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Global Value Chains and Subnational Exposure to Geopolitical Tensions

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Abstract

Geopolitical tensions are reshaping Global Value Chains (GVCs), yet little is known about the magnitude of these effects and, especially, how they translate into uneven exposures at the subnational level. This paper argues that subnational regions are a critical unit for understanding GVCs and their changes under geopolitical fragmentation. We develop a regional exposure index that links global sensitivities from structural gravity estimations of GVC-related trade with granular regional trade data. Evidence from Italian regions reveals pronounced heterogeneity in both upstream and downstream exposure, depending on sectoral specialization and partner composition. These findings suggest that geopolitical fragmentation not only reshapes GVCs but also reconfigures regional economic vulnerabilities, with direct implications for cohesion, competitiveness, and policy design.

Keywords: Global Value Chains, Regional Development, Gravity, Geopolitical tensions, Trade policy.

JEL: F14, F23, F51.

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1. Introduction

For many years, geopolitics played only a limited role in the mainstream economics literature. Over the past decade, however, geopolitical tensions have increasingly shaped the international economic environment. These tensions have manifested through restrictive trade policy measures, sanctions, the weakening of multilateral institutions, and even open conflicts. Their impact has extended beyond a few strategic industries to the broader functioning of the global economy, prompting a renewed interest in geopolitics within economics.

Key events have accelerated this shift. The escalation of rivalry between the United States (US) and China over technological leadership culminated in the March 2018 announcement of sweeping U.S. tariffs on Chinese imports. The Covid-19 pandemic subsequently highlighted the fragility of global supply chains, as export bans and bottlenecks in critical inputs underscored vulnerabilities and fuelled debates on diversification, reshoring, and resilience. The Russian invasion of Ukraine in February 2022 brought geopolitics to the forefront of international policy discussions, particularly regarding access to raw materials, energy supply, and strategic technologies. These episodes have motivated a new wave of domestic industrial policies, incentives for reshoring, and export restrictions (Evenett et al., 2024; Juhász et al., 2024), while also leading to unprecedented sanctions regimes, especially in Europe. By December 2024 the European Union (EU) had prohibited €91.2 billion of imports and €48 billion of exports to Russia, equivalent to more than half of bilateral trade flows (European Council, 2024).

The use of sanctions is not new, but their scope and intensity have expanded significantly over recent decades (Morgan et al., 2023). The impact of sanctions and trade restrictions is magnified in Global Value Chains (GVCs), given the backward and forward linkages that characterize production networks (Ghodsi & Stehrer, 2022; Muradov, 2017). Empirical evidence shows that sanctions reduce GVC participation, with the effects materializing gradually over time (Le et al., 2022; Bruno et al., 2023). Studies of Russia's energy industry, for example, document disruptions to forward GVC participation and estimate potential long-term Gross Domestic Product (GDP) losses exceeding 10% (Du & Wang, 2022; Winkler et al., 2022).

More broadly, geopolitical tensions are becoming significant drivers of GVC reconfigurations. Directly, they operate through trade policy, sanctions, and targeted industrial policies; indirectly, they affect firms' internationalization strategies by raising uncertainty and altering the business climate across countries. Recent studies show that geopolitical alignment fosters trade, foreign direct investment (FDI), and capital flows (Aiyar et al., 2024; Campos et al., 2023; Gopinath et al., 2024; Hakobyan, 2023; Ruta, 2022), whereas misalignment fosters fragmentation (Jakubik & Ruta, 2023). Trade between geopolitical blocs, identified via voting patterns at the United Nations (UN), is now growing more slowly than trade within blocs (Blanga-Gubbay et al., 2023; Seong et al., 2024; WTO, 2024). Structural gravity estimates confirm that geopolitical distance has become an independent

barrier to trade: since 2018, its elasticity has turned significantly negative for manufacturing, beyond the effects of geographical distance and conventional trade policy frictions (Giovannetti et al., 2025; Bosone & Stamato, 2024; Nana & Ouedraogo, 2023).

Overall, a growing body of evidence points to geopolitics as an increasingly important determinant of global trade and production structures. Yet explicit analyses of how geopolitical tensions reshape GVCs remain relatively limited, leaving an open research agenda on the mechanisms and territorial consequences of this transformation. Furthermore, despite mounting evidence that geopolitics is reshaping trade and GVCs, little is known about how these dynamics translate into uneven exposures at the subnational level.

We contribute to this literature in two main ways. Conceptually, we argue that subnational regions are a key unit for understanding GVCs under geopolitical fragmentation. Methodologically, we operationalize geopolitical exposure at the regional level by proposing a novel index that links global sensitivities from structural gravity estimations with granular regional trade data. We acknowledge, however, that data availability remains a key limitation to advancing research on the subnational aspects of GVCs and to address the lack of data, we start by focusing on Italian regions, an interesting case study.

Three main strands of literature help situate our work on the subnational dimensions of GVCs, intersecting and complementing each other.

First, the international business literature which closely investigates the functioning of GVCs, multinational enterprises (MNEs) and FDIs, offering nuanced insights and conceptual frameworks. Early international business research examined the location choices of multinational firms through qualitative analyses and case studies. Managing GVCs across various actors, regions, and countries requires advanced coordination, typically overseen by a multinational lead firm involved in FDIs, seen as a direct way through which GVCs "touch down" on territories, with direct implications for local employment, knowledge and technology transfer. The classic Ownership-Location-Internalization (OLI) Eclectic Paradigm (Dunning, 1977, 1996) helps to understand region-specific aspects of the location determinants of FDIs especially in its recent formulations emphasizing the subnational role of innovation dynamism, human capital and local socio-institutional characteristics (Crescenzi and Rodriguez-Pose, 2011; Iammarino and McCann, 2013).

Second, the international economics and industrial organization literature has historically focused on national aspects of GVCs with mathematical models and quantitative empirical analyses (Antràs, 2020a). This perspective was driven by the global and national policy relevance of trade and GVCs. Over the last three decades, the increasing availability of inter-country input-output (ICIO) tables as well as micro-data – more recently even with firm-to-firm transactions – also contributed to complement country-level studies with a wave of firm-level ones (Bernard et al., 2018). The new data availability came with the development of new methods to measure country-sector GVC activity

(Johnson & Noguera, 2012; Koopman et al., 2014; Borin and Mancini, 2019) and theoretical models of GVCs based on imperfect competition where firms play a crucial role (e.g. Antràs 2015, 2020b; Antràs & Chor, 2013, 2022). While the input-output analyses provided accurate global and macro-level representations of GVCs, the firm-level literature highlighted new mechanisms and sources of heterogeneity hardly visible with country-level lenses. These developments, in turn, brought cross-fertilization between economics and international business on concepts like GVC participation, position, functions within GVCs, upgrading, and GVC governance modes (Gereffi, 1999; Gereffi et al., 2005). The growing theoretical and empirical acknowledgment of complexities and micro-level heterogeneous effects further emphasized the spatial distribution of economic activity, geographic disparities, complementing case studies with more quantitative geographic research (Cantwell and Iammarino, 2003).

Third, the economic geography literature has more directly and increasingly focused on the subnational aspects of GVCs, highlighting how local factors, spatial dependencies, and regional policies shape GVC participation and outcomes, also providing insights for regional development. GVC activity is global yet embedded in territories with diverse local economic, social, and institutional dynamics. Therefore, the region can be seen as the critical unit bridging the macro-country level with the micro-firm aspects of GVCs (Crescenzi & Harman, 2023). Subnational GVC participation is highly heterogenous both in intensity and qualitative aspects. Regions can differ in their degree and mode of integration, reflecting the specific stages, tasks, and functions performed locally. The literature has identified mechanisms like agglomeration economies, market access and labour market conditions as key determinants of the location of different GVC stages (Crescenzi et al., 2014). General equilibrium models clearly show that the location of GVC production is endogenously shaped by spatial proximity between upstream and downstream stages (Antràs & De Gortari, 2020).

The importance of the subnational dimension as an active space that contributes to GVC configurations clearly emerges from the economic geography literature on Global Production Network (see the GPN 1.0 and GPN 2.0 frameworks; Coe et al., 2008a, 2008b; Coe and Yeung, 2015, 2019).[1] GVC "territoriality" is envisioned as a conceptual lens in which the role of the geographical space goes beyond being the anonymous physical surface on which GVCs distribute their activities (Coe et al., 2015). There is a vertical organizational dimension from global to local and vice versa in which some functions are globally organized while others are inherently local because critical inputs

[1] It is important to note that different strands of the literature use partly overlapping terminologies to describe broadly similar phenomena of global production organization. In this paper, we use the term Global Value Chain (GVC), while recognizing that related concepts, such as Global Production Network (GPN) or Global Commodity Chain (GCC), emphasize different analytical dimensions and are rooted in distinct conceptual traditions. In particular, GPN denotes a well-established framework within economic geography (see Coe & Yeung, 2015; Gereffi, 2019). Our preference for GVC reflects a concern for methodological transparency, as it directly connects with the empirical literature on GVC measurement based on input-output data employed in our analysis.

and know-how are territorially embedded. This vertical dimension intersects and combines with a horizontal territorial dimension describing the spatial embeddedness with which GVC "touch down" and spread within territories at a local, regional or national scale. The horizontal dimension implies a lateral expansion of GVC activity that brings about spatial spillovers as well as possible inter-regional competition and uneven territorial development, whose empirical counterparts can be found in the importance of explicitly considering proximity, relatedness, clusters, spatial correlation, local institutional contexts and performing multilevel analyses (Rodriguez-Pose & Crescenzi, 2008; Van Oort et al., 2012; Boschma, 2017; Cortinovis et al., 2017).

Recent empirical evidence on the GVC participation and position of NUTS2 European regions, based on the latest regional input-output tables (EUREGIO data for year 2010), demonstrates that GVC activities are strongly influenced by regional characteristics and spatial spillovers, with significant spatial dependence (Bolea et al., 2022). For the same European regions, GVC participation appears shaped by agglomeration economies, with specialized regions attracting high-value FDIs while capital cities deter manufacturing due to resource constraints (Kimino, 2024). Similar findings regarding the importance of subnational aspects of GVCs are available for China, where province-level GVC participation indicators based on the new Trans-national Inter-regional Input-Output table, covering 30 Chinese provinces for 2007 and 2012, uncover high spatial heterogeneity (Xie et al., 2021).

While this body of work underscores the importance of regions in shaping and being shaped by GVCs, it has largely abstracted from the growing role of geopolitics in influencing global production networks. There is very limited literature specifically addressing the subnational dimension of geopolitical tensions, either with or without a GVC perspective. Existing economics research on the role of geopolitics is very recent and most studies focus on national-level impacts, sectoral outcomes, or firm-level responses, with only indirect evidence about the subnational dimension. There is, therefore, a need for more granular, subnational analyses of how geopolitical shocks affect trade flows and firm behaviour as country-level research may miss critical dynamics unfolding at the regional level.

Subnational actors are not just recipients of national-level decisions passively exposed to geopolitical rivalries, they also have agency in various forms. Subnational governments often devise regional industrial interventions and play a critical role in implementing national strategies, while their incentives may not perfectly align with those of the central government. Regions may engage in tax or subsidy competition or respond differently to geopolitical shifts depending on their foreign economic linkages (Evenett, 2021).

As mentioned above, geopolitical alignment plays a significant role in driving the country-level geographical allocation of FDIs (Aiyar et al., 2024), whereas mis-alignment can lead to fragmentation and disruptions (Jakubik & Ruta, 2023).

While research specifically addressing subnational exposure to geopolitical tensions is scant, related literature has examined other forms of regional exposure to national and international trends. Studies on globalization have shown that the heterogeneous subnational exposure to Chinese imports (the so-called "China shock") contributed to shaping economic and political outcomes (Autor et al., 2020; Colantone & Stanig, 2018a; 2018b). Trade exposure is also associated with regional inequality (Rodriguez-Pose, 2012). Similarly, recent tariffs' increases due to the recent US-China trade war are likely to yield uneven effects across NUTS2 European regions according to their trade specialization (Almazán-Gómez et al., 2025). These findings suggest that similar approaches could yield important insights for geopolitics.

Overall, not only is research explicitly focusing on GVCs reorganization in response to geopolitical tensions scant – as argued above – but the few studies on closely related topics, like trade and FDIs, crucially miss the subnational dimension. Our paper fills this gap and offers new insights in this direction by operationalizing regional exposure to geopolitical shocks through a Regional Exposure Index (REI) than links global GVC sensitivities to regional trade structures.

Our results show that geopolitical tensions are indeed reshaping GVCs. An increase in the geopolitical distance between two countries reduces GVC-related trade by 7.2% on average. The effect has increased , and is heterogeneous across sectors and stronger among geopolitical rivals. Applying our index to Italy, we show that subnational regions display highly heterogeneous degrees of exposure depending on their sectoral specialization and the geography of their trade relations. We find stronger vulnerabilities on the export side (downstream exposure) for some regions, while others are exposed on the import side (upstream exposure). Many regions show downstream exposure vis-à-vis the US, while upstream exposure is frequent vis-à-vis China and Russia.

By combining insights from international trade and economic geography, our analysis shows how geopolitical fragmentation does not only reshape global production networks but also reconfigures regional economic vulnerabilities, with direct implications for cohesion, competitiveness, and policy design.

The rest of the paper is organized as follows. Section 2 discusses the data and describes our methodological approach. Section 3 provides the main results on the sensitivity of GVC-related trade and the regional exposure to geopolitical tensions. Section 4 concludes.

2. Data and Methodology

Our analysis starts with the global country-level analysis based on gravity estimation of the effect of geopolitical distance on GVC trade, and then moves to the subnational analysis of exposure to geopolitical tensions. In subsection 2.1, we discuss data issues and describe the data employed in the gravity model as well as the subnational data used to assess regional-level exposure. Then subsection 2.2 describes our two-step methodology. Our analytical approach focuses on understanding how

geopolitics influence bilateral trade patterns within GVCs, and how these effects manifest at the subnational level. To capture this, we propose a novel measure – the Regional Exposure Index (REI) – which evaluates regional vulnerability to global geopolitical shocks. The REI is derived from the gravity estimates that incorporate global GVC linkages and geopolitical fragmentation. We use sectoral bilateral trade shares at the NUTS2 level (imports and exports) for Italian regions, enabling a detailed analysis by partner and trade direction.

2.1. Data

The literature so far has mainly used inter-country input-output (ICIO) for worldwide GVC analyses,[2] which only provide the national dimension. To our knowledge, there are a no subnational-level datasets with a worldwide coverage that can provide a complete representation of GVCs in a way comparable to ICIO tables, despite the recent statistical efforts to advance in this direction, providing useful bases for understanding the subnational dimensions of GVCs.

The EUREGIO tables, which unfortunately stop in year 2010, and recent updates efforts made by other researchers to extend them to 2017 (Almazán-Gómez et al., 2023), cover NUTS2 European regions with a NACE2 sectoral disaggregation, merging data from WIOD (the 2013 release) with regional economic accounts and interregional trade estimates (Thissen et al., 2018). Another source of data suited for subnational GVC analysis is the GTAP (Global Trade Analysis Project) data with its subnational extensions to specific regions; however, they typically require ad hoc manipulations. For instance, micro-founded ICIO-GTAP tables using firm-level data from specific countries (Italy and France), with a potential regional focus, have been recently proposed (Fusacchia et al., 2025), but the available data do not currently allow the computation subnational GVC indicators nor timely ones.

As inter-country inter-regional input-out data is often lacking either in terms of subnational geographical coverage, time or sectoral detail, several studies have retrieved to firm-level dataset with the clear advantage of granularity, but with limitations in terms of international coverage and representativeness (Amador & Cabral, 2016; Giunta et al., 2022). Lastly, an intermediate ground between input-output tables and firm-level data is represented by subnational trade statistics. This data provides a good national and international representativeness as well as detailed sectoral or product detail, and is usually updated more regularly. Unfortunately, the coverage of this type of subnational data is again often limited to single countries.

Using data from a microlevel survey on annual shipments of goods by road (European Road Freight Transport survey by Eurostat), a recent paper has systematically explored for the first time the European trade patterns with a subnational detail, highlighting the presence of home bias and the relevance of geographical distance and administrative regional borders (Santamaria et al., 2023).

[2] Amongst the Input Output tables the most used are WIOD (World Input-Output Database; last year 2014), ICIO-TiVA (Trade in Value-Added; last year 2020), Eora (last year 2022), ADB-MRIO (last year 2022).

However, trade statistics do not provide direct information on the input-output relationships, which implies that GVC indicators cannot be readily calculated. While this can be seen as a matter of precision rather than feasibility, and thus as a partial limitation; more importantly, this road-based trade data only covers goods from 12 aggregated industries and the latest year is 2017, making it not viable for our research question.

Given these data limitations, we combine national and subnational data sources to carry out a two-step analysis: first at the global level, to capture cross-country GVC linkages; and then at the territorial level, to assess regional exposure.

The country-level analysis captures global linkages between countries. We build a dataset combining: i) bilateral trade flows linked to global value chains (GVCs); ii) symmetric, time-varying geopolitical distance measures between country pairs; and, iii) standard gravity variables from the CEPII database (Conte et al., 2022), such as GDP, geographic distance, regional trade agreements and WTO membership, in order to control for structural trade determinants.

The GVCs data covers 35 sectors spanning from agriculture, to construction, and 14 manufacturing industries, as well as 17 service industries, for 60 countries from 2000 to 2022 (except for the period between 2001 and 2006). These data represent approximately 93% of global production. We use the Asian Development Bank's (ADB) multi-country input-output tables, which have been refined using the Borin & Mancini methodology (2019, 2021, 2023). This methodology captures both backward and forward GVC participation, i.e. we consider trade flows that either embed foreign inputs or feed into partner countries' exports.

Geopolitical distance is measured using the “ideal point” methodology from UN General Assembly voting data (Voeten et al., 2009; Bailey et al., 2017), which positions countries on an ideological scale and allows for consistent intertemporal comparisons. Compared to simpler voting similarity scores, this approach better captures shifts in foreign policy preferences. Distances range from 0.77 to 4.09, with an average of 0.99. Following Jakubik & Ruta (2023), we classify bilateral ties as “Friends” (the lowest 25%), “Partners” (the middle 50%), and “Rivals” (the top 25%).

For the subnational analysis, we use Italy’s granular regional trade data to examine how geopolitical tensions translate into heterogeneous GVC vulnerabilities. Data from ISTAT COE provide trade patterns (imports and exports) for the 20 Italian regions with partner countries worldwide, categorised by the three-digit CPA product level. To align these data with the macro findings, we restricted the analysis to partners included in the ADB data, aggregating products to identify the 14 ISIC manufacturing industries in the GVCs data from 2017 to 2022.

2.2. Methodology

We propose a two-step analytical framework to assess the global and regional exposure of Global Value Chains (GVCs) to geopolitical dynamics. In the first step, we estimate a structural gravity

model using bilateral GVC trade flows and measures of geopolitical distance, capturing the dense web of interdependencies linking trade, production, and political relations across borders. This allows us to construct a global exposure index that reflects not only direct ties but also the wider architecture of the international production system. In the second step, we weight the estimated coefficients by regional trade shares to assess how this exposure varies across Italian regions, sectors, and trade partners, offering a spatially grounded lens on geopolitical exposure.

Our empirical strategy is based on the structural gravity framework (Anderson, 1979; Anderson & van Wincoop, 2003), which has become a cornerstone in international trade analysis for its ability to account for multilateral resistance (origin and destination market access costs) and third-country effects. These features are relevant for GVCs, where production is fragmented across multiple borders and each link in the chain is embedded in a wider network of trade relations. Controlling for these network effects enables us to understand how geopolitical tensions in one part of the system can have an impact on others.

A key novelty of our contribution lies in shifting from traditional gravity models based on gross trade to an approach grounded in value-added trade. Unlike earlier standard models, which often aggregate final and intermediate goods and overlook the sectoral interdependencies that define GVCs, our framework addresses the spatial and relational complexity of global production directly. This distinction is crucial, as the disaggregation of production increases the sensitivity of intermediate goods trade to trade costs, while value-added flows reveal more nuanced dynamics (Noguera, 2012). This also helps shed light on the longstanding "distance puzzle" (Baldwin & Taglioni, 2014), as spatial frictions interact differently with fragmented production networks (Miroudot et al., 2009; Conconi et al., 2020).

Recent advances in trade theory have begun to integrate input-output linkages within structural gravity models, explicitly accounting for value-added trade within GVCs (Aichele & Heiland, 2018; Shepherd, 2022). Our analysis builds on this body of work, particularly Shepherd's (2022) framework, which employs similar indicators and data sources and provides a natural point of comparison.

In such a setting, trade costs are not simply additive, they accumulate and magnify across stages of production. As Johnson (1969) and others have noted, each upstream cost is embedded into downstream stages, amplifying the impact of frictions such as tariffs or policy shocks. Because firms often contribute only a modest share of value-added relative to gross output, small changes in trade costs can significantly affect competitiveness. Moreover, GVCs are marked by a duality: on one hand, they are characterized by sunk costs, asset specificity, and coordination frictions that generate inertia and stickiness (Antràs, 2020b; Di Stefano et al., 2022); on the other, their governance by large, often multinational firms allows for strategic spatial reconfiguration in response to geopolitical risks. This

tension between structural rigidity and organizational flexibility is central to understanding how GVCs adjust in uncertain environments.

To bring this global framework into a regional perspective, we introduce the Regional Exposure Index (REI), which connects macro-level geopolitical tensions to subnational economic geographies. Assuming that regions remain largely subject to national-level geopolitical positioning, we compute a weighted average of the estimated geopolitical sensitivity coefficients, using each region's trade composition as weights. In this way, we map how Italian regions are differentially exposed to geopolitical tensions, by trade direction (import/export), and by the nature of their trading partners: thereby grounding global dynamics in the spatial realities of regional economies.

2.2.1. Estimation of geopolitical elasticity

To measure how geopolitical tensions influence the reorganization of GVC, we estimate a structural gravity model. Our baseline equation is:

$$GVC_{k,ijt} = exp\left(\pi_{k,it} + \chi_{k,jt} + \mu_{k,ij} + \beta geopol_{ijt} + controls\right) \times \varepsilon_{k,ijt} \quad (1)$$

The dependent variable is GVC-related trade (in millions of USD) for sector k, from origin country i to destination country j, in year t. We estimate a gravity model using the Poisson Pseudo-Maximum Likelihood (PPML) estimator (Santos Silva & Tenreyro, 2006), which handles zero trade flows and heteroskedasticity. To address confounding factors, we implement a three-way fixed effects model: sector-origin-year ($\pi_{k,it}$), sector-destination-year ($\chi_{k,jt}$), and country pair-sector ($\mu_{k,ij}$), capturing multilateral resistance, market access costs, and bilateral time-invariant factors (Baldwin & Taglioni, 2006). A baseline "naïve" gravity is also estimated to validate the sample, controlling for GDP, distance, and standard covariates.

We examine how the impact of geopolitical distance varies depending on the type of bilateral relationship between countries. To do this, we classify all country pairs into three groups: Friends, Rivals and Partners.[3] This approach allows us to see whether trade behaves differently when countries are close allies, distant rivals, or somewhere in the middle. Furthermore, to provide a more detailed picture, we also test this heterogeneity by dividing country pairs into quintiles of geopolitical distance, which helps us capture how trade is influenced not only at the extremes but also across the full spectrum of political alignment.

In international politics, some countries play a central role in the geopolitical scenario. Thus, we also look separately at cases involving China, Russia, and the United States. By isolating these actors, we can assess whether GVCs flows linked to them react differently to geopolitical tensions compared to other countries, highlighting their role in shaping global patterns.

[3] As mentioned above, Friends include those with the closest geopolitical alignment (the lowest 25% of distances); Rivals represent the most distant relationships (the top 25%); and Partners fall in between and serve as the benchmark for comparison.

Moreover, we explore whether the influence of geopolitical distance has remained constant or changed over time. By examining how the effect evolves across different periods, we can identify whether political tensions have evolved over time and shaped GVCs' patterns in recent years.

Finally, we move to a detailed heterogeneity analysis across different relationships, countries, and sectors with a focus on manufacturing industries. This specification is crucial to link macro evidence and subnational. The extended models keep the full set of high-dimensional fixed effects (unilateral and bilateral) and introduce a set of interactions, as expressed in the following equation:

$$GVC_{k,ijt} = exp\left(\pi_{k,it} + \chi_{k,jt} + \mu_{k,ij} + D_{at} D_k \beta_{k,a} geopol_{ijt} + controls\right) + \varepsilon_{k,ijt} \quad (2)$$

The coefficients $\beta_{k,a}$which capture the average effect by sector and type of geopolitical relationship, serves as our proxy for geopolitical exposure in the construction of the REI. This coefficient reflects a global parameter that encapsulates the overall exposure of GVCs and geopolitical networks to which subnational entities are inherently connected.

2.2.2. Measuring subnational exposure

Building on the gravity estimations of the semi-elasticities of GVC trade to geopolitical distance, we proceed to construct an indicator of subnational exposure to geopolitical risk. The idea is to combine the country-sector sensitivities estimated from the global gravity model with regional trade structures, which reflect both the sectoral specialization of regions and their international linkages.

To this end, we construct a relative Regional Exposure Index (REI) that measures the exposure of each region r in year t relative to the national average. Formally:

$$REI_{t,r} = \frac{E_{t,r}}{E_t} \times 100$$
$$E_{t,r} = \sum_c \sum_s w_{t,r,c,s} \tilde{\beta}_{c,s} \quad E_t = \sum_c \sum_s W_{t,c,s} \tilde{\beta}_{c,s} \quad (3)$$

Here, $\tilde{\beta}_{c,s}$ are the absolute values of the statistically significant ($p < 0.1$) country c, sector s coefficients from the gravity model (all the relevant estimated coefficients are negative), while the weights are regional and national trade shares:

$$\tilde{\beta}_{c,s} = \begin{cases} -\hat{\beta}_{c,s} & \text{if } p < 0.1 \\ 0 & \text{otherwise} \end{cases}$$
$$w_{t,r,c,s} = \frac{z_{t,r,c,s}}{\sum_c \sum_s z_{t,r,c,s}} \quad W_{t,c,s} = \frac{\sum_r z_{t,r,c,s}}{\sum_r \sum_c \sum_s z_{t,r,c,s}} \quad (4)$$

The term z denotes the trade flows (imports, exports, or total trade, i.e. the sum of the two). Considering import and export separately allows us to decompose the total REI into import and export exposure components, REI^{imp} and REI^{exp}, with the overall index being a weighted average of the two.

A useful feature of this formulation is that it preserves additivity. In fact, the percentage point contribution of each partner country can be expressed as:

$$REIcon_{t,r,c} = \frac{\sum_s w_{t,r,c,s}\tilde{\beta}_{c,s}}{E_t} \times 100 \quad (5)$$

so that the regional index is obtained by summing across partners: $REI_{t,r} = \sum_c REIcon_{t,r,c}$.

Intuitively, the REI captures how sensitive a region's trade is to geopolitical shocks, relative to the national benchmark. A value of 120 implies a region is 20% more exposed than the country average; a value of 80 implies 20% less exposure.

This approach has the advantage of being anchored in a rigorous global gravity estimation while also reflecting territorial trade structures and bilateral linkages. It is transparent and essentially descriptive, providing a first operationalization of subnational exposure to geopolitical tensions that can be extended to other countries and levels of aggregation.

3. Results

3.1. The effect of geopolitical distance on GVC

The baseline results indicate that, particularly at the extremes of geopolitical rivalry, geopolitical distance has a statistically significant and negative impact on GVC-related export flows. Column 2 in Table 1 shows that trade integration is sensitive to geopolitical alignment when economic size, geographic distance, and multilateral resistance are controlled for. A one-unit increase in geopolitical distance is associated, on average, with a 7% decrease in bilateral trade flows within GVCs, suggesting that changes in UN-based political alignment meaningfully reshape bilateral GVC flows. Shifts from "friends" to "rivals" are associated with average declines of GVC-related trade of about 14% (in a range from –10% to –30%).[4]

Unpacking the average effect, the analysis of political relationships reveals that "friends", i.e. politically aligned countries, show a positive but not statistically significant coefficient (Table 1, column 3). This suggests that they are likely to be indifferent to political orientation when choosing a partner. Conversely, trade flows between rival countries are significantly lower, with a negative and statistically significant coefficient for "rivals" (column 3). This implies that geopolitical antagonism dampens GVC connectivity. The quantile breakdown of ideal point distance confirms the results (column 4), highlighting the non-linear nature of the effects: GVC flows between countries in the most geopolitically distant quintile (the fifth) are significantly lower by around 7%, reflecting the

[4] The average effect (semi-elasticity) of geopolitical distance on GVC-related trade is -7.2% (calculated as $exp(\beta) - 1$ from column 2 of Table 1). The average, minimum and maximum distance increases to turn friends into rivals are 1.897, 1.367 and 4.054, which give the average effects of -13.7% (average friends turn into average rivals), -9.9% (worse friends turn into just rivals) and -29.3% (best friends turn into worse rivals).

baseline effect of geopolitical distance. Whereas smaller political distances (the second and third quintiles) show negligible or non-significant effects.

Table 1. Baseline

VARIABLES	(1) PPML	(2) PPML	(3) PPML	(4) PPML
GDP origin (ln)	0.399***			
	(0.030)			
GDP destination (ln)	0.711***			
	(0.012)			
Distance (ln)	-0.594***			
	(0.022)			
Geopolitical distance		-0.075***		
		(0.015)		
FRIENDS			0.008	
			(0.006)	
RIVALS			-0.029***	
			(0.009)	
Geopolitical distance (quintiles):				
2nd				0.000
				(0.005)
3rd				0.002
				(0.010)
4th				-0.026*
				(0.015)
5th				-0.070***
				(0.018)
Observations	1,849,037	1,940,794	1,940,794	1,940,794
Origin-Sector FE	Yes	No	No	No
Destination-Sector FE	Yes	No	No	No
Year-Sector FE	Yes	No	No	No
Origin-Destination-Sector FE	No	Yes	Yes	Yes
Origin-Year-Sector FE	No	Yes	Yes	Yes
Destination-Year-Sector FE	No	Yes	Yes	Yes
Pseudo R2	0.831	0.977	0.977	0.977

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

When considering the influence of major geopolitical actors: China, Russia and the United States (see Table 2), we notice a large heterogeneity in the way in which each country contributes to the broader pattern of geopolitical GVCs exposure. This underscores the different geopolitical strategies of the major powers and their varying roles within global production networks. Russia's marginal effect is the strongest and most negative, reflecting its systemic role in sectors such as mining and quarrying, as well as its complex ties with geopolitical rivals. Hence, despite being highly sensitive to geopolitical alignment, Russia is still embedded in networks where the political divides are present. A similar pattern emerges for the United States, albeit with a smaller magnitude. This indicates that, while geopolitical distance reduces trade flows with the US, its centrality in global networks fosters trade connections that extend beyond its closest allies. In contrast, China exhibits a distinct pattern. Its positive and statistically significant coefficient implies that its trade is less constrained by

geopolitical alignment than that of other countries. Rather than discriminating between politically aligned or rival countries, China appears to maintain and expand trade relations more broadly, emphasising market access and economic interdependence over political considerations. From a gravity perspective, the size effect (and relevance in GVCs and GPNs) compensates for the effect of geopolitical trade costs.

Table 2. Key Actors

VARIABLES	(1) PPML	(2) PPML	(3) PPML
Geopolitical distance (GD)	-0.043**	-0.099***	-0.062***
	(0.017)	(0.017)	(0.015)
GD × USA	-0.156***		
	(0.037)		
GD × CHN		0.097***	
		(0.037)	
GD × RUS			-0.238***
			(0.082)
Observations	1,940,794	1,940,794	1,940,794
Origin-Destination-Sector FE	Yes	Yes	Yes
Origin-Year-Sector FE	Yes	Yes	Yes
Destination-Year-Sector FE	Yes	Yes	Yes
Pseudo R2	0.977	0.977	0.977

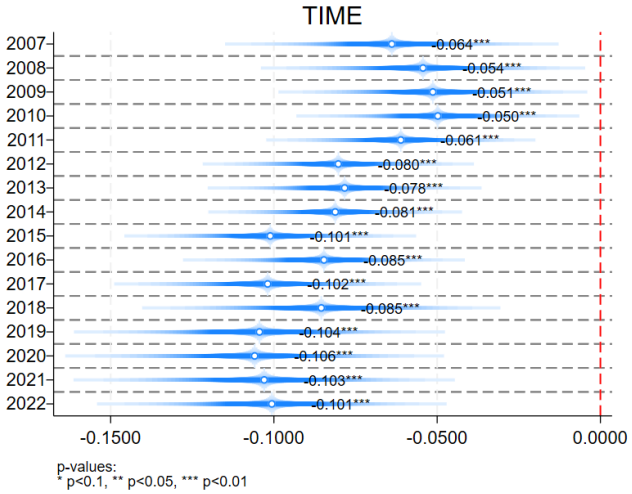
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The evolution of the estimated impact of geopolitical tension on GVCs-related trade over the period 2007–2022 (Figure 1) shows that the effect is negative and statistically significant. Furthermore, it increases over time. This indicates a consistent drag of geopolitical distance on GVC bilateral flows. The growing magnitude of this effect suggests an increasing sensitivity to geopolitical frictions.

In the early years of our sample (2007–2014), the impact ranged from -5% to -6%. This was consistent with the relatively stable global environment that followed China's accession to the WTO, and the generally cooperative international trade order. A marked increase in the geopolitical distance effect occurred from 2015 onward, when the coefficient dropped to -10.1%. This shift is likely to correspond to key geopolitical events, such as Russia's annexation of Crimea, the escalation of sanctions, and the growing influence of populist and nationalist politics in the US and Europe.

The effect remained high in subsequent years, reaching its peak in 2020 at -10.6%, amid the disruption to supply chains caused by the COVID-19 pandemic and the resulting amplification of geopolitical tensions, including the U.S.-China trade war. And it remains persistently high until 2022. This suggests that geopolitical tensions have become a structural feature of the global GVCs landscape, exerting a sustained and growing influence on the organisation of international production networks.

Figure 1. Time Heterogeneity



Note: this regression includes 1,940,794 observations. The three-way fixed effects (FE) are Origin-Destination-Sector FE, Origin-Year-Sector FE and Destination-Year-Sector FE.

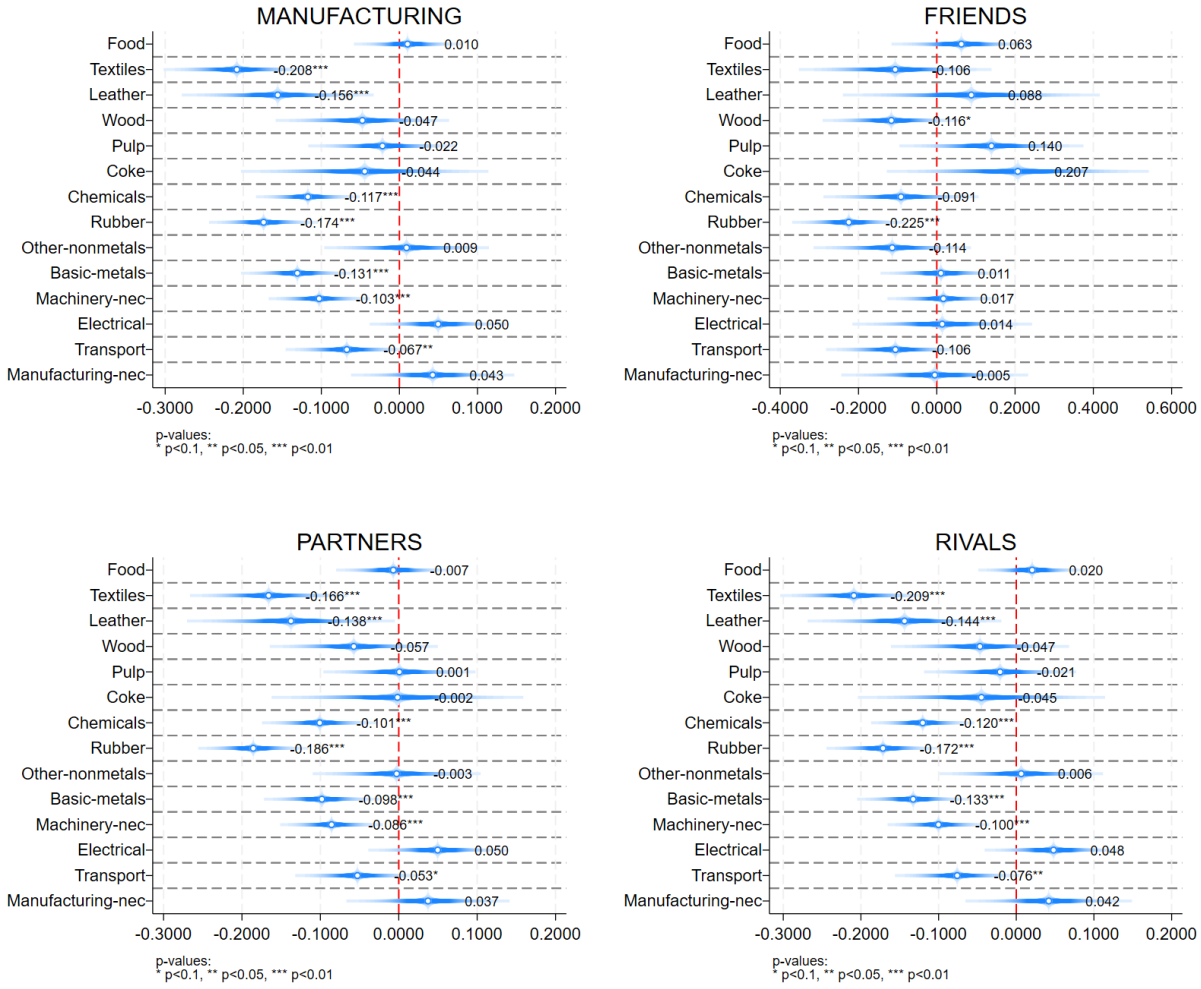
The effect of geopolitical distance varies across sectors, depending on characteristics such as fragmentation and (imported) intermediate input dependence. These characteristics are key drivers of geopolitical trade vulnerability, regardless of the political alignment between trading partners.

Overall, Figure 2 shows that manufacturing sectors are exposed to geopolitical tensions in different ways. Sectors characterised by high levels of production fragmentation (Hakobyan, et al., 2023), such as textiles, leather, chemicals, rubber, basic metals and machinery, exhibit a negative and statistically significant effect. This indicates that global value chains in these sectors are more sensitive to geopolitical distance and suggests that the more geographically dispersed the production process, the more vulnerable it is to geopolitical frictions.

Figure 2 allows to distinguish between partners and further disaggregates these effects by the type of geopolitical relationship between trading partners (FRIENDS, PARTNERS, and RIVALS). The patterns observed are largely consistent across these groups, particularly for rivals and partners, where the same highly fragmented sectors remain significantly exposed. This reinforces the idea that the structure of production, rather than political alignment alone, plays a central role in determining trade sensitivity.

Interestingly, GVC trade between geopolitical allies (FRIENDS) shows fewer sectors with significant exposure. Only wood and rubber emerge as significantly affected. This may reflect the resource-based nature of these industries, as not all countries possess these resources, meaning the initial stages of production often occur abroad. This makes them structurally dependent on cross-border trade, even among allies.

Figure 2 Sector Heterogeneity (focus on manufacturing)



Note: this regression includes 1,940,794 observations. The three-way fixed effects (FE) are Origin-Destination-Sector FE, Origin-Year-Sector FE, and Destination-Year-Sector FE. Here are shown only manufacturing industries, while the regression contains all the other sectors (Agriculture, Forestry and Fisheries, Mining and Quarrying, Electricity, Gas and Water, Construction, and the 17 Services industries).

3.2. The geopolitical exposure of Italian NUTS2 regions

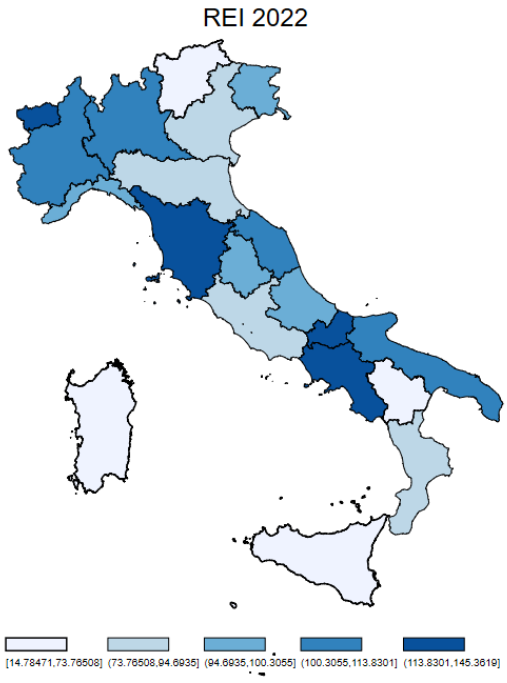
Using Italy's detailed regional trade data[5], we show how geopolitical tensions expose GVC to (local & global) vulnerabilities. The geography of subnational geopolitical exposure, described by the Regional Exposure Index (REI), provides a heterogeneous picture. In Figure 3, the map shows the overall REI for Italian regions in 2022, with darker shades of blue representing higher exposure levels to geopolitical risks through trade in GVCs. This figure highlights a heterogeneous regional

[5] The regional trade data for Italy (provided by the National Statistical Institute, Istat) are reliable and cover the period of interest. We believe that Italy could represent an interesting case to be generalized in future research.

pattern: Italy's industrial core and some central-southern hubs are more vulnerable to global geopolitical shocks, while peripheral and less industrialized areas are relatively shielded.

The heterogeneous exposure across Italy suggests that some regions have a strong integration in global value chains that are geopolitically sensitive. Northern industrial regions (Lombardia, Piemonte and to a lesser extent Veneto) show medium exposure, reflecting diversified trade structures but still significant links to global supply networks.

Figure 3. Regional Exposure Index 2022

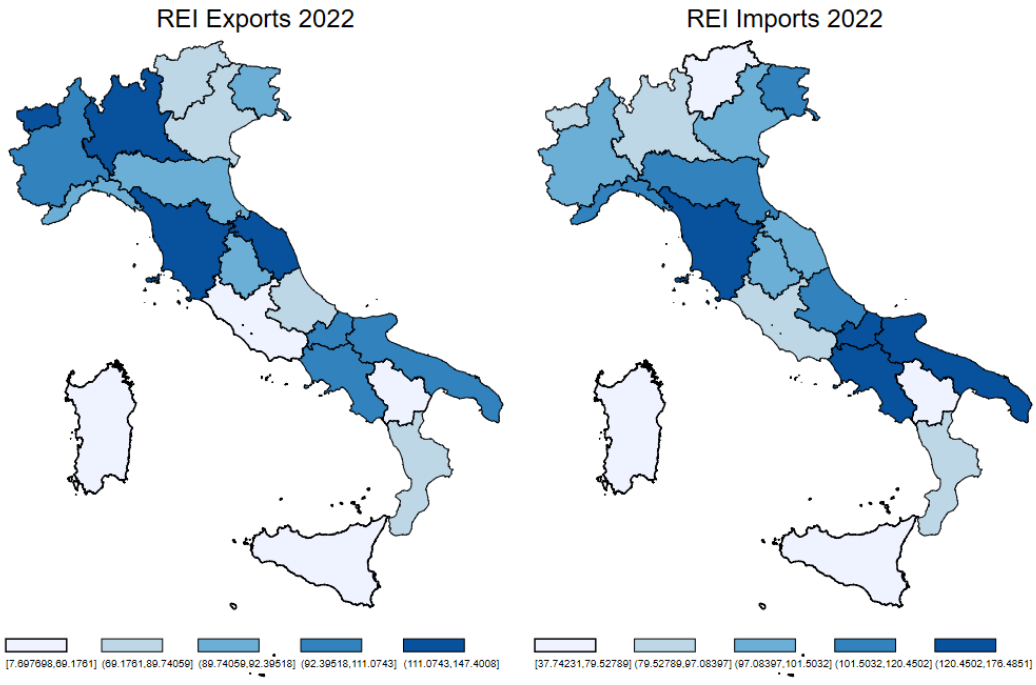


Analysing the same index over time (Figure 4), most regions show moderate fluctuations around the baseline, indicating relative stability between 2016 and 2022. As also shown in Figure 1, this period is crucial in geopolitical and GVCs' time evolution. Notably, Campania, Molise and Toscana demonstrate an upward trend, with exposure intensifying particularly after 2020. Northern manufacturing regions maintain consistently stable but above-average values, while southern regions tend to remain at or below the baseline.

Some areas, including Toscana, Umbria, and Trentino-Alto Adige, exhibit greater year-to-year variability, suggesting localized, sector-specific vulnerabilities. The REI also reflects the diverse impact of the COVID-19 pandemic across Italian regions, especially during the significant economic shutdown of 2020. In geographically peripheral regions like Sardegna and Umbria, exposure spiked sharply, whereas more centrally located regions with stronger infrastructure networks, such as Toscana, demonstrated greater resilience to such global disruptions. Therefore, we can see a polarization between stable, low-exposure regions and a group of industrial and logistic centres with rising sensitivity to geopolitical disruptions.

Figure 4. REI 2016-2022

Figure 5. REI Exports and Imports 2022



The breakdown between exports and imports (Figure 5) allows us to single out the asymmetric nature of these vulnerabilities. High export exposure is concentrated in a few industrial hubs, notably Toscana, Lombardia, and Marche, while import exposure is more geographically diffuse, affecting central, southern and some northern regions (e.g., Campania, Puglia, Toscana, Emilia-Romagna and Friuli Venezia Giulia).

Figure 6 clearly illustrates this asymmetry: regions such as Toscana and Lombardia exhibit high export exposure (REI_exp), whereas Molise and Campania display elevated import exposure (REI_imp). In contrast, regions like Sardegna and Sicilia fall well below the national average on both dimensions, highlighting their relative isolation in international trade flows. Most regions are below the bisector, indicating the import exposure is generally a more pressing issue than export exposure. The positioning of many regions near the intersection of the red crosshairs suggests a general clustering around average levels (Piemonte is basically representative of Italy in terms of exposure), but the outliers are both highly exposed and minimally integrated. Revealing their structural diversity in regional trade dependencies.

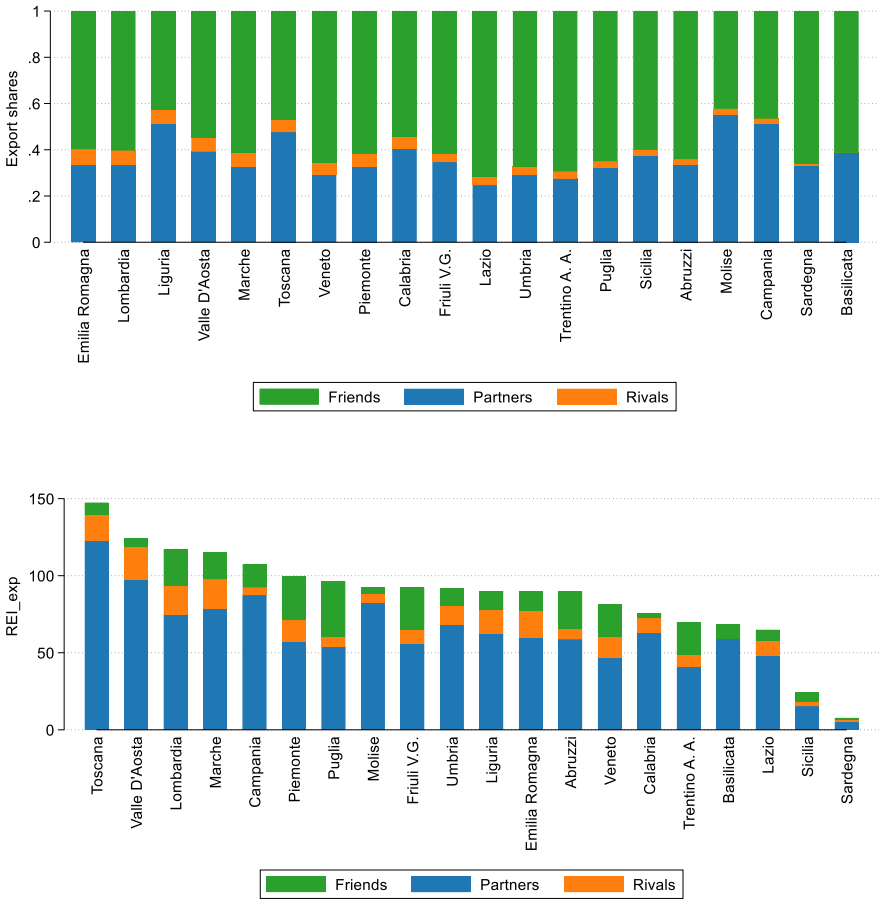
Figure 6. REI Import and Exports Correlation (2022)

Let us now focus on the directionality of exports. Figure 7 provides the perspectives on regional export exposure and the composition of export destinations by geopolitical alignment (i.e., Friends, Partners, Rivals) in 2022. The top panel shows the relative shares of each partner type in total exports, while the bottom panel displays the corresponding REI_exp values, disaggregated by partner group.

The data reveal notable regional differences in both exposure levels and export partner diversification. Regions such as Toscana, Valle d'Aosta, and Lombardia exhibit high export exposure,

with a significant share directed toward “Partners” and “Rivals”. Particularly in Emilia-Romagna, Lombardia and Toscana, the share of exports to Rival countries is relatively high, amplifying its strategic vulnerability in the face of geopolitical tensions. In contrast, regions like Sardegna, Sicilia, and Basilicata show much lower levels of export exposure overall and maintain a more limited engagement with Rival economies. Interestingly, Puglia is highly friends export-oriented, indicating a more cautious or diversified trade orientation. This underscores not just the magnitude of regional export dependence but also the geopolitical quality of trade ties. While higher exposure to global markets may bring economic benefits, a heavier reliance on less politically aligned or unstable partners (Rivals) could pose long-term strategic risks, particularly under conditions of global uncertainty or sanctions.

Figure 7. REI and export shares by partner types (2022)

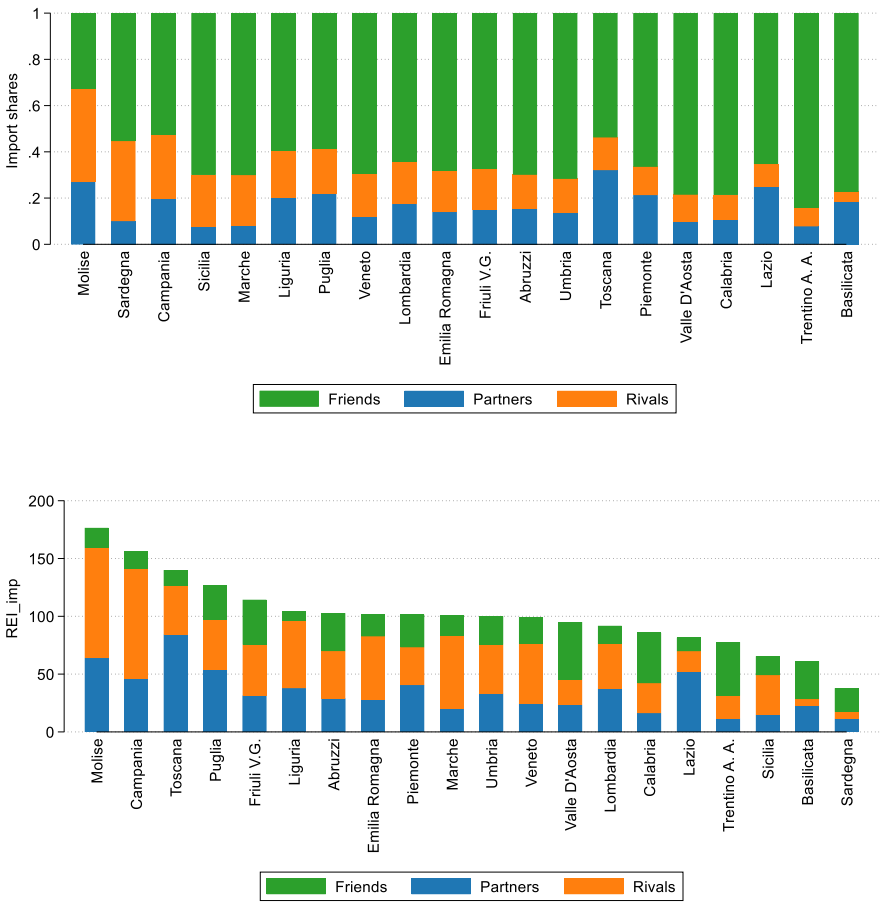


Focusing on the import side, Figure 8 offers insight into the structure and intensity of regional import dependencies in 2022, distinguishing not only the magnitude of exposure (bottom panel) but also the geopolitical composition of import partners (top panel). There are relevant regional asymmetries. Regions like Molise, Campania, Sardegna, and Sicilia register the highest import exposure levels (REI_imp), and a substantial portion of their imports originates from Rival

countries, making them particularly vulnerable to global geopolitical tensions or trade disruptions. This risk is especially evident in Molise, which stands out for both the intensity of its exposure and the high share of imports from Rivals. On the other hand, regions such as Basilicata, Trentino-Alto Adige, and Lazio exhibit lower overall import exposure and rely predominantly on Friend economies, suggesting more secure and stable supply chains. Even among industrialized regions like Emilia-Romagna and Lombardia, exposure is more balanced, with a relatively moderate share of imports from Rival countries. Interestingly, while some regions (e.g. Liguria, Puglia, Friuli-Venezia Giulia) have mid-level import exposure, their high reliance on Rivals introduces a layer of strategic vulnerability not immediately apparent from REI values alone.

Looking at import, we depict the dual dimension of vulnerability: not just how much a region imports, but from whom. Regions heavily dependent on imports from geopolitically unstable or rival countries are exposed to greater economic risk, regardless of their overall trade intensity. This reinforces the importance of partner diversification and strategic reshoring or friend-shoring in regional trade planning. These findings align with those discussed in Figure 6.

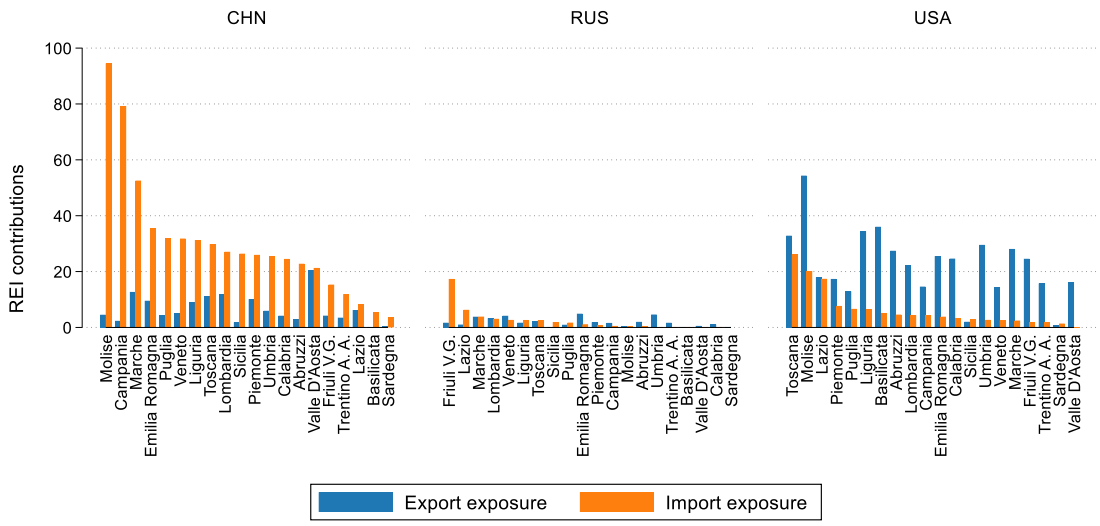
Figure 8. REI and import shares by partner types (2022)



Finally, we analyse the regional exposure also related to different partners. Figure 9 illustrates the regional contributions to (REI) for Italy with respect to geopolitical tensions with partners that are key actors in the international geopolitics, China (CHN), Russia (RUS), and the United States (USA), looking both at import and export exposure. The graphs underscore the importance of considering both the directionality (import vs. export) and spatial differentiation (territoriality) of geopolitical risk when assessing the vulnerability of regional economies embedded in global value chains.

The patterns reveal significant asymmetries in exposure profiles across both regions and trading partners. Firstly, the exposure to China is predominantly driven by imports, with southern regions such as Molise, Campania, and Marche exhibiting particularly high exposure. This reflects a strong dependence on Chinese inputs (intermediates) in regional production structures. In contrast, exposure to the United States is mainly export-driven, indicating that several regions, most notably Toscana, Molise, and Piemonte, are highly reliant on the U.S. as a destination market. This is particularly important considering the new Trump administration's approach to trade policies. Exposure to Russia is comparatively limited in magnitude but remains concentrated in specific regions, and as expected is mainly due to the import channel.

Figure 9. REI contributions (imports and exports) of key geopolitical actors



4. Conclusion

Over the past decade, trade policy shifts and geopolitical rivalries have increasingly put international trade and global value chains (GVCs) under pressure. While GVCs have demonstrated resilience, they also exhibit a degree of stickiness, reflecting sunk costs and specific investments that make firms cautious in undertaking costly revisions of their internationalization strategies (Di Stefano et al., 2022; Antràs, 2020b). This does not imply inaction, but rather more incremental adaptations, such

as supplier diversification, inventory management, and the reinforcement of relationships in less geopolitically risky markets. Recent evidence, however, suggests that GVCs are starting to react to the changing context where they operate (Giovannetti et al., 2025). Most of the research is carried out at global or national level while research on the subnational aspects of geopolitics and GVC reconfigurations is still lagging behind.

This paper contributes to filling this gap in two ways. Conceptually, we highlight that the subnational lens is indispensable for understanding how geopolitics reshapes GVCs. Methodologically, we provide a transparent way of linking global gravity-based sensitivities to territorial structures.

On the conceptual side, we argue that subnational exposure is a critical yet underexplored dimension of how geopolitics reshapes GVCs. Our argument builds on and bridges different strands of the literature, from international business to trade and economic geography, positing that the region is a central unit of analysis in which critical inputs and know-how are territorially embedded. This echoes the GPN perspective (Coe & Yeung, 2015), where global processes are constantly mediated by local dynamics, feeding back into the global organization of production. Geopolitical shifts along this global-local-global nexus can generate asymmetric territorial impacts.

On the methodological side, this paper proposes a first operationalization of regional exposure to geopolitical shocks through a novel Regional Exposure Index (REI) based on state-of-the-art structural gravity estimations and granular regional trade data. Our analysis provides new evidence that geopolitical tensions are becoming a significant driver of GVC reconfigurations. The gravity results indicate that geopolitical distance has turned into a measurable barrier to GVC-related trade, with potentially large effects when relationships shift from "friends" to "rivals" (on average about -14%, with a range from -10 to -30%). Then, we consider how these global geopolitical tensions translate into uneven GVC vulnerabilities at the subnational level. Applying this index to Italian NUTS2 regions highlights pronounced heterogeneity: some regions are primarily exposed on the import side, implying risks from upstream bottlenecks, while others are more vulnerable on the export side, reflecting market access constraints and downstream demand. Moreover, the source of exposure differs across partners, with some regions most affected by China, others by the United States or Russia.

These findings underscore that geopolitical shocks have a crucial territorial dimension and that adopting a subnational lens is essential to fully understand the reach and implications of geopolitical tensions for GVCs. Our results suggest that asymmetric exposures risk is exacerbating regional disparities and hampering cohesion. This connects with the broader debate on the future of EU Cohesion Policy. As Rodriguez-Pose (2025) has argued, cohesion policy should move beyond a redistributive role and act as a forward-looking development engine. Similarly, Iammarino et al. (2019) emphasize that policy design must be sensitive to each region's economic and social fabric. Our findings suggest that geopolitical exposure should be part of this forward-looking perspective,

as lagging or stagnant regions may be disproportionately vulnerable to international geopolitical fragmentation.

The policy implications extend to both subnational and national levels. At the subnational level, regions can play a proactive role in GVC participation and upgrading by engaging with firms, investors, skills, and ideas beyond national boundaries. At the national level, central governments must recognize that geopolitical tensions can undermine national (and EU) cohesion through their uneven subnational impacts. Related studies on globalization shocks (e.g. Autor et al., 2020; Colantone & Stanig, 2018a, 2018b) show that such asymmetries can also have political and social consequences, reinforcing the urgency of incorporating territorial heterogeneity into policy responses.

Finally, there are several opportunities for further work. Further extensions could refine the analysis at the NUTS3 level or across countries; incorporate interregional trade to capture substitution and adjustment; and distinguish backward from forward GVC participation. Given these possible extensions, we believe that our approach can stimulate further research aimed at assessing the uneven territorial implications of a more fragmented global economy.

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