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How Will Geopolitical Risk Play Its Role in the Global Value Chain?

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ABSTRACT

The construction of the Global Value Chain (GVC) has benefited the global economy. However, while geopolitical risk has been believed to affect trade and investment volumes, does it truly impact countries' integration into the Global Value Chain? In this article, we develop a theoretical framework to explore the impact of geopolitical risk on GVC participation and how 'internal' and 'external' forces will moderate it. Then, we construct a geopolitical risk index by applying the bipartite network with a combination of the Fitness and Complexity (FC) algorithm and Matrix-Estimation exercise. Based on this, we conduct empirical studies based on data encompassing 77 countries from 1995 to 2020. The results show that geopolitical risk indeed hinders the enhancement of GVC participation, but financing convenience actually alleviates such hindrance; meanwhile, political alignment and media attention, as external forces, moderate the negative impact of geopolitical risk on GVC participation, both directly by affecting the geopolitical risk, or by indirectly influencing the alleviating role of financing convenience.

JEL Classification: F4, P45

1 | Introduction

The 'World without Borders' has ushered us into the 'Age of Global Value Chains' (Robertson and White 2007). Over the past few decades, globalisation has led to substantial expansions in trade and significant gains in efficiency (World Bank 2019). In order to generate value added in goods and services, the global production network—linking processes such as production, distribution and recycling—has gradually taken shape, which is what we refer to as the Global Value Chain (GVC). However, on the other hand, differences in the extent of countries' participation in the GVC have increasingly produced a 'Matthew Effect', shaping an ever more unequal world. States and groups that have failed to benefit from GVC participation have grown sceptical of, or even resistant to, globalisation, which has been epitomised by the rise of far-right parties in certain countries and the supporters of the 'Trump 2.0' era (Dür et al. 2020; Faber 2024). Moreover, globalisation has been criticised for being oversold, which has caused serious political consequences, for example, exacerbating local wealth disparities and fostering socioeconomic inequity (Castañeda and Shemesh 2020). It has also been associated with the diffusion of various forms of risk and the intensification of global tension (LiPuma and Lee 2004), which implies a heightened threat of global economic fragmentation, especially for countries situated along geopolitical fault lines.

Russia's invasion of Ukraine constitutes the most severe geopolitical crisis to emerge in Europe since World War II (Dodds et al. 2023; Liu and Lee 2025). Nevertheless, such an episode is far from isolated: the global political landscape has since undergone dramatic upheavals. In the Middle East, where critical maritime chokepoints (e.g., the Suez Canal, the Bab el-Mandeb Strait and the Strait of Hormuz) are totally controlled by Islamic countries, longstanding sectarian rivalries between Sunni and Shia groups, as well as the enduring Israeli–Palestinian conflict, have perpetuated regional instability (Miller 1 2006). In

Latin America, disputes between Venezuela and Guyana (also Colombia), the Nicaragua–Colombia border conflict and persistent tensions between the Dominican Republic and Haiti have become key geopolitical flashpoints.[1] In Africa, military coups have surged in frequency,[2] and Sudan, at present, is witnessing one of the largest massacres of the twenty-first century.

Due to the abrupt onset and broad destructive impact, geopolitical tensions constrain channels of financing accommodation, increase firm-level operation and decision-making costs, and ultimately lead to a contraction of investment at the intensive margin while delaying firms' expansion decisions at the extensive margin (Huynh et al. 2024). A large body of research has documented their adverse effects on bilateral trade flows, foreign investment volumes and macroeconomic performance (Caldara and Iacoviello 2022; Cevik 2023). More importantly, under heightened geopolitical tension, firms may find it optimal to reduce R&D with high sunk costs in products and downgrade product quality, which will substantially erode not only the economic foundations and capabilities but, more crucially, the willingness of nations to participate in GVCs.[3]

An even more critical question concerns how states can design effective policy instruments to mitigate these negative impacts. Countries experiencing military takeovers often confront economic sanctions and exclusion from international financial institutions.[4] Meanwhile, rational investors and multinational corporations tend to withdraw from, or adopt a wait-and-see attitude toward, high-risk regions (Lu and Liu 2024). Consequently, geopolitical tensions severely diminish the availability of external financing. In such circumstances, government efforts to relax financial constraints and provide higher levels of financing facilitation may serve as an effective policy response.

From an external perspective, the very term geopolitical risk implies that such risks are inherently relational—arising from interactions among geopolitical entities—making a stable external environment particularly vital. Political alignment, especially multilateral cooperation mechanisms, has thus been increasingly expected to act as stabilising forces (Thongsawang 2025). On the other hand, media coverage, which is usually shaped by outlets' own geopolitical positions or editorial biases, tends to exhibit selective preferences in reporting geopolitical events (Rimpiläinen 2020), potentially amplifying perceived risks. Therefore, examining the interaction between external factors and domestic policies will also be essential. When the effectiveness of domestic policy is constrained, are there sufficiently robust external substitutes to provide support? Conversely, how should domestic policy respond, or be designed to respond, to the negative externalities generated by geopolitical risks?

Therefore, we aim to explore how geopolitical risk affects countries' participation in the GVC and how such effects are moderated by both 'internal forces' and 'external forces' by constructing a theoretical model. Subsequently, empirical analyses on sample data from 77 countries spanning from 1995 to 2020 are conducted to seek to provide evidence-based support. The findings align with the expectations of the theoretical model presented in this article, as geopolitical risk indeed manifests a negative impact on GVC participation, while financing convenience helps mitigate such an obstacle to GVC participation enhancement. Moreover, political alignment and media attention, as the 'external forces', have also been proven to manifest both direct and indirect moderating effects.

This article makes contributions in several aspects: First, we establish a baseline model exploring how geopolitical risk impacts GVC participation with its transmission mechanisms. Second, by employing the bipartite network framework, we construct the geopolitical risk indicator, which allows us to account for 'heterogeneity' and 'interconnectedness'. Third, we construct a conceptual bridge to analyse the interaction between 'internal' and 'external forces', which enables us to investigate how these forces jointly shape engagement in the GVC, thereby generating more insightful and policy-relevant implications.

The remainder of this article will be structured as follows. Section 3 presents the details of the theoretical model. Section 4 outlines the specific settings of the empirical analyses. In Section 5, this article analyses and discusses the empirical results. Last, Section 6 offers concluding remarks and presents corresponding policy recommendations.

2 | Literature Review

Characterised by cross-regional resource allocation and multistage production coordination (Kersan-Škabić 2019), the Global Value Chain has become the backbone and central nervous system of the world economy (Cattaneo et al. 2010). Securing an advantageous position in the GVC, and thereby continuously benefiting from global production, has long been a central concern for many economies. A large body of research on domestic production factors and industrial policy suggests that higher levels of GVC participation can generally be attributed to stronger factor endowments, greater industrial capacity, higher inflows of FDI, greater human capital input, stronger technological innovation capability, higher domestic institutional quality, more developed financial markets and more open trade policies (Antràs and De Gortari 2020; Ge et al. 2020; Okah Efogo et al. 2022; Reddy et al. 2021; Yameogo and Jammeh 2019). Such factors are typically associated with lower production and trade costs, better protection of intangible assets, the establishment of technological and trade networks, overcoming the complexities and relative scarcity of technology and knowledge, and higher product differentiation (Amador and Cabral 2016; Antràs 2015; Fernandes et al. 2022; Hoekman 2014). From the perspective of external stability and regional coordination, Regional Trade Agreements (RTAs), regional integration and improved service accessibility are all effective mechanisms for reducing trade barriers among member states (Antràs 2020; Fan et al. 2024), which have been shown to significantly promote economies' participation in the GVC (Amador and Cabral 2016).

With escalating international conflicts, regulations and sanctions, geopolitical tensions appear to be pushing globalisation towards 'fragmentation' (Caldara and Iacoviello 2022). As a network-based production paradigm, GVCs are inherently rooted in geographic interactions across countries, making them vulnerable to geopolitical shocks. Heightened geopolitical risks raise energy prices, exacerbate inflation, impede investment and distort national trade flows, with capital controls and sanctions

further undermining supply-chain resilience (Li et al. 2025; Wang et al. 2022). Firms, as the core units operating within the GVCs, also face elevated uncertainty that significantly affects operational efficiency and profitability (Barro and Ursúa 2012).

Given the cross-regional and multi-stage nature of the GVC, particularly the fact that GVC activities require firms to engage in multiple cross-border operations,[5] the costs of trade activities and the associated financial liquidity are undoubtedly fundamental prerequisites for GVC participation. Understanding how economies embed themselves into the GVC thus requires close attention to the role of financing convenience. Indeed, GVC participation commonly involves building cross-border supply-chain networks, securing foreign certifications and standards, engaging in cross-border logistics and coordinating digitalised supply-chain operations (Statsenko et al. 2025; Zaninović and Bugarčić 2023)—all of which hinge on robust financing capacity. Under geopolitical strain, higher financing convenience reduces funding thresholds and costs, prevents disruptions in production, logistics and trade arising from liquidity shortages (Nemat et al. 2025), and helps firms maintain supply-chain layouts and market positions while preserving buffer capacity against future shocks (Guizani 2024). Accordingly, domestic policies that enhance financing convenience, thereby helping to activate resource and capital mobility, constitute a potentially important tool for mitigating the adverse effects of geopolitical tensions.

However, for being shaped by interactions among diverse actors, unilateral domestic financial measures alone may be insufficient to offset the adverse impact of geopolitical risks, making it necessary to consider external sources of stabilisation. In recent years, regional cooperation and economic integration have gained increasing prominence. Favourable political relations—particularly institutionalised political alignment with coordination mechanisms—are widely recognised as an important external stabiliser (Bhaumik et al. 2025).[6] Through mechanisms, for example, emergency trade channels, temporary tariff reductions and multilateral agreements (Jiang and Yu 2021); as well as collective security or economic-assistance arrangements, political alignments facilitate resource integration, strengthen regional value-chain resilience (Kano et al. 2020) and buffer geopolitical shocks originating outside the alignment. Political relationships have also long been considered an important factor influencing the flow of capital (Portes and Rey 2005). Trade and capital barriers largely stem from information asymmetries and external transaction costs, which intensify as political relations deteriorate (Kempf et al. 2023). Political proximity, whether ideological or institutional, tends to increase intergovernmental cooperation and interdependence, reduce information asymmetries and policy uncertainty, thereby lowering financing costs and improving firms' access to project funding (Aiyar et al. 2024). Examining the interaction between external political stability and domestic financial policies is thus essential for understanding how economies integrate into regional and global production systems.

Meanwhile, as an increasingly central conduit for political information, the media acts as a powerful amplifier of political risk (Bryce et al. 2025). Media dynamics have also become closely associated with the rise of populism.[7] In contrast to political alignment, media attention represents a potentially 'harmful' factor. Although media coverage may enhance transparency and reduce agency costs (Jensen and Johnston 2011), the inherent instability and loss-oriented characteristics of geopolitical risks provide fertile ground for sensationalised narratives. This amplification heightens creditors' risk assessments and induces more cautious responses (Atri et al. 2021; Cheng et al. 2024). Media coverage shapes public perceptions of risk, transmits signals to investors and exacerbates negative market sentiment (Kumar and Thussu 2023), thereby raising forward-looking decision costs and disrupting the entire value chain. Elevated media attention typically reduces market stability and investor confidence, increases the opportunity cost of holding capital and raises external financing costs (Dang et al. 2022), potentially outweighing any benefits from reduced information asymmetry (Tetlock 2007). Understanding how domestic policies respond to such negative external forces is therefore crucial during periods of geopolitical tension.

Most existing research examines how domestic factors drive improvements in GVC participation, which are largely associated with capacities for factor input and industrial output, thus placing strong demands on the effectiveness of domestic policies. However, evidence from initial endowments and established regional patterns suggests that external environmental or institutional factors also play an inescapable role in shaping participation in the GVC. Apart from a limited set of empirical studies on regional trade policies, the existing literature lacks a systematic examination of external drivers. In particular, most studies treat the internal and external determinants of GVC participation in isolation. This leaves us unable to understand how domestic policies interact with external conditions to jointly shape countries' GVC-related behaviour, or how domestic policies respond to external shocks. Such omissions substantially limit the policy insights that can be derived from the current literature.

3 | Theoretical Model

In order to investigate how geopolitical risk affects participation in the Global Value Chain, we aim first to construct a partial equilibrium model so as to provide theoretical support for empirical studies in the following text. GVC participation is generally believed to be related to the capability of producing high-value-added products, which involves high input–output ratios, technology- or capital-intensive, profitable and high-quality (Antràs 2020). Such production activities are typically located at the high-value-added end of the value chain, enabling entities to benefit from GVC participation (Ndubuisi and Owusu 2021). Therefore, in this section, we aim to construct the theoretical framework by embedding product quality and geopolitical risk while also incorporating the interaction of financing convenience.

3.1 | Quality Preference

A common approach to incorporating product quality into the equilibrium framework is to introduce a quality parameter into the consumer's utility function. In this case, consumer utility is determined not only by the quantity of the product but also by the quality (Feenstra et al. 2014).

Beyond this, foreign demand is also considered to be further adjusted by a trade discount factor, commonly formalised as the 'iceberg trade cost' in trade models, which introduces a wedge between foreign and domestic demand (Hallak and Sivadasan 2013). Iceberg trade costs are usually considered important and constitute a component of the price of high-quality goods (Hummels and Skiba 2004); and critically, iceberg costs are typically assumed to depend on product quality as well (Hallak and Sivadasan 2009). Accordingly, the consumer's utility function reflects its relations with product quality via two distinct aspects.

By assuming the utility takes the Constant Elasticity of Substitution (CES) form, the utility of a representative consumer in destination country j, who has access to a certain variety v included in a set of goods $\mathbb{V}_j$, can be expressed as:

$$\mathcal{U}_j = \left[\int_{v \in \mathbb{V}_j} \omega_{ij} \left(\frac{\xi_{ij}}{\delta_{ij}} x_{ij} \right)^{\rho} dv \right]^{1/\rho} \tag{1}$$

where:

- i and j denote the resource (exporting) country and the destination (importing) country, respectively;
- ρ denotes the substitution parameter meeting $\rho < 1$;
- ω_{ij}, that is, $\omega_{ij}(v)$, denotes the share parameter of variety v, meeting $\omega_{ij} \geq 0$ and $\int_{v \in \mathbb{V}_j} \omega_{ij} dv = 1$;
- ξ_{ij} and x_{ij}, that is, $\xi_{ij}(v)$ and $x_{ij}(v)$, denote the quality and quantity of variety v, respectively;
- δ_{ij}, that is, $\delta_{ij}(\xi)$ denotes the discount factor related to the quality ξ; meanwhile, δ_{ij} should also be continuous, twice differentiable and non-increasing with respect to ξ, that is, $\delta' \leq 0$. This assumption will help ensure the traceability of the iceberg trade cost, and its essence is conceptually related to a reduced form of the Alchian–Allen effect (Lugovskyy and Skiba 2015).

For a representative consumer in destination country j, the budget constraint E_j implies that the following condition holds:

$$\int_{v \in \mathbb{V}_j} p_{ij} x_{ij} dv \leq E_j \tag{2}$$

where:

- p_{ij}, that is, $p_{ij}(v)$, denotes the price of variety v;
- $\sigma = \frac{1}{1-\rho}$ is the elasticity of substitution;
- E_j denotes the budget constraint of the consumer.

Given a specific product quality, the representative consumer will choose a specific quantity of the product to maximise utility, under the budget constraint. Assuming that such an optimisation problem admits an interior solution, the optimal quantity x_{ij} can be derived using the method of Lagrange multipliers. Then, the optimal quantity will meet the following condition:

$$x_{ij} = \frac{\omega_{ij}^{\sigma} p_{ij}^{-\sigma}}{\mathcal{P}_j^{1-\sigma}} \left(\frac{\xi_{ij}}{\delta_{ij}} \right)^{\sigma-1} E_j \tag{3}$$

where $\mathcal{P}_j = \left[\int_{v \in \mathbb{V}_j} \omega_{ij}^{\sigma} \left(\frac{\xi_{ij}}{\delta_{ij}} \right)^{1-\sigma} p_{ij}^{1-\sigma} dv \right]^{\frac{1}{1-\sigma}}$ denotes the aggregate price index in the CES form.

3.2 | Production Strategy

We have incorporated product quality into the consumer utility framework in the preceding discussion. Accordingly, it means that, while considering firms' production decisions, product quality should likewise be taken into account. Actually, while introducing product quality, for a firm, production activities entail two processes: quantity-producing and quality-creating.

First, the process of producing quantity is typically associated with variable costs, namely, at a given output level and factor prices, the firm's production decisions will be minimising variable costs (Hallak and Sivadasan 2013). Thus, by assuming the Cobb–Douglas form and constant returns to scale, the production function with process productivity ϕ can be written as:[8]

$$Y = f(K, L, M) = \phi K^{\alpha} L^{\beta} M^{\zeta} \tag{4}$$

where:

- K, L and M denote capital, labour force and intermediate input, respectively;
- α, β and ζ denote the output elasticity of each factor, meeting $\alpha, \beta, \zeta > 0$;
- $\alpha + \beta + \zeta = 1$, which denotes constant returns to scale.

Then, the unit variable costs c of production with quality ξ for the quantity-producing process at a given output level can be solve by linear programming, which can be finally expressed as:

$$c(\xi) = \frac{1}{\phi} r^{\alpha} w^{\beta} \varrho^{\zeta} \xi^{\mu} \tag{5}$$

where:

- $r = \frac{p_K}{\alpha}$, $w = \frac{\widetilde{p_L}}{\beta}$ and $\varrho = \frac{\widetilde{p_M}}{\zeta}$. Thereinto, p_K, p_L and p_M denote the price of each factor.
- $\mu = \beta \varpi_L + \zeta \varpi_M$, meeting $\varpi_L, \varpi_M > 0$. Here, in order to introduce the product quality ξ into the optimisation process of a firm, it will be a feasible approach to assume that the price p_L and p_M for the factors of labour force L and intermediate input M are quality-related, namely, a firm should pay average quality-related wage $p_L = \widetilde{p_L} \xi^{\varpi_L}$ for labour force and pay average quality-related purchasing price $p_M = \widetilde{p_M} \xi^{\varpi_M}$ for intermediate inputs bundle.

The unit variable cost presented by Equation (5) actually encompasses product quality, implying the optimal unit variable cost

chosen by a firm to produce a specific quantity of products at a given product quality ξ.

Second, besides quantity-producing, production activities also involve the process of quality-creating, incurring fixed costs (Sutton 2007), which are seen to be related to product R&D costs or costs associated with implementing control systems to prevent item defects (Syverson 2011). Analogous to quantity-producing, 'creating' quality can be seen to require inputs of the labour force, capital and intermediate input combined within the production function in the Cobb–Douglas form with product productivity φ. Such a cost can be represented as the same exponents with quantity-producing but allows non-constant returns to scale (Hallak and Sivadasan 2009):

$$\xi = g(K, L, M) = \left(\varphi K^{\alpha} L^{\beta} M^{\zeta}\right)^{1/\iota} \tag{6}$$

where:

- K, L and M still denote capital, labour force and intermediate input; and α, β and ζ still denote the their corresponding output elasticity meeting $\alpha, \beta, \zeta > 0$.
- $\alpha + \beta + \zeta = 1$ and $\iota > 0$, which allows non-constant returns to scale.

Worthy mentioning, the input factors K, L and M, with their corresponding output elasticity, in two different processes are consistent, insuring that their optical inputs in such two processes remain unchanged. The differences between them and between different firms are derived from process and product productivity, as well as the non-constant returns to scale parameter ι.

Then, the summative fixed cost F of production with quality ξ for the quality-creating process can be also solve by linear programming, which can be finally expressed as:

$$F(\xi) = F_0 + \frac{1}{\varphi} r^{\alpha} w^{\beta} \varrho^{\zeta} \xi^{\eta} \tag{7}$$

where:

- F_0 denotes other fixed costs unrelated to product quality;
- $r = \frac{p_K}{\alpha}$, $w = \frac{\widetilde{p_L}}{\beta}$ and $\varrho = \frac{\widetilde{p_M}}{\zeta}$;
- $\eta = \iota + \beta\varpi_L + \zeta\varpi_M$. Here, as mentioned above, we still designate the quality-related prices $p_L = \widetilde{p_L}\xi^{\varpi_L}$ and $p_M = \widetilde{p_M}\xi^{\varpi_M}$.

In fact, the two costs $c(\xi)$ and $F(\xi)$, both positively correlated with quality, meet intuition, as they mainly depend on the quality-correlated prices p_L and p_M, namely, $\varpi_L > 0$ and $\varpi_M > 0$ essentially imply that to produce higher-quality products, both labour and intermediate input factors need to be paid higher prices.

3.3 | Equilibrium Price

The relevant factors can be grouped into two categories: those associated with the production process and those related to the export financing process.

From the perspective of the production process, the first key factor is iceberg trade costs. Transportation in export activities will incur iceberg trade costs, which means that firms need to suffer more costs for commodity depletion (Irarrazabal et al. 2015). Iceberg trade costs also constitute an important component of the price formation mechanism for high-quality products; and as previously discussed, iceberg trade costs are intrinsically linked to product quality (Hallak and Sivadasan 2009; Hummels and Skiba 2004).

The second factor is the marginal cost. In the production and export process, firms may incur additional implicit or explicit operational and managerial costs. In fact, such a component of cost can capture the effects of geopolitical risks (Huynh et al. 2024), which in turn manifest in the unit variable cost.

From the perspective of export financing, the first determinant is the expected financing fraction of the firm. For some reasons, for example, liquidity needs and supply-chain risk management, etc., firms often seek for external, cross-sectoral funding to support their export activities (Hertzel et al. 2023). This portion of export financing is typically associated with variable costs.

The second determinant is the actual accessible financing fraction. Due to financial constraints arising from information asymmetry and limited accessibility to financial resources (St-Pierre et al. 2018; Ullah 2020), firms are often unable to obtain the full amount of funds they desire—or even sufficient financing to cover their expected future cash flows or profits; instead, they will receive only a fraction of the latter (Feenstra et al. 2014). This implies that the external financing process inevitably introduces an external financing cost (Almeida et al. 2011). Moreover, such a cost can also capture the influence of geopolitical risks, as external financing activities tend to be hindered under higher geopolitical uncertainty (Jeon et al. 2022).

Based on the above assumptions, when the market is in equilibrium, a firm's budget constraint requires that the amount of external funds obtained must satisfy its external financing demand (Ding et al. 2018), which can be expressed as:

$$\max_{p} \ (p - c)x = \left(p - \frac{1}{\phi}\tau\kappa w^{\beta} r^{\alpha} \varrho^{\zeta} \xi^{\mu}\right) \frac{p^{-\sigma}}{\mathcal{P}^{1-\sigma}} E \tag{8a}$$

$$\text{s.t.} \ \ \vartheta\left[p - (1-\psi)\frac{1}{\phi}\tau\kappa w^{\beta} r^{\alpha} \varrho^{\zeta} \xi^{\mu}\right] \frac{p^{-\sigma}}{\mathcal{P}^{1-\sigma}} E \geq (1-\psi)\left(\frac{1}{\phi}\tau\kappa w^{\beta} r^{\alpha} \varrho^{\zeta} \xi^{\mu}\right) \frac{p^{-\sigma}}{\mathcal{P}^{1-\sigma}} E \tag{8b}$$

where:

- $\tau \geq 1$ denotes the iceberg trade cost incurred during exporting.
- $\psi \in (0, 1)$ denotes the 'expected fraction'. Specifically, it is the fraction of expected external funds to production costs that the firm aims to raise. Of course, ψ actually captures the firm's external financing needs, including domestic type and cross-border type; but here, we do not intend to distinguish between the two here, and assume that ψ is constant, namely, γ- and ξ-irrelevant.

- $\vartheta \in (0,1)$, that is, $\vartheta(\gamma) \in (0,1)$, denotes the 'accessible fraction'. Specifically, it is the fraction of actual accessible external funds to prospective future profits or cash flows that the firm can actually obtain. On the basis of existing well-documented fact, ϑ can be believed to be non-increasing with respect to γ, namely, $\vartheta' \leq 0$; and it desires to note that, ϑ actually denotes the practically attainable part of original borrowing, which means that there exists considerable costs while proceeding external financing, and such financing encompasses two different types—domestic type $\widehat{\vartheta}_d \in (0,1)$ and cross-border $\widehat{\vartheta}_f \in (0,1)$, with securable fraction $s_d \in (0,1)$ and $s_f \in (0,1)$, namely, $\vartheta = \widehat{\vartheta}_d s_d + \widehat{\vartheta}_f s_f$.
- κ, that is, $\kappa(\gamma)$, denotes the managerial cost incurred during the firm's operations. As mentioned above, it has also been well-confirmed by existing research that higher risk of suffering from geopolitical risk is associated with lower management efficiency (Huynh et al. 2024) and weaker competitive advantage (Hassan et al. 2019), resulting in higher managerial costs; thus, κ meets $\kappa' > 0$.

At this stage, we have linked the two core factors of interest, that is, product quality and geopolitical risk, within a unified market equilibrium framework. In the next step, we can investigate the direct relationship between them by solving for the equilibrium price and profit-maximising conditions of the firm.

By applying the method of Lagrange multiplier and subsequently eliminating the multiplier λ, the optimal price p that satisfies the budget constraint can be expressed as:

$$p = \frac{\sigma}{\sigma - 1}\Theta\left(\frac{1}{\phi}\tau\kappa w^{\beta} r^{\alpha} \varrho^{\zeta} \xi^{\mu}\right) \tag{9}$$

where $\Theta = \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\psi}{\vartheta} + 1 - \psi\right)$.

Equation (9) represents the price that a firm should choose for its product under market equilibrium, which is jointly determined by two key factors emphasised in this article: product quality ξ and geopolitical risk γ. Intuitively, to maximise process profits, the optimal product price rises with product quality, as higher-quality production requires more expensive labour and intermediate inputs, and may also involve higher iceberg trade costs. Additionally, as geopolitical risk increases, the product price chosen by the firm also rises, due to heightened external financing constraints and increased operational management costs.

3.4 | Quality Decision

Given a certain demand presented by Equation (3), a firm should choose price p and quality ξ to maximise its post-entry profits, which involves fixed costs generated from the whole production activities:

$$\max_{p,\xi} \pi(p,\xi) = \frac{1}{\sigma}\left(\frac{p}{\mathcal{P}}\right)^{1-\sigma}\left(\frac{\delta}{\xi}\right)^{1-\sigma} E - F_0 - \frac{1}{\varphi} w^{\beta} r^{\alpha} \varrho^{\zeta} \xi^{\eta} - F_x \tag{10}$$

where F_x denotes other fixed exporting cost for exporting unrelated to price and quality.

The optimal price p^* has been given by the standard CES solution presented in Equation (9). Therefore, the key point of firms' making production decisions lies in choosing the quality of products. Decision on choosing the optimal quality ξ just corresponds to calculate the partial deviation of $\pi(p,\xi)$ with respect to ξ, and let it be 0:

$$\mathscr{R}(\xi,\gamma) = \frac{\partial \pi(p,\xi)}{\partial \xi} = 0 \tag{11}$$

At this point, the functional relationship between product quality ξ and geopolitical risk γ is embedded in an implicit function $\mathscr{R}(\xi,\gamma)$. To examine how geopolitical risk influences the firm's decisions on product quality, one can take the partial derivative of the implicit function with respect to γ. At this point, the partial derivative of $\mathscr{R}$ naturally incorporates the relationship between ξ and geopolitical risk γ, that is, $\frac{\partial \xi}{\partial \gamma}$ f. Actually, based on Equation (11), we can obtain:

$$\frac{\partial \xi}{\partial \gamma} \propto \underbrace{-\frac{\kappa'}{\kappa}}_{\text{negative}} + \underbrace{\frac{\psi}{\psi + (1-\psi)\vartheta}\frac{\vartheta'}{\vartheta}}_{\text{negative}} \tag{12}$$

where:

- The first term in the right-hand side is negative, for $\kappa' > 0$ and $\kappa > 0$;
- The second term is also negative, for $\psi \in (0,1)$, $\vartheta' < 0$ and $\vartheta > 0$.

Equation (12) indicates that as geopolitical risk increases, the representative firm will choose to produce lower-quality products to realise its optimisation. Furthermore, the impact of geopolitical risk on the firm's production decisions is primarily realised through two channels. First, geopolitical risk directly increases the firm's managerial costs, which is captured by the first term on the right-hand side of the equation. Second, production costs are uplifted for the difficulty of the firm's external financing deteriorated by geopolitical risk, which is reflected by the second term; and such an effect will also depend on the convenience of domestic financing. Therefore, we propose the first proposition as follows:

Proposition 1. *Geopolitical risk will have a negative impact on participation in the Global Value chain.*

3.5 | Internal Force

For further scrutinise the role of financing convenience, we consider redividing the summational parameter of attainable funds ϑ, into domestic and cross-border types with their respective shares, that is, $\vartheta = \widehat{\vartheta}_d s_d + \widehat{\vartheta}_f s_f$, and performing further partial differentiation. Of course, the following four additional conditions must also be satisfied:

- $\widehat{\vartheta}_d', \widehat{\vartheta}_f' < 0$, that is, both $\widehat{\vartheta}_d$ and $\widehat{\vartheta}_f$, the same as ϑ, also adhere to first-order derivatives being negative.
- $0 < s_f < s_d < 1$, for explicit external financing costs will lead to the actual fraction of obtainable cross-border funds

being smaller than the domestic counterpart, even without considering opportunity costs (Rahaman 2011). Also, firms tend to choose and will find it easier to obtain financing through domestic channels, even under equal costs (Pástor and Veronesi 2012).

- $\widehat{\vartheta}_f' < \widehat{\vartheta}_d' < 0$, for the influence of domestic channels on a firm's external financing should be less than that of cross-border ones, while facing higher geopolitical risks (Cao et al. 2019).

At this point, financing convenience can be captured by the accessible fraction of domestic funds, indicating that higher financing convenience will increase s_d, and we assume that s_f is somehow independent of financing convenience, at least compared to s_d.

Additionally, worth noting that we assume ψ in this model to be exogenously given or endogenous only to production inputs, not to product quality, geopolitical risks or financing convenience.

Then, investigating the moderating role of financing convenience in the relationship between geopolitical risk and GVC participation can be realised by calculating the partial deviation of $\frac{\partial \xi}{\partial \gamma}$ with respect to s_d. And it is not difficult to prove that:

$$\frac{\partial^2 \xi}{\partial \gamma \partial s_d} > 0 \tag{13}$$

Equation (13) suggests that a higher value of s_d will result in a higher value of $\frac{\partial \xi}{\partial \gamma}$, which means that higher financing convenience will do favour to mitigate the negative impact of geopolitical risk on firms' decision on quality creating. Therefore, we propose the following second proposition:

Proposition 2. *Higher financing convenience will alleviate the negative effect of geopolitical risk on the GVC participation.*

3.6 | External Moderation

On the basis of our understanding of how geopolitical risks affect product quality decisions and the role of financing convenience, we aim to explore further how 'external forces' moderate the relationship between such variables. In fact, in the previous model construction, we have considered the optimisation of a representative firm within a country as the aggregate product decision behaviour of all firms in that country.

Therefore, the 'external forces' referred to here actually denote non-domestic factors that can influence product decisions, and can be considered exogenously given relative to domestic production processes, especially the original cross-border external funds $\widehat{\vartheta}_f$ and the corresponding financing costs s_f. Considering an external force, for example, political collaborations, external policy changes or regional emergencies, etc., may affect both the original accessible funds and financing costs (Correa et al. 2022). Thus, we consider recombining $\widehat{\vartheta}_f$ and s_f into ϑ_f, which represents the actual funds available through cross-border channels for financing, to capture such a force.

In order to understand the moderation role of external forces, we can follow the same way to calculate partial differentiations with respect to ϑ_f. First, with regard to the relationship where geopolitical risks hinder the production of high-quality products, we can conduct the partial deviation of $\frac{\partial \xi}{\partial \gamma}$ with respect to ϑ_f. And it will be also not difficult to prove that:

$$\frac{\partial^2 \xi}{\partial \gamma \partial \vartheta_f} > 0 \tag{14}$$

Equation (14) implies that, as the accessibility of external funds through cross-border channels increases, the negative impact of geopolitical risks on product quality decisions diminishes. However, it is worth noting that, the implicit assumption here is that 'external forces' regulate the relationship between geopolitical risks and product quality decisions only by means of influencing the accessibility of actual funds available through cross-border channels for external financing, but independent of the firm's own managerial costs κ.

In this article, we examine two fundamentally different types of external forces, that is, political alignment—which exerts a positive effect (by increasing cross-border external funding $\widehat{\vartheta}_f$), and media attention—which generates a negative effect (by reducing $\widehat{\vartheta}_f$). Against the backdrop of these two external forces, accordingly, this article puts forward the following two propositions:

Proposition 3a. *The formation of political alignment mitigates the adverse effects of geopolitical risk by increasing cross-border external funding.*

Proposition 3b. *Greater media attention amplifies the adverse effects of geopolitical risk by reducing cross-border external funding.*

Then, in terms of the impact of external forces on the moderation of financing convenience, we can calculate the partial deviation of $\frac{\partial^2 \xi}{\partial \gamma \partial s_d \partial \vartheta_f}$ with respect to θ_f. And under certain conditions (e.g., when domestic financing is not readily accessible, which is precisely the case this article is concerned with), we can also prove that:

$$\frac{\partial^2 \xi}{\partial \gamma \partial s_d \partial \vartheta_f} > 0 \tag{15}$$

Equation (15) suggests that, as the accessibility of external funds through cross-border channels enhances, the alleviating effect of financing convenience on the negative impact of geopolitical risks on product quality decisions is also enlarged. Unlike the mediating role of external forces represented in Equation (14), the external forces here do not require independence from the firm's own managerial costs κ.

Following the same logic mentioned above, we also investigate the effects of two external forces on the moderating role of

financing convenience. Accordingly, the following two propositions will be empirically examined below:

Proposition 4a. *The formation of political alignment strengthens the positive moderating effect of financing convenience by increasing cross-border external funding.*

Proposition 4b. *Greater media attention weakens the positive moderating effect of financing convenience by reducing cross-border external funding.*

4 | Empirical Specification and Data

4.1 | Econometric Model

Formally, to investigate the impact of geopolitical risk on GVC participation, this article considers employing TWFE-OLS estimations as baseline specification, as follows:

$$GVC_{it} = \alpha + \beta geo\text{-}polit_{it} + \sum_{k=1}^{K} \theta_k X_{k,it} + \lambda_t + \mu_i + \varepsilon_{it} \tag{16}$$

where GVC_{it} denotes the participation or position of countries in the GVC; $geo\text{-}polit_{it}$ denotes geopolitical risk countries exposed to; $X_{k,it}$ denotes control variables; λ_t and μ_i denote time fixed effects and individual fixed effects respectively; ε_{it} denotes the error term. If expectations met, the coefficient β will capture the marginal effect of geopolitical risk on GVC participation, that is, $\widehat{\beta} < 0$.

For testing whether there exists moderating effects with regard to internal and external forces, we consider incorporating the dual interaction terms (i.e., *geo-polit* × *int-force* and *geo-polit* × *ext-force*) and triple interaction term (i.e., *geo-polit* × *int-force* × *ext-force*) into Equation (16). Corresponding model specifications are provided in the Supporting Information.

Here, we will focus on the coefficients of dual and triple interactions. When we investigate the role of financing convenience, if expectations are met, we can obtain significant estimates of γ, that is, $\widehat{\gamma} > 0$. And while we investigate the effect of external forces, if expectations are met, we can obtain significant estimates of γ and δ that share the same sign—either positive or negative, that is, $\widehat{\gamma}, \widehat{\delta} < 0$ or $\widehat{\gamma}, \widehat{\delta} > 0$.

4.2 | Variable Specification and Data

4.2.1 | Explained Variable

GVC metrics derived from traditional trade-based frameworks significantly underestimate global GVC activities, misrepresent participation in key sectors such as services and upstream manufacturing, and exaggerate risks during critical stages like early trade liberalisation in large economies. Therefore, this article draws on Borin et al. (2021) approach, conducting measurements of GVC participation by applying the tripartite decomposition method to global production networks, which extend beyond import–export dynamics and encompass international and domestic production relationships. Such an output-related framework encompasses not only the GVC activities traced in value-added and final goods but also all the exchanges of inputs within the intermediate production stages related to GVCs (Borin et al. 2021). In every part of regressions, this article will first conduct regressions by setting output-related GVC participation (oGVC) as the dependent variable based on the tripartite decomposition of outputs. Additionally, this article will also conduct regressions by setting each of the three components of oGVC—pure backward (pb-oGVC), pure forward (pf-oGVC) and two-sided (ts-oGVC) of output-related GVC participation—as dependent variables. The construction details of these four indicators are provided in Supporting Information.

4.2.2 | Core Explanatory Variable

In fact, the concept of geopolitics is broad and richly connoted; quantitative measures of geopolitical risk are typically constructed by applying dimensionality reduction techniques to multidimensional risk indicators related to geopolitics in order to build a composite index. Common dimensionality reduction methods include the entropy method, Principal Component Analysis (PCA), t-distributed Stochastic Neighbour Embedding (t-SNE) and more recently, Uniform Manifold Approximation and Projection (UMAP).

However, for social science applications, each method comes with distinct limitations. For instance, the entropy method and PCA prioritise reducing data into a single dimension based on the 'maximum variance'. Yet, maximum variance does not necessarily imply 'importance'.[9] Moreover, both PCA and entropy methods rely on linear mappings, which ignore the topological structure and heterogeneity of the original high-dimensional data. While t-SNE and UMAP retain local structures of high-dimensional data via nonlinear mappings, they generally lack interpretability and, more importantly, fail to ensure 'directionality', that is, they map spatial distances without preserving meaningful relational positioning between data points.

To address the aforementioned limitations, this article follows the approach of Sciarra et al. (2020), Zhang and Zhang (2024) and Zhang (2024), and then constructs the geopolitical risk indicator by integrating the bipartite network framework with the Fitness and Complexity (FC) algorithm and the Matrix-Estimation exercise, which will help to reduce the dimensionality of high-dimensional data.

Prior to applying the strategy to construct the indicator, this article preprocesses the risk evaluation data of various countries across different items and maps them into the nodes and edges of a bipartite network, as the bipartite network framework relies on network construction.[10]

Given that the scoring ranges of individual indicators are inconsistent, this article first applies Max-Min standardisation to each indicator. And then, this article calculates the ratio of each country to the average in terms of risk assessment scores, for each indicator and year, as follows:

$$R_{ict} = \frac{A_{ict}}{\sum_c A_{ict}} \tag{17}$$

where A_{ict} denotes the risk assessment score of country c for item i in year t. Conceptually, R_{ict} can be interpreted as the 'gain' derived from geopolitical stability relative to the average level. A value greater than 1 implies an 'excess return', whereas a value below 1 implies a 'loss' due to geopolitical risk. This interpretation of R_{ict} facilitates a better understanding of the economic meaning of the composite geopolitical risk indicator presented later.

For any given year t, the matrix R_{ict} constitutes a bipartite network (more precisely, the elements of the Adjacency Matrix of the bipartite network), consisting of two types of nodes—country and item nodes (V)—with edges (E) connecting nodes of different types. The values of R_{ict} represent the edge weights.

Geopolitical risk and geopolitical stability—or alternatively, the 'loss' induced by risk and the 'value' conferred by stability (which may refer to economic benefits or abstract political influence)—are in fact two sides of the same coin. In the bipartite network framework, one can evaluate geopolitical risk or stability (in other words, the associated 'loss' or 'value') via the notion of compliancy as modelled in the coupled equations:

$$\begin{cases} X_c = f\left(Y_1, Y_2, \cdots, Y_t, M_{\mathrm{cp}}\right) \\ Y_p = g\left(X_1, X_2, \cdots, X_c, M_{\mathrm{cp}}\right) \end{cases} \tag{18}$$

In terms of bipartite network analysis, X_c denotes the 'complicacy' of a country node, which, in the context of this article, represents the value that country c derives from geopolitical stability (hereafter referred to as 'country value'). Y_p refers to the 'complicacy' of an item node, representing the value that item i contributes to countries in general (hereafter 'item value'). Equation (18) implies that, country value X_c depends on the item values of its connected item nodes ($Y_1, Y_2, \ldots, Y_t$) and their linkages (M_{cp}); similarly, item value Y_p depends on the country values of its connected country nodes ($X_1, X_2, \ldots, X_c$) and their linkages (M_{cp}).

By solving Equation (18) with a specific algorithm, $\hat{X}_c$ and $\hat{Y}_p$ can be obtained, which are referred to as 'complexities' (corresponding to estimated or quantified 'country value' or 'item value'), distinguishing them from the aforementioned 'complicacy' (corresponding to real or potential 'value')—the latter denotes the attribute of nodes, while the former is the quantification of the latter.

In fact, in this article, we solve for X_c and Y_p using the Fitness and Complexity (FC) algorithm proposed by Tacchella et al. (2012), which sequentially computes the country proximity matrix $N_{cc'}$ and the item proximity matrix $G_{pp'}$. The two matrixes can be expressed as:

$$\begin{cases} N_{cc'} = \dfrac{\sum_{c'} M_{cp} M_{c'p}}{\left(s'_p\right)^2 s_{c'} s_c} \\ G_{pp'} = \dfrac{\sum_{p'} M_{cp} M_{cp'}}{\left(s_p\right)^2 s'_{p'} s'_p} \end{cases} \tag{19}$$

By applying the FC algorithm, the original 2 mode network is decomposed into two 1 mode networks containing only one node type, where nodes (of the same type) are directly linked; in this context, the country proximity matrix $N_{cc'}$ and the item proximity matrix $G_{pp'}$ contain only country nodes or only item nodes, respectively; and countries are directly connected to countries, the same as items to items. These matrices describe such a 'proximity': similarity in assessment score situation between countries, and similarity in countries' score distribution across items.

The core idea of this algorithm is: higher 'value' a country gaining from geopolitical stability should indicate broader item assessment, higher assessment score within each field, and in fields of higher stability 'value' an item contributing to countries; similarly, higher 'value' an item contributing to countries should imply fewer referring countries, a higher assessment score of referring countries and higher 'value' of countries gaining from geopolitical stability.

Finally, this article adopts the Matrix-Estimation exercise proposed by Sciarra et al. (2018) to construct the geopolitical risk indicator:

$$geo\text{-}polit_c = \left(\sum_{i=1}^{s} \lambda_i^N \left(v_{c,i}^N\right)^2 \right)^2 + 2 \sum_{i=1}^{s} \left(\lambda_i^N\right)^2 \left(v_{c,i}^N\right)^2 \tag{20}$$

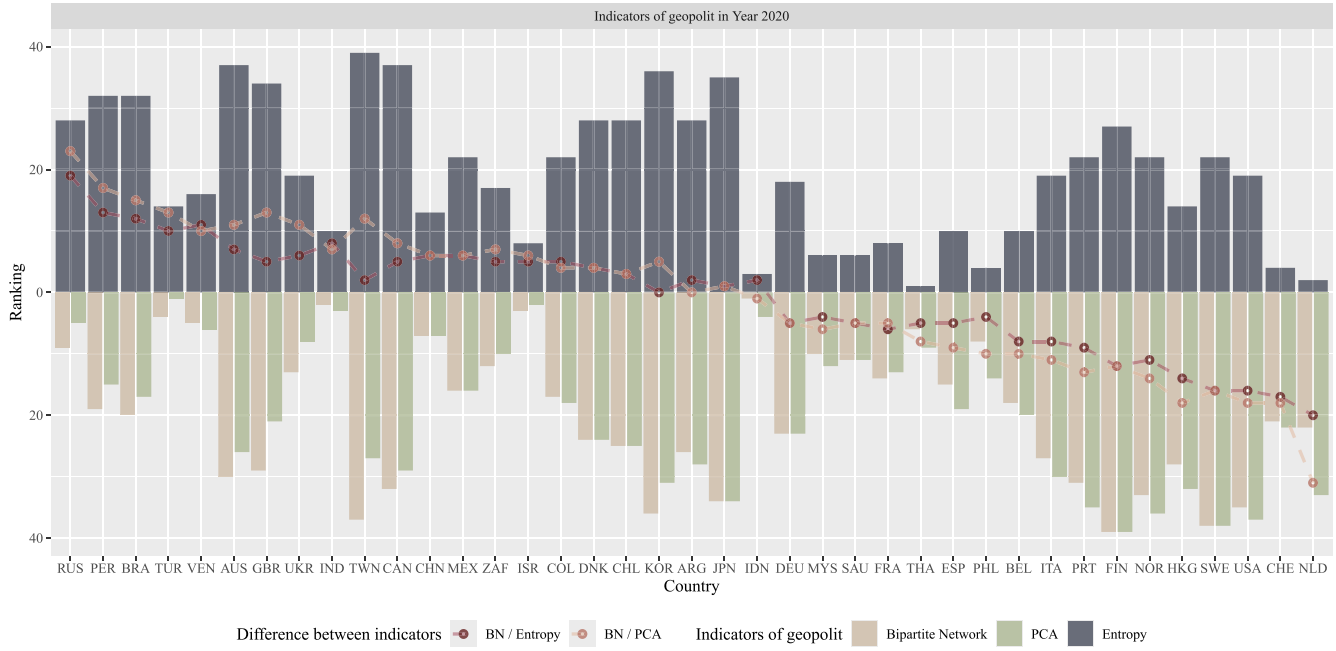
where $geo\text{-}polit_c$ denotes the 'value' of country c gaining from geopolitical stability; λ_i and $v_{c,i}$ denote the eigenvalue and eigenvector of proximity matrix $N_{cc'}$; s denotes the sth-order (sth-largest eigenvalue and corresponding sth-largest eigenvector).

As discussed earlier, interpreting the risk assessment score for a specific item (or its multiple relative to the average level) of countries as the 'value' deriving from political stability within a specific domain, the constructed geopolitical risk indicator effectively captures the aggregate 'return' a country obtains from overall geopolitical stability. Aligned with the directionality of the risk assessment scores in ICRG, a higher value of the geopolit indicator implies that a country is exposed to lower geopolitical risk, or, in other words, that it suffers less potential loss while facing geopolitical uncertainty.

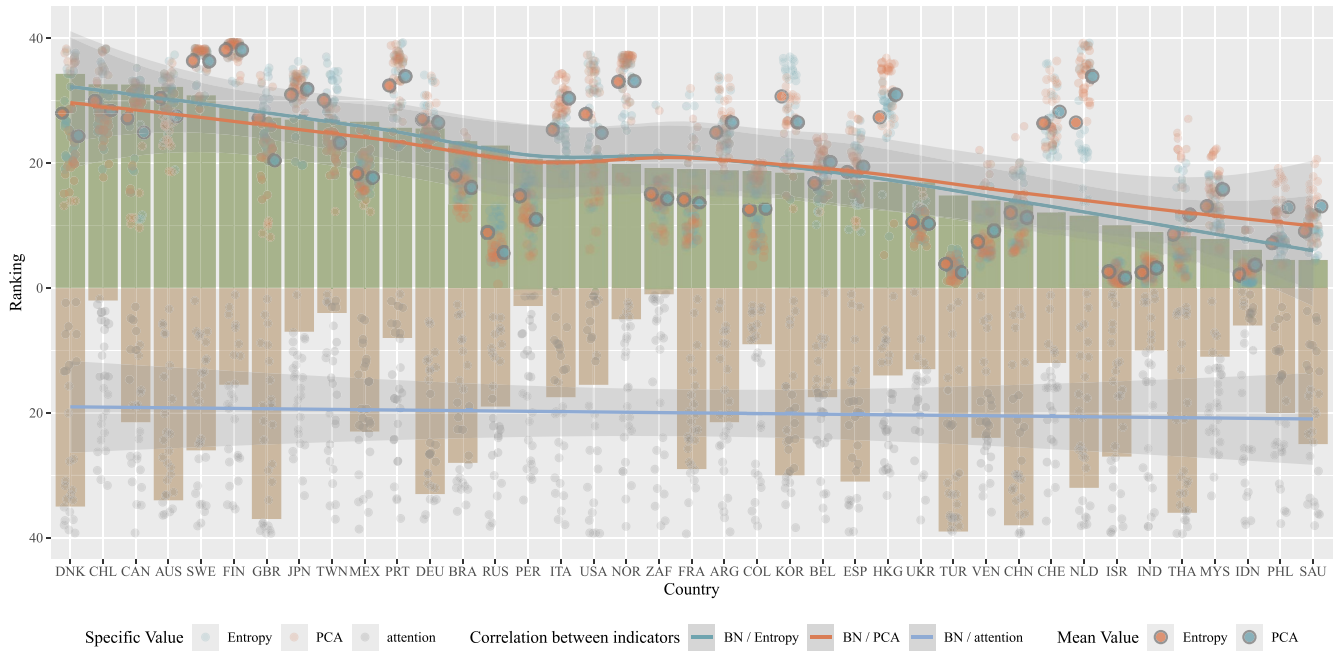
Referring to the concept of eigenvector centrality from Matrix-Estimation and the core logic of the Fitness and Complexity (FC) algorithm, the construction of the geo-polit indicator accounts for both the 'heterogeneity' of different items in contributing to geopolitical stability and the 'interconnectedness' across these items, which goes beyond the capacity of conventional dimensionality reduction techniques.

It is particularly noteworthy that, in order to enhance the interpretability of the geo-polit coefficient in subsequent empirical analyses, this article recalculates the annual percentile ranking of each country or region based on the absolute value of its geo-polit. In the baseline regression, along with a series of robustness checks and endogeneity handling, the percentile ranking of geo-polit is used as the key explanatory variable. A higher percentile ranking indicates that the country or region is exposed to lower geopolitical risk and faces more minor potential losses accordingly.

Of course, we also briefly present the distinctions between geo-polit and alternative indicators, and provide a concise interpretation to illustrate the validity and reliability of our measurement. Comparisons between geo-polit (expressed as percentile ranks) and those constructed using conventional PCA and Entropy methods are shown in Figure 1a. As discussed earlier, both PCA and Entropy are linear mapping methods.[11] This linearity typically results in homogenisation, that is, not only high-risk cases may be underestimated, but low-risk cases are overestimated, thereby flattening heterogeneity across units. In contrast, the



(a) Comparison of indicators in 2020.



(b) Comparison of indicators from 1995-2020.

FIGURE 1 | Comparison of indicators based on different methods. [Colour figure can be viewed at wileyonlinelibrary.com]

nonlinear mapping method based on a bipartite network avoids such distortion, as reflected in Figure 1a, which shows more pronounced differences in the percentile ranks of geopolitical risk.

For example, over the past decade, events such as Russia's annexation of Crimea and the outbreak of the Russia–Ukraine conflict have sharply worsened the geopolitical situation in Eastern Europe, while a series of military coups in Latin America have likewise corresponded to higher geopolitical risks. However, as the figure shows, indicators derived from the PCA and Entropy methods substantially underestimate such risks, with rank differences exceeding 20 places in some cases. Conversely, within the European Union (e.g., Northern and Western Europe), geopolitical risks should be lower, as the EU functions as a highly integrated bloc approaching a political union, meaning that member states are unlikely to generate mutual geopolitical threats to their neighbours. However, as the figure indicates, conventional measures overestimate such risks, again by more than 20 places.

As will be elaborated later, we deliberately refrain from using media coverage frequency as a proxy for geopolitical risk, treating it instead as an indicator of media attention, which captures a distinct, perception-oriented dimension of geopolitical concern. In our view, the two are distinct entities, implying that no apparent correlation should exist between them. By contrast, geo-polit should display a strong correlation with conventional indicators, since they do not eliminate the underlying relationships but just smooth out some kind of heterogeneity. We present the comparison results of these indicators (averaged for the period 1995–2020) in Figure 1b, with the *x*-axis ordered from high to low according to the percentile ranks of geo-polit. The results align well with our expectations: geo-polit and media attention show almost no correlation, whereas geo-polit is strongly correlated with traditional measures.

4.2.3 | Moderating Variable

The moderating variable referring to the 'internal force' used in the empirical research is financing convenience. To capture financing convenience (or financial development), this article uses the ratio of domestic credit to the private sector (in % of GDP), which will be abbreviated as 'fin-conve' in the following text.[12]

The first moderating variable referring to 'external force' is political alignment. In order to capture the status of political alignment among countries, following the approach of Cevik (2023) and Aiyar et al. (2024), we apply the dynamic ordinal spatial model proposed by Bailey et al. (2017) to estimate the ideal point distance, using the United Nations General Assembly (UNGA) voting data. Ideal point depicts countries' preferences over foreign policies and voting similarity, and is, in fact, some kind of reflection of the state's ideology (Argyle et al. 2021). For the ideology of a proposal or policy and a senator, the ideal points or so-called 'Bliss points', of them correspond to their coordinates in Euclidean space, respectively. While the distance between the two points is smaller, the senator is more inclined to accept such a proposal or policy; and vice versa. A closer distance between ideal points also implies more similar foreign policy preferences between countries, which in turn suggests a greater tendency toward political alignment (Raess et al. 2022). Building on this, this article further calculates the reciprocal of the average Ideal Point Distance (IPD) of a country with all other countries to measure the proximity of political stance or the presence of political alignment, which will be abbreviated as 'pol-align' in the following text.

The second moderating variable referring to 'external force' is media attention. This article considers capturing media attention on geopolitical events or risks by measuring the proportion of articles that mention adverse geopolitical events in representative newspapers relative to the total number of articles, which will be abbreviated as 'pol-align' in the following text. It is essentially the GPR index proposed by Caldara and Iacoviello (2022); however, we prefer to interpret it more as a measure of media attention rather than actual risk of geopolitical risk confronted by countries. This is because media disclosures of geopolitical events can be significantly influenced and constrained by various domestic and international political factors (Bernhardt et al. 2008), including ideological issues, government disclosure willingness and political sensitivity, which usually give rise to media bias (Tejedo-Romero and Ferraz Esteves Araujo 2023). However, the impact of media attention on cross-border trade and investment activities is indeed real and influential, particularly in terms of affecting market participants' sentiments.

4.2.4 | Other Variable Specifications

Final, drawing on previous studies, we select the following 13 control variables for conducting regressions in the following sections: GDP per capita growth (growth), patent application (patent), FDI net inflow (FDI), net international liquidity (liquidity), government consumption (government), natural resource (resource), corruption risk (corruption), democratic accountability (accountability), education expenditure (education), employment rate (employment), advanced education enrollment (enrollment).

The abbreviations, names, descriptions of each variable, with their descriptive statistics are provided in the Supporting Information. In consideration of the data range of OECD ICIO table and the International Country Risk Guide, the data sample we used in conducting regressions in the following text includes 77 countries from 1995 to 2020. Worthy mentioning, to prevent outliers from biassing the estimation results, all samples used in the subsequent regressions are winsorised. Specifically, we apply a 1% winsorisation at both the lower and upper tails to the dependent variables, the core explanatory variable, the control variables and the moderating variables included in the regressions.

5 | Result and Discussion

5.1 | Baseline Result

The results of baseline regressions are shown in Table 1. In line with our expectations—derived from Proposition 1, the coefficients of geopolitical risk are all significantly negative

TABLE 1 | Results of baseline regressions.

	GVC participation			
	oGVC	**pb-oGVC**	**pf-oGVC**	**ts-oGVC**
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Geo-polit	−1.704***	−1.568***	−1.627***	−1.662***
	(0.309)	(0.316)	(0.342)	(0.312)
Observation	687	687	687	687
Adjusted R^2	0.496	0.499	0.495	0.445
Year FEs	✓	✓	✓	✓
Country FEs	✓	✓	✓	✓
F statistic	159***	130***	215***	121***
	[0.000]	[0.000]	[0.000]	[0.000]

***$p < 0.01$.

in all four groups of regressions at a high enough significance level, which means that higher risk of undergoing geopolitical risk indeed hampers participation enhancement in the Global Value Chain. The coefficients of geo-polit across different groups are generally consistent, indicating that the negative effect of geopolitical risk on GVC participation—regardless of the type of production process involved—is broadly similar. This also suggests that the baseline regression results are relatively robust.

Since the geo-polit indicator used in the baseline regression is standardised based on percentile ranking, the coefficients can be interpreted in terms of economic significance. The coefficients of geo-polit across the four groups are −1.704, −1.568, −1.627 and −1.662, respectively. This implies that a one-percentile increase in geopolitical risk of a country (i.e., a 0.01 percentage point increase in geo-polit) leads to:

a. A 1.704% decrease in the value-added of all activities in an intermediate position.

b. A 1.568% decrease in the value-added associated with backward-related production processes.

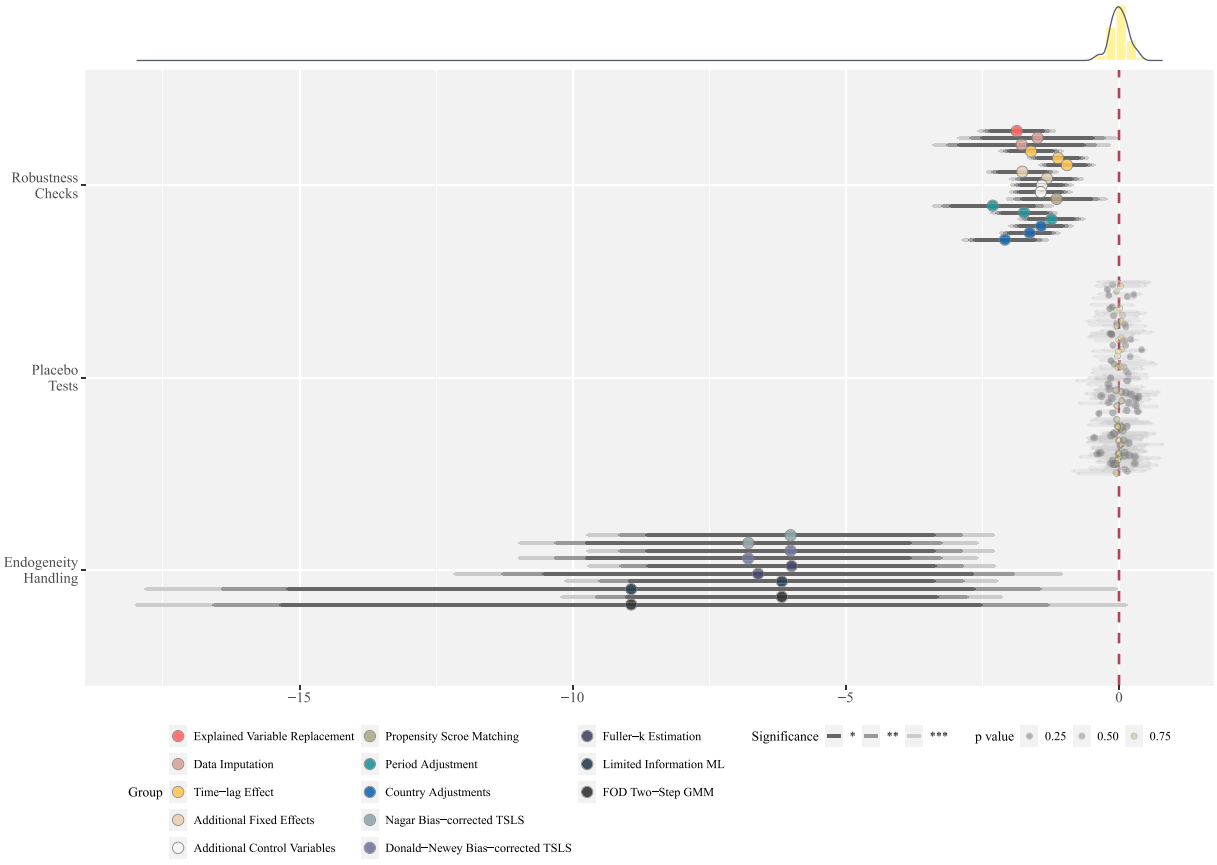
c. A 1.627% decrease in the value-added associated with forward-related production processes.

d. A 1.662% decrease in the value-added related to two-sided production processes.

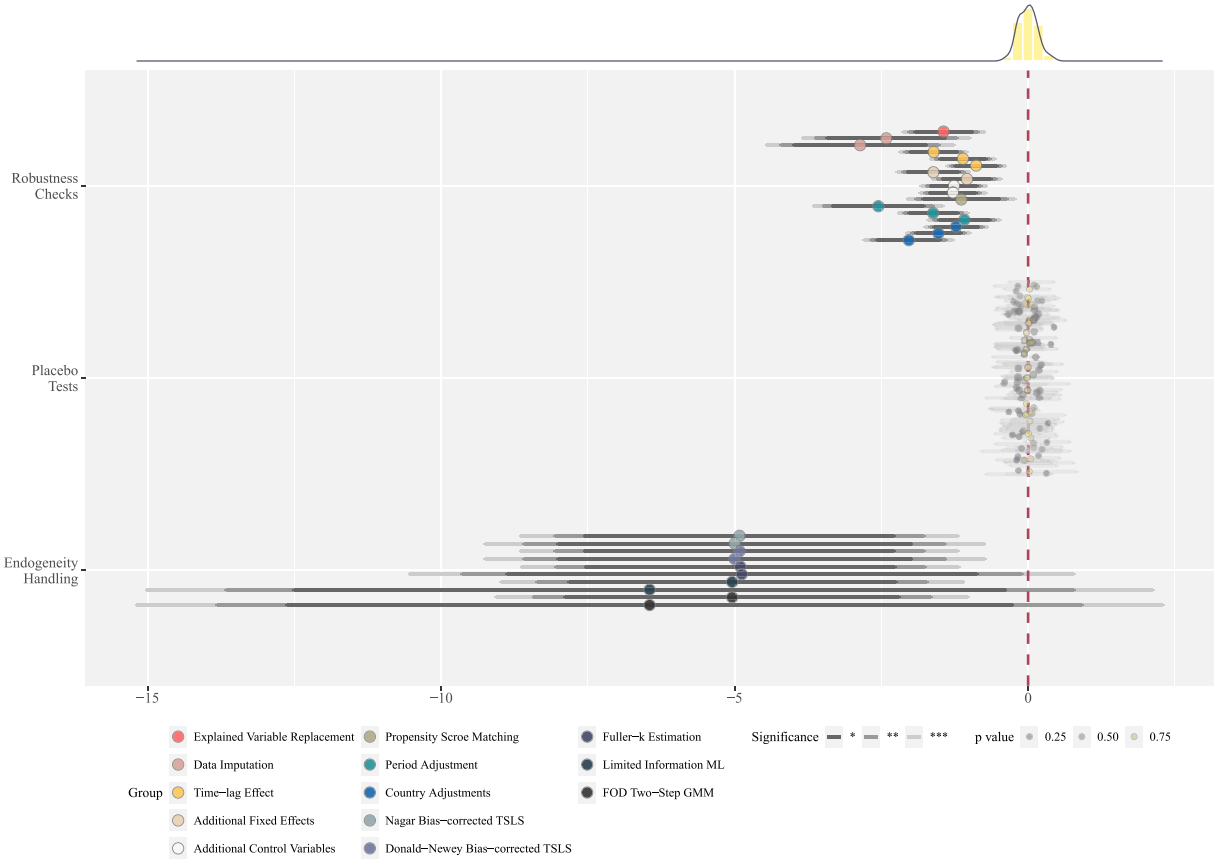
5.1.1 | Robustness Check

For the purpose of ensuring the robustness of the baseline regression results, a total of eight robustness checks are conducted. Specifications for robustness check designs are provided in the Supporting Information. The results of the robustness checks are presented in Figure 2. Subfigures (a) to (d) display only the coefficients of geo-polit along with their confidence intervals. The full regression results for each robustness check are provided in the Supporting Information. The results show that the geo-polit coefficients remain significantly negative at sufficiently high confidence levels across nearly all robustness checks. Furthermore, the point estimate obtained from the baseline regression deviates considerably from the sampling distribution obtained through 500 times of bootstrap resampling. This finding holds across all four alternative explained variables, indicating that the conclusions drawn from the baseline regression are robust and reliable, and providing stronger support for Proposition 1.

Of course, several aspects of the robustness checks merit further discussion. First, in the robustness checks based on explained variable replacement, the absolute values of the geo-polit coefficients are even larger than in the baseline regressions. As mentioned earlier, traditional trade-related GVC metrics may underrepresent participation in critical sectors such as services and upstream manufacturing. The generally larger coefficients across these alternative specifications provide empirical support for this concern. The results based on the geo-polit indicators, reconstructed by the imputed data, show coefficients that are nearly identical to those in the baseline regressions. This implies that the indicator construction strategy, which is based on a bipartite network framework and the nonlinear FC algorithm, is relatively robust to missing data. In the time-lag effect tests, the lagged terms of geo-polit also exhibit significantly negative coefficients at high confidence levels. This suggests that the negative effect of geopolitical risk on GVC participation is temporally persistent, although such an effect clearly diminishes over time. After introducing additional control variables and interactive fixed effects, the coefficients remain largely consistent with the baseline results. This implies that the baseline regression sufficiently accounts for potential omitted variable bias. Moreover, the regression results based on samples matched through the PSM procedure suggest that systematic ex ante differences among individuals in the baseline sample do not constitute significant confounding. All covariates in the matched sample also pass the imbalance tests.[13] Finally, the regressions conducted on samples with adjustments to the period and country scopes yield coefficients that are broadly consistent with those in the baseline regressions. This indicates that potential risk from

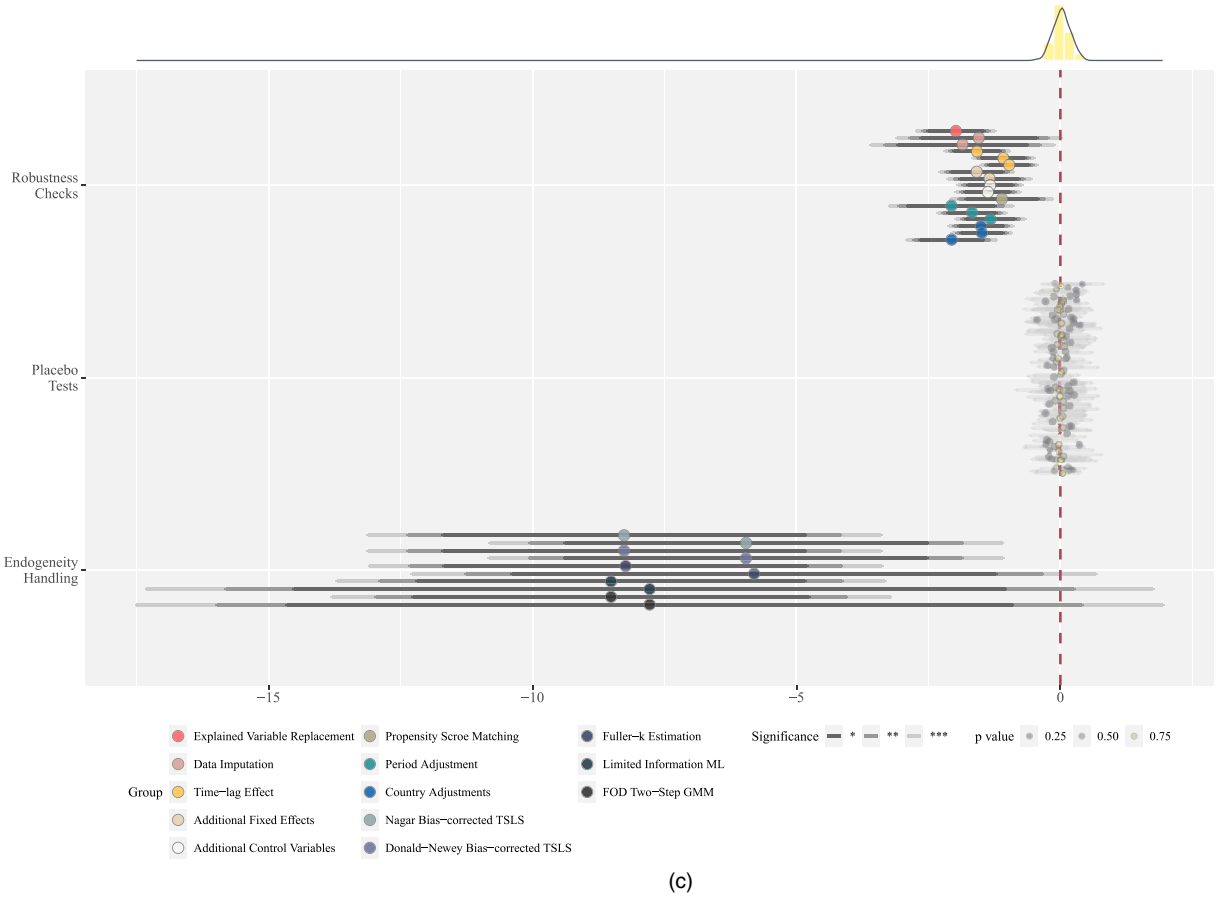


(a)

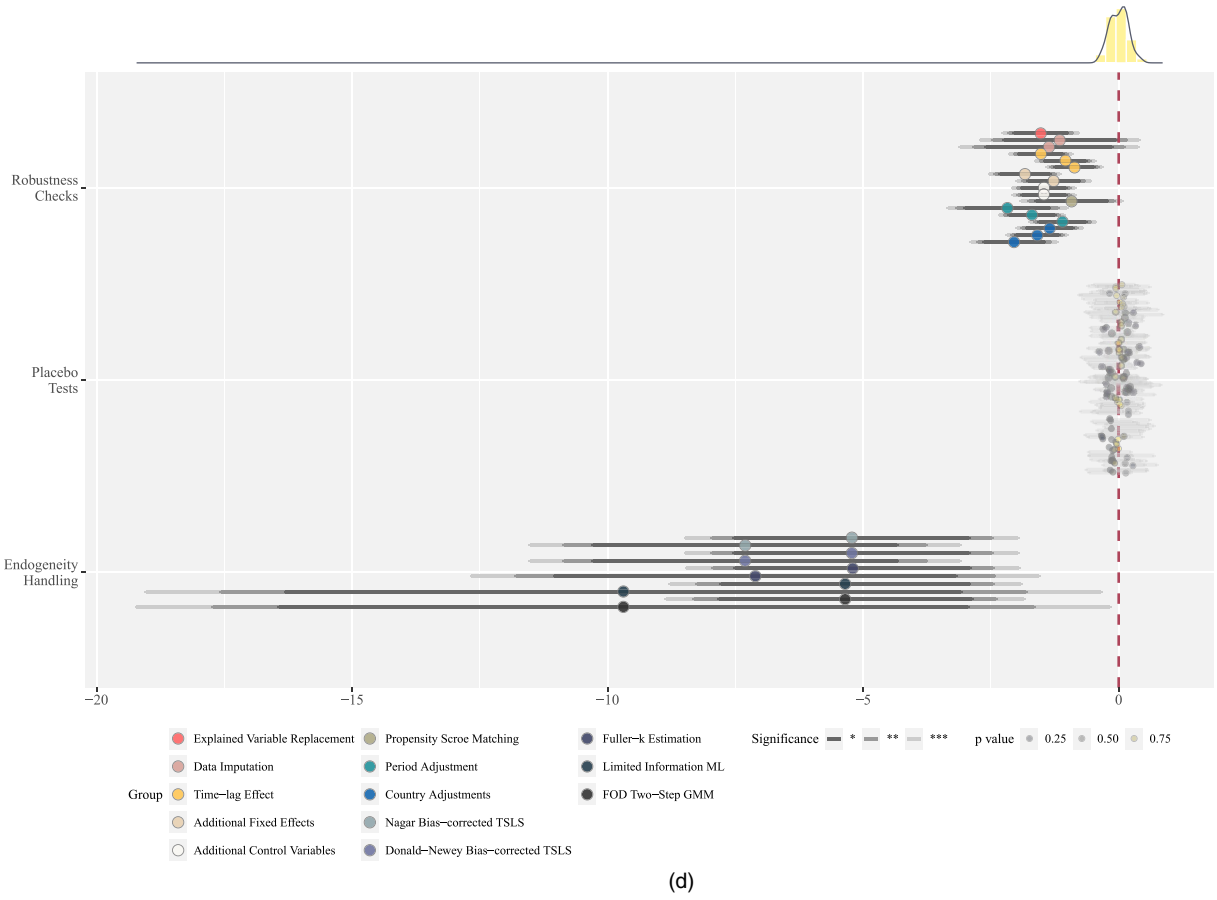


(b)

FIGURE 2 | Results of robustness checks. Subfigures (a–d) show the results of oGVC, pb-oGVC, pf-oGVC and ts-oGVC as the explained variables, respectively. [Colour figure can be viewed at wileyonlinelibrary.com]



(c)



(d)

FIGURE 2 | (Continued)

major economic events does not substantially affect the baseline conclusions, and that any country-level unobserved confounders do not materially bias the estimated effects in the baseline results.

5.1.2 | Endogeneity Handling

Specifically, this article constructs two instrumental variables for TSLS regressions. The first instrumental variable is constructed based on the total number of deaths from domestic armed conflicts occurring in all geographically contiguous neighbours of each country (or region) in each year (log-transformed). We define such an IV as 'neighbouring exposure' (abbreviated as 'exposure' hereafter), which can be expressed as:

$$\text{exposure}_{it} = \sum_{j \in \mathbb{C}_i} \text{armed conflict deaths}_{jt} \tag{21}$$

where $\mathbb{C}_i$ denotes all geographically contiguous neighbouring countries (or regions) of country i.

We argue that it satisfies the key assumptions required for a valid IV. First, the (monotonic) relevance assumption will be held: a higher level of armed conflict in neighbouring countries implies that a country will be more exposed to adverse geopolitical influences. It is particularly relevant since conflicts along land borders often consist of the dominant form of geopolitical confrontation. Second, the exogeneity assumption is also plausible, as a country's geographical adjacency and its neighbours' internal conflicts are largely exogenously determined, meaning that individual countries have virtually no control over either. More importantly, this IV should also satisfy the exclusion restriction. We argue that the most direct and shortest causal pathway through which a higher level of neighbouring conflict affects a country's participation in GVC is via an increase in its own geopolitical risk. In other words, even if greater exposure influences various political or economic fundamentals, the primary mechanism should still operate through heightened geopolitical tensions, rather than through any unrelated, non-geopolitical channels. Of course, its validity and robustness will be further verified through a series of empirical tests.

The second IV is a Bartik-oid IV, which is essentially a Shift–Share IV, consisting of two components: a 'Shift' that captures global-level shocks or changes, and a 'Share' that measures country-specific initial conditions. In our construction, the Shift is defined as the absolute change in the global average of the geopolitical risk, while the Share represents the proportion of armed conflicts in a country's neighbouring states relative to total global armed conflicts in the initial year (i.e., 1995). We define this IV as 'external pressure' (abbreviated as 'pressure' hereafter), which can be expressed as:

$$\text{pressure}_{it} = \left(\frac{\text{average geo-polit}_{t}}{\text{average geo-polit}_{t-1}} - 1 \right) \times \frac{\sum_{j \in \mathbb{C}_i} \text{armed conflicts}_{it_0}}{\sum_{j \neq i} \text{armed conflicts}_{it_0}} \tag{22}$$

We also believe that this instrument will satisfy the standard IV assumptions. First, higher values of both the Shift and Share imply that the country is more likely to be affected by global (and especially regional) geopolitical shocks, since geographic contiguity exposes it directly to conflict spillovers, amplifying the transmission of geopolitical risks. Second, this IV should be sufficiently exogenous, as the global average level of geopolitical risk is not determined by any single country's situation and, as previously noted, geographic adjacency and neighbouring conflicts are exogenous to specific countries.[14] Finally, the exclusion restriction is also expected to hold: global average geopolitical conditions can be interpreted as the general external pressure faced by a country, while the intensity of neighbouring conflicts reflects the ease with which such global pressures will be transmitted. Hence, higher pressure is expected to affect GVC participation primarily through its impact on geopolitical risk, rather than through alternative, non-geopolitical mechanisms.

Table 2 reports the TSLS regression results using 'external pressure' and 'neighbouring exposure' as IVs. Here, we only present (i) the first-stage results for each IV; (ii) the second-stage estimates using oGVC as the dependent variable; and (iii) several diagnostic tests for IV validity.

Regardless of whether pressure or exposure is used as the IV, the coefficient of geo-polit remains significantly negative at a sufficiently high level, reinforcing the conclusion that geopolitical risks hinder participation in the GVC. Notably, the absolute values of the TSLS coefficients are larger than those of the baseline OLS estimates, implying potential endogeneity arising from reverse causality, which is further supported by the Durbin–Wu–Hausman test. Moreover, other IV diagnoses and first-stage regression results confirm the validity of the IVs.

Naturally, the effectiveness of the IVs also depends on whether they satisfy the exclusion restriction assumption (Angrist and Pischke 2009). Thus, following the approaches of Acemoglu et al. (2001); Nunn and Wantchekon (2011), we conduct four complementary tests. The results of four exclusion restriction tests are summarised in the Supporting Information. It shows that the second-stage coefficients of the IVs (as covariates) are statistically insignificant at the 10% level; the reduced-form regressions using the EU sample also yield statistically insignificant IV coefficients at the 10% level. Furthermore, across specifications that either exclude all controls or include additional controls, the coefficient of geo-polit remains significantly negative and consistent in magnitude with the baseline TSLS results. These findings collectively suggest that the selected IVs plausibly satisfy the exclusion restriction assumption.[15]

To further validate the robustness of TSLS estimations, this article implements several additional IV-based approaches, including Nagar bias-corrected TSLS, Donald-Newey bias-corrected TSLS, Fuller-k Estimation, Limited Information Maximum Likelihood Estimation (LIML), and a two-step system GMM estimator with Forward Orthogonal Deviation (FOD). These results have been illustrated in Figure 2, and full regression results are provided in the Supporting Information. All instrument-based estimations yield significantly negative coefficients of geo-polit, lending further support to the robustness and reliability of the TSLS results. Taken together, we have sufficient grounds to conclude that Proposition 1 is adequately supported by the empirical evidence.

TABLE 2 | Results of TSLS regressions.

	Exposure as IV		Pressure as IV	
	First stage	Second stage	First stage	Second stage
	Geo-polit	oGVC	Geo-polit	oGVC
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Panel A: ~ TSLS regression results				
Exposure	3.557***			
	(0.900)			
Pressure			0.151**	
			(0.067)	
Geo-polit (fitted)		−6.172***		−8.929**
		(1.793)		(4.039)
Control variables	✓	✓	✓	✓
Observation	687	687	687	687
Adjusted R^2	0.109	0.206	0.076	−0.263
Year FEs	✓	✓	✓	✓
Country FEs	✓	✓	✓	✓
F statistic	19.1***	102***	8.64***	124***
	[0.000]	[0.000]	[0.000]	[0.000]
Panel B: ~ IV diagnosis results				
Durbin–Wu–Hausman	14.686***		3.201*	
(*p* value)	(0.000)		(0.074)	
Anderson–Rubin F	11.847***		7.846***	
(*p* value)	(0.001)		(0.005)	
Bootstrap *F*	3.681*		4.330**	
(*p* value)	(0.056)		(0.048)	
Montiel-Olea–Pflueger effective *F*	4.393**		5.369**	
(*p* value)	(0.036)		(0.029)	
Conditional Likelihood Ratio	25.308***		4.513**	
CLR confidence interval	[−8.659, −3.685]		[−15.216, −2.642]	
H_0: relative OLS bias > 5% (*p* value)	(0.000)		(0.035)	
H_0: relative OLS bias > 10% (*p* value)	(0.000)		(0.040)	
H_0: relative OLS bias > 20% (*p* value)	(0.000)		(0.049)	

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

5.2 | Financial Convenience as Internal Force

Theoretically, this article has shown, through the equilibrium model constructed in the previous text, how geopolitical risk interacts with domestic financing convenience to affect countries' positioning in the GVC. Empirical evidence also confirms that international trade and division of labour participation within the GVC require significant financing, and the ease of accessing capital substantially influences the development of manufacturing industries (Becker et al. 2013). Financial constraints act as obstacles in credit allocation and regulation processes, limiting financing capacity and suppressing export expansion and GVC upgrading (Reddy and Sasidharan 2021). Improvements in financing convenience imply reduced information asymmetry and lower firm financing costs, which in turn promote investment in capital-intensive goods and intermediate inputs, thereby transforming the industrial structure.

TABLE 3 | Results of moderating effect of financing convenience.

	GVC participation			
	oGVC	pb-oGVC	pf-oGVC	ts-oGVC
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Geo-polit × fin-conve	0.261***	0.225**	0.420***	0.232***
	(0.074)	(0.082)	(0.120)	(0.075)
Control variable	✓	✓	✓	✓
Observation	396	396	396	396
Adjusted R^2	0.412	0.402	0.336	0.381
Year FEs	✓	✓	✓	✓
Country FEs	✓	✓	✓	✓

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

Thus, this article incorporates the moderating variable fin-conve into the regression to empirically investigate the moderating effect of financing convenience as an 'internal force'. Furthermore, by replacing the moderating variable with its lead 1/2 terms and lagged 1/2 terms, we further explore both the anticipation and time-lag effects of financing convenience. The regression results for the moderating effect are presented in Table 3; the marginal effect of fin-conve on geo-polit are presented in Figure 3a, while the anticipation and time-lag effect results are illustrated in Figure 3b. Full results are all available in the Supporting Information.

In comparison with the baseline regression coefficients of geo-polit, the moderating effect results clearly indicate that higher domestic financing convenience can indeed help mitigate the negative impact of geopolitical risk on GVC participation. The marginal effects results indeed indicate that a higher level of fin-conve mitigates the negative impact of geo-polit and renders its simple slope statistically insignificant. Moreover, such a mitigating effect appears to be generally consistent across GVC participation measures associated with different production processes.

It is worth noting that due to the limited coverage of the fin-conve data, the panel dataset used for the moderating effect regressions contains more missing values than the baseline regressions. However, the issue of missing data exists only for the moderating variable fin-conve; the two other moderating variables, which capture external forces, do not suffer from serious data omission. To ensure that the missing data does not introduce substantial bias into the estimation results while retaining as many observations as possible in investigating other types of moderating effects, this article conducts additional robustness checks using three approaches.

- First, fin-conve will be incorporated into the baseline regression model without the interaction term (the number of observations matches that of the moderating effect model).
- Second, data entries with missing values in fin-conve will be excluded from the baseline regression sample (with the same number of observations as the moderating effect model).
- Third, fin-conve will be linearly interpolated for each individual based on the time series, and the moderating effect regression will be re-estimated (with the same number of observations as the baseline regression).

The results show that in the first two approaches, the coefficients of geo-polit remain significantly negative, while in the third approach, the coefficient of geo-polit × fin-conve remains significantly positive. These findings suggest that the limited coverage of the fin-conve data does not significantly impact the estimation results. Detailed regression results are provided in the Supporting Information.

Furthermore, the examination of both anticipation and time-lag effects reveals that the mitigating effect of enhanced financing convenience manifests a certain temporal continuity, for the coefficients of the interaction terms between lagged values of fin-conve and the core explanatory variable remain significantly positive. On the other hand, there is no strong evidence of anticipation effects, as the coefficients of the interaction terms between the lead 1/2 terms of fin-conve and the core explanatory variable are statistically insignificant at the 10% level. This result aligns well with our theoretical expectations, corresponding to Proposition 2.

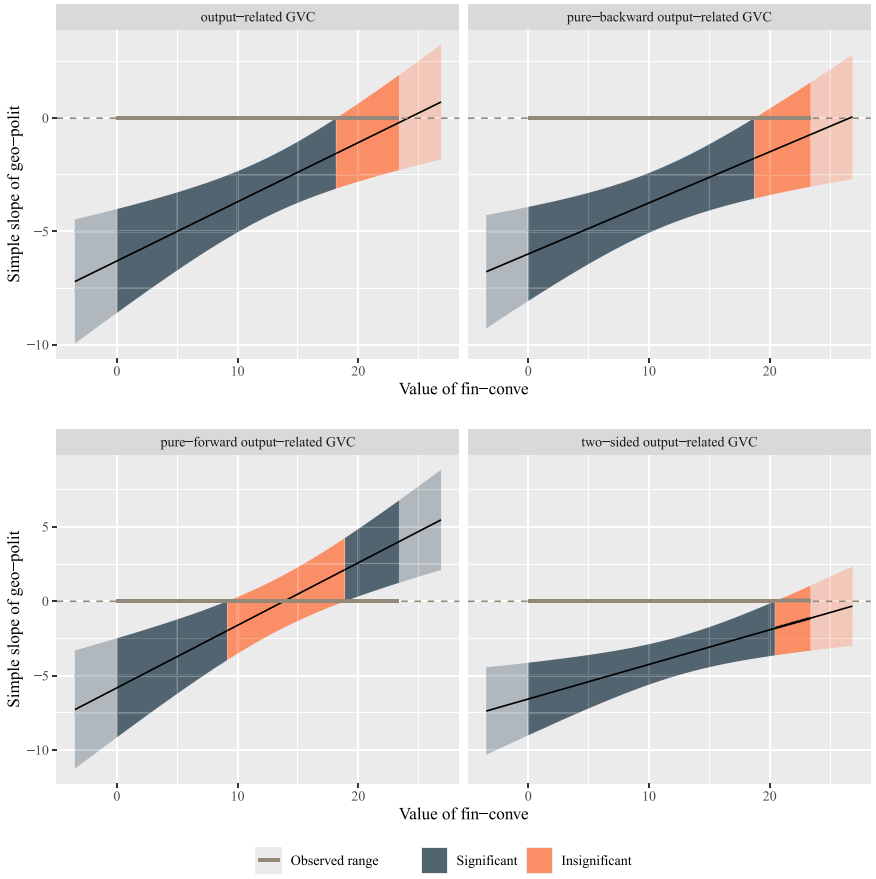
5.3 | Interacting With External Force

5.3.1 | Political Alignment

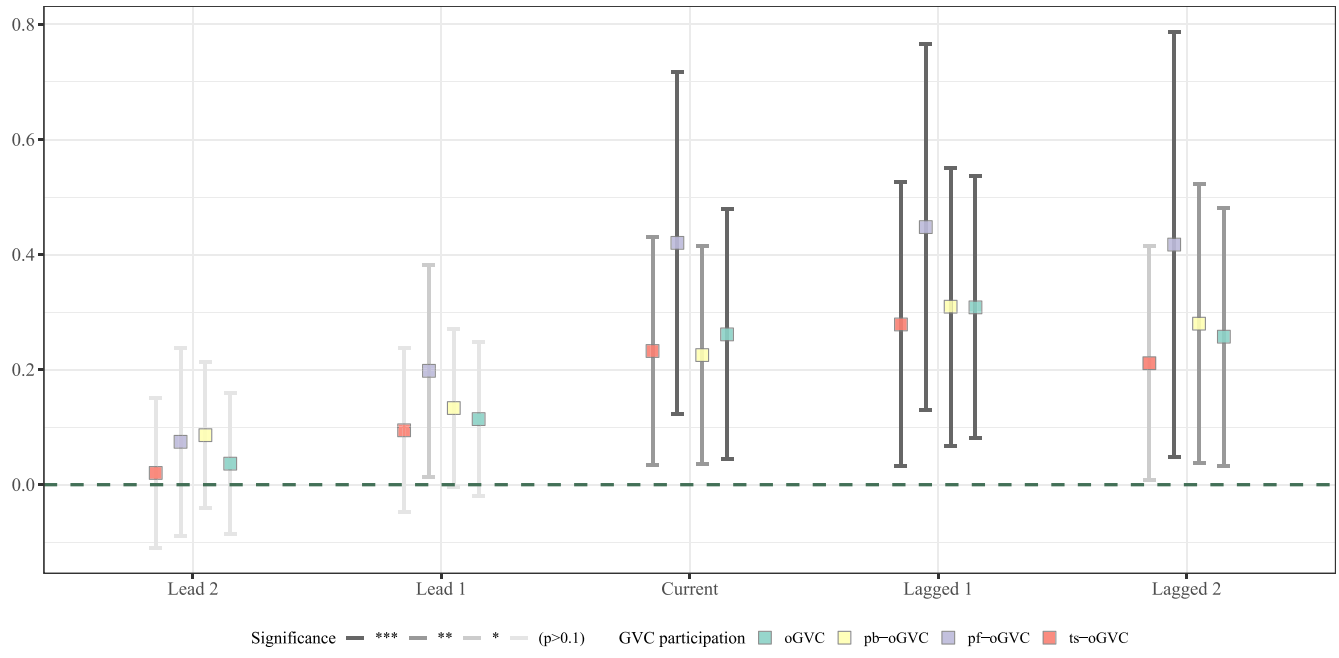
In the previous text, this article has already demonstrated how external forces will influence the improvement of GVC participation either directly—via interaction with geopolitical risks, or indirectly—via interaction with domestic financing convenience through a theoretical equilibrium model. Political alignment, as a common form of external force, is thus expected to exert a positive moderating effect, whether directly or indirectly, in facilitating GVC participation.

In this section, this article incorporates political alignment both as a moderating variable and in interaction with the core explanatory variable (geo-polit) to assess the direct moderating effect. Additionally, the lagged 1/2 terms of the political alignment variable are included to investigate potential time-lag effects. Similarly, beyond assessing the indirect moderating effect of political alignment via triple interactions with geo-polit and fin-conve, this article also examines time-lag effects by replacing the lagged 1/2 terms of the political alignment variable from the triple interactions. The results of the direct and indirect moderating effects are presented in Table 4; the marginal effect of pol-align on geo-polit and geo-polit × fin-conve are presented in Figure 4a, while the corresponding time-lag effects are visualised in Figure 4b. Full results are provided in the Supporting Information.

Compared to the baseline regression, the results show that political alignment indeed demonstrates a significantly positive direct moderating effect, as evidenced by the significantly



(a) Marginal effect of fin-conve.



(b) Anticipation and time-lag effects of fin-conve.

FIGURE 3 | Marginal, anticipation and time-lag effects of financing convenience. [Colour figure can be viewed at wileyonlinelibrary.com]

positive coefficients of the interaction term geo-polit × pol-align. This suggests that greater overall political proximity to other countries mitigates the negative impact of geopolitical risks. Furthermore, political alliances also exhibit a significantly positive indirect moderating effect, as the coefficients of the triple interaction term are significantly positive at high significance levels. This implies that alignment with other countries enhances the positive moderating effect of domestic financing convenience, thereby indirectly promoting GVC participation. The marginal effects results also show that higher pol-align not only

TABLE 4 | Results of moderating effect of political alignment.

	GVC participation			
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Geo-polit × pol-align	0.721***			
	(0.209)			
Geo-polit × fin-conve × pol-align		0.497**		
		(0.194)		
Geo-polit × attention			−0.578***	
			(0.130)	
Geo-polit × fin-conve × attention				−0.154**
				(0.069)
Control variable	✓	✓	✓	✓
Observation	663	385	687	396
Adjusted R^2	0.558	0.444	0.500	0.436
Year FEs	✓	✓	✓	✓
Country FEs	✓	✓	✓	✓

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

directly alleviates the adverse effect of geo-polit (as reflected by the smaller and statistically insignificant simple slope), but also strengthens the positive moderating effect of fin-conve (as the simple slope becomes larger and statistically significant), thereby exerting a more pronounced indirect moderating effect. All of these findings are consistent with our expectations in Propositions 3a and 4a.

From the perspective of time-lag effects, both the direct and indirect moderating effects of political alignment display clear temporal continuity. The coefficients on the lagged interaction terms—whether dual or triple—remain significantly positive at high levels. It indicates that the formation of stable and widespread political alliances or a general convergence in political stance contributes to the sustained mitigation of the negative impact of geopolitical risks on GVC participation.

5.3.2 | Media Attention

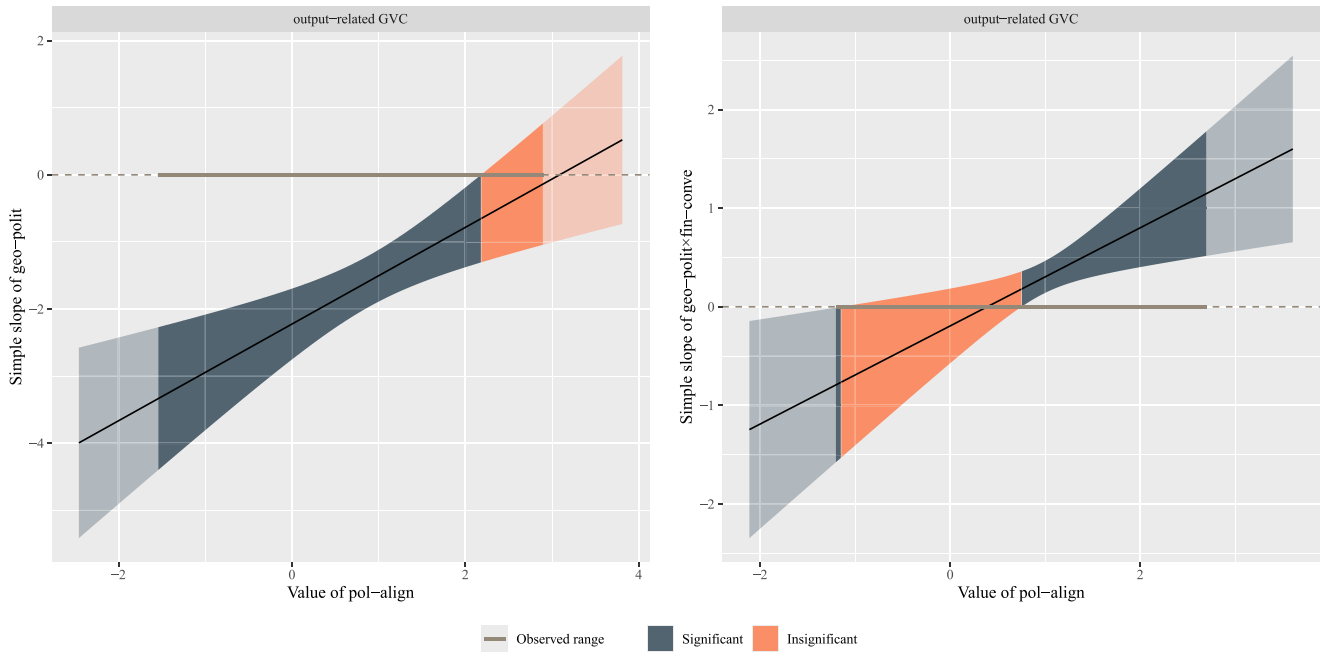
Following the same empirical strategy as in the previous text, this article incorporates attention through the inclusion of dual and triple interaction terms to evaluate its direct and indirect moderating effects. In addition, the temporal continuity of these effects is further examined by replacing attention with its lagged 1/2 terms. The results of the moderating effects are presented in Table 4; the marginal effect of attention on geo-polit and geo-polit × fin-conve are presented in Figure 5a, while the time-lag effect analyses are visualised in Figure 5b; full results are provided in the Supporting Information.

The regression results reveal that media attention indeed exerts significantly negative direct and indirect moderating effects, as evidenced by the consistently and significantly negative coefficients on both dual and triple interaction terms involving attention. This indicates that heightened media attention not only amplifies the negative impact of geopolitical risk on GVC participation but also hampers the positive moderating role of financing convenience, thereby indirectly obstructing improvements in GVC participation. The marginal effects results also reveal that higher attention not only directly exacerbates the negative effect of geo-polit (as evidenced by the increased absolute value and continued significance of the simple slope) but also largely weakens the positive moderating role of fin-conve. All of these results provide empirical support for our expectations in Propositions 3b and 4b.

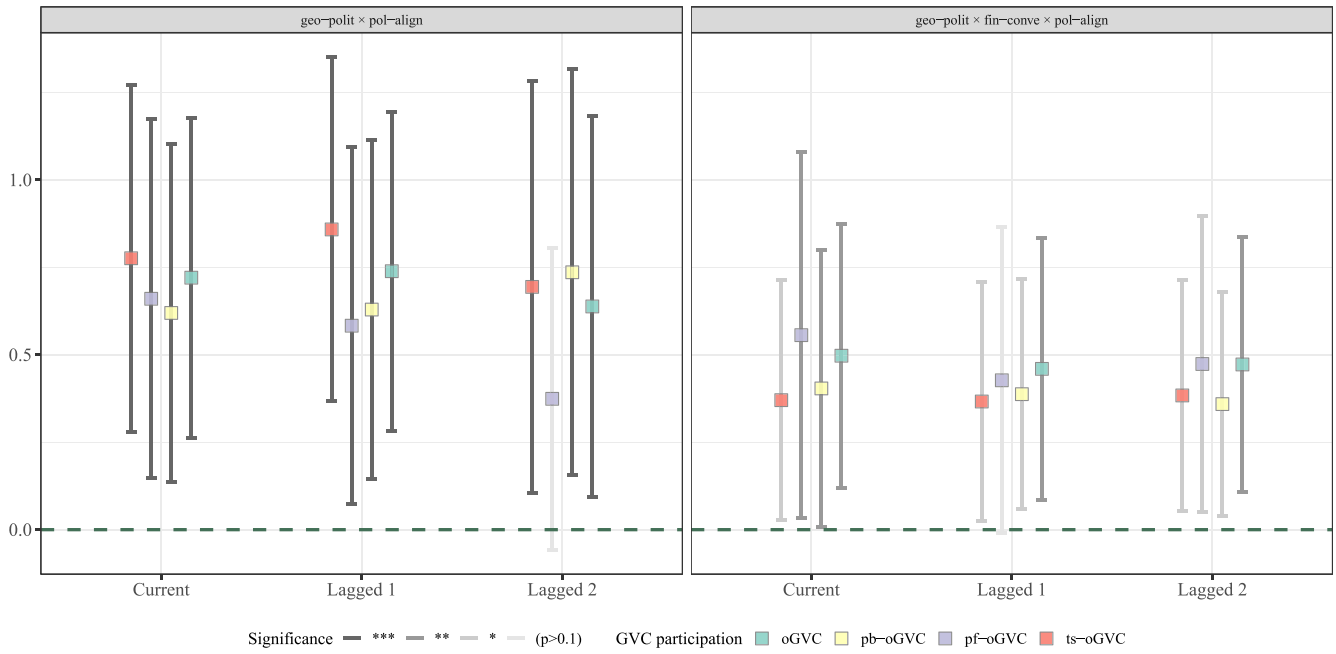
Interestingly, and in stark contrast to the results of political alignment, media attention does not exhibit significant temporal continuity. The coefficients of interaction terms involving lagged 1/2 terms of attention are statistically insignificant at the 10% level. It suggests that both the direct and indirect moderating effects of media attention decay rapidly over time; such a finding aligns intuitively with the inherently short-lived nature of media reporting and news cycles.

6 | Concluding Remark

Understanding how geopolitical risk affects economies' integration into the GVC is of vital importance, as it helps identify strategies to mitigate negative effects and guides the formulation of sound and effective macroeconomic policies. In this article, we develop a theoretical framework to examine how geopolitical risk will affect a country's position in the GVC, incorporating 'internal force' and 'external forces'. Then, we conduct empirical analyses using panel data for 77 countries or regions from 1995 to 2020 to test the validity of our model. The results tell us that geopolitical risk exerts a significant negative impact on GVC participation, while financial convenience



(a) Marginal effect of pol-align.

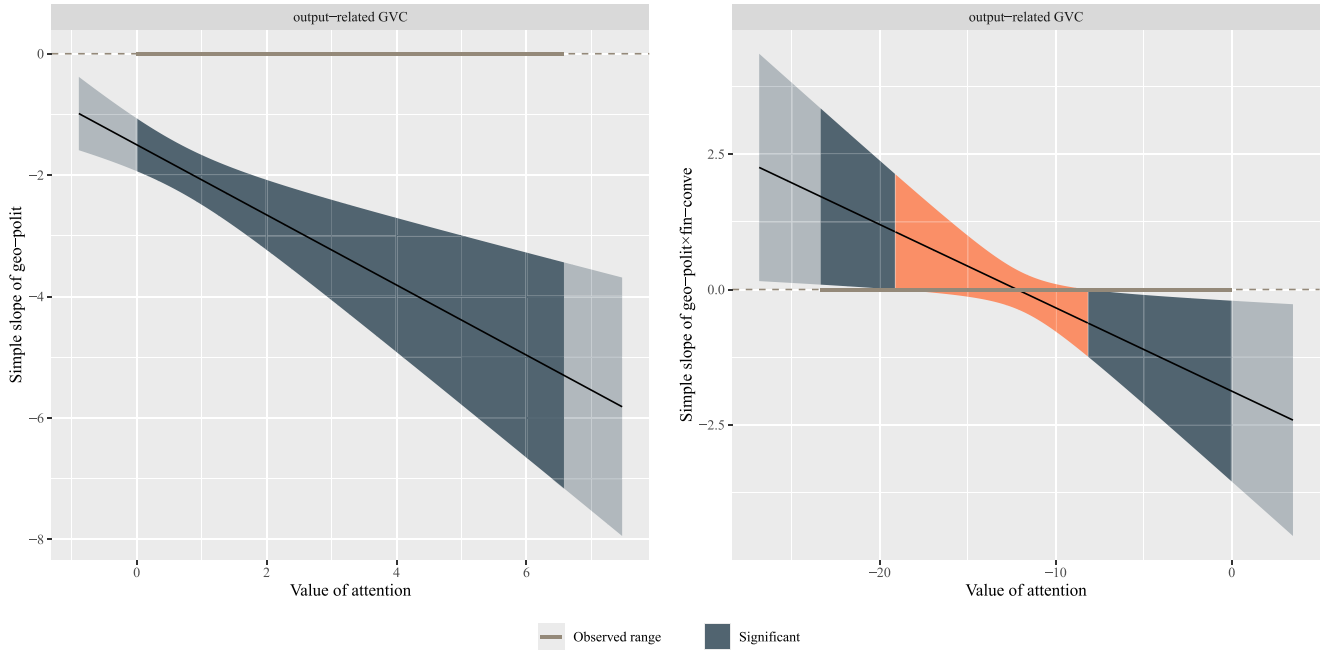


(b) Time-lag effect of pol-align.

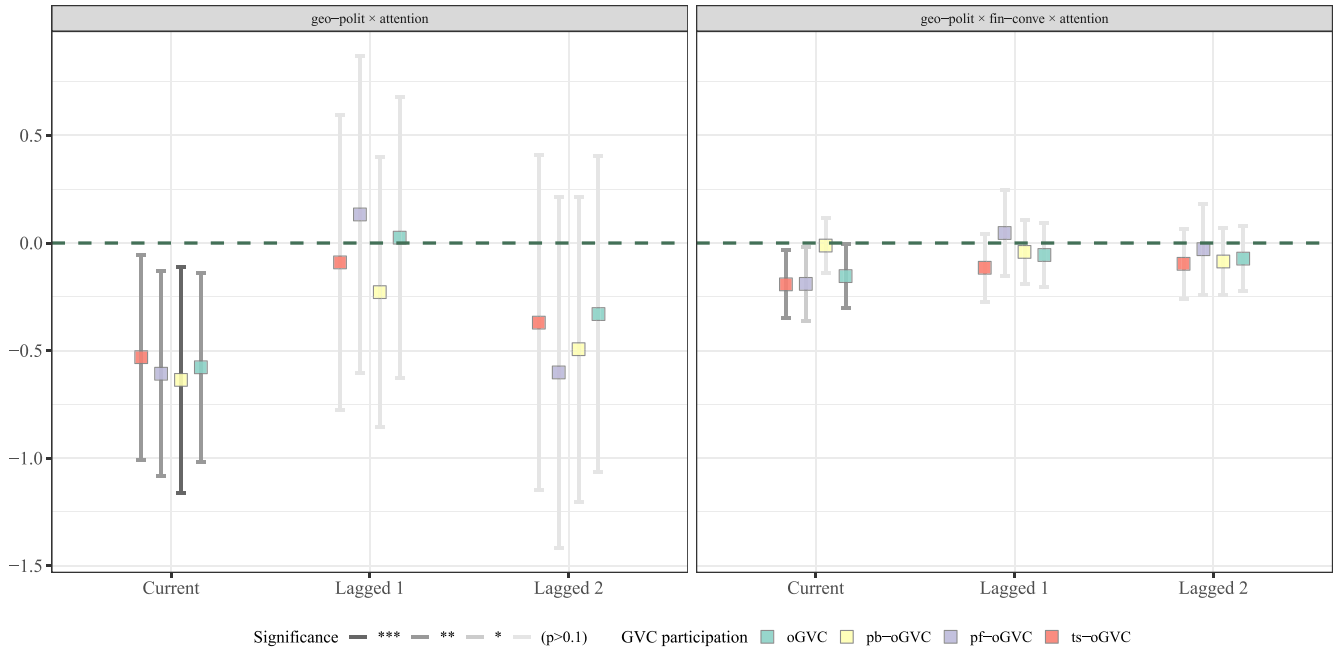
FIGURE 4 | Marginal and time-lag effects of political alignment. [Colour figure can be viewed at wileyonlinelibrary.com]

helps to mitigate such a negative effect by exhibiting temporal continuity. Political alliances, as a beneficial external force, significantly attenuate the adverse effect of geopolitical risk via both direct and indirect pathways, with marked temporal persistence; in contrast, media attention exacerbates the adverse effect through comparable pathways, yet such effect dissipates rapidly.

These research findings can provide us with some valuable policy insights. First, enhancing the accessibility and convenience of corporate financing represents a sound domestic approach. However, such improvement often depends on highly developed capital markets and a higher degree of financial liberalisation, which may not be feasible for less developed countries. Notwithstanding, political alignment offers a more feasible and politically relevant alternative. Multilateral cooperation frameworks, for example, the Regional Comprehensive Economic Partnership (RCEP) and the 'Belt and Road' Initiative, provide good illustrations, which aim to promote regional integration and supply chain complementarity to reduce external dependence. Those least developed economies can also connect with aid and investment resources through Economic Community of West African States (ECOWAS), Association of South East Asian Nations (ASEAN) or various



(a) Marginal effect of attention.



(b) Time-lag effect of attention.

FIGURE 5 | Marginal and time-lag effects of media attention. [Colour figure can be viewed at wileyonlinelibrary.com]

regional financial arrangements, as in the case of East African logistics corridors. Moreover, in the media era, the rapid and widespread dissemination of information related to negative market sentiment may shape national image and may further fuel populism and anti-globalisation ideologies. To mitigate this, establishing rapid-response mechanisms, together with proactive communication through authoritative outlets and multilateral platforms, can help alleviate value-chain decoupling triggered by geopolitical risks.

Of course, this article leaves several open questions that merit further investigation in future research. First, the quality of the original data used for measuring geopolitical risk remains a considerable constraint. Future efforts could improve upon this by using contextual analysis of government reports and media sources to build a more comprehensive database. Second, future research could explore the roles of other internal forces and their interactions with geopolitical risk. Especially, future studies may benefit from investigating additional types of external influences and alternative transmission channels, which could yield richer and more actionable policy insights. Third, differences are expected to exist among various types of GVC participation. It implies that the negative effects of geopolitical risks may vary across different forms of GVC participation. Future

research could focus on exploring the sources and transmission mechanisms underlying such heterogeneity.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Endnotes

[1] See: "The resurgence of inter-state tensions in the Americas in a complex geopolitical landscape." IISS, 27 March, 2025. Available at: https://www.iiss.org/events/2025/03/The-resurgence-of-inter-state-tensions-in-the-Americas-in-a-complex-geopolitical-landscape.

[2] See: "Soldiers and Citizens: Military Coups and the need for Democratic Renewal in Africa." UNDP, 14th July, 2023. Available at: https://www.undp.org/africa/publications/soldiers-and-citizens.

[3] Benefits with capabilities of gaining benefits are also often understood as closely linked to countries' willingness to participate. Some viewpoints argue that the gains from GVCs crucially depend on whether countries can "voluntarily participate" (World Bank 2019).

[4] For instance, following the 2023 coup in Niger, the Economic Community of West African States (ECOWAS) imposed stringent sanctions, tightening liquidity conditions and restricting access to global capital markets.

[5] According to Antràs (2020) and Fernandes et al. (2022), GVCs refer to trade flows in which imported intermediate inputs are processed and then exported, implying that participating in the GVC is fundamentally distinguished from engaging solely in exporting or importing.

[6] A prominent example is Russia's turn toward China and other BRICS economies to seek economic and political support following Western sanctions (Yushkov and Alexeev 2024).

[7] For example, the ascent of Italy's Five Star Movement relied heavily on social-media mobilisation (Bracciale et al. 2021).

[8] Worth mentioning, process productivity ϕ differs from product productivity φ described in the following text.

[9] An individual sub-indicator may be conceptually crucial to the meaning of the composite index, but may still be assigned a low weight due to its more minor contribution to variance.

[10] This article utilises risk assessment data provided by the International Country Risk Guide (ICRG) and selects 6 indicators relevant to geopolitical risk.

[11] Indeed, Entropy can hardly be considered a true dimensionality-reduction approach.

[12] This indicator is obtained from the IMF International Financial Statistics. See: Aghion et al. (2007).

[13] The criterion for passing the test is that the p-value of the t-test between samples is not $< 5\%$.

[14] Worthy noting, even if the share component is partially endogenous, providing the shift remains exogenous, the resulting estimator will be unbiased and consistent (Borusyak et al. 2022, 2025).

[15] In practice, strict satisfaction of the exclusion restriction is virtually impossible, but as long as the degree of violation is limited, the IVs will remain valid (Conley et al. 2012).

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** twec70077-sup-0001-Supinfo.pdf.