive or catch-up innovation efforts immediately when uncertainty rises, such that short-term innovation output does not drop and exceeds

https://doi.org/10.7441/joc.2026.02.01

planned expectations. For example, companies may accelerate R&D or product development (creation) in response to geopolitical threats. However, this short-lived positive blip is relatively small in magnitude and not sustained, as the dominant effect of GPR materializes with a lag (the next period's demand and output downturn becomes the main theme, as reflected by the strongly negative lagged GPR effects discussed above). In sum, the baseline results suggest that geopolitical risk shocks act as a significant drag on firms' IQP, primarily by depressing demand and output-related performance in the following period and causing internal-external structural imbalances (internal reconfiguration vs. external market engagement). These findings support the view that rising geopolitical uncertainty can undermine innovation-driven productivity growth at the firm level.

To examine how the impact of geopolitical risk varies with firms' digital intensity, we compute average marginal effects (AMEs) and conditional marginal effects of GPR on the IQPI outcomes across the distribution of digitalization. Three robust patterns emerge. First, the marginal effect of lagged geopolitical risk, GPR_{t-1}, on the composite IQPI remains negative across all quartiles of digitalization, with only a mild attenuation at the upper quartile. The AME is materially close to the baseline coefficient, confirming that higher digital intensity does not overturn the adverse effect of GPR. Second, conditional on digitalization, the most pronounced marginal effects concentrate on the Demand-Output Index and the Output-Demand gap: GPR_{t-1} continues to depress Demand-Output and to widen Output-Demand gap, yet the slope becomes flatter at higher levels of digitalization (consistent with the interaction sign reported in the main tables), implying that digital tools modestly help firms realign supply with weakened demand. Third, the current GPR_t retains a short-lived positive marginal effect on Creation-Expectation gap, largely invariant to digitalization, which echoes the baseline "defensive creation" blip without altering longer-run demand-driven losses. Taken together, Tab. 4 indicates that the marginal influence of geopolitical risk is broadly stable across digitalization levels, with economically small amelioration limited to the supply-demand mismatch channel. These results naturally bridge to the moderation evidence and reinforce the conclusion that digitalization is not a general buffer to geopolitical risk in the short run, although it may provide targeted operational benefits in turbulent periods.

Tab. 4 – Marginal effects of GPR and digitalization. Source: own research

	(1) *Y_IQPI*	(2) *Y_exp-cre*	(3) *Y_dem-out*	(4) *Y_sha-cfg*	(5) *Out_minus _Dem*	(6) *Cre_minus _Exp*	(7) *Cfg_minus _Sha*
ME_GPR_P10	0.129	0.151	0.117	0.118	0.125	0.705	-0.242
	(0.747)	(0.952)	(0.286)	(0.630)	(0.358)	(1.595)	(-0.230)
ME_GPR_P50	0.120	0.141	0.130	0.088	0.136	0.779*	-0.182
	(0.695)	(0.936)	(0.311)	(0.500)	(0.403)	(1.771)	(-0.173)
ME_GPR_P90	0.063	0.078	0.211	-0.096	0.209	1.243**	0.187
	(0.351)	(0.691)	(0.428)	(-0.607)	(0.721)	(2.509)	(0.168)
ME_L1_P10	-0.499***	-0.286	-1.095***	-0.113	1.546***	0.071	3.199***
	(-3.900)	(-0.978)	(-3.958)	(-0.475)	(5.938)	(0.169)	(4.829)
ME_L1_P50	-0.510***	-0.310	-1.101***	-0.116	1.500***	0.078	3.213***
	(-4.090)	(-1.103)	(-4.035)	(-0.514)	(5.925)	(0.182)	(4.969)
ME_L1_P90	-0.576***	-0.455**	-1.139***	-0.133	1.214***	0.121	3.302***

https://doi.org/10.7441/joc.2026.02.01

	(-5.074)	(-2.183)	(-4.282)	(-0.742)	(5.573)	(0.216)	(5.529)
Obs.	768	768	768	768	768	768	768

Notes: Test statistics are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

4.3. Moderating Effect of Digitalization

We incorporate the firm's digitalization level as a moderating variable to assess whether digital capabilities buffer or alter the impact of geopolitical risk. Tab. 5 reports the results of Model A with the interaction terms between GPR and the digitalization index (*Digital*). Compared with the baseline results in Tab. 3, Tab. 5 shows that the main effects of GPR remain largely consistent. For instance, the coefficient of GPR_{t-1} on the overall IQPI is still significantly negative ($p < 0.01$ in Column 1), very close to the baseline magnitude. Lagged GPR also continues to significantly drag down the Demand-Output composite ($p < 0.01$ in Column 3) and increase the Configuration-Sharing gap ($p < 0.01$ in Column 7) in a similar fashion to the baseline model. Meanwhile, the current GPR_t effect on the Creation-Expectation gap persists ($p < 0.10$ in Column 6), indicating a short-term uptick in creation output relative to expectations when a geopolitical shock hits. These consistencies suggest that adding the digitalization moderator does not fundamentally change the direct influence of geopolitical risk on IQP; rather, it allows us to see if high vs. low digital firms experience these effects differently.

Turning to the interaction terms, we find that digitalization plays a generally modest moderating role. Most $GPR \times Digital$ interaction coefficients are statistically insignificant or only marginally significant, implying that the firm's digitalization level does not dramatically alter the impact of GPR. However, some exceptions exist at the sub-index level. In the Expectation-Creation composite (*Y_exp-cre*), the lagged $GPR_{t-1} \times Digital$ interaction is negative and significant ($p < 0.05$ in Column 2). This indicates that for firms with a higher level of digitalization, the negative effect of GPR_{t-1} on the expect-create dimension becomes more negative. In other words, digital-intensive firms see a slightly larger drop in that combined index following a geopolitical shock, relative to less digital firms. Similarly, the interaction for the Output-Demand gap is negative and significant ($p < 0.01$ in Column 5), suggesting that digitalization mitigates the widening of the output-demand misalignment. In other words, firms with a higher level of digitalization experience a smaller increase in the output surplus (or demand shortfall) after a geopolitical shock. This represents a potentially beneficial moderating effect since it indicates that digital capabilities help firms better align supply with the weakened demand under uncertainty. This is consistent with the notion that digital technologies (like agile supply-chain management or data analytics) can improve a firm's responsiveness to demand changes during turbulent times, thereby reducing excess output or inventory build-up when demand falls.

https://doi.org/10.7441/joc.2026.02.01

Tab. 5 – Regression results with digitalization as a moderator: GPR effects on IQPI at different digital levels. Source: own research

	(1) *Y_IQPI*	(2) *Y_exp-cre*	(3) *Y_dem-out*	(4) *Y_sha-cfg*	(5) *Out_minus _Dem*	(6) *Cre_minus _Exp*	(7) *Cfg_minus _Sha*
GPR_t	0.109	0.129	0.144	0.055	0.153	0.865*	-0.119
	(0.632)	(0.903)	(0.335)	(0.329)	(0.466)	(1.962)	(-0.112)
GPR_{t-1}	-0.523***	-0.337	-1.108***	-0.120	1.455***	0.091	3.226***
	(-4.305)	(-1.257)	(-4.107)	(-0.564)	(5.874)	(0.206)	(5.097)
$GPR_t \times Digital$	-0.004	-0.003	0.011	-0.019	-0.006	0.044	0.054
	(-0.378)	(-0.780)	(0.599)	(-1.078)	(-0.526)	(0.987)	(1.660)
$GPR_{t-1} \times Digital$	-0.004	-0.012**	-0.004	0.004	-0.053***	-0.015	0.017
	(-0.455)	(-2.172)	(-0.403)	(0.158)	(-2.953)	(-0.264)	(0.424)
Usd_cny×export	1.226***	-0.126	0.951*	2.864***	-4.040***	-4.916***	-1.651*
	(6.765)	(-0.727)	(1.783)	(9.713)	(-6.171)	(-4.668)	(-1.882)
Obs.	768	768	768	768	768	768	768
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.359	0.137	0.296	0.445	0.695	0.781	0.388

Notes: The digitalization moderator is the firm's digitalization index (*Digital*). All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. Standard errors are clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

4.4. Robustness Tests

We conduct several robustness tests to verify the reliability of the above findings. Overall, the results remain qualitatively consistent with our main conclusions across these alternative specifications. We summarize the key robustness checks and findings below.

(1) Robustness Test 1: Alternative GPR Measure

First, we re-estimate the models using an alternative specification of geopolitical risk, that is, a standardized GPR shock (denoted *z_GPRshock*) in place of the level of GPR. This variable captures monthly changes in geopolitical risk, as unexpected "shocks" might matter more than the absolute risk level. We include both the current and one-period lag of *z_GPRshock*, as well as the interaction terms with digitalization in the moderated version. The regression outcomes confirm that our earlier results are robust, as shown in Tab. 6. Lagged GPR remains a significant negative driver of the IQPI ($p < 0.01$, when standardized) and the Demand-Output sub-index (significantly negative, Column 3), while significantly increasing the Output-Demand gap and Configuration-Sharing gap. The current GPR shock still shows no significant effect on the overall index but continues to yield a positive effect on the Creation-Expectation gap, mirroring the behavior of the level measure. Importantly, the interaction terms with *Digital* in this specification are very similar to the main model: most are insignificant, with the lagged *GPR* × *Digital* interaction remaining significantly negative for the Expectation-Creation dimension (p <0.05) and for the Output-Demand gap (p <0.01). In conclusion, geopolitical risk shocks suppress IQP, and digitalization offers limited moderation of this effect.

https://doi.org/10.7441/joc.2026.02.01

Tab. 6 – Robustness Test 1: Alternative GPR Measure. Source: own research

	(1) *Y_IQPI*	(2) *Y_exp-cre*	(3) *Y_dem-out*	(4) *Y_sha-cfg*	(5) *Out_minus _Dem*	(6) *Cre_minus _Exp*	(7) *Cfg_minus _Sha*
z_GPR_t	0.036	0.039	0.052	0.016	0.027	0.241*	-0.069
	(0.722)	(0.869)	(0.432)	(0.350)	(0.267)	(1.793)	(-0.224)
z_GPR_{t-1}	-0.112***	-0.063	-0.255***	-0.018	0.341***	0.036	0.762**
	(-2.676)	(-0.727)	(-2.713)	(-0.348)	(2.926)	(0.218)	(2.466)
$z\_GPR_t \times Digital$	-0.004	-0.003	0.009	-0.018	-0.002	0.039	0.053
	(-0.427)	(-0.836)	(0.550)	(-1.065)	(-0.245)	(1.088)	(1.603)
$z\_GPR_{t-1} \times Digital$	-0.006	-0.012**	0.000	-0.006	-0.039**	0.035	0.025
	(-0.658)	(-2.446)	(0.007)	(-0.328)	(-2.614)	(0.924)	(0.488)
$Usd\_cny \times export$	1.285***	-0.087	1.073*	2.880***	-4.211***	-5.006***	-2.036**
	(6.748)	(-0.513)	(1.932)	(9.700)	(-6.013)	(-4.698)	(-2.078)
Obs.	768	768	768	768	768	768	768
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.359	0.137	0.296	0.445	0.695	0.781	0.388

Notes: The digitalization moderator is the firm's digitalization index (*Digital*). All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. Standard errors are clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

(2) Robustness Test 2: Alternative Digitalization Measure

We also test whether our moderation results depend on how digitalization is measured. In the main models, digitalization is proxied by firms' digitalization index (capturing intangible digital assets). As a robustness check, we substitute an alternative digital index, which is referred to as *DIGI*, based on a different methodology of digital transformation developed by Wu et al. (2021) as shown in Tab. 7. The regression with *GPR* × *DIGI* interactions reveals that the core GPR effects remain intact and lagged GPR still significantly reduces *Y_IQPI* and *Y_dem-out* while increasing misalignment gaps, with magnitudes very close to before. However, the moderating pattern shows some differences under this alternate digital metric. Notably, the $z\_GPR_{t-1} \times DIGI$ interaction is positive and significant for the Output-Demand gap ($p < 0.05$), in contrast to the negative interaction found using the *Digital*. This suggests that firms scoring high on *DIGI* actually experience a slightly larger widening of the Output-Demand gap when facing a GPR shock, implying that this type of digitalization might intensify external market exposure or push output even as demand falls. Additionally, the $z\_GPR_t \times DIGI$ interactions for the Creation-Expectation gap turn positive and marginally significant under the *DIGI* measure, whereas they were negative or insignificant with the asset measure (*Digital*). These differences indicate that not all forms of "digitalization" behave identically: the specific aspects of digital transformation captured by *DIGI* might influence how firms respond to geopolitical disturbances, amplifying certain responses in some cases.

Nonetheless, the main effects of *GPR* are unchanged and the moderation by this alternate digital measure is still not widespread. Thus, our conclusion of a limited moderating role of digitalization holds, though the direction of interaction can vary with different facets of digitalization.

https://doi.org/10.7441/joc.2026.02.01

Tab. 7 – Robustness Test 2: Alternative Digitalization Measure.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Y_IQPI	***Y_exp-cre***	***Y_dem-out***	***Y_sha-cfg***	***Out_minus _Dem***	***Cre_minus _Exp***	***Cfg_minus _Sha***
z_GPR_t	0.030	0.041	0.042	0.008	0.037	0.253^{*}	-0.069
	(0.625)	(0.904)	(0.358)	(0.181)	(0.398)	(1.875)	(-0.212)
z_GPR_{t-1}	-0.108^{**}	-0.066	-0.248^{**}	-0.010	0.333^{***}	0.042	0.765^{**}
	(-2.529)	(-0.752)	(-2.645)	(-0.216)	(2.863)	(0.255)	(2.444)
$z\_GPR_t \times DIGI$	0.013	0.006	-0.005	0.037	0.020	0.116^{*}	0.041
	(1.093)	(0.934)	(-0.481)	(1.225)	(0.545)	(1.708)	(0.757)
$z\_GPR_{t-1} \times DIGI$	0.020	0.007	-0.005	0.058	0.102^{**}	0.055	0.097
	(1.254)	(0.800)	(-0.465)	(1.342)	(2.584)	(0.682)	(1.471)
Usd_cny×export	1.183^{***}	-0.003	0.772	2.792^{***}	-4.313^{***}	-4.371^{***}	-2.405^{**}
	(6.443)	(-0.017)	(1.406)	(9.502)	(-5.585)	(-4.207)	(-2.196)
Obs.	744	744	744	744	744	744	744
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.342	0.137	0.271	0.466	0.662	0.783	0.343

Notes: All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. Standard errors are clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

(3) Robustness Test 3: Exchange Rate Control Specification

Our baseline models included the USD/CNY bilateral exchange rate and its interaction with export share as controls to account for firms' differential exposure to currency fluctuations. In this robustness test, we replace it with an alternative measure: the Nominal Effective Exchange Rate (*NEER*) interacted with export share. The *NEER* is a broader index of the currency's value against a basket of trading-partner currencies, which allows us to test whether using a trade-weighted exchange rate measure alters our findings. Re-estimating the models with *NEER × export* (in place of *Usd_cny×export*) produces similar results as shown in Tab. 8. The coefficients on GPR_t and GPR_{t-1} are unchanged in significance and magnitude across all IQP dimensions. Lagged GPR remains a strong negative factor for overall IQP and demand-side indices, and current GPR still only affects the Creation-Expectation gap. The digital interaction terms also mirror the prior outcomes. Meanwhile, the *NEER × export* control itself enters significantly in the expected direction: for instance, we see significantly negative coefficients on *NEER×export* for the Output sub-dimension and positive effects on the domestic-oriented indices. This indicates NEER appreciation, which makes exports relatively expensive and tends to hurt the external-oriented innovation outcomes, which is consistent with economic intuition. However, controlling for *NEER* rather than the bilateral rate does not change the core GPR impact estimates, reinforcing the robustness of our main results to how exchange rate exposure is modeled.

All these robustness tests bolster confidence in our findings. Regardless of whether we use a shock-based GPR index, an alternative digitalization metric, or different control specifications, the central results hold: Geopolitical risk exerts a significant negative influence on firms' IQP, particularly by suppressing demand-driven aspects and inducing structural mismatches, and typical levels of digitalization provide limited cushion against these effects.

https://doi.org/10.7441/joc.2026.02.01

Tab. 8 – Robustness Test 3: Exchange Rate Control Specification. Source: own research

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Y_IQPI	***Y_exp-cre***	***Y_dem-out***	***Y_sha-cfg***	***Out_minus _Dem***	***Cre_minus _Exp***	***Cfg_minus _Sha***
z_GPR_t	-0.074	0.234	-0.327	-0.129	0.289	1.063*	0.796
	(-0.497)	(1.438)	(-0.947)	(-0.573)	(0.828)	(1.822)	(0.817)
z_GPR_{t-1}	-0.675***	-0.259	-1.450***	-0.315	1.477***	0.690	3.796***
	(-4.833)	(-0.997)	(-5.357)	(-1.102)	(6.216)	(1.126)	(5.898)
$z\_GPR_t \times Digital$	-0.030	-0.026	0.014	-0.076	0.051	0.261**	0.166**
	(-1.565)	(-1.022)	(0.387)	(-1.471)	(0.998)	(2.262)	(2.594)
$z\_GPR_{t-1} \times Digital$	-0.040**	-0.059*	-0.043	-0.019	-0.098**	0.081	0.070
	(-2.124)	(-1.820)	(-1.363)	(-0.391)	(-2.588)	(0.590)	(1.072)
$NEER \times export$	-0.082***	0.002	-0.142***	-0.107**	0.357***	0.374***	0.152***
	(-4.703)	(0.141)	(-4.168)	(-2.283)	(9.647)	(4.026)	(3.077)
Obs.	768	768	768	768	768	768	768
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.363	0.163	0.379	0.409	0.690	0.676	0.451

Notes: All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. Standard errors are clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

(4) Robustness Test 4: Endogeneity Test

We employ an instrumental-variable (IV) approach to address potential endogeneity in the relationship between geopolitical risk and firm-level IQP outcomes, particularly reverse causality (e.g., high-IQPI firms may be differentially exposed to geopolitical shocks) and measurement noise in the China-specific GPR series. The results are shown in Tab. 9. Specifically, we use the global GPR index excluding China-related events (denoted as *GPRC_avg_ex_Chn*) and its lag as instruments for the contemporaneous and lagged China-related GPR terms (GPR_CN and GPR_L1). The identifying assumption is that global geopolitical risk shocks unrelated to China primarily affect firms only through their impact on the China-related geopolitical risk environment faced by Chinese digital-economy firms, while being plausibly orthogonal to firm-specific time trends and macro controls. However, global geopolitical risk may still influence Chinese firms indirectly through global demand, financial conditions, or supply-chain transmission channels. Therefore, the IV strategy should be viewed as a supportive robustness design rather than a fully decisive causal identification.

https://doi.org/10.7441/joc.2026.02.01

Tab. 9 – Robustness Test 4: Endogeneity Test. Source: own research

	(1) *Y_IQPI*	(2) *Y_exp-cre*	(3) *Y_dem-out*	(4) *Y_sha-cfg*	(5) *Out_minus _Dem*	(6) *Cre_minus _Exp*	(7) *Cfg_minus _Sha*
z_GPR_t	-0.072	0.106	-0.114	-0.209	0.071	1.539**	-0.350
	(-0.39)	(0.64)	(-0.23)	(-0.84)	(0.17)	(2.51)	(-0.20)
z_GPR_{t-1}	-0.575***	-0.718***	-1.015***	0.012	1.476***	1.104	3.531***
	(-3.15)	(-3.52)	(-2.83)	(0.05)	(3.09)	(1.64)	(3.61)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	792	792	792	792	792	792	792
Kleibergen-Paap rk LM *p-value*	0.051	0.051	0.051	0.051	0.051	0.051	0.051
Kleibergen-Paap rk Wald F	14.76	14.76	14.76	14.76	14.76	14.76	14.76
Durbin-Wu-Hausman *p-value*	0.177	0.037	0.974	0.670	0.466	0.000	0.695

Notes: All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. *t-statistics* in parentheses. Standard errors are heteroskedasticity-robust and clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

The first-stage diagnostics provide strong evidence of instrument relevance. The Sanderson–Windmeijer first-stage F-tests for excluded instruments are highly significant, and the *Kleibergen-Paap rk Wald F* statistic equals 14.76, exceeding conventional weak-IV thresholds (e.g., the rule-of-thumb of 10) and indicating that weak-instrument concerns are unlikely to drive our 2SLS estimates. The Kleibergen-Paap rk LM under identification test yields a *p-value* of approximately 0.051, which is marginal at the 5% level but supports identification at the 10% level. Taken together, these statistics suggest that the excluded instruments are sufficiently predictive of the endogenous GPR regressors in our specification. We further report Durbin-Wu-Hausman (DWH) tests to assess whether the suspected endogenous regressors (GPR_t and GPR_{t-1}) can be treated as exogenous. The results indicate that endogeneity concerns are outcome-dependent. For the composite IQPI outcome, the DWH test fails to reject exogeneity ($p = 0.177$), suggesting that our baseline fixed-effects estimates for the overall IQPI are not driven by severe endogeneity. Accordingly, we interpret the IV results as complementary robustness evidence addressing reverse causality and measurement issues, rather than as a standalone identification strategy.

In contrast, for selected sub-dimensions and gap measures (e.g., *Y_exp-cre* with $p = 0.0369$, and *Cre_minus_Exp* with $p < 0.001$), the DWH tests reject exogeneity, implying that OLS/FE estimates for these outcomes may suffer from endogeneity bias. In these cases, we treat the IV results as preferred specification for outcomes. Importantly, across outcomes, the IV-2SLS estimates remain qualitatively consistent with the baseline patterns, thereby providing additional supportive evidence for the baseline findings.

4.5. Further analysis

(1) Heterogeneity Analysis for Different Digital Transformation Types

To capture heterogeneity within digitalization, we follow Wu et al. (2021) by decomposing firms' digital transformation into two broad dimensions: digital technologies (covering AI, Blockchain, Cloud-computing, and Big-data) and digital technology application (Application), which emphasizes the deployment of digital tools in operations and managerial processes.

Based on the component measures by Wu et al. (2021), we construct standardized indicators for the five dimensions and interact them with contemporaneous and lagged geopolitical risk, thereby identifying heterogeneous buffering effects across digital transformation types. Given the relatively small firm sample, we interpret these heterogeneity patterns conservatively and view them as indicative rather than definitive. The results are shown in Tab. 10.

Tab. 10 – Regression results with digitalization as a moderator: Different digital transformation types. Source: own research

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	AI	**Blockchain**	**Cloud-computing**	**Big-data**	**Application**
z_GPR_t	0.011	0.001	0.003	0.001	-0.019
	(0.07)	(0.01)	(0.02)	(0.01)	(-0.13)
z_GPR_{t-1}	-0.466***	-0.468***	-0.469***	-0.470***	-0.502***
	(-4.23)	(-4.19)	(-4.22)	(-4.22)	(-4.58)
Digital transformation type:					
Digital component (Z)	-0.488***	-0.010	-0.007	-0.150*	0.081
	(-5.08)	(-0.13)	(-0.12)	(-1.95)	(1.15)
Interactions with GPR:					
z_GPR_t × Digital component	0.047	-0.027	0.023	0.033	0.055
	(1.26)	(-1.02)	(0.61)	(1.13)	(1.50)
z_GPR_{t-1} × Digital component	0.083**	-0.041	0.028	0.040	0.127***
	(2.23)	(-1.40)	(0.80)	(1.51)	(3.97)
Controls	Yes	Yes	Yes	Yes	Yes
Obs.	750	750	750	750	750
Adj. R^2	0.364	0.356	0.355	0.355	0.364

Notes: All regressions include firm fixed effects and firm-specific time trends. Control variables (not reported for brevity) are presented in Tab. 1. *t-statistics* in parentheses. Standard errors are clustered by month (year-month). *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

The results indicate that the lagged geopolitical risk term exerts a significantly negative effect on firms' IQP forces (Y_IQPI). Importantly, this adverse impact is significantly attenuated for firms with stronger AI and application-oriented digitalization: the interaction terms z_GPR_{t-1}×AI and z_GPR_{t-1}×Application are significantly positive, suggesting that AI-enabled analytics and application-layer integration may translate external shocks into a faster "sense-analyze-respond" cycle. This pattern is consistent with the dynamic capabilities view, wherein resilience under heightened uncertainty depends on firms' sensing, seizing, and reconfiguring capacities (Teece, 2007). By contrast, blockchain/cloud-computing/big-data components may function more as general-purpose infrastructure whose buffering value materializes only when complemented by process redesign and organizational deployment. This may explain why these interaction estimates are weaker and less robust in our sample window. Overall, the heterogeneity evidence helps explain why the *average* buffering effect of digital transformation may appear limited, while suggesting that the stabilizing role primarily stems from AI and application deepening in our sample, providing mechanism-consistent support rather than contradicting the baseline findings (Wu et al., 2021; Mikalef et al., 2021; Dubey et al., 2021).

(2) Case Studies on Internal Reconfiguration

To further illustrate how the internal reconfiguration mechanism enables firms to cope with geopolitical risk and stabilize their IQP, we examine two real-world Chinese company cases: Hikvision and Contemporary Amperex Technology Co. Ltd. (CATL). Following case-study guidance (Yin, 1981; Eisenhardt, 1989; Eisenhardt & Graebner, 2007; Siggelkow, 2007), we

https://doi.org/10.7441/joc.2026.02.01

selected cases using four criteria and provided immediate verifiable evidence for each criterion. (1) Both cases exhibit salient geopolitical risk exposure, as the U.S. Entity List explicitly added Hikvision in October 2019 (also blacklisted in 2020, 2022, 2023, 2025), and CATL's overseas expansion and U.S.-linked licensing partnership have repeatedly faced policy scrutiny. (2) Both firms offer information-rich and verifiable disclosures, because Hikvision and CATL release full annual results as listed companies. (3) Both cases show observable internal reconfiguration actions, including R&D investment, supply chain and compliance arrangements, capacity placement, and partnership redesign, all of which are traceable in official texts. (4) The two firms represent industry heterogeneity, since they are from different industries, which helps us compare mechanism consistency across sectors.

Hikvision, a leading surveillance equipment provider, has been repeatedly targeted by geopolitical actions (especially the US-China tech tensions), including being placed on U.S. trade blacklists and export control lists. This raises uncertainty for cross-border technology access and supply arrangements. Initially, we saw contractual and organizational boundary adjustments under external scrutiny. In December 2024, Hikvision disclosed exiting five Xinjiang-related contracts through five subsidiaries added to a U.S. blacklist in 2023, with those units' ceasing operations. Public disclosures suggest at least three internal reconfiguration channels: 1) Supply-chain and risk-control arrangements - In its 2025 half-year report, Hikvision states that geopolitics have continuously impacted the global supply system and that it "strives to develop a diversified supply network and maintain reasonable inventory levels." It also notes strengthened risk control and resource-allocation adjustments under geopolitical risks. 2) R&D investment and capability building - Hikvision disclosed RMB 11.86 billion in R&D spending in 2024, equivalent to 12.83% of revenue, up from 11.80% in 2022. This indicates that the firm continued to prioritize capability building as external uncertainty increased. 3) Business-mix rebalancing - Hikvision increasingly emphasized innovation-oriented businesses as a new growth engine, against the backdrop of heightened uncertainty for overseas revenue prospects. For 2023, it reported overseas revenue of RMB 28.97 billion (32.42% of total revenue) and innovative business revenue of RMB 18.55 billion (20.77% of total revenue). For 2024, it reported international main business revenue of RMB 25.99 billion (28.10% of total revenue) and innovative business revenue of RMB 22.48 billion. Together, these disclosures suggest a reallocation of strategic attention toward innovation-led business lines while managing exposure to external markets. These facts can be read as observable manifestations of internal reconfiguration: under heightened uncertainty, the firm reallocates resources toward supply-chain resilience, compliance and risk control, while sustaining R&D. Such actions are logically consistent with preserving the innovation and efficiency foundations of IQP. In terms of observable outcomes, Hikvision reported revenue of RMB 92.49 billion in 2024 (+3.52% YoY), suggesting that it maintained operational scale despite persistent external constraints.

CATL, the world's largest EV battery maker, sits at the heart of the global electric vehicle supply chain. Because EV batteries are highly globalized, policy and geopolitical shifts quickly influence firms' location and partnership choices. In this context, we observed three internal reconfiguration channels: 1) European capacity replacement - CATL announced that its Thuringia (Germany) plant kicked off cell production in December 2022, disclosing an initial permitted capacity of 8 GWh/year, planned capacity of 14 GWh, and total investment up to €1.8 billion. In August 2022, it announced a €7.34 billion investment to build a 100 GWh plant in Debrecen, Hungary. 2) Iterative adjustment of partnership structures under policy constraints - In North America, CATL participated in the value chain primarily through technology-licensing and partnership arrangements rather than direct exports. In 2023, it announced a battery project in Michigan with an investment of USD 3.5 billion and a technology-cooperation setup with a local partner. In 2024, the project was scaled down, with planned capacity reduced from 35 GWh to 20 GWh and expected jobs reduced from 2,500 to 1,700. This adjustment reflects flexible changes in investment scale, governance arrangements, and the boundary of collaboration in response to heightened policy uncertainty. 3) Strengthening resource security while building a closed-loop recycling system - Beyond capacity placement, CATL sought to reduce exposure to critical-mineral volatility through upstream resource and recycling initiatives. For example, in April 2022, it disclosed the Indonesia EV Battery Integration Project, with a joint investment of about US$5.968 billion, spanning nickel mining and processing, battery materials, battery manufacturing, and battery recycling. This vertically integrated design can be interpreted as a form of internal reconfiguration that buffers external supply risks and stabilizes production inputs.

Hikvision and CATL operate in different industries, yet a similar pattern emerges. The experiences of Hikvision and CATL demonstrate that when faced with external geopolitical risks, firms can leverage internal reconfiguration mechanisms to absorb shocks and keep their IQP steady or improve it. Hikvision focused on internal market and supply-chain adjustments, while CATL emphasized global capacity deployment and technology diversification. Their specific approaches differed, but both showcased dynamic capabilities. Hikvision applied AI technology to develop new application scenarios, and CATL utilized digital management to coordinate its global production network. These cases illustrate how digitalization can empower internal reconfiguration and enhance resilience to risk. Altogether, they provide illustrative support for our theoretical model: firms can rely on strategic internal resource reallocation and capability-building to navigate geopolitical turbulence, thereby continuing to drive innovation and sustain competitive advantage in an uncertain world.

5 CONCLUSION

This study investigates the impact of geopolitical risk on firms' innovation-led quality productivity, conceptualized as IQP, and examines whether digital transformation helps firms withstand such external shocks. Using a comprehensive firm-level panel dataset and a decomposed IQPI framework, we provide micro-level evidence on how geopolitical shocks translate into changes in innovation creation, market realization, and their internal–external alignment.

Firstly, we find strong evidence that geopolitical risk events adversely affect firms' innovation-related productivity, with the largest deterioration concentrated in the demand and market-realization dimensions. This pattern is consistent with the broader macro evidence that geopolitical risk foreshadows weaker real activity and investment conditions (Caldara & Iacoviello, 2022), and with firm-level political risk research emphasizing how uncertainty reshapes corporate decision environments and outcomes (Hassan et al., 2019). Simultaneously, our sub-index and gap results clarify mixed innovation responses to geopolitical risk. Several studies document that geopolitical risk may coincide with higher innovation inputs, patenting under threat, or competition incentives (Jia et al., 2022; Wang & Wang, 2024), and supply-chain transmitted risk can stimulate R&D intensity under specific conditions (Huang et al., 2025). Our evidence suggests a reconciliation: firms may display a short-run creation response or a temporary expectation-creation divergence, yet the dominant drag is derived from demand

https://doi.org/10.7441/joc.2026.02.01

contraction and weaker commercialization. In other words, innovation may still occur, but it becomes harder to be absorbed and monetized, thereby reducing IQP on net.

Secondly, we document that geopolitical risk is associated with widening internal-external imbalances. A novel aspect of our analysis is examining the Creation-Expectation and Output-Demand gaps. We observe that following a geopolitical shock, firms tend to increase internal configuration efforts even as outcomes decline, which manifests as a wider Configuration-Sharing gap. This is consistent with the emerging international business literature on de-risking and supply-chain adjustment under geopolitical rivalry (Yang et al., 2025) and on how geopolitical risk reshapes first-tier supply bases (Bai et al., 2025). This is also aligned with evidence that firms respond to global value chain reconfiguration by reorganizing sourcing and backshoring supply activities to reduce exposure (Barbieri et al., 2026). Our study shows that such internal strengthening at the firm level along with decomposed productivity indicators can coexist with weakening external realization. The resulting mismatch may erode the efficiency of innovation investment when internal efforts do not translate into market outcomes.

Thirdly, our analysis indicates that digital transformation, in its current form, offers only a limited buffer against the negative effects of geopolitical risk. This finding adds nuance to the growing evidence that digitalization can improve resilience in downturns and crises (Copestake et al., 2024) and digital adaptability and agility can strengthen supply-chain resilience (Dubey et al., 2023; Dubey et al., 2024). In our setting, however, digital intensity does not systematically offset the demand-side suppression that accompanies geopolitical shocks. Many digital initiatives are designed to enhance efficiency and growth under stable conditions, rather than to manage fragmentation and geopolitical disruption. Moreover, digitalization may deepen international linkages and exposure, making some firms more sensitive to geopolitical frictions. Related evidence shows digital transformation can promote outward investment, which may increase external exposure under geopolitical risk (Wen et al., 2024). Finally, digital reliance can introduce new vulnerabilities potentially altering firms' innovation strategies and increasing operational risks (Lattanzio & Ma, 2023). Taken together, our findings imply that the resilience value of digital transformation is conditional: it may help where it supports fast reconfiguration and coordination, but it does not shield against market contraction and geopolitical uncertainty.

These findings offer implications for both scholarship and practice. For researchers and policymakers, geopolitical risk should be considered an important factor influencing firm-level innovation and productivity. Traditional IQP studies focus on R&D investments, market competition, or policy supports. Our study shows that geopolitical stability is also important for sustaining innovation performance. Ensuring a stable international environment may thus be crucial for firms to fully realize their innovation potential. Moreover, as China promotes IQP as a national strategy, our evidence suggests that external risks could impede this strategy's success by disrupting the demand and utilization of new innovations. Policymakers might need to complement technology-push initiatives with measures to buffer firms against external shocks. For example, they may create stronger domestic demand buffers, support diversification of markets, or build risk-sharing mechanisms for innovation projects during turbulent times.

From a managerial perspective, the findings also yield several relevant implications for firms. First, firms can leverage digital tools to enhance supply chain resilience under geopolitical uncertainty. The adoption of real-time data analytics, AI-enabled demand forecasting, and

https://doi.org/10.7441/joc.2026.02.01

digitally coordinated supply chain systems can improve visibility and responsiveness, reducing vulnerability to external disruptions. Second, to mitigate R&D risks and sustain IQP, firms may increasingly rely on open innovation mechanisms, such as collaborative R&D platforms, strategic partnerships, and internal capability reallocation, rather than concentrating innovation efforts within isolated units. Third, firms facing elevated geopolitical exposure may consider diversified market layouts and selective localization strategies, including reconfiguring international market portfolios and strengthening regional partnerships, to reduce excessive dependence on specific countries or technologies. Together, these firm-level strategies complement internal reconfiguration and help translate IQP into longer-term competitiveness under geopolitical uncertainty.

Several limitations of this study should be acknowledged. First, the empirical analysis is based on a relatively small sample of innovation-driven digital economy firms located in the Yangtze River Delta region. While this setting allows for a focused examination of firms with high exposure to geopolitical risk and strong innovation intensity, it may limit the generalizability of the findings to traditional manufacturing sectors, small- and medium-sized enterprises, or firms operating in less developed regions. Accordingly, the conclusions are most applicable to digitally intensive firms in economically advanced areas. Future research could extend this framework to broader firm populations by incorporating more diverse industries, ownership structures, and regional contexts, particularly as firm-level, high-frequency data on IQP become more widely available. Furthermore, the current sample size does not permit credible ownership-based heterogeneity tests (e.g., SOEs vs. non-SOEs), which are deferred to future research with a broader firm sample.

Firms' responses to geopolitical risk are not confined to internal reconfiguration alone. As illustrated in our cases, firms may adopt different strategic pathways depending on their external exposure and capability base. Some firms prioritize supply chain diversification and localization to reduce critical dependencies. Others strengthen collaborative innovation and strategic partnerships to sustain innovation momentum under external constraints. Export-oriented and globally embedded firms may also adjust market portfolios and international positioning to mitigate geopolitical frictions. These strategic choices often operate in parallel with internal reconfiguration and jointly shape the trajectory of IQP and longer-term competitiveness. Future research could more systematically examine how different response portfolios complement or substitute internal reconfiguration across firm types and industries. Additionally, network-based exposure measures and transmission mechanisms could be explored. For example, recent work shows that geopolitical risk transmitted through supply-chain partners can have distinct effects on firm innovation investment (Huang et al., 2025), suggesting promising directions to combine firm-level exposure mapping with decomposed IQP indicators. Future studies may also disentangle specific digital capabilities and organizational complements, such as alliance management, supply-chain analytics, and digital agility, that effectively protect innovation-led productivity under geopolitical stress (Dubey et al., 2024).

In conclusion, this paper provides empirical evidence that rising geopolitical risks pose a tangible threat to firm-level IQP, primarily by curtailing market-driven outcomes and inducing misalignment between internal innovation efforts and external realization. Digital transformation, a key facet of modern productive forces, does not fundamentally overturn these risk effects, although it can modulate specific impact channels. These insights contribute to the understanding of how macro-level uncertainties filter down to micro-level innovation

https://doi.org/10.7441/joc.2026.02.01

performance. As geopolitical tensions persist, strengthening demand resilience, supply-chain robustness, and disruption-oriented digital capabilities will be essential for sustaining innovation outcomes and translating them into real productivity gains.

References

1. Ayadi, I., & Jahmane, A. (2025). The impact of economic policy uncertainty and digital integration on ESG practices in European companies. *Research in International Business and Finance*, 76, 102826. https://doi.org/10.1016/j.ribaf.2025.102826
2. Bai, X., Zhou, K. Z., Zhang, B., & Xie, E. (2025). The dual effects of geopolitical risk on MNCs' first-tier supply base: A political economy perspective. *Journal of International Business Studies*, 56(9), 1125–1149. https://doi.org/10.1057/s41267-025-00805-y
3. Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, 131(4), 1593-1636. https://doi.org/10.1093/qje/qjw024
4. Barbieri, P., Di Stefano, C., Elia, S., Fratocchi, L., & Pensa, C. (2026). Supply backshoring as a strategy to reduce transaction costs in an era of global value chain reconfiguration. *Journal of International Management*, 32(1), 101313. https://doi.org/10.1016/j.intman.2025.101313
5. Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of management, 17(1), 99-120.
6. Barney, J. B. (2001). Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of management review*, 26(1), 41-56.
7. Bernanke, B. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, 98(1), 85–106. https://doi.org/10.2307/1885568
8. Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica*, 77(3), 623-685. https://doi.org/10.3982/ECTA6248
9. Bloom, N. (2014). Fluctuations in uncertainty. *Journal of Economic Perspectives*, 28(2), 153–176. https://doi.org/10.1257/jep.28.2.153
10. Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American Economic Review*, 112(4), 1194-1225. https://doi.org/10.1257/aer.20191823
11. Copestake, A., Estefania-Flores, J., & Furceri, D. (2024). Digitalization and resilience. *Research Policy*, 53(3), 104948. https://doi.org/10.1016/j.respol.2023.104948
12. Dubey, R., Bryde, D. J., Blome, C., Dwivedi, Y. K., Childe, S. J., & Foropon, C. (2024). Alliances and digital transformation are crucial for benefiting from dynamic supply chain capabilities during times of crisis: A multi-method study. *International Journal of Production Economics*, 269, 109166. https://doi.org/10.1016/j.ijpe.2024.109166
13. Dubey, R., Bryde, D. J., Dwivedi, Y. K., Graham, G., Foropon, C., & Papadopoulos, T. (2023). Dynamic digital capabilities and supply chain resilience: The role of government effectiveness. *International Journal of Production Economics*, 258, 108790. https://doi.org/10.1016/j.ijpe.2023.108790
14. Dubey, R., Gunasekaran, A., Childe, S. J., et al. (2021). Empirical investigation of data

analytics capability and organizational flexibility as complements to supply chain resilience. *International Journal of Production Research*, 59(1), 110-128.

15. Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, 14(4), 532-550.
16. Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50(1), 25-32.
17. El Baz, J., Ruel, S., & Ardekani, Z. F. (2023). Predicting the effects of supply chain resilience and robustness on COVID-19 impacts and performance: Empirical investigation through resources orchestration perspective. *Journal of Business Research*, 164, 114025.
18. Guo, J., Sun, L., & Yang, X. (2024). How geopolitical risk affects firms' internationalization performance: Evidence from China. *Heliyon*, 10(9), e30152. https://doi.org/10.1016/j.heliyon.2024.e30152
19. Gulen, H., & Ion, M. (2016). Policy uncertainty and corporate investment. *Review of Financial Studies*, 29(3), 523-564. https://doi.org/10.1093/rfs/hhv050
20. Handley, K., & Limão, N. (2017). Policy uncertainty, trade, and welfare: Theory and evidence for China and the United States. *American Economic Review*, 107(9), 2731-2783. https://doi.org/10.1257/aer.20141419
21. Hassan, T. A., Hollander, S., Van Lent, L., & Tahoun, A. (2019). Firm-level political risk: Measurement and effects. *Journal of Finance*, 74(4), 1675-1726. https://doi.org/10.1111/jofi.12752
22. Huang, Z., Guo, Z., Chen, J., & Huang, J. (2025). Sharing weal and woe: Do geopolitical risks affect corporate innovation? A global supply chain perspective. *International Review of Financial Analysis*, 106, 104474. https://doi.org/10.1016/j.irfa.2025.104474
23. Ivanov, D. (2022). Digital supply chain management and technology to enhance resilience by building and using end-to-end visibility during the COVID-19 pandemic. *IEEE Transactions on Engineering Management*, 69(5), 1783-1796. https://doi.org/10.1109/TEM.2022.3141677
24. Ivanov, D., & Dolgui, A. (2021). A digital supply chain twin for managing disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control*, 32(9), 775-788. https://doi.org/10.1080/09537287.2020.1768450
25. Jia, S., Yang, L., & Zhou, F. (2022). Geopolitical risk and corporate innovation: Evidence from China. *Journal of Multinational Financial Management*, 66, 100772. https://doi.org/10.1016/j.mulfin.2022.100772
26. Jiang, K., Chen, L., Li, J. et al. (2025). The risk effects of corporate digitalization: exacerbate or mitigate? *Humanities and Social Sciences Communications*, 12, 317. https://doi.org/10.1057/s41599-025-04628-y
27. Julio, B., & Yook, Y. (2012). Political uncertainty and corporate investment cycles. *Journal of Finance*, 67(1), 45-83. https://doi.org/10.1111/j.1540-6261.2011.01707.x
28. Khatib, S. F. A., Abbas, A. F., Igwe, M. N., Yue, S., & Sulimany, H. G. H. (2025). Mind the tides: A systematic review of the geopolitical risk literature. *Politics & Policy*, 53(3), e70028. https://doi.org/10.1111/polp.70028

https://doi.org/10.7441/joc.2026.02.01

29. Kim, O. S. (2019). Does political uncertainty increase external financing costs? Evidence from U.S. gubernatorial elections. *Journal of Financial and Quantitative Analysis*, 54(5), 2141-2178. https://doi.org/10.1017/S0022109018001329
30. Lattanzio, G., & Ma, Y. (2023). Cybersecurity risk and corporate innovation. *Journal of Corporate Finance*, 82, 102445. https://doi.org/10.1016/j.jcorpfin.2023.102445
31. Lee, C.-C., Zhang, J., Yu, C.-H., & Fang, L. (2023). Geopolitical risk and corporate innovation in China. *Emerging Markets Finance and Trade*, 59(2), 498-513. https://doi.org/10.1080/1540496X.2022.2121682
32. Miao, S., & Hu, Y. (2025). Measurement of new quality productivity development level and factor identification of obstacle factors in China. *Sustainability*, 17(4), 1758. https://doi.org/10.3390/su17041758
33. Mikalef, P., Conboy, K., Krogstie, J. (2021). Artificial intelligence as an enabler of B2B marketing: A dynamic capabilities micro-foundations approach. *Industrial Marketing Management*, 98, 80-92.
34. Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy, 48*(8), 103773. https://doi.org/10.1016/j.respol.2019.03.018
35. Nose, M., Honda, J., et al. (2023). Firm-level digitalization and resilience to shocks: The role of fiscal policy. *IMF Working Paper* WP/23/95. https://www.imf.org/en/Publications/WP/Issues/2023/05/12/Firm-Level-Digitalization-and-Resilience-to-Shocks-The-Role-of-Fiscal-Policy-532600
36. Perotti, E. C., & Kulatilaka, N. (1998). Strategic growth options. *Management Science*, 44(8), 1021-1031. https://doi.org/10.1287/mnsc.44.8.1021
37. Porter M E. (1985). Competitive advantage: creating and sustaining superior performance. NY: *Free Press*.
38. Ren, X., Cao, Y., Liu, P. J., & Han, D. (2023). Does geopolitical risk affect firms' idiosyncratic volatility? Evidence from China. *International Review of Financial Analysis*, 90, 102843. https://doi.org/10.1016/j.irfa.2023.102843
39. Rumokoy, L. J., Omura, A., & Roca, E. (2023). Geopolitical risk and corporate investment in the metals and mining industry: Evidence from Australia. *Pacific-Basin Finance Journal, 79*, 101991. https://doi.org/10.1016/j.pacfin.2023.101991
40. Schulze, A., & Brusoni, S. (2022). How dynamic capabilities change ordinary capabilities: Reconnecting attention control and problem-solving. *Strategic Management Journal*, 43(12), 2447-2477.
41. Siggelkow, N. (2007). Persuasion with case studies. Academy of management journal, 50(1), 20-24.
42. Sun, H. (2024). New quality productivity, institutional environment and sustained firm innovation. *Review of Economic Assessment*, 3(4), 39. https://doi.org/10.58567/rea03040002
43. Teece, D. J. (2018). Business models and dynamic capabilities. *Long Range Planning*, 51(1), 40-49. https://doi.org/10.1016/j.lrp.2017.06.007
44. Teece, D. J., Peteraf, M., & Leih, S. (2016). Dynamic capabilities and organizational agility: Risk, uncertainty, and strategy in the innovation economy. *California*

Management Review, 58(4), 13-35. https://doi.org/10.1525/cmr.2016.58.4.13
45. Teece, D. J. (2007). Explicating dynamic capabilities: the nature and micro foundations of (sustainable) enterprise performance. *Strategic management journal*, 28(13), 1319-1350.
46. Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research, 122*, 889-901. https://doi.org/10.1016/j.jbusres.2019.09.022
47. Wang, X., & Wang, M. (2024). Geopolitical risk and corporate innovation: Evidence from risk preference and risk-taking capacity perspectives. *Economics Letters,* 241, 111820. https://doi.org/10.1016/j.econlet.2024.111820
48. Wen, Y., Tao, Y., & Tang, H. (2024). Geopolitical risk, digital transformation, and corporate outward foreign direct investment. *Finance Research Letters*, 69(Part A), 106171. https://doi.org/10.1016/j.frl.2024.106171
49. Wu, F., Hu, H., Lin, H., & Ren, X. (2021). Corporate digital transformation and capital market performance: Evidence from stock liquidity. *Management World*, 37(7), 130-144. https://doi.org/10.19744/j.cnki.11-1235/f.2021.0097 (In Chinese)
50. Xu, B., Zeng, J., & Watada, J. (2014). *Changes in production efficiency in China: Identification and measuring*. New York: Springer. https://doi.org/10.1007/978-1-4614-7720-4
51. Yang, B., Song, J., Wei, Y., & Li, J. (2025). Navigating geopolitical risks: How U.S. firms adjust supply chains amid U.S.-China rivalry. *Journal of International Business Studies,* 56(7), 937–949. https://doi.org/10.1057/s41267-025-00800-3
52. Yin, R. K. (1981). The case study as a serious research strategy. *Knowledge,* 3(1), 97-114.
53. Yue, S., Bajuri, N. H., Khatib, S. F. A., & Lee, Y. (2024). New quality productivity and environmental innovation: The hostile moderating roles of managerial empowerment and board centralization. *Journal of Environmental Management*, 370, 122423. https://doi.org/10.1016/j.jenvman.2024.122423
54. Zhang, X., Zhu, K., & Tong, J. (2021). Digital transformation and firm performance: Evidence from China's listed companies. *China Industrial Economics*, 2021(5), 137-155. (In Chinese)
55. Zheng, M., Liu, X., & Huang, D. (2020). Economic policy uncertainty and corporate innovation: Empirical evidence from China. *Frontiers of Economics in China*, 15(3), 496-518. https://doi.org/10.3868/s060-009-020-0003-8
56. Zheng, Y. (2024). How to scientifically understand "new quality productivity". *Bulletin of Chinese Academy of Sciences*, 39(5), 797-803. https://doi.org/10.16418/j.issn.1000-3045.20240406004

Contact Information

Dan Luo, Ph.D.
a. Hangzhou Normal University
Alibaba Business School
China
b. Hangzhou City University
ESG and Sustainable Development Research Center
China
E-mail: luodan@hznu.edu.cn

Yiran Wang
c. Hangzhou Administration for Financial Regulation
China
E-mail: OliviaWANG7720@163.com

prof. Yong Chen, Ph.D. (Corresponding Author)
b. Hangzhou City University
ESG and Sustainable Development Research Center,
China
d. Hangzhou City University
School of Business,
China
E-mail: chenyong@hzcu.edu.cn

https://doi.org/10.7441/joc.2026.02.01

Appendix A

Table A

Framework of Innovation-led Quality Productivity Index (IQPI).

<table>
<tr><th>First-order</th><th>Second-order</th><th>Third-order</th><th>Fourth-order</th></tr>
<tr><td rowspan="6">IQPI (composite)</td><td rowspan="2">Expectation-Creation Index</td><td>Expectation Index</td><td>Expectation Rate</td></tr>
<tr><td>Creation Index</td><td>Creation Rate</td></tr>
<tr><td rowspan="2">Demand-Output Index</td><td>Demand Index</td><td>Demand Rate</td></tr>
<tr><td>Output Index</td><td>Output Rate</td></tr>
<tr><td rowspan="2">Sharing-Configuration Index</td><td>Sharing Index</td><td>Sharing Rate</td></tr>
<tr><td>Configuration Index</td><td>Configuration Rate</td></tr>
</table>

Following Xu et al. (2014), the construction adopts a nonparametric identification framework. At the bottom level, a time-varying partially linear specification decomposes each module into a linear component and a non-linear component. The construction follows the formulation (1) below:

$$Y(t) = g(t) + \sum_{i=1}^{n} a_i\,(t)\,Y_i(t) + \varepsilon(t) \qquad (1)$$

In which $g(t)$ is the non-linear component, and $\sum_{i=1}^{n} a_i\,(t)\,Y_i(t) + \varepsilon(t)$ is the linear component. The linear component is normalized to form expectation, demand, and sharing rates. The non-linear component is represented by g_{it}, and the corresponding quality-oriented rate is constructed as $G_{it} = \exp(-g_{it})$, yielding creation, output, and configuration rates. The underlying firm-level data for each indicator and their scaling are shown in Table B.

Table B

Construction of Fourth-Order Rates and Aggregation Scheme of the Innovation-led Quality Productivity Index (IQPI).

Fourth-order indicator	Underlying firm-level data (monthly)	Linear vs. Non-linear component	Scaling
Expectation rate	Market value	Linear component (normalized)	[0,1]
Creation rate	Market value	Non-linear component	[0,1]
Demand rate	Revenue	Linear component (normalized)	[0,1]
Output rate	Revenue	Non-linear component	[0,1]
Sharing rate	Tax	Linear component (normalized)	[0,1]
Configuration rate	Tax	Non-linear component	[0,1]
Third-/Second-order indices	Aggregated fourth-order rates	Nonparametric path-converged aggregation (Xu et al., 2014)	[0,100]
Composite IQPI	Aggregated higher-order indices	Joint structural design (Xu et al., 2014)	[0,100]

All fourth-order rates are normalized to the interval [0,1], and all higher-order indices (third-order, second-order, and composite IQPI) are linearly scaled to the interval [0,100]. June 2020 serves as the normalization benchmark for tracking relative monthly dynamics.

https://doi.org/10.7441/joc.2026.02.01

The bottom-up aggregation from fourth-order rates to first-order indices follows the nonparametric path-converged technique in Xu et al. (2014), allowing the data structure to determine relative weights without subjective assignment. Subsequently, a joint structural design connects the first-order indices top-down to generate the second-order indices and the composite IQPI.

The structural gap indicators are defined as simple differences between the corresponding fourth-order rates:

Output-Demand gap = Output rate - Demand rate

Configuration-Sharing gap = Configuration rate - Sharing rate

Creation-Expectation gap = Creation rate - Expectation rate

All gap measures therefore reflect short-run imbalances between paired dimensions and inherit the scaling properties of the underlying rates.

Appendix B

Table A
Name List of Companies

Company Name	ID code
Dahua Technology	002236.SZ
Hikvision	002415.SZ
EASTmoney	300033.SZ
Silan Microelectronics	600460.SH
Hundsun Technologies	600570.SH
Wolong Electric Drive	600580.SH
Joyson Electronics	600699.SH
TaxFriend	603171.SH
ArcSoft	688088.SH
Foscam	688475.SH
Supcon Technology	688777.SH
Changchuan Technology	300604.SZ

https://doi.org/10.7441/joc.2026.02.01

Appendix C

Table A
Pearson correlation matrix.

	(1) *Y_IQPI*	(2) GPR_t	(3) GPR_{t-1}	(4) *ppi_industry*	(5) *usd_cny*	(6) *export_share*	(7) *IIP*	(8) *TariffRatio*	(9) *LPR*	(10) *PMI*
Y_IQPI	1.000									
GPR_t	-0.054	1.000								
GPR_{t-1}	-0.197^{***}	0.480^{***}	1.000							
ppi_industry	0.135^{***}	0.086^{*}	0.049	1.000						
usd_cny	-0.216^{***}	0.032	0.114^{**}	-0.663^{***}	1.000					
export_share	-0.183^{***}	0.011	0.012	-0.067	0.007	1.000				
IIP	0.226^{***}	0.025	-0.264^{***}	-0.025	-0.183^{***}	-0.006	1.000			
TariffRatio	-0.064	-0.158^{***}	-0.190^{***}	0.125^{***}	-0.448^{***}	-0.005	0.127^{***}	1.000		
LPR	-0.091^{*}	-0.167^{***}	-0.182^{***}	0.328^{***}	-0.628^{***}	-0.004	-0.062	0.696^{***}	1.000	
PMI	0.158^{***}	-0.080^{*}	-0.383^{***}	-0.003	-0.174^{***}	-0.005	0.482^{***}	-0.013	0.009	1.000
Obs.	792	792	792	792	792	792	792	792	792	792