

The Impacts of Cumulative Tariff Rates on Global Value Chains

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Abstract

This study analyzes the impacts of tariffs on global value chain participation by employing value-added trade statistics and the idea of cumulative tariff rates for 12 sectors from 168 countries over the years 1990 to 2015. The main finding is that both market access and input tariff rates have significant negative impacts on sectoral global value chain participation. The effect is persistent in the analysis we employ cumulative tariff rates. Apart from these policy determinants, sector and country-level endowments such as higher relative length, capital intensity, FDI stock, and education level appear as major drivers for higher total, forward, and backward GVC participation.

Keywords: Input tariff, cumulative tariff, global value chains

JEL Codes: F13, F14

1. Introduction

Since the 1980s, the production process of countries has been enormously fragmented across borders/locations in a way that countries can specialize a specific part of the production chain according to their comparative advantages. Nowadays, the increasing share of world trade is mostly attributable to the trade of intermediates used in production in the importer country (World Development Report, 2020). For this reason, trade policies in the form of tariff and non-tariff barriers draw more attention, even if successive autonomous and multinational liberalization efforts have been especially realized over the last decades.

In these highly interconnected world economies, tariffs on intermediates that can cross borders more than once also generate indirect costs to producers and customers apart from their initial direct effect. This idea of amplifying tariff rates, that is, the cumulative effect of a tariff, is first systematically analyzed using input-output (IO) tables by Rouzet and Miroudot (2013). They mainly suggest a reduction in tariff rates with also many things such as improvements in transportation and communication technologies are more likely to increase

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fragmentation in the global value chains (GVCs). However, this inevitably raises the cumulative effect of a tariff, that is indirect portion coming from crossing more borders. Given this argument, they also expect a higher impact in the vertical specialization pattern of trade, that is a transaction of inputs to be used in the country's exported products.

In this light, we first calculate input and output tariff rates as well as GVC participation in terms of value-added terms by employing the decomposition methodology of Wang et al. (2017) because calculating tariffs in gross terms also leads to some indirect effects arising from double counting issues in gross trade statistics. We then calculate cumulative tariff rates by employing Rouzet and Miroudot (2013) calculation strategy. Lastly, we provide a more complete picture of the effects of tariff policy by calculating tariff rates by using value-added trade statistics and tracking cumulative tariff rates along with the value chain via employing sectoral and technological heterogeneities in the EORA26 sample from the year 1990 to the year 2015 (Lenzen et al., 2012, 2013).

The main novelty of this study is the calculation of input tariff rates utilizing value-added trade statistics from product-level tariff rates as well as benefiting the concept of cumulative tariff rates along a value chain. Furthermore, apart from the calculation of these variables, this study also provides empirical evidence regarding the effects of this variety of tariff policy measures on the global value chain participation indices.

The empirical analysis finds out that both initial and cumulative tariffs have a negative effect on total, forward, and backward GVC participation. Given the cascading impacts of these trade barriers, the importance and necessity of autonomous, regional, and global liberalization efforts are evident. As important as trade liberalization, capacity building of the country/sector is quite important to reap the benefits of GVCs. Specifically, given the significant U-shaped pattern of the position index, accruing new functions like adding more productive processes into a production activity can be seen as a good instrument to move along the production chain, a functional upgrading. Increasing capital intensity, attracting more FDI, and incentivizing higher education levels, in general, are other factors significantly stimulating GVC participation. Even if the general results are robust, there are also some distinctions in the effects of tariff rates depending on the country and sector-level heterogeneities.

The study is organized as follows. The next section reviews the literature. The third section describes the data. The fourth section explains the empirical methodology. The fifth section presents estimation results, and the final section completes the study.

2. Literature Review

The concept of cumulative tariffs along with the global value chain is not new, but calculating cumulative tariffs and analyzing their impact are quite new research avenues thanks to the newly released inter-country input-output tables (WIOD, OECD, and EORA). In one of the earliest studies, Yi (2003, 2010) offers a theoretical model investigating a magnified effect of tariff reductions on trade using a multistage production function multiple crosses bordering. Ferrantino (2012) illustrates that total trade cost rises exponentially when the number of production stages increases. Baldwin and Venables (2013) characterize production chains as snake and spider types. In their theoretical framework, shipping and any other coordination costs are also included as trade costs through global production chains.

Apart from these conceptual foundations in theoretical models, some studies calculate the cumulative cost of trade (Koopman et al., 2010; Fally, 2012; Rouzet and Miroudot, 2013; Muradov, 2017). Koopman et al. (2010) consider gross trade statistics and multistage production as two main reasons for the amplification of trade costs. Their findings regarding both transportation and tariff costs reveal that Asian countries have the highest magnification ratios because of their involvement in longer production chains. It is important to note that by following their idea, we track the sector's value-added in the global value chain and calculate both tariffs and cumulative tariffs by using value-added trade statistics.

Fally (2012) employs transportation costs and defines cumulative tariff rates, but he does not give any detailed discussion of the concept. Rouzet and Miroudot (2013) elaborate on the concept in a bilateral framework by providing a detailed calculation methodology. Their simulation results suggest that if tariffs on Chinese products decrease by 30%, cumulative imposed tariffs of the European Union (EU) and Japan on Chinese products reduce by 5%. Muradov (2017) proposes two measures as cumulative tariff rates and the number of border crossings by employing data from 2001, 2005, and 2010. He finds out that while the average number of border crossings increases, faced cumulative tariff decreases. Recently, some studies have employed the methodology addressed in these theoretical models and calculated the cumulative tariff burden. However, these studies (Mao and Görg, 2020; Wu

et al., 2021) focus only on the trade war between the US and China and present some descriptive results. Therefore, this study significantly contributes to the scarce empirical literature related to cumulative tariffs.

3. Data

We employ mainly four different databases. The first is the EORA26 database (Lenzen et al., 2012, 2013). We use inter-country input-output tables covering 186 countries and 26 sectors for the period of 1990-2015. Since the tariff rate is mainly relevant with only nine manufacturing, mining, agriculture, and fishing sectors, we continue with these sectors. We calculate both forward and backward GVC participation indices as well as both forward and backward lengths from this database by employing the value-added decomposition methodology of Wang et al. (2017). Forward GVC participation contains domestic value added in exported products. Backward GVC participation consists of foreign value added in imported products.

Production lengths of these trade volumes count how often these intermediates are utilized in the production process until they are consumed as final products. In other words, a length number counts the number of production stages in a value chain both from the user and producer sides. It also shows the fragmentation and complexity level of trade. Following Wang et al. (2017), we take the ratio of forward length to backward length, so-called as the position index, to reach a more consistent estimate regarding a relative production length. We also use data on gross fixed capital formation and labor compensation of sectors provided by the IO tables of EORA26. We divide gross fixed capital formation by labor compensation to reach the capital intensity of sectors.

The second database is the World Integrated Trade Solution (WITS-TRAINS) database. We obtain bilateral effectively applied tariff rates at the product level (HS 6-digit codes) from this database. We can thus differentiate tariffs on intermediates from tariffs on final products by utilizing their broad economic category (BEC) codes. We then aggregate this product-level data to reach sector-level variables (via HS6-ISIC Rev. 3 concordance table provided by the OECD). We calculate both faced and imposed input tariff rates. Following the calculation steps indicated in Rouzet and Miroudot (2013), we also calculate the cumulative tariff rates of each measure.

The third database is the FDI database on flows and stock of the United Nations Conference on Trade and Development (UNCTAD). We take countries' foreign direct investment (FDI) stock as a share of their GDPs. As the last database, we utilize the Our World in Data which combines three published datasets: Lee-Lee (2016); Barro-Lee (2018), and the Human Development Report (HDR, 2018) of the United Nations Development Programme. We utilize the average years of schooling of the adult population of countries. After merging the variables coming from these four different databases, we end up with 12 sectors and 168 countries as an operational sample. Since EORA26 country and sectoral coverage are relatively wide, we aim to separate analyses for subgroups. To achieve this, we benefit from the historical income classification provided by the World Bank and the R&D intensity (technology) classification of the Organization for Economic Co-operation and Development (Galindo-Rueda and Verger, 2016). We categorize sectors mainly into two groups high and low technology. High-tech sectors are metal products; electrical and machinery; transport equipment; other manufacturing. The low-tech sectors are food and beverages; textiles and wearing apparel; wood and paper; petroleum, chemical, and non-metallic mineral products; and recycling.

Table 1 presents the descriptive statistics of the variables we employ in the empirical analysis. We observe higher mean values of backward GVC participation compared to those for forward GVC participation for both country groups, which is mainly driven by the manufacturing sectors. In addition, both imposed and faced tariff rates are approximately 6%. Both faced and imposed cumulative tariffs are 1 percentage point higher than the initial tariffs.

Table 2 presents the position index of sectors (weighted averages of countries by trade) through time by considering countries' income levels. Since we employ the forward production length by deciding the optimal level of cross bordering, we want to analyze the trends in a position index, that is, relative forward length in this visual illustration. The darker blue in cells means a higher position index and vice versa. Even if there is no trend in position through the years except for the recycling sector, especially after the year 2007, there is obvious sectoral heterogeneity in this measure. Recycling; petroleum, chemical, and non-metallic mineral products; mining; and metal products sectors are in the relatively upstream part of a production chain.

Table 1. Summary statistics

| Variables | Obs. | Mean | SD |
|---------------------|-------------|-------------|-----------|
| GVC/VA (%) | 2,177,626 | 0.88 | 8.00 |
| Forward GVC/VA (%) | 2,522,693 | 0.29 | 3.48 |
| Backward GVC/VA (%) | 2,177,626 | 0.57 | 6.98 |
| iTariff_faced | 2,397,108 | 0.06 | 0.12 |
| iTariff_imposes | 2,069,235 | 0.06 | 0.09 |
| icuTariff_faced | 2,397,108 | 0.07 | 0.12 |
| icuTariff_imposes | 2,069,235 | 0.07 | 0.10 |
| Position | 2,485,346 | 0.97 | 0.22 |
| GFCF_LC (hundred) | 2,523,272 | 0.34 | 13.66 |
| FDI/GDP | 2,435,016 | 0.78 | 12.19 |
| Schooling | 2,384,684 | 8.51 | 2.95 |

Notes: “SD” stands for standard deviation. “GVC” means the summation of forward and backward GVC linkages. “VA” represents the sectoral value added and all trade measures are expressed as their shares in sectoral value added. “i” and “icu” mean input and cumulative input tariffs, respectively. GFCF_LC is calculated by dividing gross fixed capital formation by labor compensation.

Table 2: Production lengths of sectors through time by income level of countries

| Sector\Year - All Countries | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|-----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Fishing | 0.77 | 0.76 | 0.79 | 0.83 | 0.79 | 0.76 | 0.80 | 0.79 | 0.77 | 0.76 | 0.74 | 0.74 | 0.75 | 0.78 | 0.80 | 0.80 | 0.80 | 0.86 | 0.88 | 0.83 | 0.88 | 0.85 | 0.84 | 0.83 | 0.84 | 0.83 |
| Agriculture | 0.86 | 0.90 | 0.88 | 0.88 | 0.90 | 0.88 | 0.86 | 0.88 | 0.88 | 0.88 | 0.87 | 0.88 | 0.88 | 0.89 | 0.89 | 0.88 | 0.88 | 0.89 | 0.90 | 0.88 | 0.88 | 0.87 | 0.88 | 0.88 | 0.91 | 0.88 |
| Other Man. | 0.87 | 0.85 | 0.87 | 0.86 | 0.86 | 0.85 | 0.86 | 0.85 | 0.85 | 0.84 | 0.84 | 0.85 | 0.83 | 0.84 | 0.83 | 0.85 | 0.82 | 0.81 | 0.82 | 0.83 | 0.82 | 0.84 | 0.81 | 0.83 | 0.82 | 0.83 |
| Recycling | 1.00 | 1.02 | 1.01 | 0.99 | 0.99 | 1.02 | 1.02 | 1.02 | 1.05 | 1.05 | 1.03 | 1.03 | 1.04 | 1.05 | 1.04 | 1.07 | 1.09 | 1.17 | 1.20 | 1.24 | 1.20 | 1.20 | 1.20 | 1.21 | 1.20 | 1.19 |
| Mining | 1.04 | 1.22 | 1.04 | 1.10 | 1.07 | 1.18 | 1.06 | 1.08 | 1.05 | 1.05 | 1.06 | 1.23 | 1.05 | 1.23 | 1.13 | 1.04 | 1.05 | 1.05 | 1.00 | 1.05 | 1.00 | 1.06 | 1.03 | 1.02 | 1.02 | 1.00 |
| Food & Beverages | 0.81 | 0.83 | 0.81 | 0.80 | 0.81 | 0.80 | 0.81 | 0.82 | 0.81 | 0.81 | 0.82 | 0.81 | 0.82 | 0.82 | 0.83 | 0.82 | 0.82 | 0.83 | 0.84 | 0.84 | 0.86 | 0.84 | 0.86 | 0.85 | 0.85 | 0.84 |
| Textiles | 0.85 | 0.85 | 0.84 | 0.82 | 0.84 | 0.83 | 0.83 | 0.82 | 0.81 | 0.81 | 0.80 | 0.81 | 0.82 | 0.81 | 0.79 | 0.80 | 0.81 | 0.82 | 0.82 | 0.83 | 0.83 | 0.84 | 0.81 | 0.83 | 0.83 | 0.85 |
| Wood and Paper | 1.00 | 1.00 | 1.02 | 1.01 | 1.00 | 1.02 | 1.02 | 1.02 | 0.99 | 0.99 | 1.01 | 1.01 | 1.04 | 1.01 | 1.07 | 1.02 | 1.02 | 1.00 | 0.99 | 1.04 | 1.02 | 1.02 | 1.01 | 1.02 | 1.03 | 1.01 |
| Petroleum | 1.15 | 1.04 | 1.17 | 1.10 | 1.09 | 1.08 | 1.18 | 1.08 | 1.17 | 1.18 | 1.19 | 1.20 | 1.24 | 1.09 | 1.12 | 1.13 | 1.11 | 1.14 | 1.11 | 1.11 | 1.17 | 1.10 | 1.14 | 1.14 | 1.12 | 1.13 |
| Metal Products | 1.05 | 1.12 | 1.00 | 1.04 | 1.03 | 1.03 | 1.02 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 0.99 | 1.01 | 1.00 | 0.99 | 0.99 | 1.00 | 0.99 | 1.00 | 0.96 | 1.00 | 0.97 | 0.97 |
| Electrical | 0.87 | 0.88 | 0.85 | 0.86 | 0.87 | 0.87 | 0.85 | 0.86 | 0.87 | 0.87 | 0.86 | 0.86 | 0.85 | 0.85 | 0.87 | 0.86 | 0.84 | 0.84 | 0.84 | 0.83 | 0.84 | 0.85 | 0.84 | 0.83 | 0.85 | 0.85 |
| Transport Equip. | 0.80 | 0.81 | 0.81 | 0.81 | 0.83 | 0.80 | 0.81 | 0.81 | 0.80 | 0.80 | 0.84 | 0.83 | 0.82 | 0.81 | 0.82 | 0.82 | 0.80 | 0.81 | 0.82 | 0.84 | 0.83 | 0.82 | 0.81 | 0.82 | 0.86 | 0.81 |

Notes: Other Man.: Other Manufacturing. Mining: Mining and Quarrying. Textiles: Textiles and Wearing Apparel. Petroleum: Petroleum, Chemical and Non-Metallic Mineral Products. Electrical: Electrical and Machinery. Transport Equip.: Transport Equipment.

4. Estimation Methodology

Following the models discussed in the literature (Fernandes et al., 2020; Banerjee and Zeman, 2020), we specify the following empirical model to investigate the association between tariff rates and global value chain participation.

$$GVC_Participation_{p,t} = \beta_0 + \beta_1 Tariff_faced_{p,t} + \beta_2 Tariff_imposed_{p,t} + \beta_3 P_{p,t} + \beta_4 P_{p,t}^2 + \beta_5 S_{c,s,t} + \beta_6 C_{c,t} + \beta_7 T_t + \varepsilon_{p,t}$$

(1)

p , c , s , and t stand for the country-sector-partner country trio, country, sector, and year, respectively. $GVC_Participation_{c,s,t}$ signifies the vector of the total, forward, and backward GVC participation. $Tariff_faced_{p,t}$ stands for faced tariff and $Tariff_imposed_{p,t}$ stands for imposed tariff. These tariffs are calculated by utilizing both value-added trade statistics and a cumulative tariff procedure. In the analysis, we employ total GVC as the left-hand side variable, we then examine the impacts of both faced and imposed tariff rates on participation. Similarly, we consider the impact of faced (imposed) tariffs on the (backward) forward GVC participation.

$P_{p,t}$ represents the relative production length, which is the position index of related trade flows. We also include the square term of the position index to catch the U-shape relationship between GVC participation and production stages (if any). $S_{c,s,t}$ represents the capital intensity of the country. $C_{c,t}$ represents the vector of country-level characteristics of a country such as the share of foreign direct investment stock in GDP and the mean years of schooling. T_t stands for year dummies.

The empirical models are estimated by employing the Fixed Effects (FE) estimation technique to get rid of the unobservable time-invariants and the omitted variable bias.

5. Results

This part presents and interprets the estimation results in three subsections as the benchmark results (Table 3), results with sectoral heterogeneity (Tables 4 to 6), and results with technological heterogeneity (Tables 7 to 9).

Benchmark Results

This sub-part represents the benchmark results of determinants of global value chain participation. In columns 1 to 3 of Table 3, we employ total GVC participation ratios by summing up backward and forward linkages. In the first three columns, the results of tariff rates are presented. Regarding the tariff variables, the findings in the first three columns suggest that both faced and imposed tariffs have a negative effect on total GVC participation with the higher impact of imposed tariffs. The results suggest that not only a market access tariff impedes the realization of benefits coming from participation into forward GVC but also a tariff that countries impose on imported intermediates hinders imported inputs. Therefore, lower tariffs and, thus, deepening cooperation among economies can be seen as the important drivers of higher participation in the global production system.

Regarding the sectoral control variables, we observe a U-shaped pattern between relative production stages, that is the position in GVC and almost all types of GVC participation. Given this significant result, we can argue that moving from the fabrication stages to the pre- or post-fabrication stages improves GVC participation. To catch this benefit, sectors can adopt new functions in their production process (Humphrey, 2004). Capital intensity displaying the sectoral endowments positively influences GVC participation regardless of forward and backward linkages. Regarding the country-level control variables, FDI stock and years of schooling are the other significant determinants to boost GVC participation. The presence of FDI stock can reshape economic structure in a way that higher productivity and production are realized (Buelens and Tirpák, 2017).

Columns 4-6 of Table 3 repeat the same exercise by using cumulative tariff rates instead of simple tariffs. The results are very similar and the conclusion we get is the same as that we can infer from columns 1-3. The market accession and input tariffs negatively affect the GVC participation level of sectors.

Table 3: Tariffs and GVC participation

| | <u>Tariff</u> | | | <u>Cumulative Tariff</u> | | |
|-------------------|----------------------|----------------------|----------------------|--------------------------|----------------------|----------------------|
| | GVCs | Forward GVCs | Backward GVCs | GVCs | Forward GVCs | Backward GVCs |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Tariff_faced | -0.304*** (0.061) | -0.129*** (0.023) | | -0.289** * | -0.122*** (0.024) | |
| Tariff_imposed | -0.695*** (0.090) | | -0.629*** (0.072) | -0.681** * | | -0.622*** (0.071) |
| Pos | -0.496*** (0.158) | -0.405*** (0.057) | -0.015 (0.133) | -0.495** * | -0.404*** (0.056) | -0.016 (0.133) |
| Pos_sq | 0.011*** (0.003) | 0.009*** (0.001) | 0.000 (0.003) | 0.011*** (0.003) | 0.009*** (0.001) | 0.000 (0.003) |
| Capital intensity | 0.646*** (0.092) | 0.061*** (0.016) | 0.571*** (0.086) | 0.655*** (0.093) | 0.060*** (0.016) | 0.580*** (0.087) |
| FDI stock | 0.017** (0.007) | 0.003 (0.002) | 0.012** (0.006) | 0.017** (0.007) | 0.003 (0.003) | 0.012* (0.006) |
| Schooling | 0.029** (0.013) | -0.000 (0.006) | 0.033*** (0.011) | 0.029** (0.013) | -0.000 (0.006) | 0.033*** (0.011) |
| Constant | 2.759*** (0.273) | 0.820*** (0.091) | 1.735*** (0.228) | 2.787*** (0.274) | 0.819*** (0.092) | 1.768*** (0.230) |
| # of Obs. | 1,850,892 | 2,182,737 | 1,930,221 | 1,850,51 | 2,182,701 | 1,930,069 |
| R-squared | 0.477 | 0.356 | 0.519 | 0.477 | 0.356 | 0.519 |

Notes: Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Results with Sectoral Heterogeneity

This subsection represents the results for trade pairs depending on their income levels as well as sectoral levels. Tables 4, 5, and 6 represent the result of the total, forward, and backward GVC participation, respectively. In Table 4, for manufacturing sectors, while faced and imposed tariff rates negatively affect GVC participation between developing-developing pairs, the faced tariff is only significant for developed-developing pairs and imposed tariff is significant for developed-developed and developing-developed country pairs. The results suggest that even if there are some differences in the effect of tariffs for country pairs, it is important to note that developed countries should regulate tariff policies on products coming from developed countries. The same is valid for developing countries regardless of the income level of trade partners. For the agriculture and mining sectors, facing tariffs from developed countries when they trade with developing economies and facing tariffs from developing countries when they trade with developing countries have negative impacts on total GVC participation. In other words, protective measures applied by developing countries can be seen as detrimental barriers in the front of GVC participation of all countries. The results are similar in the analysis we employ cumulative tariff rates.

Via Tables 5 and 6, we also provide some robustness checks and test the reliability of our results. As can be noticeable, the results are quite parallel with the results provided in Table 4 with minor distinctions. For manufacturing sectors, while the faced tariff rate decreases forward GVC participation, imposed tariff reduces backward GVC participation. Note that similar to Table 3, given the much higher estimated coefficients, imposed tariffs have more influential effects on participation. For agriculture and mining sectors, while faced tariffs have minor effects on forward GVC participation, the impacts of imposed tariffs on GVC participation differ for countries. Contrary to developing countries, one interesting result is that developed countries benefit from protectionism on agriculture and mining products, which is consistent with the identified effects of the US agricultural policy and the EU common agricultural policy.

Table 4: Tariffs and GVC participation by sectors

| Total | Tariff | | | | Cumulative Tariff | | | |
|---------------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|
| | Developed-Developed (1) | Developed-Developing (2) | Developing-Developing (3) | Developing-Developed (4) | Developed-Developed (5) | Developed-Developing (6) | Developing-Developing (7) | Developing-Developed (8) |
| Tariff_faced | 0.125 (0.243) | -0.255*** (0.054) | -0.245*** (0.079) | 0.358 (0.755) | 0.060 (0.221) | -0.240*** (0.051) | -0.235*** (0.079) | 0.430 (0.755) |
| Tariff_imposed | -2.763** (1.309) | -0.007 (0.043) | -0.494*** (0.126) | -1.580*** (0.266) | -2.326* (1.224) | 0.007 (0.060) | -0.475*** (0.128) | -1.571*** (0.260) |
| # of Obs. | 148,492 | 513,505 | 787,098 | 401,797 | 148,508 | 513,586 | 786,464 | 401,952 |
| R-squared | 0.519 | 0.594 | 0.374 | 0.555 | 0.520 | 0.594 | 0.374 | 0.555 |
| Manufacturing | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.027 (0.258) | -0.266*** (0.057) | -0.262*** (0.091) | 0.283 (0.800) | -0.034 (0.236) | -0.251*** (0.055) | -0.255*** (0.090) | 0.363 (0.799) |
| Tariff_imposed | -3.480** (1.552) | -0.015 (0.047) | -0.596*** (0.150) | -1.906*** (0.326) | -2.991** (1.450) | -0.028 (0.066) | -0.572*** (0.153) | -1.898*** (0.319) |
| # of Obs. | 117,157 | 427,173 | 649,747 | 323,146 | 117,174 | 427,277 | 649,325 | 323,274 |
| R-squared | 0.489 | 0.592 | 0.366 | 0.546 | 0.490 | 0.593 | 0.366 | 0.545 |
| Agriculture & Mining | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.339* (0.193) | -0.114** (0.052) | -0.094** (0.047) | 0.081 (0.182) | 0.228 (0.194) | -0.093** (0.047) | -0.044 (0.045) | 0.022 (0.183) |
| Tariff_imposed | 0.814 (0.710) | 0.064 (0.092) | 0.038 (0.095) | -0.082 (0.109) | 0.978 (0.785) | 0.230 (0.142) | 0.038 (0.092) | -0.085 (0.110) |
| # of Obs. | 31,335 | 86,332 | 137,351 | 78,651 | 31,334 | 86,309 | 137,139 | 78,678 |
| R-squared | 0.893 | 0.615 | 0.856 | 0.950 | 0.893 | 0.615 | 0.858 | 0.950 |

Notes: We employ the first specifications in Table 3. We use the same control variables in all panels, but they are not reported here. Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Tariffs and forward GVC participation by sectors

| Total | Tariff | | | | Cumulative Tariff | | | |
|---------------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|
| | Developed-Developed (1) | Developed-Developing (2) | Developing-Developing (3) | Developing-Developed (4) | Developed-Developed (5) | Developed-Developing (6) | Developing-Developing (7) | Developing-Developed (8) |
| Tariff_faced | 0.008 (0.022) | -0.089*** (0.013) | -0.128*** (0.047) | -0.117*** (0.038) | -0.014 (0.021) | -0.085*** (0.013) | -0.118** (0.047) | -0.132*** (0.038) |
| # of Obs. | 162,871 | 586,221 | 978,876 | 454,769 | 162,882 | 586,281 | 978,740 | 454,798 |
| R-squared | 0.953 | 0.822 | 0.288 | 0.885 | 0.953 | 0.820 | 0.288 | 0.885 |
| Manufacturing | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.011 (0.022) | -0.094*** (0.014) | -0.139** (0.055) | -0.124*** (0.040) | -0.008 (0.021) | -0.090*** (0.014) | -0.131** (0.055) | -0.136*** (0.040) |
| # of Obs. | 129,329 | 490,254 | 813,291 | 366,756 | 129,340 | 490,342 | 813,261 | 366,785 |
| R-squared | 0.964 | 0.843 | 0.271 | 0.815 | 0.964 | 0.841 | 0.271 | 0.815 |
| Agriculture & Mining | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.094 (0.090) | -0.051 (0.034) | -0.090** (0.039) | 0.068 (0.169) | 0.018 (0.095) | -0.039 (0.032) | -0.052 (0.038) | -0.001 (0.169) |
| # of Obs. | 33,542 | 95,967 | 165,585 | 88,013 | 33,542 | 95,939 | 165,479 | 88,013 |
| R-squared | 0.942 | 0.769 | 0.877 | 0.953 | 0.942 | 0.769 | 0.877 | 0.953 |

Notes: We employ the fourth specification in Table 3. We use the same control variables in all panels, but they are not reported here. Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Tariffs and backward GVC participation by sectors

| Total | <u>Tariff</u> | | | | <u>Cumulative Tariff</u> | | | |
|---------------------------------|--------------------------------|---------------------------------|----------------------------------|---------------------------------|--------------------------------|---------------------------------|----------------------------------|----------------------------------|
| | Developed- Developed (1) | Developed- Developing (2) | Developing- Developing (3) | Developing- Developed (4) | Developed- Developed (5) | Developed- Developing (6) | Developing- Developing (7) | Developing- -Developed (8) |
| Tariff_imposed | -2.570** (1.292) | 0.044 (0.040) | -0.411*** (0.054) | -1.486*** (0.261) | -2.197* (1.205) | 0.034 (0.058) | -0.401*** (0.053) | -1.478*** (0.255) |
| # of Obs. | 149,970 | 542,093 | 833,473 | 404,685 | 149,976 | 542,134 | 833,135 | 404,824 |
| R-squared | 0.405 | 0.515 | 0.478 | 0.541 | 0.406 | 0.515 | 0.478 | 0.540 |
| Manufacturing | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_imposed | -3.144** (1.534) | 0.029 (0.045) | -0.474*** (0.065) | -1.786*** (0.320) | -2.730* (1.433) | 0.008 (0.064) | -0.462*** (0.063) | -1.784*** (0.313) |
| # of Obs. | 118,604 | 453,542 | 691,842 | 325,890 | 118,611 | 453,577 | 691,589 | 326,000 |
| R-squared | 0.402 | 0.517 | 0.477 | 0.540 | 0.403 | 0.517 | 0.477 | 0.539 |
| Agriculture & Mining | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_imposed | 0.299** (0.133) | 0.150* (0.078) | -0.054*** (0.012) | -0.086*** (0.019) | 0.436** (0.194) | 0.204 (0.129) | -0.052*** (0.012) | -0.070*** (0.018) |
| # of Obs. | 31,366 | 88,551 | 141,631 | 78,795 | 31,365 | 88,557 | 141,546 | 78,824 |
| R-squared | 0.496 | 0.476 | 0.595 | 0.559 | 0.495 | 0.476 | 0.595 | 0.558 |

Notes: We employ the seventh specification in Table 3. We use the same control variables in all panels, but they are not reported here. Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Results with Technological Heterogeneity

This subsection represents the results for trade pairs depending on their income levels as well as the technology level of sectors. Tables 7, 8, and 9 present the results of the total, forward, and backward GVC participation, respectively. While higher faced tariff rates have negative impacts on GVC participation between developed-developing pairs, imposed tariffs have significant negative impacts on developed-developed trade partners and developing economies for high-tech sectors as shown in Table 7. For low-tech sectors, the main difference from the above panel is that both tariff rates reduce GVC participation between developing-developing pairs, which simply implies that to improve integration among developing countries, further reduction in tariff rates among them is needed.

The results presented in Tables 8 and 9 are parallel with the results provided in Table 7 with minor distinctions. For high-tech sectors, while a higher faced tariff rate is related to a lower level of GVC participation between developed-developing and developing-developing trade pairs, the effect of the imposed tariff is negative only for developing countries. For low-tech sectors, while faced tariff rates negatively affect GVC participation between developed-developing trade partners and developing countries, imposed tariff negatively affects GVC participation of developing countries regardless of the income levels of trading partners.

Table 7: Tariffs and GVC participation by technology classification

| Total | Tariff | | | | Cumulative Tariff | | | |
|------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|
| | Developed-Developed (1) | Developed-Developing (2) | Developing-Developing (3) | Developing-Developed (4) | Developed-Developed (5) | Developed-Developing (6) | Developing-Developing (7) | Developing-Developed (8) |
| Tariff_faced | 0.125 (0.243) | -0.255*** (0.054) | -0.245*** (0.079) | 0.358 (0.755) | 0.060 (0.221) | -0.240*** (0.051) | -0.235*** (0.079) | 0.430 (0.755) |
| Tariff_imposed | -2.763** (1.309) | -0.007 (0.043) | -0.494*** (0.126) | -1.580*** (0.266) | -2.326* (1.224) | 0.007 (0.060) | -0.475*** (0.128) | -1.571*** (0.260) |
| # of Obs. | 148,492 | 513,505 | 787,098 | 401,797 | 148,508 | 513,586 | 786,464 | 401,952 |
| R-squared | 0.519 | 0.594 | 0.374 | 0.555 | 0.520 | 0.594 | 0.374 | 0.555 |
| High Technology | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | -0.478 (0.328) | -0.256*** (0.080) | -0.138 (0.086) | 0.917 (1.737) | -0.432 (0.313) | -0.238*** (0.076) | -0.124 (0.083) | 0.963 (1.738) |
| Tariff_imposed | -5.346* (3.180) | -0.035 (0.047) | -0.392*** (0.089) | -2.399*** (0.584) | -4.587 (2.976) | -0.107 (0.068) | -0.367*** (0.085) | -2.357*** (0.566) |
| # of Obs. | 56,731 | 213,048 | 315,472 | 156,043 | 56,739 | 213,130 | 315,330 | 156,116 |
| R-squared | 0.442 | 0.547 | 0.514 | 0.571 | 0.444 | 0.547 | 0.515 | 0.571 |
| Low Technology | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.574 (0.356) | -0.257*** (0.073) | -0.330*** (0.121) | -0.015 (0.262) | 0.422 (0.316) | -0.244*** (0.069) | -0.322*** (0.121) | 0.075 (0.275) |
| Tariff_imposed | -0.890** (0.395) | 0.013 (0.066) | -0.561*** (0.200) | -1.045*** (0.218) | -0.690* (0.407) | 0.091 (0.092) | -0.544*** (0.203) | -1.064*** (0.221) |
| # of Obs. | 91,761 | 300,457 | 471,626 | 245,754 | 91,769 | 300,456 | 471,134 | 245,836 |
| R-squared | 0.722 | 0.622 | 0.352 | 0.538 | 0.722 | 0.622 | 0.352 | 0.537 |

Notes: We employ the first specifications in Table 3. We use the same control variables in all panels, but they are not reported here. Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Tariffs and forward GVC participation by technology classification

| Total | Tariff | | | | Cumulative Tariff | | | |
|------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|
| | Developed-Developed (1) | Developed-Developing (2) | Developing-Developing (3) | Developing-Developed (4) | Developed-Developed (5) | Developed-Developing (6) | Developing-Developing (7) | Developing-Developed (8) |
| Tariff_faced | 0.008 (0.022) | -0.089*** (0.013) | -0.128*** (0.047) | -0.117*** (0.038) | -0.014 (0.021) | -0.085*** (0.013) | -0.118** (0.047) | -0.132*** (0.038) |
| # of Obs. | 162,871 | 586,221 | 978,876 | 454,769 | 162,882 | 586,281 | 978,740 | 454,798 |
| R-squared | 0.953 | 0.822 | 0.288 | 0.885 | 0.953 | 0.820 | 0.288 | 0.885 |
| High Technology | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.009 (0.021) | -0.088*** (0.019) | -0.090*** (0.015) | -0.105 (0.072) | -0.011 (0.020) | -0.081*** (0.017) | -0.080*** (0.014) | -0.120* (0.071) |
| # of Obs. | 62,875 | 245,130 | 394,420 | 176,375 | 62,881 | 245,200 | 394,388 | 176,389 |
| R-squared | 0.966 | 0.797 | 0.879 | 0.915 | 0.966 | 0.797 | 0.879 | 0.915 |
| Low Technology | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_faced | 0.003 (0.036) | -0.089*** (0.018) | -0.153** (0.078) | -0.133*** (0.041) | -0.020 (0.035) | -0.086*** (0.019) | -0.143* (0.078) | -0.148*** (0.041) |
| # of Obs. | 99,996 | 341,091 | 584,456 | 278,394 | 100,001 | 341,081 | 584,352 | 278,409 |
| R-squared | 0.949 | 0.832 | 0.278 | 0.878 | 0.949 | 0.830 | 0.278 | 0.878 |

Notes: We employ the fourth specification in Table 3. We use the same control variables in all panels, but they are not reported here. Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Tariffs and backward GVC participation by technology classification

| Total | Tariff | | | | Cumulative Tariff | | | |
|------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|----------------------------|-----------------------------|------------------------------|-----------------------------|
| | Developed-Developed (1) | Developed-Developing (2) | Developing-Developing (3) | Developing-Developed (4) | Developed-Developed (5) | Developed-Developing (6) | Developing-Developing (7) | Developing-Developed (8) |
| Tariff_imposed | -2.570** (1.292) | 0.044 (0.040) | -0.411*** (0.054) | -1.486*** (0.261) | -2.197* (1.205) | 0.034 (0.058) | -0.401*** (0.053) | -1.478*** (0.255) |
| # of Obs. | 149,970 | 542,093 | 833,473 | 404,685 | 149,976 | 542,134 | 833,135 | 404,824 |
| R-squared | 0.405 | 0.515 | 0.478 | 0.541 | 0.406 | 0.515 | 0.478 | 0.540 |
| High Technology | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_imposed | -5.031 (3.145) | -0.001 (0.050) | -0.409*** (0.074) | -2.287*** (0.575) | -4.363 (2.940) | -0.062 (0.063) | -0.399*** (0.072) | -2.253*** (0.557) |
| # of Obs. | 57,447 | 224,079 | 332,877 | 157,383 | 57,450 | 224,099 | 332,806 | 157,447 |
| R-squared | 0.378 | 0.471 | 0.477 | 0.569 | 0.380 | 0.471 | 0.478 | 0.569 |
| Low Technology | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Tariff_imposed | -0.744** (0.315) | 0.075 (0.060) | -0.413*** (0.075) | -0.952*** (0.209) | -0.595* (0.320) | 0.100 (0.090) | -0.403*** (0.074) | -0.967*** (0.211) |
| # of Obs. | 92,523 | 318,014 | 500,596 | 247,302 | 92,526 | 318,035 | 500,329 | 247,377 |
| R-squared | 0.515 | 0.542 | 0.478 | 0.501 | 0.513 | 0.542 | 0.478 | 0.500 |

Notes: We employ the seventh specification in Table 3. We use the same control variables in all panels, but they are not reported here. Clustered robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6. Conclusion

This study investigates the effects of tariffs on global value chain participation utilizing value-added trade statistics and the concept of cumulative tariff rates for 12 sectors from 168 countries through the period 1990-2015. The main finding is that tariff rates significantly deteriorate the global value chain participation of sectors in these highly fragmented production networks. According to the empirical findings, both initial and cumulative tariffs have detrimental impacts on total, forward, and backward GVC participation. To realize the benefits of GVCs, country/sector capacity building is just as crucial as trade liberalization. Given the strong U-shaped pattern of the position index, adding new functions, such as adding more productive processes to manufacturing, can be considered a good tool for moving along the production chain, or functional upgrading. Other factors encouraging GVC participation include increasing capital intensity, attracting more FDI stock, and rewarding higher education levels in general. Even while the overall findings are consistent, there are some differences in the effects of tariff rates based on the income level of countries and sector heterogeneities. In general, manufacturing industries, low-tech sectors, developing countries, and trade between developed-developed countries are seen as more vulnerable groups.

Overall, while the global value chains get larger and longer, a particular interest is drawn into tariff policies. Trade barriers especially in the form of tariff rates are still a significant concern because of their cumulative effect along with global value chains. Given the significant results of this study, we can claim that policymakers ought to track the domestic value-added of sectors along with the value chain and focus on the indirect effect of tariff rates by taking the length of trade flows into account.

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