The Ripple Effect of Sanctions: Exploring the Impact on Global Value Chains using a Gravity Model

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Abstract

The article explores and quantifies the intertwined relationship between trade sanctions, Global Value Chains (GVC) participation and revealed comparative advantage (RCA). It presents an original theoretical framework exploring the interaction between sanctions, RCA, and GVC. The empirical exercise adopts an estimation strategy underpinned by a multi-country and multi-sector gravity model exploiting the OECD-Trade in Value Added (TiVA) and the Global Sanctions Data Base (GSDB). The analysis is based on a purpose-built dataset covering GVC participation indexes on 66 origin and destination countries for 23 sectors over the period 1995 and 2018. The analysis fills an important gap in the literature, focused solely on the relationship between GVC and RCA, on the one hand, and trade sanctions and GVC, on the other. We find that the effects of sanctions differ from the buyer (backward) and seller (forward) perspectives; that the RCA in a specific country-sector pair plays a key role in driving sanctions' negative impact, and finally that the level of heterogeneity of the impact is such that only a fine-grained analyses of each sector vis-à-vis its RCA stance could paint the full picture of this complex phenomenon.

Keywords: Trade Sanctions, GVC, RCA, Gravity Model

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1 Introduction

Global value chains (GVC) have become a dominant feature of world trade and investment patterns, encompassing developing, emerging, and developed economies. The whole process of goods production, from raw materials to finished products, is increasingly carried out wherever the necessary skills and materials are available at competitive cost and quality around the globe (Antras and Chor, 2022; Baldwin et al., 2022; Fernandes et al., 2020). The growing fragmentation of production across borders highlights the need for countries to have an open, predictable, and transparent trade and investment regime as tariffs, non-tariff barriers, and other restrictive measures (quotas, export subsidies, regulations) impact not only foreign suppliers but also domestic producers (Le et al., 2022; Du and Wang, 2022; Winkler et al., 2022; Bellora and Fontagné, 2020). Moreover, ambitious comprehensive policy agendas to leverage engagement in GVC into more inclusive growth and employment are growing in importance (Ravenhill, 2014). Success in international markets today depends as much on the capacity to import inputs as on the capacity to export goods and services at the right price and the right level of quality

required by the market (Baldwin, 2022). Furthermore, sanctions have increased a lot in the past decades, especially in financial and trade sanctions (Morgan et al., 2023). Sanctions are defined as "restrictive policy measures that one or more countries take to limit their relations with a target country to persuade that country to change its policies or to address potential violations of international norms and conventions" (Morgan et al., 2009, 2023). A sanction case is defined for each year in which there is an active sanction imposed by a sanctioning state, called the sender, on a sanctioned state, called the target. Senders and targets can be individuals or groups of countries (i.e. European Union). In the former case, sanctions are called unilateral and in the latter multilateral. Since the 1990s, the proportion of sanctions imposed multilaterally has increased substantially, with the United Nations and the European Union greatly expanding their use. As a consequence, the number of sanction cases has almost tripled in the past three decades (GSDB calculations). Using the European Union-Russia case as an example, the European Council (2023) calculates that, since February 2022, the EU has banned over 43.9 billion Euro in exported goods to Russia and 91.2 billion Euro in imported goods. This means that 49% of Russian exports and 58% of imports are currently sanctioned, compared to 2021.

This article is aimed at shedding light on the intricate relationship between trade sanctions, GVC participation, and revealed comparative advantages (RCA). Many considerations motivate the present study, as explained in detail below.

The EU-Russia case made above shows the importance to better understand how sanctions affect value chains.

The distorting characteristics possessed by trade sanctions make their relationship with GVC particularly interesting. Sanctions imposed by senders can trigger counter-sanctions. Such retaliatory responses are likely to magnify the initial sanction effect along GVC. The economic impact of sanctions is quite complex and, according to Morgan et al. (2023), it passes through three channels, namely: the direct effect on a target, the counter-sanction effect and, finally, the so-called "third-party nation" channel. The last channel works through both "general equilibrium effects" and "extra-territorial" sanctions. The former happens when economic activities that are disrupted by sanctions intensify trade relationships with third countries. The latter consists of penalties on non-sanctioned countries due to their engagement in activities with a sanctioned state.

The complexity of sanctions' effects has clear implications. If we compare trade sanctions with other trade impediments, such as tariffs and NTMs (non-tariff measures), we can note that they are quite similar. Sanctions are cumulative when intermediate inputs are traded across borders multiple times, such as in the case of GVC (OECD, 2013). This can add significant costs to the price of the finished good and, thus, this can affect the decisions of firms involved in GVC. Moreover, on top of this, sanctions have the "extra-territorial" channel that neither tariffs nor NTMs possess. Hence the aforementioned cumulative effect on costs might be magnified.

Another important aspect that motivates the present research lies in the fact that sanctions' effectiveness is quite uncertain. Unlike tariffs but like NTMs, sanctions are not always effective in reaching their purported objectives. Although it is expected that trade sanctions have a negative impact on a country's participation in GVC, it is possible to find positive effects. On the one hand, trade sanctions can disrupt existing GVC by limiting the availability of inputs or markets for finished goods. This can lead to increased costs and reduced competitiveness for firms that rely relatively more on these inputs or markets (Du and Wang, 2022). On the other hand, trade sanctions can also provide incentives for countries to diversify their sources of inputs and markets, which can lead to increased GVC participation (Mityakov et al., 2013; Raymond et al., 2022). When a country is cut off from a key supplier of a certain input due to trade sanctions, it may look to other countries to fill that gap. This can lead to the development of new supply chains and partnerships, which can ultimately increase GVC participation. Additionally, trade sanctions can create opportunities for domestic producers of not-sanctioned countries to

fill gaps in the market left by foreign suppliers of sanctioned-one (Pond, 2017). Firms that are subject to trade sanctions may seek to diversify their suppliers or shift their production to other countries or regions, leading to the development of new GVC. Alternatively, firms may decide to bring production back to their home country or region to reduce their exposure to trade sanctions, leading to the re-shoring (or friend-shoring) of production. This can lead to the development of new industries and supply chains, or the re-shoring of production, which can enhance GVC participation over the long term (Goldthau and Tagliapietra, 2022). Using GSDB data, Yotov et al. (2020) find that sanctions' success rate has steadily declined after 1995. In the case of trade sanctions, this might mean that general equilibrium effects, resulting in trade enhancements, have dominated the original trade-disruption motive. Chowdhry et al. (2022) analyse the role of coalitions for explaining a similar result. Coalitions of countries have twin objectives of raising the punitive force of sanctions whilst lowering domestic welfare losses. Hence, powerful coalitions can reduce the welfare losses borne by individual sanctioning states and, thus, making trade enhancement possible.

Finally, we assess the role of revealed comparative advantage (RCA) in driving the impact of trade sanctions. RCA is intrinsically linked to supply chains and production networks (Felbermayr et al., 2021). To understand how sanctions can have a ripple effect on GVC and their relation with RCA, consider a country that is subject to an embargo or export control. In this case, firms in other countries relying on the country's inputs or products of the former may be unable to access them, leading to delays or disruptions in production. This can have a ripple effect on entire GVC, as delays or disruptions in one part of the chain can affect other stages of production (Winkler et al., 2022; Du and Wang, 2022). If a country is subject to tariffs or export controls on certain products or inputs, it may become less competitive in such sectors or be forced to shift its production to other areas where it has a lower initial comparative advantage. This can have long-term effects on a country's industrial structure and international trade patterns (Le et al., 2022; Pond, 2017). Moreover, since trade sanctions can vary depending on the specific reasons they have been imposed, the sectors that are targeted by sanctions may not necessarily be related to the RCA of the sanctioned country. The impact of trade sanctions can differ according to a country's RCA by restricting its access to certain markets or inputs. Countries may target sectors in which the sanctioned country has a high RCA to maximize the impact of the sanctions. When a country relies heavily on exports of a particular product or industry in which it has a comparative advantage, sanctions targeting such industry could have a more significant impact on the country's economy (Baldwin et al., 2022). Targeting a sector based solely on RCA may not always be the most effective approach, though. It could result in unexpected consequences, such as harming industries and firms in other countries that rely on inputs from the sanctioned country (Winkler et al., 2022). In some cases, sanctions may be targeted at sectors where the sanctioned country has a low RCA in order to reduce its ability to export certain goods and services in an "emerging" RCA area. Still, this may weaken the overall economic position of the sanctioned country if the increasing costs go through more expensive inputs for domestic producers reducing the competitiveness of firms in other sectors (Bellora and Fontagné, 2020). In summary, the impact of trade sanctions on GVC participation depends on a variety of factors, including the specific nature of the sanctions, the specific industries and products affected, and the institutional and investment environment of the countries involved.

This article aims to provide an assessment of the impact of trade sanctions on the GVC participation in target countries. Specifically, we test three hypotheses:

1. Trade sanctions restricting access to foreign intermediate goods affect a country's position in regional and global supply chains (impact on backward links for buyers);

2. Trade sanctions can add a significant cost to the price of the finished good that in turn affects the production and investment decisions of firms involved in GVC (impact on forward links for sellers);

3. The RCA in a specific country-sector pair plays a key role in driving the impact of trade sanctions.

The article presents an original theoretical framework that explores the interaction between trade sanctions, RCA and GVC. The work also explores and assesses empirically the implications of trade sanctions on GVC via a gravity model using information from the latest Trade in Value Added (TiVA) data and the Global Sanctions Database (GSDB). The analysis is based on a purpose-built data set covering GVC participation indexes of 66 origin and destination countries for 23 sectors related to goods or products, excluding the services sector[1], over the period 1995 and 2018. To the best of our knowledge, the present work is the first in the literature that uses a multi-country and multi-sector gravity model for exploring the interconnections between trade sanctions, GVC participation and RCA.

The article is structured as follows: section 2 provides a literature review; section 3 describes a simple model of Economic Sanctions, Specialisation and GVC; section 4 describes the empirical strategy; section 4 provides information on data and some descriptive statistics, section 5 presents and discusses the results and finally, section 6 concludes.

2 Literature review

2.1 The relationship between trade restrictions and GVC

Policy impediments to trade, such as tariffs and non-tariff measures (NTMs), matter a lot in GVC, because in GVC goods cross borders multiple times and each time they do so, they incur the cost of the trade barrier they face (Yi, 2003, 2010; Ferrantino, 2012; OECD, 2013). For what concerns tariffs, according to Muradov (2017) the aforementioned magnification effect can be attributed to two forces. The first one is multiple border crossings because of international vertical specialization. This in turn means that in the presence of GVC, trade policy measures are amplified via backward and forward linkages (Ghodsi, 2022). The second force in action is the one originally identified by Baldwin and Venables (2013) in the valuation of trade flows. In essence, trade costs apply to the gross value of exports rather than to the net value generated by the last producer. The result of these two forces is that the cumulative tariff increases with the average number of borders crossed. The established literature agrees on the detrimental effect of tariffs on exports and other relevant variables. Regarding NTMs, there is much less consensus on their effect on exports. For example, the impact of formal standards on trade in GVC has been assessed in the recent works of Blind et al. (2018) and Ghodsi (2022). Both studies find that standards can both hamper or enhance trade. More in detail, Ghodsi (2022) calculate a trade restrictiveness index and use a structural gravity model to assess the impacts of NTMs. They find that NTMs have a trade-hampering effect when product regulations and standards across countries diverge from each other substantially; while they have a trade-enhancing effect when product regulations ensure the implicit quality of products along the whole GVC. A similar conclusion is reached by Blind et al. (2018), when estimating the influence of national and European standards on trade in value-added and gross trade flows within Europe. Their results show that national standards, which largely differ from the others, damage trade while European standards foster trade. This is because European standards mitigate the information asymmetry along European Single Market value chains.

Differently from the literature on the economic effects of policy impediments on GVC participation, there is not much empirical evidence on the impact of sanctions specifically on GVC participation, or at least this literature is quite scant. Moreover, the relationship between GVC participation and RCA versus the impact of trade sanctions on GVC has been looked at separately by the recent literature. The following paragraphs review these "separate" strands of established works

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[1]Goods and services can have distinct drivers and determinants of GVC participation.

so that the contributions of the articles will be clearer.

For what concerns the effect of sanctions on GVC participation, despite the political intent of economic sanctions could be promoting human rights and liberal economic relationships (Cortright and Lopez, 2000; Peksen, 2019), sanctions' impact is measured in terms of the economic damage that they cause (Felbermayr et al., 2021).

Adverse international policy actions, such as trade sanctions, are expected to boost GVC participation when the value chain disruption they cause leads to diversification. Mityakov et al. (2013) analyse the case of the oil industry in the US from 1960 till 2000. They find that US import diversification in response to international politics could be welfare-improving, as it might represent a mechanism for internalising the externalities caused by non-domestic (i.e. international) policy-makers. More recently, Raymond et al. (2022) find that firms respond to global political risk by diversifying their exports.

Trade sanctions can also favour GVC participation in the case of re-shoring. Goldthau and Tagliapietra (2022), for example, descriptively observe that countries severely affected by the energy supply shortages, due to the Russia-Ukraine war, are evaluating the technological and economic viability of new domestic energy projects.

Turning now to the negative impact of trade sanctions on GVC participation, in their recent work Le et al. (2022) originally employ a multi-country empirical strategy and they document a negative association between sanctions and GVC, including backward and forward linkages. An interesting case of sanctions and backward GVC participation is the Sino-American trade war of the past few years recently described by Bellora and Fontagné (2020). The article finds that the tariffs imposed by the US and the Chinese retaliation have led to a lower US backward GVC (as buyer) participation that has ultimately led to a drop in US competitiveness, mostly at the expense of their clients, possibly even generating a lower US forward GVC participation (as seller). The article concludes that the Sino-American war has been extremely detrimental to the US. Turning now to sanctions and forward GVC participation, the case of the Ukraine war and the sanctions imposed on Russia is exemplary. Winkler et al. (2022) descriptively documents Russia's high forward GVC participation and much less important backward GVC participation. The authors note that trade sanctions have disrupted Russia's forward GVC participation in the energy industry, especially as a seller of oil but also of metals and chemicals sectors products. This disruption is going to feedback into the GVC participation of other countries, especially neighbour economies that are highly dependent on these exports. Thus, the sanctions on Russia are adding strains to global GVC. Employing a structural multi-country gravity model, Du and Wang (2022) quantify the impact of sanctions cutting Russia's participation in intermediate and final goods trade. The article finds that these sanctions would cause a permanent decrease in Russian GDP of 11.98%. As for other countries' (negative) spillover effects, the authors calculate a loss of 0.56% in real income for Eastern European countries, 0.25% for Western European ones, and 0.23% for China.

Another relevant strand of the literature analyses the disruptive effect that trade policy uncertainty can have on trade flows. This is relevant both because sanctions are an instrument of trade policy and because they generate uncertainty, for example in trade costs. Although different studies use different proxies for measuring policy, the established literature seems to agree on the negative impact of policy uncertainty on trade flows.

Constantinescu et al. (2020) employ the Economic Policy Uncertainty (EPU) measure of Baker et al. (2016) for quantifying the impact of economic policy uncertainty on trade growth. They found that policy uncertainty discourages firms' investment to serve foreign markets or to source inputs internationally and, thus, it has a negative effect on trade. Interestingly they found a similar result for trade linked to GVC. However, they underline that, in the case of GVC, trade patterns might be quite sticky as investment might be specific to a particular (bilateral) production relationship.

Osnago et al. (2015) define policy uncertainty as the difference between binding tariff

commitments and applied tariffs. They find that trade policy uncertainty has a negative impact on exports. Moreover, they found that this effect is heterogeneous, in the sense that such a negative impact is particularly severe in the presence of GVC and low institutional quality. In the case of GVC, their finding is consistent with Harrigan and Venables (2006) and the mechanism related to agglomeration forces that, similarly to tariffs, discourage goods from crossing borders multiple times. In essence, when production is fragmented, as it is on GVC, the marginal cost of timeliness is very high, and this cost is higher if goods have to cross the borders multiple times.

2.2 The relationship between RCA and GVC

Since the end of World War II, and especially after the attack on the Twin Towers in September 2001, there has been a spectacular increase in the use of sanctions targeting specific foreign industries and enterprises (Morgan et al., 2023). From the 1990s onward, the so-called "GVC revolution" has also happened (Baldwin et al., 2022). This term indicates the increasing complexity and international character of supply chains, where a firm (or a country) participates in a GVC if it contributes value in at least one stage in that specific GVC. In this context, one firm (or country) can self-select into foreign upstream (as seller) or downstream industries (as a buyer), based on its comparative advantages, thus enjoying forward or backward GVC participation, as shown by Antras and Chor (2022) in their model inspired by Melitz (2003).

The relationship between GVC and comparative advantages has been analysed by Romalis (2004). Using a New Trade Theory model, derived from a Heckscher-Ohlin framework with a continuum of goods, monopolistic competition, and transport costs, this article shows how countries capture larger shares of world production and trade of commodities that use more intensively their relatively abundant factors. A natural resource-abundant country is predicted to participate in GVC via forward linkages (as seller), due to the fact that natural resources are used in several downstream industries and, especially, in the ones intense in natural resources. On the other side, a low-skilled labour-abundant country, which has a cost advantage in the assembly production process, is predicted to experience backward GVC participation (as a buyer) because of high imports of intermediate inputs to be assembled and possibly re-exported. Finally, a high-skilled labour-abundant country is likely to show forward GVC participation (as seller) as its comparative advantage lies in skill-intense production stages, such as Research and Development.

The empirical exercise of Romalis (2004) confirms that countries' factor endowments and industries' factor intensities can explain forward and backward participation in GVC. Fernandes et al. (2020), using a gravity model and exploiting the interactions between a country's factor endowments and the intensity with which a sector uses a particular factor, conclude that factor endowments are key determinants for GVC participation. More generally, Ito et al. (2017), using World Input-Output Database (Timmer et al., 2014) find that Heckscher-Ohlin type comparative advantages explain the patterns of participation in GVC. Countries contribute relatively more value-added in global productions using their relatively more abundant factor intensively.

2.3 The relationship between RCA and sanctions

The relationship between comparative advantages and sanctions has been less investigated than the strands previously reviewed. Pond (2017) empirically assesses the hypothesis that trade sanctions are associated with a higher degree of trade protection, which is proxied through tariff rates. She finds supportive evidence for such a hypothesis. Interestingly, the explanation of this result relies on the comparative advantages mechanism. If sanctions limit the exports (and thus the production) of goods in which the Home country has a comparative advantage and/or if

they limit the imports of foreign production, in which the domestic economy does not have a comparative advantage, then the domestic economy will end up increasing the production of goods in which it does not have a comparative advantage. Hence, relatively inefficient domestic producers will benefit from the sanctions and they will push for restrictive trade measures, such as tariffs.

New trade theories and new economic geography have analysed the interaction between comparative advantages and agglomeration economies in the presence of intermediate goods, see for example (Krugman and Venables, 1995; Amiti, 2005; Redding, 2016). Pfluger and Tabuchi (2019) theoretically explores the relationship between trade costs, comparative advantages and agglomera-tion economies in a setting in which intermediate goods are tradable, which is a key feature in a world characterised by GVC. In this model, firms' location depends both on comparative advantages (i.e. structural characteristics) and increasing returns. As already explained, in the spirit of Harrigan and Venables (2006) agglomeration forces discourage trade in intermediate inputs. The key novel result of the work is that a variation in trade costs affects firms' location decisions (and thus exporting decisions) in a heterogeneous way, depending on which location force will dominate. In particular, a reduction in trade costs fosters dispersion and, hence, encourages trade in intermediaries, the more the sector is dominated by comparative advantages; while the same reduction in trade costs will discourage trade in intermediaries if the sector is dominated by increasing returns.

This article contributes to all three strands of the literature, theoretically framing and empirically exploring the interconnections between trade sanctions, GVC participation, and comparative advantages.

3 A simple model of Economic Sanctions, Specialisation, and GVC

In a traditional RCA model à la Ricardo the "unit labour requirement" (the lower the higher the productivity) for home is α_{LN} for product "N" and the "unit labour requirement" for Foreign is α_{LN}^* for the very same product. It follows that the ranking of products according to the relative productivity of Home vs. Foreign is the following (the lower the relative ratio the higher the relative productivity of Home and vice-versa):

$$\frac{\alpha_{L1}}{\alpha_{L1}^*} < \frac{\alpha_{L2}}{\alpha_{L2}^*} < \frac{\alpha_{L3}}{\alpha_{L3}^*} < \cdots < \frac{\alpha_{LN}}{\alpha_{LN}^*} \tag{1}$$

Let w be the wage rate per hour in Home and $w*$ be the wage rate in Foreign (for simplicity we consider an economy-wide wage rate, without loss of generalisability). Goods will be produced by the country whose cost is lower. The cost of generic product "i" will be $w\alpha_{Li}$ in Home and $w^*\alpha_{Li}^*$ in Foreign. Home will produce good i only if:

$$w\alpha_{Li} < w^*\alpha_{Li}^*$$
$$\frac{\alpha_{Li}^*}{\alpha_{Li}} > \frac{w}{w^*}$$

The inequality would be inverted in case the cost is lower in Foreign and, thus, Foreign will end up producing good i.

It follows that, for a given Home/Foreign wage ratio, it can be derived which country (Home or Foreign) will specialise in which products and hence start exporting them. Suppose that:

$$\frac{\alpha_{L1}}{\alpha_{L1}^*} < \frac{\alpha_{L2}}{\alpha_{L2}^*} < \frac{\mathbf{w}*}{\mathbf{w}} < \frac{\alpha_{L3}}{\alpha_{L3}^*} < \cdots < \frac{\alpha_{LN}}{\alpha_{LN}^*} \tag{2}$$

Home will produce (and export) goods 1 and 2 and Foreign will produce (and export) goods 3 ... N.

Suppose a sanction on some Home's specific products is now introduced. In particular, we assume that Home is sanctioned on both goods 1 and 2[2] by increasing its unit labour requirements $\alpha_{L1} + S^1$ and $\alpha_{L2} + S^2$. Let's suppose that these sanctions are not "compensated" by a reduction of Home wage and let's suppose the sanctions (S^1 and S^2) are as such that the following two inequalities hold:

$$w(\alpha_{L1} + S^1) < w^* \alpha_{L1}^*$$
$$\frac{\alpha_{L1}^*}{(\alpha_{L1} + S^1)} > \frac{w}{w^*}$$

$$w(\alpha_{L2} + S^2) > w^* \alpha_{L2}^*$$
$$\frac{\alpha_{L2}^*}{(\alpha_{L2} + S^2)} < \frac{w}{w^*}$$

This signifies that Home will still produce and export product 1 but now Foreign will be more efficient in producing good 2, which will be "subtracted" from the RCA portfolio of Home.

How would this directly affect participation in the Global Value Chain in Home? As far as Home's forward GVC participation is concerned we need to consider the domestic value added contained in intermediate goods and services exported to partner countries that re-export them to a third country as embodied in other products as a ratio of total Home exports. The potential direct disruption of the forward GVC participation depends on the RCA[3]. Home now has lost its RCA on product 2 and it will need to act accordingly. In other words, the interaction of RCA and sanctions does change both the size and scope of Home GVC participation. The likelihood that Home's GVC participation is disrupted will be proportional to the "strength" of the initial level of RCA of a product, as illustrated by the following three cases: a) a sanction on a product not experiencing any RCA will not have any impact; b) a sanction on a product with a relatively low RCA will marginally decrease the measure of both the numerator and denominator of the GVC forward participation, with a modest impact; c) a sanction of a product with a relatively high RCA will substantially decrease the measure of both the numerator and denominator of the GVC forward participation, with a relevant effect[4]. On the other side, by hitting high RCA products, sanctions will also jeopardise the country's backward GVC. As far as Home's backward GVC participation is concerned, we need to consider the foreign value added contained in intermediate goods and services imported from partner countries to re-export them to a third country as ratio of total Home export[5]. If Home has lost product 2, it will require fewer inputs for the production of such goods from foreign countries, and hence the backward GVC participation will be affected[6].

Finally, how would these sanctions affect Foreign GVC participation? By the same token, Foreign will now benefit from an enhanced forward GVC participation via the addition of

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[2]Sector and product coincide in this case. Note that we do not need the foreign country to be the sanctioning country, it can be a "third" country.

[3]However, the forward GVC participation could be NOT impacted if home exports to countries who are final consumers of the good.

[4]Suppose a sanction is imposed to product 3 for Home, this has no impact on the ranking and hence on the GVC.

[5]These theoretical predictions are fully in line with proposition 1 in Pond (2017) stating that "sanctions increase the production of import-competing goods and decrease the production of export goods" (page 1077). In our article, we do not focus on market protection, though (see proposition 2 page 1080).

[6]If product 2 is not re-exported by the home country but just consumed, the backward GVC participation will not be affected, of course.

product 2 to the list of goods that it exports (provided that the receiving countries are not final consumers). Moreover, Foreign will probably require more inputs for product 2 from foreign suppliers in order to produce product 2 as Foreign can now count on a new RCA "specialised" product in its portfolio.

Summing up, sanctions have a direct effect on the "forward GVC participation" via the contraction or expansion of exports (contraction for countries losing RCA to others, expansion for countries gaining RCA from others) as well as an indirect effect via contraction or expansion of import within "backward GVC participation", via the intermediate inputs required for the products to be re-exported (gained or lost). In other words, sanctions do not work only on target countries but on the whole redistribution of existing RCAs across countries.

3.1 The Welfare Effect of the sanction

Let us use a simplified measure of producer welfare[7] as the difference between the price and the cost of production of each good produced in Home and Foreign respectively, $P_i - w\alpha_{Li}$ and $P_i^* - w^*\alpha_{Li}^*$. It can be easily shown that the total welfare pre-sanction is higher than the welfare post-sanction. This is due to the fact the new "portfolio" of allocated products vis-a-vis RCAs is geared towards less efficient producers (product 2 has shifted from producer Home to Foreign). The following inequality (welfare pre-sanction higher than welfare post)

$$\sum_{i=1}^{2} P_i - w\alpha_{Li} + \sum_{i=3}^{N} P_i^* - w\alpha_{Li}^* > P_1 - w(\alpha_{L1} + S^1) + \sum_{i=2}^{N} P_i^* - w\alpha_{Li}^* \tag{3}$$

holds under the assumption that $P_1 - w\alpha_{L1} > P_1 - w(\alpha_{L1} + S^1)$, that is always true for $S^1 > 0$ and the assumption $P_2 - w\alpha_{L2} > P_2^* - w^*\alpha_{L2}^*$, that can we rewritten as $P_2 - P_2^* > w\alpha_{L2} - w^*\alpha_{L2}^*$. If $P_2 - P_2^* > 0$ then $P_2 - w\alpha_{L2} > P_2^* - w^*\alpha_{L2}^*$ it always true because $w\alpha_{L2} < w^*\alpha_{L2}^*$. For the implausible case of $P_2 - P_2^* < 0$ welfare could improve post sanction if only if $P_2^* - P_2 > S^1$ meaning that the inefficient product 2 producer -Foreign- should charge for the good not only a higher price than the efficient producer Home, but also an high enough price to overcome the sanction imposed on product 1.

4 Empirical framework

The article estimates a gravity model, commonly used to analyze and understand international bilateral trade flows between countries. It assesses whether trade sanctions affect the country's GVC participation, whether it is in the position of a seller (so-called forward GVC) or a buyer (so-called backward GVC).

The gravity model is based on the idea that the size of a country's economy and its proximity to other countries are key factors in determining bilateral trade (Tinbergen, 1962; Anderson, 1979; Anderson and van Wincoop, 2003). Indeed, the gravity model can be used to assert country participation in global value chains (Noguera, 2012; Choi, 2013) via forward and backward trace linkages. More specifically, the aforementioned hypotheses are tested by estimating an augmented gravity equation in multiplicative form using a Poisson pseudo-maximum-likelihood (PPML) estimator, commonly adopted in seminal empirical cutting-edge analyses (Silva and Tenreyro, 2006; Yotov et al., 2016). To take into account potential simultaneity problems, our independent variable, namely the dummy for the presence of the trade sanction, is consistently taken with a year lag. Additionally, we inflate our specification including a set of importer, exporter, sector, and time-specific fixed-effects dummies to control for unobservables and/or imperfectly measured variables, and account for multilateral resistance terms (Head and Mayer, 2014; Fally, 2015).

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[7]The analysis of the consumer welfare is beyond the scope of this article.

Do trade restrictions affect backward GVC participation of a buyer country via restricted access to foreign intermediate goods? Namely, we suppose that country i is an exporter of intermediate goods to j (as a buyer), and one of the following scenarios unfolds: a) i applies a voluntary export restriction (VER) on its exports to j; b) j applies a trade sanction on imports of intermediate goods from target country i. The following model is estimated:

$$BackwardGVC_{ijs,t} = exp[\beta S_{ij,t-1} + \delta_{is,t} + \delta_{js,t} + \delta_{ijs}] \times \epsilon_{ijs,t}. \qquad (4)$$

According to Koopman et al. (2010), the the dependent variable, backward GVC participation ($BackwardGVC_{ijs,t}$), can be defined as the ratio of total foreign value-added content of export generated by industry s in country i (foreign) embodied in the total exports of country j, $EXGR\_BSCI_{is,j,t}$, and the total gross exports of country j, $EXGR_{j,t}$:

$$BackwardGVC_{ijs,t} \equiv \frac{EXGR\_BSCI_{is,j,t}}{EXGR_{j,t}}, \qquad (5)$$

The variable $S_{ij,t-1}$ is a dummy taking the value 1 if the country i, that is the supplier in sector s, applies an export restriction to the buyer country j at time $t-1$ and 0 otherwise, or j stops importing intermediate goods from country i (import sanction). Furthermore, fixed effects origin country-sector-time, $\delta_{is,t}$, exporting country-sector-time, $\delta_{js,t}$ and country-pair-sector, δ_{ijs}, capture key drivers of a country's level of participation in global value chains. In the estimation of gravity equations, fixed effects are commonly used to account for the "Multilateral resistance term" (Fally, 2015), factors impeding trade between all countries. Including fixed effects provides more accurate estimates of the effects of specific and unobservable variables on bilateral trade flows, especially in the case of disaggregated analysis where data may not be readily available. By adding country-sector-specific fixed effects, we account for variations in characteristics within countries and sectors over time. Hence, the inclusion of country pair-sector fixed effects considers bilateral and sectoral dynamics that play a role in influencing bilateral GVC linkages in turn.

Conversely, to assess if trade sanctions add significant cost to the price of the finished good that in turn affects the production and investment decisions of firms involved in GVC (impact on forward links to a seller, country j), we estimate the following gravity equation:

$$ForwardGVC_{ijs,t} = exp[\beta S_{ij,t-1} + \delta_{is,t} + \delta_{js,t} + \delta_{ijs}] \times \epsilon_{ijs,t}. \qquad (6)$$

where the forward GVC participation, $ForwardGVC_{ijs,t}$, is defined as the ratio of the total domestic value added of the sector s of country j embodied in the exports to the re-exporting country i, $EXGR\_BSCI_{js,i,t}$, and the gross exports of the country j, $EXGR_{j,t}$:

$$ForwardGVC_{ijs,t} \equiv \frac{EXGR\_BSCI_{js,i,t}}{EXGR_{j,t}}. \qquad (7)$$

In this case, the variable $S_{ij,t}$ is a dummy taking the value 1 if the country j, that is the supplier in sector s, applies an export restriction to the buyer country i at time $t-1$ and 0 otherwise, or i stops importing goods from country j (import sanction).

We also assess how trade sanctions affect different sectors according to the competitiveness of seller j in that sector s. The test computes the Revealed comparative advantage (RCA) in sector s as the ratio of country j's share of its total exports to the corresponding share of total world exports. Ultimately, by splitting the equations (4) and (6) according to the RCA of the source country, we can evaluate the significance of RCA in moderating the effects of trade sanctions. With this in mind, we proceed to estimate the following interacted (moderated) models:

$$BackwardGVC_{ijs,t} = exp[\beta_1 S_{ij,t-1} + \beta_2 RCA_{is,t-1} + \beta_3 S_{ij,t-1} \times RCA_{is,t-1} + \delta_{is,t} + \delta_{js,t} + \delta_{ijs}] \times \epsilon_{ijs,t}. \qquad (8)$$

$$ForwardGVC_{ijs,t} = exp[\beta_1 S_{ji,t-1} + \beta_2 RCA_{js,t-1} + \beta_3 S_{ji,t-1} \times RCA_{js,t-1} + \delta_{js,t} + \delta_{is,t} + \delta_{jis}] \times \epsilon_{jis,t}. \tag{9}$$

The coefficient of β_1 represents the effect of the presence of a trade sanction between i and j, the coefficient of β_2 indicates the effect of changes in RCA, and the coefficient of the interaction, β_3, is the increase in the effectiveness of trade sanctions for a change in RCA.

5   Data and descriptive statistics

Our empirical analysis is built on data provided by two main sources: the OECD-WTO TiVA database, edition 2021[8], and the Global Sanctions Data Base (GSDB)[9].

The GSDB classifies the collected sanctions according to three dimensions (Felbermayr et al., 2020): the type of sanction (trade sanctions, financial sanctions, travel restrictions, weapons sanctions, military assistance, plus a residual category collecting other sanctions); the goal of the sanctions (policy change, regime destabilization, territorial conflict, war prevention, terrorism, war ending, human rights, democracy, and other goals); and the success of the sanctioning (Success/Partial Result, Success/Full Result, Resolution by Negotiation, Improvement/Failure, In Progress). Regarding trade sanctions, an important aspect of the GSDB is their classification based on the direction of the trade flows involved (export sanctions, import sanctions, sanctions in both directions of trade), the extent of their coverage, and their severity (i.e., partial or complete).

Our dataset includes 2,368,080 observations on 66 origin and destination countries for 23 sectors over the period 1995 and 2018. In Appendix A we provide descriptive statistics of the main variables in our dataset and the list of countries and sectors used in the empirical analysis. Figure 1 depicts the evolution of the number of trade sanctions over the period 1995-2018. It is noticeable that countries have indeed introduced or erased sanctions through time. Especially the number of sanctions was very high before 1996, then it dropped in the late 1990s till 2012 when the total number of sanctions bounced back to the level of 1995. Trade sanctions have been increasingly used in the last twenty years as a tool for international diplomacy and to achieve foreign policy objectives. [10] One reason why trade sanctions have become more common in recent years is the increasing interdependence of the global economy, which makes it easier for countries to impose sanctions that have a significant impact on their target economy.

Trade sanctions have unintended consequences for both GVC participation and RCA. We look at the evolution of the backward and forward GVC participation by distinguishing the sample between sanctioned and non-sanctioned countries (Figure 2). Non-sanctioned countries exhibit increasing GVC participation, and trade-sanctioned countries exhibit high volatility in their participation in GVC and a rapidly decreasing trend. Such volatility may be due to the tendency for firms and countries to seek alternative suppliers or markets in response to trade sanctions. Indeed, if a country is no longer able to import certain intermediate inputs due to sanctions, it may seek to diversify its sources of supply by developing new trading relationships or investing in domestic production capabilities. If a country is no longer able to export finished goods due to sanctions, it may seek to find new buyers in other markets or shift production

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[8]The 2021 edition of the TiVA database provides indicators for 66 economies and covering the period 1995-2018. The industry list covers 45 unique industrial activities organised in a hierarchy (including aggregates for total manufactures and total services). OECD-WTO TiVA database is publicly accessible at https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm

[9]The updated GSDB (2021) covers 1101 publicly traceable, multilateral, plurilateral, and purely bilateral sanction cases over the 1950-2019 time period. GSDB is publicly accessible at https://globalsanctionsdatabase.com/

[10]The United States has been a significant user of trade sanctions and does so by a wide margin. Additionally, countries such as Canada, Russia, and Europe have employed trade sanctions in response to specific geopolitical events.

Figure 1: Number of trade sanctions per year (1995–2018)
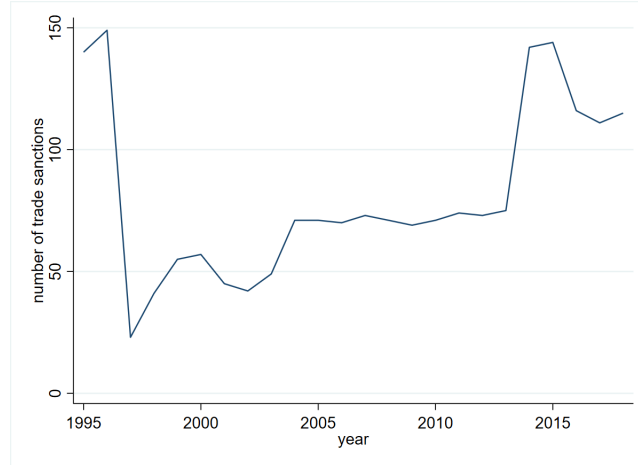
Note: Elaborations on GSDB. Accessible at: https://globalsanctionsdatabase.com/.

Figure 2: Backward and forward GVC participation, 1995–2018 (percentages)
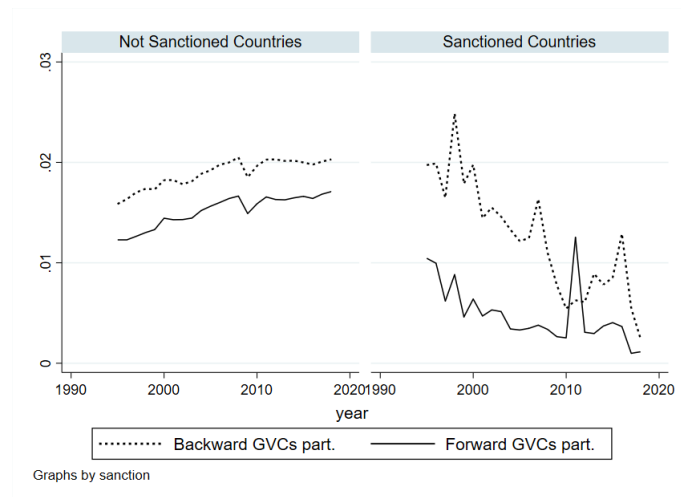
Note: The figure shows the yearly cross-country average of the GVC indexes. Elaborations on OECD-WTO TiVA database. Accessible at: https://stats.oecd.org/.

Figure 3: Revealed comparative advantage (RCA), 1995-2018
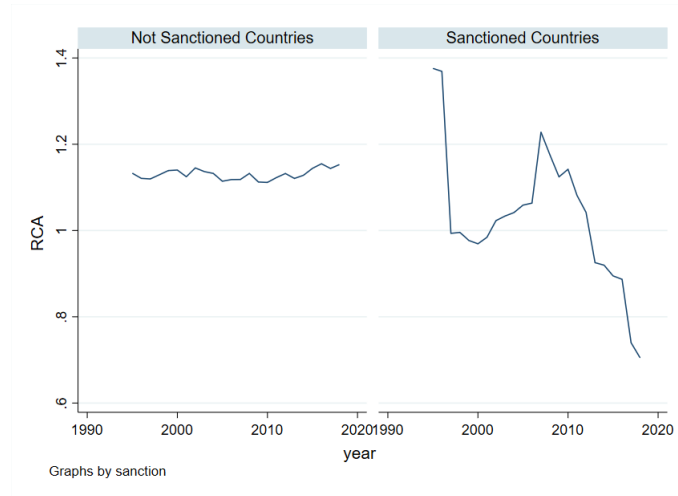
Note: The figure shows the yearly cross-country average of the RCA. Elaborations on OECD-WTO TiVA database. Accessible at: https://stats.oecd.org/.

to meet domestic demand. Similarly, Figure 3 shows that trade sanctions have a negative impact on the sanctioned country's RCA by reducing its ability to export goods in the affected industries or sectors. Indeed, a country that is no longer able to import certain intermediate inputs due to sanctions may be forced to reduce production in the affected sectors, leading to a decline in its RCA.

6   Econometric results

The research question the article attempts to address is whether, ceteris paribus, the imposition of a trade sanction in a specific period affects the country's position in the GVC, when it is in a position as a buyer (backward GVC: hypothesis 1) or when it is in a position as a seller (forward GVC: hypothesis 2).

Let's start with hypothesis 1. Table 1 shows the impact of trade sanctions restricting access to foreign intermediate goods on backward GVC participation,, as predicted by the theoretical model. Column (1) reports results for the whole sample, while columns (2) and (3) present results of sample splits according to the level of the RCA of the origin country (below and above the median). We can appreciate which group of countries drives the estimated coefficient in column (1), the High RCA ones (the model has in fact shown how the impact is relevant for high RCA products).

In the overall sample, sanctions have a negative and statistically significant coefficient of -0.07 at the 10% significance level. This indicates that the presence of a trade sanction decreases the backward GVC participation by approximately 7% ((exp(-0.07)-1)x100). This occurs because it becomes more costly for the buyer country to import intermediate goods to be used for exports. Considering the role of the RCA, it appears that sanctions exert a stronger influence on countries with a higher comparative advantage (column 3), whereas this relationship does not hold for countries with a lower comparative advantage (column 2) (again, as the model entails).

Table 1: Buyer perspective: Backward GVC participation

	(1) Full sample	(2) Low RCA	(3) High RCA
$TradeSanction_{ij,t-1}$	-0.07*	-0.01	-0.09**
	(0.04)	(0.03)	(0.04)
Constant	-1.05***	-2.30***	-0.81***
	(0.00)	(0.00)	(0.00)
N	2,223,389	1,086,650	1,130,493
pseudo R^2	0.53	0.42	0.52

Notes: Robust standard errors clustered by country-pairs in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
High sub-sample includes countries above the median,
Low includes the remaining countries.
Included (unreported) are origin country-sector-time, exporting country-sector-time,
and country-pair-sector fixed effects.

Country buyers that source intermediate goods from countries with a higher comparative advantage (above the median) and experience market restrictions are more significantly impacted by sanctions. This is due to their inability to substitute the goods with domestic production or the need to switch to less efficient exporters as alternative suppliers. This was precisely the prediction of our simplified theoretical model.

The adoption of a dichotomous variable on RCA might provide a general idea about the role of the RCA but it is not statistically convenient and it relies on the chosen threshold (the median). The number of observations for each sample was also reduced. Hence, we also estimate the impact of trade sanctions on GVC via the fully interacted model described in equation (8).[11] Results are shown in Table 2 in three specifications of the model with a one-year, three-year, and five-year lag. The coefficient that is significant for the 3 and 5-year lag is the interacted one $TradeSanction_{ij,t-n} \times RCA_{is,t-n}$. As far as GVC backward participation is concerned, trade sanctions do not work on their own, but via the interaction with RCA. Furthermore, trade sanctions do not exert their full impact before a certain period, ranging from around 3-5 years. Trade sanctions dampen the backward GVC participation for sectors with relatively higher RCA (with an impact of 10% on backward GVC participation).

Let's move now to our hypothesis 2. Table 3 shows the negative impact of trade sanctions restricting the export of intermediate goods on forward GVC participation (a decrease of 6%).

Table 2: Interacted model: Backward GVC participation

	(1) 1-year lag	(2) 3-year lag	(3) 5-year lag
$TradeSanction_{ij,t-n}$	0.00	0.04	0.02
	(0.04)	(0.04)	(0.04)
$TradeSanction_{ij,t-n} \times RCA_{is,t-n}$	-0.08	-0.11**	-0.11**
	(0.05)	(0.05)	(0.05)

[11]Given the numerous cases in which the variable RCA equals zero within our dataset, applying the natural logarithm to RCA would lead to a significant reduction in available observations. Therefore, we opt to commonly employ the strategy of applying the natural logarithm to (1+RCA). However, when considering the logarithm of RCA, the estimated results remain robust. The results are available upon request to the authors.

		-1.05***	-1.04***	-1.03***
Constant		(0.00)	(0.00)	(0.00)
N		2,223,389	2,029,919	1,836,398
pseudo R^2		0.53	0.53	0.53

Notes: Robust standard errors clustered by country-pairs in parentheses.

$RCA_{is,t-n}$ is $ln(1 + RCA_{is,t-n})$

$n = 1$ in column (1), $n = 2$ in column (2), $n = 5$ in column (3).

Included (unreported) are origin country-sector-time, exporting country-sector-time, and country-pair-sector fixed effects. RCA variable is absorbed by the ijt FE.

As in Table 1, Column (1) reports results for the whole sample, and columns (2) and (3) present results of sample splits according to the below/above median RCA respectively. Also for forward GVC participation, we detect High RCA ones to be driving the results. We estimate the impact of trade sanctions on forward GVC participation via the fully interacted model described in equation (9) and we show the results in Table 4 in three specifications of the model with one year, three years and five years lag. The coefficient that is now significant for the 1 and 3-year lag is the interacted one $TradeSanction_{ij,t-n} \times RCA_{is,t-n}$. Also concerning forward GVC participation, trade sanctions do not work on their own, but *via* the interaction with RCA of the source country. Trade sanctions exert their full impact after one year by dampening forward GVC participation for sectors with relatively higher RCA. Hence, the effect seems to be lower than the backward GVC participation but "faster".

Table 3: Seller perspective: Forward GVC participation

	(1) Full sample	(2) Low RCA	(3) High RCA
$TradeSanction_{ij,t-1}$	-0.06**	-0.04	-0.06**
	(0.03)	(0.04)	(0.03)
Constant	-0.91***	-1.32***	-0.66***
	(0.00)	(0.00)	(0.00)
N	2,076,166	1,031,913	1,035,458
pseudo R^2	0.52	0.47	0.55

Notes: Robust standard errors clustered by country-pairs in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

High sub-sample includes countries above the median,

Low includes the remaining countries.

Included (unreported) are origin country-sector-time, exporting country-sector-time, and country-pair-sector fixed effects.

Table 4: Interacted model: Forward GVC participation

	(1) 1-year lag	(2) 3-year lag	(3) 5-year lag
$TradeSanction_{ij,t-n}$	-0.02	-0.01	0.03
	(0.04)	(0.04)	(0.03)

$TradeSanction_{ij,t-n} \times RCA_{js,t-n}$	-0.07*	-0.08**	-0.05
	(0.04)	(0.04)	(0.03)
Constant	-0.91***	-0.89***	-0.88***
	(0.00)	(0.00)	(0.00)
N	2,076,166	1,885,456	1,695,079
pseudo R^2	0.52	0.52	0.53

Notes: Robust standard errors clustered by country-pairs in parentheses.

$RCA_{is,t-n}$ is $ln(1 + RCA_{is,t-n})$

$n = 1$ in column (1), $n = 2$ in column (2), $n = 5$ in column (3).

Included (unreported) are origin country-sector-time,exporting country-sector-time,

and country-pair-sector fixed effects. RCA varibale is absorbed by the ijt FE.

Table 5 dissects further the sample by looking at the impact of the sanction by sector, namely "Agriculture, Hunting, Forestry and Fishing", "Mining and Quarrying", "Electricity, gas and Water Supply" and "Manufacturing" (sub-sectors). The "Agriculture, hunting, forestry and fisheries" sector seems to substantially suffer from the buyer perspective. "Mining and quarrying", and "Electricity, gas and Water Supply" from both perspectives (buyer and seller) but to a lesser extent, because the negative coefficient is in the latter case smaller.

As far as manufacturing is concerned, there is a broad confirmation of the whole sample regressions results. In the case of the buyer perspective, the coefficient of the dummy $TradeSanction_{ij,t}$ is statistically significant in 13 sectors out of 16, but within a quite varied panorama, with possibly "perverse" effects of enhancement of the backward GVC participation after a sanction for some sectors ("Textiles", "Paper products and Printing", "rubber and Plastic products" and "Other Manufacturing"). In these sectors, in response to sanctions, countries may enhance their domestic industries, aiming to decrease their dependence on foreign suppliers. This shift has the potential to foster an expansion in backward GVC participation, as domestic firms strive to address the gaps created by the restricted imports.

Table 5: Impact of Sanctions by sector

Independent variable: $TradeSanction_{ij,t-1} \times Sector_{dummy}$	Backward GVC as buyer	Forward GVC as seller
Agriculture , hunting, forestry and fishing	-3.70***	-0.09
	(0.20)	(0.24)
Mining and quarrying	-1.49***	-0.61***
	(0.14)	(0.21)
Electricity, gas and water supply	-1.58***	-1.00***
	(0.23)	(0.21)
Manufacturing:		
Food products, beverages and tobacco	-0.56***	-0.15
	(0.16)	(0.20)
Textiles and apparel	0.39***	0.05
	(0.12)	(0.38)
Paper products and printing	0.24**	-0.42**
	(0.11)	(0.21)
Coke and refined petroleum products	-1.40***	-0.66**
	(0.48)	(0.26)

Chemical and chemical products	-0.89***	-0.48**
	(0.14)	(0.19)
Pharmaceuticals, medicinal chemical and botanical prod.	-1.61***	-0.58***
	(0.13)	(0.20)
Rubber and plastics products	0.48***	-0.51**
	(0.11)	(0.22)
Other non-metallic mineral products	-0.39***	-0.56***
	(0.14)	(0.20)
Basic metals	0.28	-1.27***
	(0.36)	(0.23)
Fabricated metal products	-1.10***	-0.87***
	(0.16)	(0.21)
Computer, electronic and optical equipment	-0.47***	-0.60***
	(0.16)	(0.20)
Electrical equipment	-0.40	-0.31
	(0.26)	(0.20)
Machinery and equipment	-0.01	-0.06
	(0.36)	(0.23)
Motor vehicles, trailers and semi-trailers	-1.06***	-0.70***
	(0.11)	(0.20)
Other transport equipment	-0.65***	-0.31
	(0.07)	(0.25)
Other Manufacturing	1.01***	0.22
	(0.14)	(0.23)
Constant	-1.90***	-1.78***
	(0.00)	(0.03)
N	2,170,740	1,983,039
pseudo R^2	0.32	0.29

Notes: Robust standard errors clustered by country-pairs in parentheses.

Included (unreported) are origin country-time,exporting country-time,

and country-pair fixed effects.

When considering the forward GVC participation in 16 manufacturing sectors, the coefficient of the dummy $TradeSanction_{ij,t-1}$ is negative and statistically significant for 10 sectors only. The impact appears to be particularly high in the sector "Basic metals" (-1.27), which indicates the difficulty of substitute producers in this specific industry.

7   Conclusions

This article investigates the potential effect of trade sanctions on a country's GVC participation, channeled through blocking a country to buy (backward) or a country to sell (forward) along the GVC. After showing a simplified theoretical model on the interaction between RCA and participation in the GVC, predicting a negative impact only in high RCA sectors, we empirically test the impact of sanctions on the participation to GVC *via* the moderation effect of the RCA. We adopt a fully-fledged gravity model controlling for a thorough battery of origin country-sector-time, exporting country-sector-time, and country-pair-sector fixed effects and we test the robustness of the results to various sub-samples. The RCA in a specific country-sector pair plays a key role in driving the sanction's negative impact, though. In other words, we show

both theoretically and empirically that a trade restriction imposed on a low RCA sector has a marginal effect but imposed on a high RCA sector causes quite a lot of damage.

Specifically, the main research question addressed in the article is whether the imposition of a trade sanction affects a country's position in the GVC when it is acting as a buyer (backward GVC) or as a seller (forward GVC). Our results show that the presence of a trade sanction leads to a decrease in backward GVC participation by approximately 7%. This decline occurs because it becomes more expensive for the buyer country to import intermediate goods that are necessary for exports (as we have also theoretically shown via a model). Considering the role of RCA, it is evident that sanctions have a stronger impact on countries having a higher comparative advantage in the sanctioned sectors, whereas this relationship does not hold for countries with a lower comparative advantage. From the seller's perspective, our findings demonstrate the adverse consequences of trade sanctions that restrict the export of intermediate goods, resulting in a 6% decrease in forward GVC participation. We observe that the sanction's impact is predominantly driven by countries with a high RCA.

Additionally, we examined the temporal aspect of sanctions by incorporating various lag periods (1, 3, and 5) in our analyses. The findings revealed time-dependent variations in the impact of sanctions on both backward and forward GVC participation. Regarding backward GVC participation, the impact of sanctions was found to be more substantial and enduring, as indicated by statistically significant coefficients observed throughout 3 to 5 years. This suggests that the effects of sanctions on backward GVC participation persist for a relatively longer duration, potentially indicating deeper structural adjustments within the supply chain. On the other hand, the impact of sanctions on forward GVC participation was observed to occur within a shorter time frame, typically within 1 to 3 years. However, the magnitude of this impact was relatively lower, signifying a more temporary and shallower effect on the progression of the supply chain.

A more detailed analysis of the sample, focusing on the impact of sanctions on different sectors, finds that the "Agriculture, Hunting, Forestry and Fishing" sector appears to be significantly affected from the buyer's perspective, whereas "Mining and Quarrying" and "Electricity, Gas and Water Supply" sectors are impacted from both the buyer's and seller's perspectives, although to a lesser extent, as the negative coefficient is smaller in the latter case. Regarding the manufacturing sector, the impact of sanctions varies across sub-sectors. Interestingly, some sectors, including "Textiles," "Paper products and Printing," "Rubber and Plastic products," and "Other Manufacturing," exhibit unexpected effects that promote participation in backward GVC following a sanction. In response to sanctions, countries in these sectors tend to strengthen their domestic industries to reduce dependence on foreign suppliers. This strategic shift toward domestic production has the potential to stimulate increased involvement in backward GVC. This phenomenon highlights the complex and dynamic nature of the effects of sanctions on different sectors within the manufacturing industry.

We posit that the level of heterogeneity of the impact observed at the sectoral level calls for more fine-grained research in the future, which could paint a heterogeneous picture of which we have just scratched the surface. We think that the policy implication of such results could be far-reaching, showing how the aims of a sanction can or cannot reach their goals if the aim is to exclude a country from participating in GVC. Sector-specific dynamic in terms of RCA has to be fully taken into account.

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