Impact of Export Sophistication on Trade Diversification: The Mediating Role of Participation in Global Value Chains

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**History**
Revised format: May 2022
Available Online: Jun 2022

**Keywords**
Export sophistication, Trade diversification, Market concentration, Global value chains, Threshold

**JEL Classification**
F1, F19

**Purpose:** The purpose of this study is two-fold: First to investigate the impact of export sophistication and participation in global value chains (GVCs) on trade diversification, and: Second, to examine the nonlinear relationship between export sophistication and trade diversification under the influence of GVCs.

**Design/Methodology/Approach:** For this, the current study constructed a panel of 105 economies covering the period 2011-2018. For empirical analysis, this study applies the static panel threshold test proposed by Hansen (1999).

**Findings:** According to the results of this study, export sophistication and participation in global value chains have a positive association with trade diversification. In addition, this study finds two thresholds of GVCs that divide the impact of export sophistication on trade diversification into three regimes. Therefore, the relationship between export sophistication and trade diversification is nonlinear.

**Implications/Originality/Value:** Therefore, this study suggests countries to produce sophisticated products and increase their participation in global value chains.

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**Introduction**
A pioneer work by Krugman (1979a) and Helpman (1981) highlighted the importance of product diversification in trade for the welfare of nations. Many researchers with the help of endogenous growth models explained various channels (innovation stimulation & learning by doing effects, knowledge spillover, technological transfer, and technology spillovers) through which export diversification affects economic growth (Helpman,1991; Matsuyama, 1992; Amin Guitierrez de Pineres and Ferrantino, 2000; Krugman,1979, Coe and Helpman, 1993, Van Meijl,1997, Das,2002 and Agosin,2007).

Keeping in view the importance of export diversification, researchers identified factors that can affect export diversification. According to a study by United Nations (2001), the investment level in a country is a source of innovation and leads to a new set of commodities. However, the role of foreign direct investment (FDI) to determine the level of export diversification is dual. FDI in exporting sector enables
an economy to diversify its exports but FDI in nontrading sectors has a weak and adverse impact on export diversification (Iwamoto and Nabeshima, 2012; Ofa et al. 2012). According to the H-O model factor endowments of a country can affect the intensive margin of exports. Elhiraika and Mbate (2014) state that the terms of trade of a country adversely affect export diversification because of an increase in the cost of exports in the international market.

However, to absorb the gains from product diversification a county relies on trading partners. Because to diversify an export basket a country requires intermediate goods and trading partners are the primary suppliers of these inputs. Similarly, to sell a final product a country again depends on its trading partners, therefore; the trading partners of a country determine the level of trade diversification. Furthermore, export product diversification (extensive export diversification) is a complex phenomenon and requires more effort, endowments, economies of scale, and productivity. Countries with diversified trading partners have an advantage over countries with less concentrated trading partners. Because trade diversification plays an important role to determine the trade volume and ability of a country to absorb adverse external shocks (Cheewtrakoolpong, 2012; Da Costa Neto and Romeu, 2011; McIntyre et al. 2018).

Trade diversification includes importing or exporting markets (trading partners) of a country and access to a large number (small number) of markets reflects a diversified (concentrated) trade portfolio for a particular nation\(^1\). Figure 1 illustrates the trend of trade diversification (trade portfolio) in the world over time, measured by the Hirschman Herfindahl index, and trade volume of the world \(^2\). According to this figure, the behavior of change in trading volume of the world, measured by the natural log of export plus import volume, follows the behavior of change in trade flows of the world with one lag behind.

However, after 2008 on average the trend of the world’s trade portfolio is not favorable and on average trade portfolio of the world has a declining trend which implies that the access to diversified markets of trade (trade flows) is diminishing. Consequently, the trade volume of the world could be affected adversely and may create a threat to the process of globalization (Da Costa Neto & Romeu, 2011). In addition, trade diversification helps a country in hedging a risk faced by a state in the case of concentrated trading partners (Önder and Yilmazkuday, 2014). Therefore, it is very important to identify the factors that play a positive role to reduce the trade concentration of countries. Because trade in goods determines the level of production activities for firms and employment opportunities for labor particularly in developing economies\(^3\).

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**Figure 1. Changes in World’s HH Market Concentration Index and Trade Volume**

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\(^1\) TCdata360.worldbank.org

\(^2\) HH Market Concentration Index is a measure of the dispersion of trade values across an exporter’s partners. A country with trade that is concentrated in a very few markets will have an index value close to 1.

McIntyre et al. (2018) conclude that a country with sophisticated products has more easy access to diversified markets than countries with traditional and primary products because the international customer is more inclined toward cost-effective, value for money, and value-added products (McIntyre et al. 2018; Green, 2020; Trivedi, 2021). However, the degree of absorption of benefits of export sophistication for trade diversification depends on the international trade linkages of a country with the rest of the world (Cheewatrakoolpong, 2012). In line with this, Soyres et al. (2020) state that participation in global value chains (GVCs) has a strong association with the trade flows of a country toward the rest of the world. Khasnobis and Aditya (2020) argue that the level of participation in global value chains significantly affects export diversification and a country with more participation in GVCs absorbs more gains from sophisticated products. It implies that the relationship between export sophistication and trade diversification may be nonlinear and this nonlinearity depends on the level of participation in GVCs.

The objective of this study is two-fold: First to investigate the impact of export sophistication on trade diversification and participation in global value chains (GVCs). The literature provides very little information on the role of export sophistication to determine trade diversification. For this, we computed export sophistication score by using the data of 259 products at Standard International Trade Classification (SITC) 3-digit level according to revision 3 for a panel of 105 countries from 2011-2018. Furthermore, to measure participation in GVCs we used the data of “backward participation” and “forward participation” by a country. Former studies analyze the impact of GVCs on export diversification rather than trade diversification, therefore; the current study is different from former studies, and. Second, to find the threshold level of participation in global value chains which divides the impact of export sophistication on trade diversification in different regimes.

To the best of our knowledge, the current study makes the first attempt to empirically analyze the impact of export sophistication and participation in GVCs on trade diversification. In addition, this is the first study that examines a nonlinear relationship between export sophistication and trade diversification. Therefore, the contribution of this study is two-fold: First, unlike many other studies, the current study provides empirical evidence on the nexus between export sophistication, GVCs, and trade diversification. Second (and perhaps the main contribution), this study determines the nonlinear relationship between export sophistication and trade diversification under the influence of participation in GVCs.

The next 2 sections provide the literature review (2) and methodology (3) followed by data and sources (4). The results and discussion are provided in section (5). The last section (6) consists of the conclusion and policy recommendations of this study.
**Literature Review**

Export diversification can be categorized into 2 types of diversification namely export product diversification and export market diversification. The former consists of the range of products and the latter captures access to international markets and determines trade diversification. Both types of a diversification play a vital role to determine the living standard of a nation because both mitigate the adverse impacts of external shocks and deterioration of terms of trade. In addition, trade diversification is a source of a wide range of income sources for a nation. These channels promote diversification-led-growth phenomenon based on export-led-growth phenomenon (Lerderman and Maloney, 2007; Herzer and Nowak-Lehmann, 2006; Gozgor and Can, 2016). Cadot et al. (2011) argue that developed economies produce different products than developing economies because of differences in factor endowments that are the sources of specialization. In addition, developed economies change the status of their diversification by abandoning old product lines and moving to new product lines with a change in capital accumulation.

However, Hausmann and Rodrik (2003) propose that to produce a wide range of products and jumped to the upper ladder or new product lines a firm needs to invest in multiple products which associate with a higher discovery cost. In light of the discovery process, Hausmann et al. (2007) state that countries should produce more sophisticated products because countries that produce more sophisticated products grow faster than countries that produce less sophisticated products. In addition, countries that produce goods that are produced by high-income (developed) economies grow faster than countries that do not produce them. After this study, researchers started to focus on the nexus between economic growth and export upgradation which leads to the sophistication-led-growth phenomenon (Atasoy, 2021; Fortunato and Razo, 2014; Minondo, 2010; Jarreau and Poncet, 2012; Lee and Malerba, 2017).

Nonetheless, both phenomena, export diversification and export sophistication are equally important for economic growth because both require the upgradation of production structures in a country. Therefore, a well-balanced approach to adopting the mixing structure of product upgrading and trading partner is desirable.

The product upgrading to increase the sophistication level of exports is indispensable for export market diversification in terms of trading partners. In addition, in the light of new trade theories, the likelihood of firms’ access to international markets is higher for firms that produced technologically advanced products (Unlu and Yilduz, 2019). Furthermore, sophisticated products give rise to brand recognition in international markets which further attracts customers from various markets of the world (Seyidoglu, 2013). In line with this, to produce sophisticated products firms import advanced technology and intermediate products which leads to knowledge creation and technology diffusion because of interaction with international buyers and sellers in foreign markets.

Due to international transactions and interaction with foreign traders, countries successfully become able to increase their trading partners and diversified their trade portfolios (Grossman and Helpman, 1991). Therefore, countries in the north and south are investing in innovations and imitations respectively to approach diversified markets (Hesse, 2008). According to Anderoni (2010), the export sophistication index reflects the productive capabilities of a country, and countries with productive and technologically advanced products successfully diversified their exports because of their productive capabilities (Ciesilk and Parteka, 2018). Basile et al. (2018) point out that the extensive margin of exports and export diversification is affected by the structural relations that vary over time between countries. In line with this, Naito (2017) argues that international trade linkages trigger the process of extensive trade margins and develop linkages between domestic and foreign economies.

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4 Classical theories of trade are comparative advantage theory and Factor Endowment theory known as Ricardian Model and Heckscher-Ohlin Model of trade respectively.
The role of global value chains is a primary driver of trade linkages of a country with the rest of the world. Because it consists of all required activities of a firm, at a domestic and international level, to convert a product from raw material and intermediate goods into a final good to be used by consumers. According to Xing et al. (2021), these activities significantly contribute to the functional upgradation of a product. Similarly, a study by the Organization of Economic Cooperation and Development (2013) states that GVCs assure the fragmentation and dispersion of operational activities across borders and also incorporate the role of services in the specialization of traded goods. In addition, it plays a significant role to develop a network among buyers and sellers across the board.

Due to cross border affiliations, GVCs are the source of cost reduction and efficient production of goods as it creates knowledge spillovers and learning-by-doing effects. Therefore, the level of participation in GVCs by a country has the potential to affect the degree of relationship between export upgrading and the trade portfolio of a country. Because more sophisticated sectors such as textile and electronics have large fragmentation of production activities across borders. Furthermore, GVCs also require investment in skills, infrastructure, and productive capacity which further explains the way through which export sophistication affects trade diversification (UNCTAD, 2013).

Methodology
The core objective of this study is to investigate the nonlinear impact of export sophistication on trade diversification under the influence of participation in GVCs. The theoretical background of the nexus between export sophistication, participation in GVCs, and trade diversification is explained in section 3.1.

Theoretical Mechanism
A sophisticated product requires more technical skills, knowledge, experience, and education to be manufactured (Can and Dughan, 2017). Developed countries produce more sophisticated products because of a better quality of factor endowments and human capital. Consequently, developed countries succeed to introduce their products in different international markets and have diversified trade portfolios. According to Hausmann et al. (2007) developing economies should produce products produced by developed economies to increase their exports and grow faster. However, for imitation of products developing economies are required to acquire advanced technology used by developed economies and the knowledge to use this technology (Dosi et al, 1988; freeman 1987).

According to Biisztray and Poitiers (2022), GVCs are the primary source of knowledge creation and innovation for firms. Therefore, GVCs are the primary driver of the productivity of firms. Similarly, Seric and Tong (2019) state that GVCs focus on specialization and research and development expenditures, therefore; it leads to more complex final goods produced by firms. Bakes et al. (2019) report that multinational firms are the primary drivers of GVCs and firms located in different regions of the world that belong to a similar business group are the key buyers of products produced by a firm belonging to their parent group operating in a different country. Based on this discussion it can be concluded that GVCs not only play a vital role to determine the trading partners of a country but also plays the role of mediator between export sophistication and the trade portfolio of a country. Figure 2 illustrates the conceptual framework of the current study.

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5 These activities range from design production, marketing, logistics, and distribution to the final consumer.
Econometric Methodology
As the objective of this study is to empirically find the impact of export sophistication on trade diversification under the influence of GVCs for a panel of countries. For this, the current study follows the methodology proposed by Hansen (1999).

The fixed-effects panel threshold model
The double threshold model used by the current study is

$$ y_{it} = \mu + X_{it}(q_{it} \leq \gamma_1)\beta_1 + X_{it}(q_{it} < \gamma_1 \leq \gamma_2)\beta_2 + X_{it}(q_{it} > \gamma_2)\beta_3 + \mu_i + \epsilon_{it} $$

(9)

Where $y_{it}$ is trade diversification, $X_{it}$ is export sophistication, $q_{it}$ is participating in the global value chain as a threshold variable, $\gamma$ is the threshold parameter that divides the impact of export sophistication, $\beta_1$, $\beta_2$, and $\beta_3$ on trade diversification in 3 different regimes, $\mu_i$ is the country fixed effect, $\epsilon_{it}$ is the error term of the model, $t$ denotes time and $i$ is for cross sections.

One can write equation 5 in the following way

$$ y_{it} = \mu + X_{it}(q_{it}, \gamma)\beta + \mu_i + \epsilon_{it} $$

(6)

where,

$$ X_{it}(q_{it}, \gamma) = \begin{cases} X_{it1}(q_{it} \leq \gamma) \\ X_{it2}(q_{it} > \gamma) \end{cases} $$

Consequently, the OLS estimator conditional on the value of $\gamma$ is $\hat{\beta} = \{X^*(\gamma)X^*(\gamma)\}^{-1}\{X^*(\gamma)y^*\}$ where $X^*$ and $y^*$ are within-group deviations and the estimator of threshold parameters is the value that minimizes the residual sum of the square that is

$$ \hat{\gamma} = arg_{\gamma} \min S_1(\gamma) $$

According to Hansen (1999) $\hat{\gamma}$ is the consistent estimator of $\gamma$ and can be tested by using the likelihood ratio statistic, as follows:

$$ LR_1(\gamma) = \frac{LR_1(\gamma) - LR_1(\hat{\gamma})}{\hat{\sigma}^2} Pr \rightarrow \xi $$

$$ Pr(x < \xi) = \left(1 - e^{-\frac{x}{\xi}}\right)^2 $$

(7)
The maximum value of the likelihood ratio (LR) series will be the corresponding value of the lower limit which is less than the quantile \( \alpha \) for a given level of significance \( \alpha \). The below inverse function of equation 7 can be used to calculate the value of \( \alpha \) quantile.

\[
c(\alpha) = -2 \log (1 - \sqrt{1 - \alpha})
\]

If \( \alpha = 0.01, 0.05, \) and \( 0.10 \), the corresponding quantiles will be 6.53, 7.35, and 10.59 respectively. However, in the case of \( LR_1(y_0) > c(\alpha) \) we will reject the null hypothesis of the significance of the threshold level. The null hypothesis of the linear versus single threshold model is as follows:

\[
H_0 = \beta_1 = \beta_2
\]

And F-statistics to test this hypothesis can be constructed as

\[
F_1 = \frac{(S_0 - S_1)}{\tilde{\sigma}^2}
\]  (8)

However, the value of the threshold is unknown, therefore, the distribution is asymptotically nonstandard. Consequently, to check the significance values of the threshold we will use the bootstrap method.

Similarly, for the case of the multiple threshold model aforesaid procedure can be repeated and the below equation can be used to show three regimes (double threshold) in the model.

\[
y_{it} = \mu + X_{it}(q_{it} \leq \gamma_1)\beta_1 + X_{it}(\gamma_1 < q_{it} \leq \gamma_2)\beta_2 + X_{it}(q_{it} > \gamma_2)\beta_3 + \mu_i + \epsilon_{it}
\]  (9)

where

\[
X_{it}(q_{it}, \gamma) = \begin{cases}
X_{it}(q_{it} \leq \gamma_1) \\
X_{it}(\gamma_1 < q_{it} \leq \gamma_2) \\
X_{it}(q_{it} > \gamma_2)
\end{cases}
\]

Data sources and Description

Measurement of Export Sophistication

As the primary objective of this study is to analyze the impact of export sophistication on the trade portfolio of a country under the influence of participation in global value chains. Hausmann \textit{et al.} (2007) introduced an index developed by following the methodology of Rodrik (2006) and called it export sophistication to determine the income level associated with the export basket of a country. Page (2012) states that the sophistication of exports reflects not only the hardware but also the software upgradation of products.

Therefore, the current study follows the methodology of Rodrik (2006) and Hausmann \textit{et al.} (2007) to compute export sophistication. Equation 1 is to measure the sophistication of the export basket of a country is given below:

\[
EXPY_c = \sum_{j \in c} S_{ic} PRODY_i
\]  (1)

Where \( PRODY_i \) is the product level sophistication of product \( i \) belong to export basket \( c \) and \( S_{ic} \) is the share of product \( i \) in export basket \( c \) of a country. However, product level sophistication is computed by equation 2

\[
PRODY_i = \sum_{j \in c_i} \left\{ \frac{S_{ij}}{\sum_{n \in c_i} S_{in}} Y_j \right\}
\]  (2)

where \( Y \) is the GDP per capita of countries exporting product \( i \), \( S_{ij} \) is the importance of product \( i \) in the export basket of country \( j \) and \( \sum_{n \in c_i} S_{in} \) is the importance of product \( i \) in the export basket of countries in set \( c \). Finally, \( PRODY \) is the weighted average of GDP per capita where weights are equal to the importance of a product \( i \) in the export basket of country \( j \) relative to the importance of product \( i \) in the export basket of all those countries that are exporting product \( i \) in set \( c \).

The current research computed export sophistication for 105 countries from 2011 to 2018 to avoid the impact of the global financial crisis of 2007-08 because this crisis severely affected the global value chains of trade (Antras, 2019). The product wise data of exports to measure productivity at SITC 3 digit level is obtained from UNCTADstat (https://unctadstat.unctad.org/EN/)
Trade Portfolio/Trade Diversification

To measure the trade diversification and trade portfolio of a country the current research used the Herfindahl-Hirschman Index (HHI) of export market concentration measured by World Integrated Trade Solutions (WITS) at the country level. HHI measures the sum of the square of market shares of each country in the international market and it is calculated as

$$HHI = \sum_{i=1}^{n} S_i^2; i = 1,2, ..., n$$  \hspace{1cm} (3)

where $S_i^2$ is the share of each country in the international export market. HHI has a range between 0 and 1 and index with a small value shows trade diversification and vice versa. To measure trade diversification, this study used the data on export market concentration obtained from World Integrated Trade Solutions (WITS) from 2011-2018. The data of GVCs is collected from United Nations Conference on Trade Development-Eura global value chain database (https://unstats.un.org/wiki/display/comtrade).

Global Value Chain Participation

Global value chain participation is measured by the level of GVCs participation instead of the ratio of GVCs to gross exports by following the methodology of Soyres et al. (2020). Because we are interested in the threshold value of the level of participation in global value chains to find its impact on the relationship between export sophistication and trade diversification nexus. The baseline equation to calculate the level of global value chain participation is

$$GVC_{participation} = DVX + FVA$$  \hspace{1cm} (4)

where GVC is the global value chain, DVX and FVA are measures of “forward participation” and “backward participation” respectively. FVA is used to measure the foreign contents in domestic exports and DVX measures the export of intermediate goods by a domestic country that is used in the final production of exports of foreign countries.

The selection of countries is based on the availability of the data for the aforementioned years and the names of countries are provided in table A.2 in the appendix. The detailed definition of variables is presented in table A.1 in the appendix. The values of descriptive statistics of GVCs, EXPY, and CAP show a large variation in the data across the countries in terms of maximum and minimum values of the panel. All variables are in natural log form except FDI.

Table 1. Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>HHI</th>
<th>EXPY</th>
<th>TOT</th>
<th>PWLA</th>
<th>CAP</th>
<th>FDI</th>
<th>GVCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Obs</td>
<td>840</td>
<td>840</td>
<td>840</td>
<td>840</td>
<td>840</td>
<td>840</td>
<td>840</td>
</tr>
<tr>
<td>Mean</td>
<td>-2.41</td>
<td>10.05</td>
<td>4.74</td>
<td>-3.61</td>
<td>13.47</td>
<td>5.57</td>
<td>16.36</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.60</td>
<td>8.79</td>
<td>0.31</td>
<td>1.48</td>
<td>2.28</td>
<td>16.77</td>
<td>2.43</td>
</tr>
<tr>
<td>Min</td>
<td>-3.45</td>
<td>9.27</td>
<td>3.83</td>
<td>-8.50</td>
<td>1.15</td>
<td>-40.21</td>
<td>11.52</td>
</tr>
<tr>
<td>Max</td>
<td>41275.56</td>
<td>10.63</td>
<td>5.67</td>
<td>0.06</td>
<td>18.35</td>
<td>280.51</td>
<td>21.11</td>
</tr>
</tbody>
</table>

Table 2 shows values of pairwise correlation which shows a linear association between variables of the model. According to the first column of table 2, all variables have a negative linear association with trade diversification except TOT and PWLA which have a positive correlation with HHI. GVCs has the highest value of correlation with HHI followed by CAP and EXPY. The value of correlation between GVCs and CAP is 0.7 which may affect the efficiency of the estimates because of the multicollinearity. Therefore, we transformed CAP into growth rate form to make sure the efficiency of parameters for regression analysis.

Table 2. Pairwise correlation

<table>
<thead>
<tr>
<th></th>
<th>HHI</th>
<th>EXPY</th>
<th>TOT</th>
<th>PWLA</th>
<th>CAP</th>
<th>FDI</th>
<th>GVCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>HHI</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXPY</td>
<td>-0.315</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOT</td>
<td>0.227</td>
<td>-0.220</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWLA</td>
<td>0.219</td>
<td>-0.058</td>
<td>0.240</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results and Discussion

The objective of the current research is to empirically analyze the impact of export sophistication and global value chains on the trade portfolio of a country. In addition, the main objective of this study is to determine the nonlinear relationship between export sophistication depending on the threshold level of participation in global value chains. Therefore, the study follows the methodology proposed by Hansen (1999) to find the threshold level of GVCs participation to determine the nonlinear relationship between export sophistication and trade portfolio. As shown in Table 3, we found 2 thresholds of GVCs with values of 12.9572 and 13.6874 respectively. These values are the natural log of GVCs. Therefore, in our model impact of export sophistication on trade diversification can be divided into 3 regimes depending on the values of the threshold variable.

Based on the number of thresholds we can define three different regimes of GVCs under the category of “lower regime” \( q \leq 12.9572 \) “moderate regime” \( 12.9572 < q \leq 13.6874 \), and “upper regime” \( 13.6874 < q \). The number of values of GVCs fall below the value of the first threshold is 74. Similarly, 56 values fall under the moderate regime, and the rest of the values fall under the upper regime. The LR statistics to check the significance of thresholds is presented in figure 2. The first threshold is significant at a 1% level of significance which rejects the null hypothesis of a linear effect of export sophistication on trade diversification and accepts the alternative hypothesis of the nonlinear effect of export sophistication on trade diversification under the influence of a single threshold value of GVCs. Similarly, the second threshold is significant at a 10% level of significance and rejects the null hypothesis of a single threshold value of GVCs and accepts the alternative hypothesis of a double threshold of GVCs. However, we did not find the third threshold and rejects the hypothesis of at most 2 thresholds according to the probability value given in table 3. It implies that the effect of export sophistication on trade diversification is different in 3 different regimes determined by the threshold values of GVCs.

### Table 3. Threshold values of GVCs

<table>
<thead>
<tr>
<th>Test Type</th>
<th>F Value</th>
<th>P Value</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
<th>Threshold Value</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single threshold effect test (H₀: no threshold)</td>
<td>83.66</td>
<td>0.00***</td>
<td>71.68</td>
<td>40.67</td>
<td>30.82</td>
<td>12.9572</td>
<td>12.8169, 12.9993</td>
</tr>
<tr>
<td>Double threshold effect test (H₀: at most one threshold)</td>
<td>30.89</td>
<td>0.07*</td>
<td>133.73</td>
<td>49.74</td>
<td>27.36</td>
<td>13.68</td>
<td>13.6635, 13.6989</td>
</tr>
<tr>
<td>Double threshold effect test (H₀: at most two thresholds)</td>
<td>24.58</td>
<td>0.18</td>
<td>120.36</td>
<td>57.84</td>
<td>36.98</td>
<td>11.69</td>
<td>11.6771, 11.7549</td>
</tr>
</tbody>
</table>

Note: This table reports the threshold estimates \( \hat{\gamma} \). F-statistics and p values are from operating bootstrap procedures 300 times for each of the three bootstrap tests. *** , ** , and * shows 1%, 5%, and 10% level of significance respectively.
Table 4 shows the results of estimates of our primary variable of interest export sophistication estimated by the fixed effects panel threshold model. According to the results of table 4, the impact of export sophistication on trade diversification is negative which implies that export sophistication has a positive association with trade diversification because lower the value of the HHI index represents a more diversified trade portfolio of a country. However, the magnitude of this effect is different in different regimes. In the lower regime, an increase in export sophistication leads to an increase in trade diversification by 0.45%. However, in the moderate regime and upper regime 1% increase in export sophistication increases trade diversification by 0.47% and 0.54% respectively. These coefficients reflect that the nature of the relationship between export sophistication and trade diversification is nonlinear and depends on the value of GVCs. Table 5 shows that GVCs is a significant source of trade diversification. A 1% increase in GVCs increases trade diversification by 0.19%.

Export sophistication reflects the productive capabilities of a country and the quality of human capital and physical capital used to manufacture the exports. In addition, sophisticated products do not only reflect hardware but also functional upgrading of products offer for sale in international markets (Andreoni, 2011). Therefore, international customers belonging to diversified international markets prefer to buy sophisticated products rather than traditional products (Westbrook and Angus, 2021). Developed economies have more productive inputs and better quality of human capital, therefore; they produce more sophisticated products than developing economies. Consequently, they have a diversified trade portfolio compared to developing economies (Husmann et al. 2007; Onder and Yilmazkuday,2014). The average value of HHI is 0.087 for developed economies and 0.13 for developing economies in the panel used by this study which shows that developed economies have a relatively more diversified trade portfolio than developing economies of this panel.

However, the level of GVCs mediates this relationship and influences the impact of export sophistication on the trade portfolio. Countries with a higher level of participation in GVCs absorb gains from export sophistication more intensively than countries with a low level of participation in GVCs. As GVCs
promote the culture of specialization and innovation because it is the main source of import of intermediate inputs used to produce final goods (Biisztray and Poitiers, 2022). In addition, it serves as a primary driver of international trade linkages that help countries to enter the international market (OECD, 2013). Because multinational enterprises (MNEs) are the primary players of GVCs and most of the time different MNEs operating in different countries belong to the same business groups and buy goods from each other. Therefore, global value chains provide easy access to international markets and create customers for domestic products in various countries (Bekes et al. 2019). Consequently, countries enjoy more penetration of their products in various international markets which enhances the impact of export sophistication on the trade portfolio of countries.

Table 5 contains the estimates of control variables. Terms of trade (TOT) are responsible for the decrease in trade diversification because countries avoid buying products from countries with expensive products. Per worker land area (PWLA) is the proxy of natural resources which in insignificant determinants of trade portfolio A country with growing physical capital produces a variety of products and foreign firms prefer to invest in such countries (Elhiraika and Mbate, 2014). Consequently, international trade linkages developed among domestic and foreign economies. The coefficient of FDI is significant and positive which implies that foreign direct investment adversely affects trade diversification in this panel. The possible reason for this adverse effect is that FDI in nontrade sectors reduces the variety of products and domestic countries prefer to engage in trading activities with the set of countries that invest in the domestic economy (Iwamoto and Nabeshima, 2012; Ofa et al. 2012).

**Conclusion and Policy Recommendations**

The purpose of the current study is dual: First to investigate the impact of export sophistication and participation in global value chains (GVCs) on trade diversification, and: Second, (perhaps the primary purpose) of this study is to find the nonlinear impact of export sophistication on trade diversification under the influence of GVCs. For this, we constructed a panel of 105 countries from 2011 to 2018. For empirical analysis, we applied Hansen (1999) test for the static panel threshold model which divided the impact of export sophistication on trade diversification under different regimes. According to regression estimates of this panel, both export sophistication and participation in GVCs are positively associated with trade diversification. In addition, the impact of export sophistication can be divided into three different regimes namely “lower regime”, “moderate regime”, and “upper regime” based on 2 threshold values of GVCs. The first and second threshold is 12.9572 and 13.6874 respectively. 1% increase in export sophistication is associated with an increase in trade diversification by 0.45%, 0.47%, and 0.54% in “low regime”, “moderate regime” and “upper regime” respectively which confirms the nonlinear impact of export sophistication on trade portfolio.
Sophisticated products can attract customers belonging to various international markets because of high-tech content, value-addition, and value for money. In addition, sophisticated products reflect the quality of human capital, physical capital, and productive capacity of a country (Hausman et al. 2007; Can and Dughan, 2017). The results of this study encourage countries to produce more sophisticated products to penetrate their products in diversified international markets. Similarly, global value chains promote the culture of innovation and knowledge creation and provide easy access to intermediate products and advanced technology. In addition, it develops international trade linkages of a domestic country with the international business community and explains the relationship between export sophistication and trade diversification (Bisztray and Poitiers, 2022; Bekes et al. 2019). Based on the empirical results, this research suggests countries to increase their participation in global value chains. For this government should impose liberalized policies to increase international trade linkages with the foreign business community. Firms should focus on functional and smart specialization in global value chains. For this government should facilitate them to identify how they can participate in global value chains more effectively and productively.

For future research, this study urges researchers to extend this analysis by applying a dynamic threshold model and finding the threshold values of GVCs to find the nonlinear relationship of trade diversification with export sophistication and control variables of the model.

References
Dosi, G., Freeman, C., Nelson, R., Silverberg, G., & Soete, L. (1988). Technical change and economic theory. Laboratory of Economics and Management (LEM), Sant’Anna School of Advanced …


Appendix:

Table A1. Data description and sources

<table>
<thead>
<tr>
<th>Series</th>
<th>Definition of Variable</th>
<th>Source</th>
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<tr>
<td>HHI</td>
<td>Natural log of Hirschman-Herfindahl index of market concentration</td>
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<tr>
<td>EXPY</td>
<td>Natural log of export sophistication</td>
<td>Authors’ calculation</td>
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<tr>
<td>TOT</td>
<td>Natural log of terms of trade</td>
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<tr>
<td>CAP</td>
<td>Natural log of per worker capital stock at constant 2017 national prices (2017US$)</td>
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<td>FDI</td>
<td>Foreign direct investment, net inflows (% of GDP)</td>
<td>WDI</td>
</tr>
<tr>
<td>PWLA</td>
<td>Natural log of per worker land area</td>
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<tr>
<td>GVCs</td>
<td>Participation in global value chains</td>
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Table A2. List of countries in Panel

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