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Integrating Trade and Disintegrating Production in Manufacturing Industries: Evidence from APEC and EU Nations

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Abstract

Nowadays, the bulk of world trade in commodities consists of intermediate goods that play a crucial role in developing production and value. As a result, the global process of production is becoming much more interconnected than ever before. Production fragmentation due to vertical disintegration has profoundly impacted growth in world trade and production by vertical specialization. This study is purported to analyze the vertical integration and international outsourcing of manufacturing firms at the cross-country level. We have calculated domestic and foreign value-added contents in export and output to measure the degree of integration and outsourcing of the manufacturing firms using the World Input-Output Database. Our analysis shows growing backward linkages and global outsourcing in developed countries in APEC and EU regions. Region-wise, we see that high-tech processed intermediate manufacturing like chemicals, pharma, computer, electronics, optical machinery equipment, and motor vehicles have expanded in the developed countries of APEC and EU. Developing APEC has revealed higher linkages in the value chain of low-tech primary products used as intermediaries and processed intermediate goods like food; coke and refined petroleum, basic metal, etc. Among emerging Asia, China has increased its linkages in GVCs in high-tech industries like computers, electronics, optical, electrical equipment, etc.

JEL Classification: C67, F14.

Keywords: vertical specialization, outsourcing, value-added trade, manufacturing, APEC, EU.

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I am deeply grieved by the sudden demise of my co-author, Prof. Alokesh Barua, due to COVID 19. I dedicate this paper as a tribute to Prof. Alokesh Barua. We sincerely thank Prof. Abhijit Das, Head, Centre for WTO Studies and Prof. Manoj Pant, Director, Indian Institute of Foreign Trade for their insightful comments, which have immensely helped us in framing the study.

1. Introduction

Economies' competitiveness is often measured in terms of its external market performance and the capacity of exporting its domestic firms abroad. One of the commonly used indicators is the country's share of world manufacturing exports. With the gradual increase in the fragmentation of the production process, measuring countries' competitiveness in terms of usual gross trade statistics portray a misleading picture due to the double-counting issue of intermediate goods and services (Bems, Johnson and Yi 2011; Cezar, Duguet, Gaulier, et al. 2017).

The emergence of the global value chains (GVC) entails exporting firms to use imported inputs in their production process (Amador, Cappariello and Stehrer 2015). These intermediate inputs account for nearly two-thirds of international trade in commodities. The major contributing factor for this trade is the increasing division of labor, causing vertical specialization in production across countries, which has led to rising trade in intermediates. Consequently, the production process is fragmented into various specialized tasks based on the comparative advantage of the nations.

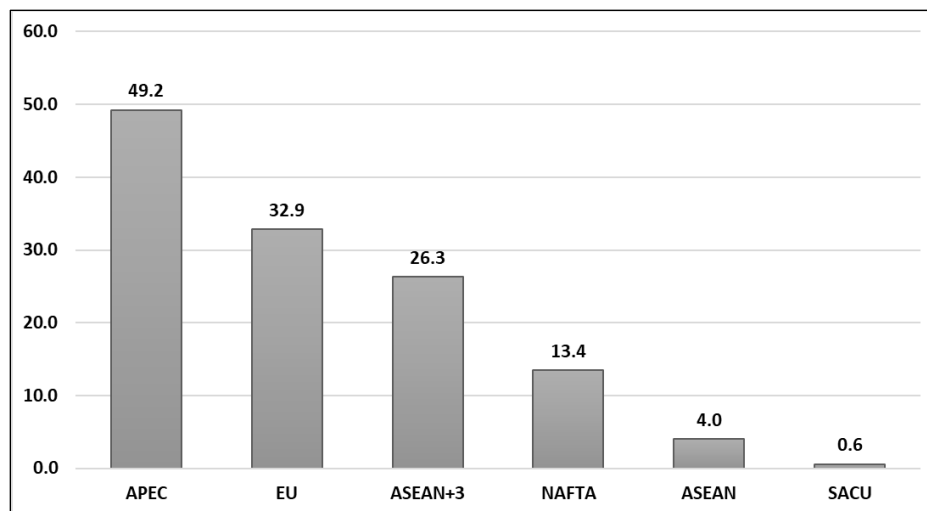
Theoretical models have been developed to tame the backward and forward linkages in an open economy, and the benefits from these linkages created by firms (Krugman and Venables, 1995; Venables, 1996; Yi, 2003, etc.). Models have been developed to capture the unbundling and offshoring of firms to focus on the breakup decisions of the production process across borders (Grossman and Rossi-Hansberg, 2008; Costinot et al., 2013). Notably, Baldwin and Nicoud (2014) have introduced an analytical framework to integrate task-trade into the trade-in-goods. They have used the framework on the four traditional theorems (Heckscher–Ohlin–Vanek, factor price equalization, Stolper–Samuelson, and Rybczynski) to show that the task-trade becomes the source of comparative advantage in final goods. Baldwin and Venables (2015) have argued that the value-added trade pattern fits the Heckscher–Ohlin–Vanek predictions and has formulated a model to show the influence of product-specific value chains on industry-competitiveness through the backward and forward linkages.

Based on these theoretical underpinnings, in empirical research, economists have developed techniques to measure the vertical specialization in trade and analyze its emergence from different nations' viewpoints. In an earlier study, Campa and Goldberg (1997) studied the external orientation of manufacturing industries of four countries, viz. the United States, Canada, the United Kingdom, and Japan. Studies of Hummels, Rapoport, and Yi (1998), Hummels, Ishii, and Yi (2001), Hanson, Mataloni and Slaughter (2005), Daudin, Riffart, and Schweisguth (2011), Johnson and Noguera (2012) and Koopman, Powers, Wang et al. (2010), Baldwin and Lopez-Gonzales (2015), etc., have captured the upstream and downstream effects by constructing and using the inter-country or world input-output tables. Our present paper contributes to the

existing literature in a similar vein where we have performed a cross-country analysis of international outsourcing and vertical integration in the manufacturing trade of selected developed and developing countries in the Asia-Pacific (APEC) and European Union (EU) regions.

APEC countries' export share in world export is highest, followed by the EU in 2018 (Figure 1). We have chosen nine countries from the APEC region, which are holding a relatively higher share in regional trade for our analysis. The countries are Australia, the US, Canada, Japan, South Korea, Russia, China, Indonesia, and Mexico.

Figure1. Share to World Export of Major Economic Regions in 2018 (in percentage)



Source: Authors' calculation from the WITS database.

Among the EU nations, we have chosen France, Germany, and Italy. We also have included the United Kingdom and India as non-APEC and Non-EU nations. Among these countries, China, India, the US, South Korea, Japan, Mexico, and Germany hold the top7 positions globally in terms of competitiveness as per the 2010 *Global Manufacturing Competitiveness Index* (IBEF, 2015). We aim to study the heterogeneity and vertical integration in the production and trade of these selected groups of economies by providing a comparative analysis.

Since the mid-nineties, economists have developed techniques to measure the vertical specialization in trade and analyze its emergence from the viewpoint of different countries. For example, Feenstra and Hanson (1999) have calculated the increase in international outsourcing between 1972 and 1990 for the United States by estimating the share of imported inputs on total purchases of intermediate products. Hummels, Ishii and Yi (2001) have developed a methodology to calculate import content in exports and used that indicator to evaluate the degree of vertical

specialization for OECD countries. In this paper, we have used the methodology proposed by Hummels, Ishii, and Yi (2001) to evaluate the extent of vertical integration by measuring the foreign value-added content (FVA) of exports. It also indicates the backward value chain participation of a country. Further, forward participation in the value chain relates to the use of domestic value-added content (DVA) in the third economies for further processing or export.

Thus, to understand the internationalization, and the forward and backward participation of manufacturing industries in GVCs, in this study, we have taken the input-output (IO) accounting framework to compute the domestic and foreign content share in countries' export and output in manufacturing. The database is the WorldInput-Output Database (WIOD) for the period 2000 to 2014.

Our analysis indicates growing backward linkages and international outsourcing of manufacturing in developed countries in APEC and EU regions. Region-wise, we see that high-tech processed intermediate manufacturing like chemicals; pharmaceuticals; computer, electronics, and optical; machinery equipment, and motor vehicles have expanded in the developed countries of APEC and EU. Developing APEC has affirmed higher linkages in the value chain of low-tech primary products used as intermediaries and processed intermediate goods like food; coke and refined petroleum; basic metal; rubber and plastic, etc. Among emerging Asia, China has increased its linkages in GVCs in the high-tech industries like computer, electronics, and optical; electrical equipment, etc.

In the next section, we have reviewed the existing literature and highlighted the lacuna, which entails us to undertake this study. In section 3, we have briefly mentioned the computational methodology and analyze the results. Section 4 concludes the study, along with some policy directions at the regional integration level.

2. Literature Review

Many previous studies have undertaken empirical research to study vertical integration and international outsourcing of manufacturing and services at the cross-country level. Hanson, Mataloni, and Slaughter (2005) have measured the vertical production networks of US multinational parent companies by using firm-level data. They have used a standard cost-minimization framework to derive the imported inputs' demand and then studied the demand-sensitivity to trade costs, taxes, factor prices, etc. They found the responsiveness of vertical production networks to trade costs conferred the theory suggested by Hummels, Rapoport, and Yi (1998), Hummels, Ishii, and Yi (2001), and Yi (2003). Miroudot and Ragoussis (2009) also have examined the aggregate trade flows of intermediate merchandise and services from 1995 to 2000 for a board of 34 nations. Developed countries are primarily involved in the trade of

intermediate inputs, which accounts for 56 percent of goods, and 73 percent of services. They also find that imports of intermediates are more delicate to exchange or trade costs.

Breda & Cappariello (2010) have assessed the degree of internationalization of production of Italy and Germany for the period 1995-2006. Their investigation depends on various indicators of international outsourcing. Direct and indirect import content of production is one such indicator, which also accounts for the import content of domestic inputs. Using the IO tables of imported products, they have estimated that the total import content (direct and indirect) in the production of Italy is 32.4 percent for Italy and 30.0 percent for Germany in 2006. Their analysis reveals a differential sectoral composition of exports in Germany is the primary reason behind their relatively higher import content.

Daudin, Riffart, and Schweisguth (2011) have computed few indicators, viz. the share of imported inputs in exports, the percentage of exports used as inputs in further exports, and the domestic content of imports to study the trade flows of value-added trade. They have used the trade and input-output data from the GTAP database for the years 1997, 2001, and 2004 for 115 countries divided into 66 regions and 55 sectors. Their study indicated possible regionalization based on vertical export rather than value-added exports. It also has shown a growing share of vertical trade to total trade for Asian countries between 1997 and 2004. Johnson and Noguera (2012) also have used the GTAP 7.1 database that includes IO tables and bilateral trade data covering 57 sectors of 94 countries with 19 composite regions for the year 2004. Based on their computation of value-added to gross exports (VAX ratio) ratio, significant differences were evidenced between value-added and gross trade flows at cross-country and cross-commodity level. These reflect the heterogeneity in a production sharing relationship. They find that more affluent countries, who export manufacturing, have low aggregate VAX ratios. But they export at higher VAX ratios within the manufacturing.

In another study, Jiang and Milberg (2012) have constructed import content of export expansion ratio (ICEER). They have used it to set apart the changes in import content from the growth in exports. The estimates also account for the structural change in the import content of exports at the sectoral level for each country. They have taken the OECD input-output dataset of five states, China, India, Brazil, South Africa, and the US, for 1995, 2000, and 2005. Their calculations are relatively close to the estimations done by Koopman, Powers, Wang, et al. (2010), even though they use different algorithms. The study reveals U-shaped pattern of vertical specialization in the case of all these economies.

Hong Ma, Z. Wang, and Kunfu Z (2015) have proposed an extension of Koopman, Wang, and Wei (2014), which segregates the regular and processing exports by foreign-invested enterprises (FIEs), and Chinese-owned enterprises (COEs). They have used the IO table of the National Bureau of Statistics of China (NBSC) of 2007. The firm-level export-import data of 135 sectors are collected from China's General Administration of Customs (CGAC) for the same year. Their estimations show lower domestic content shares in processing and total exports by FIEs, and 59 percent domestic content share in gross Chinese export. FIEs in China made about 45 percent of the homegrown substance or domestic content in Chinese exports. Heterogeneity is evident at the firm level in its domestic content shares.

Société Générale (2015) has prepared an EcoNote on Germany and has done a comparative analysis for France and the UK. The study has argued that the imported value contents of German export are notably similar to that of France and the UK. The calculations carried out using the OECD database show that the imported value-added content of German exports has gone up significantly between the mid-1990s to mid-2000s. There is a growing proportion of inputs manufactured abroad, which are included in German exports. They have recorded a 20 – 27 percent increase in share within a decade. The import content of export of manufacturing industry is 23 percent in 1990 and 31 percent in 2000. This study also noticed that the proportion of foreign value-added included in exports has slightly decreased in the UK.

In a more recent study, Cezar, Duguet, Gaulier & Vicard (2017) have determined the import content of exports for eight nations: China, Japan, Spain, Germany, France, the UK, Italy, and the US. They have used the WIOD database to compute the value indicators for the period 1995-2011. Their nation-level figuring uncovers that the import content of France's exports rose by 9 points in 1995 to 29 percent in 2011. Germany has a comparative advancement (+10.5 points), just as Spain (+10) and Italy (+9). Significant economies as the US, Japan, and China add proportionately more domestic value added to their exports.

Organization for Economic Co-operation and Development (OECD) consistently brings out country-notes using the Trade-in-Value-Added (TiVA) database, which covers the analysis of domestic and foreign value-added contents in exports (goods and services) at different years. Table 1 summarizes the estimates drawn from various country-notes of our chosen country for the years 2008, 2009, and 2011.

Table 1. OECD estimates of DVA and FVA indicators of select countries (in percentage)

Region	Countries	Year	DVA*	FVA**
APEC Countries	Australia (AUS)	2011	85.9	14.1
		2009	86.9	13.1
	Canada (CAN)	2011	76.6	23.4
		2009	77.7	22.3
		2008	64.0	22.7
	United States (US)	2011	85.0	15.0
		2009	88.5	11.5
	Japan (JAP)	2011	85.3	14.7
		2009	88.8	11.2
		2008	84.3	15.7
	Russia (RUS)	2011	86.3	13.7
		2009	87.3	12.7
	South Korea (KOR)	2011	58.4	41.6
		2009	62.5	37.5
	China (CHN)	2011	52.8	47.2
		2009	50.9	49.1
	Indonesia (INDO)	2011	88.0	12.0
		2009	88.9	11.1
	Mexico (MEX)	2011	68.3	31.7
		2009	66.5	33.5
Non-APEC Country	India (IND)	2012	74.9	25.1
		2005	81.2	18.8
EU Countries	Italy (ITA)	2011	73.6	26.4
		2009	78.9	21.1
		2008	74.3	25.7
	Germany (GER)	2011	74.5	25.5
		2009	78.2	21.8
	France (FRA)	2011	74.9	25.1
		2009	78.5	21.5
Non-EU Country	United Kingdom (UK)	2011	77.1	22.9
		2009	81.2	18.8

* Domestic value-added embodied in exports of intermediate goods and services.

** Foreign value-added content of gross exports

Source: Country-notes – OECD.org

TiVA estimations reveal that, among APEC nations, Mexico and China's FVA contents in their exports of intermediate goods and services have reduced during 2009-2011. Processing trade is most prevalent in these two countries. For South Korea and the US, we find an increase in FVA contents in their gross exports, whereas, for the rest

of nations, either it has marginally increased or stagnant during 2009-2011. India's country note is available from 2005 to 2012. We find a substantial increase in their FVA contents in exports of intermediate goods and services in 2012 over 2005. In the UK, we see an increase in FVA content in export, whereas the three EU nations follow more or less the same ratios in their FVA and DVA contents during 2009 -2011.

Our study can be considered an improvement over the existing studies by providing a cross-country analysis at aggregated and disaggregated manufacturing level using a more updated WIOD database. The analysis will help to discern the relative positions of the selected countries in terms of their forward and backward linkages in the global production process of the manufacturing sector. Our study also helps understand the architecture of the regional value chain of the industry, which has significant implications in policy framing.

3. Methodology and Analysis

3.1 Data and Methodology

WIOD (release 2016) has covered the data for the period 2000–2014. The industrial classification adheres to ISIC rev. 4, and the IO tables comply with the 2008 version of System of National Accounts (SNA). WIOD provides an intermediate input-use table of 54 manufacturing and service sectors. To calculate the DVA and FVA, we have considered all 54 sectors' intermediate inputs. The industry-level analysis focuses on 18 manufacturing sectors (See Appendix I for the Industry codes and description).

Following Hummels, Ishii, and Yi (2001), we have calculated the domestic and foreign content in each unit of the final demand of domestic manufacturing products. The underlying three equations are specified using the value-based input-output table of the WIOD database:

$$Y^G = Z^D \cdot Y^G + Y^D \quad \text{with} \quad Y^D = C^D + X^D \quad (1)$$

$$IM = Z^M \cdot Y + Y^M \quad \text{where} \quad Y^M = C^M + X^{RX} \quad (2)$$

$$uZ^D + uZ^M + Z^V = u \quad (3)$$

Where, Y^G is a 54×1 vector of gross output, and Y^M is the 54×1 vector of final demands for imported products. Z^D and Z^M are 54×54 vectors of domestic inputs and imported inputs coefficient matrices, respectively. Y^D is the 54×1 vector of final demands for domestically produced products. C^D and C^M are private and public consumptions (domestic and imported). X^D and X^{RX} are gross export and re-exports, respectively. IM is a 54×1 vector of imports. Z^V is 1×54 vector of the ratios of value-added to gross output for each industry, and u is 1×54 vector of 1's.

From equation (3), we compute the additional domestic value-added (VA_D), and foreign value-added (VA_F) in each unit of final demand of domestic products as:

$$VA_D = Z^V(I - Z^D)^{-1} \quad (4)$$

$$VA_F = uZ^M(I - Z^D)^{-1} = u - Z^V(I - Z^D)^{-1} \quad (5)$$

Where, $(I - Z^D)^{-1}$ is the 54×54 inverse Leontief matrix that captures the intermediate domestic inputs embodied in domestic outputs.

3.2 Results and Discussion

3.2.1 DVA and FVA contents in Manufacturing Export

Country-level estimation reveals that for APEC developed nations, the FVA contents in gross manufacturing exports (GMX) have increased substantially for Japan and South Korea by 17.7 and 6.4 percentage points respectively in 2014 over 2000 (Table 2). It reveals that both these Asian giants have substantially increased their backward linkages in manufacturing-GVC during the period. Accordingly, the DVA contents of these countries have fallen, which indicates lower forward participation in production and consumption networks. Our estimates are relatively closer to the estimates done by OECD using TiVA databases for these two countries (see Table 1). The foreign value-added contents in aggregate manufacturing exports have increased marginally in the United States, Australia, and Russia. Accordingly, domestic contents have been reduced in these countries. Hence, indicating their relatively higher backward participation and lower forward participation in manufacturing GVCs. In the case of Canada, the FVA content has marginally increased by 0.6 percentage point in 2014 over 2000.

Table 2. DVA and FVA Contents in Manufacturing Exports at country level during 2000-2014 (in percentage)

Region	Country	DVA				FVA			
		2000	2005	2010	2014	2000	2005	2010	2014
APEC Countries	AUS	75.6	77.0	75.4	72.3	24.4	23.0	24.6	27.7
	CAN	62.1	62.3	64.4	63.2	37.5	38.1	35.4	36.9
	US	85.2	83.3	82.7	80.4	14.8	16.7	17.3	19.6
	RUS	80.7	80.0	82.7	79.5	19.3	20.0	17.3	20.5
	JAP	88.7	84.0	79.2	71.0	11.3	16.0	20.8	29.0
	KOR	63.3	63.5	56.8	56.9	36.7	36.5	43.2	43.1
	CHN	79.7	71.6	75.3	79.6	20.3	28.4	24.7	20.4
	INDO	76.6	76.8	79.4	77.3	23.4	23.2	20.6	22.7
	MEX	55.7	55.3	54.0	56.6	44.3	44.7	46.0	43.4
Non-APEC Country	IND	85.5	79.0	72.3	72.6	14.5	21.0	27.7	27.4
EU Countries	FRA	65.8	64.1	60.7	59.4	34.2	35.9	39.3	40.6
	GER	71.2	69.7	65.5	64.6	28.8	30.3	34.5	35.4
	ITA	71.4	69.9	66.7	66.6	28.6	30.1	33.3	33.4
Non-EU Country	UK	70.0	68.7	62.8	65.0	30.0	31.3	37.2	35.0

Source: Authors' calculation from WIOD, 2016 release.

Coming to the developing and emerging economies of the APEC region, again, we find Asian countries follow a similar pattern in terms of their linkages in manufacturing-GVCs. Both China and Indonesia's domestic and foreign value contents in their manufacturing exports lie within a range between 76.6 – 79.7 percent and 20.3 – 23 percent respectively during 2000-2014. These shares also are more or less constant, which reveal stagnant forward and backward participation in manufacturing-GVCs during the period. For Mexico, these shares are relatively high as compare to other APEC economies of our consideration. Non-APEC Asian emerging economy, India, shows a decrease in domestic content in export and an increase in foreign content, revealing higher backward participation over forward during the period.

Finally, for the EU member countries and non-EU countries, we find that Italy and Germany, and the UK's DVA and FVA contents in their manufacturing export exhibits similar percentages. Overall, we see that the foreign contents in manufacturing exports have increased with a fall in domestic content in all countries that reveal higher global integrated production and consumption network.

3.2.2 DVA and FVA contents in Manufacturing Output

Domestic and foreign value-added content of gross manufacturing output (GMY) measures are tendered to the degree of vertical integration; hence they are another practicable indicator to assess international outsourcing. Eggar & Eggar (2003) have used these measures the first time. Using these indicators, they reckoned the average annual change of global outsourcing of eleven European countries in the nineties. Breda and Cappariello (2010) have used similar indicators to gauge the international outsourcing of manufacturing and services of two 'bazaar economies', viz. Italy and Germany for the years 1995, 2000, and 2006. In a similar vein, we have calculated these indicators to study the degree of international outsourcing of the manufacturing sector of the selected countries. Table 3 reports the DVA and FVA contents in each unit of aggregate manufacturing outputs for the years 2000, 2005, 2010, and 2014, using the method explained in section 3.1.

Table 3. DVA and FVA Contents in Manufacturing Outputs at country level during 2000-2014 (in percentage)

Region	Country	DVA				FVA			
		2000	2005	2010	2014	2000	2005	2010	2014
APEC Countries	AUS	76.3	77.2	77.3	74.4	23.7	22.8	22.7	25.6
	CAN	65.5	65.6	67.1	65.3	34.5	34.4	32.9	34.7
	US	85.5	82.6	82.3	80.7	14.5	17.4	17.7	19.3
	RUS	80.0	78.8	80.4	77.4	20.0	21.2	19.6	22.6
	JAP	88.6	83.2	78.4	71.0	11.4	16.8	21.6	29.0
	KOR	64.2	63.9	57.2	57.7	35.8	36.1	42.8	42.3
	CHN	82.9	75.5	78.1	81.7	17.1	24.5	21.9	18.3
	INDO	78.2	77.1	82.4	80.0	21.8	22.9	17.6	20.0
Non-APEC Country	MEX	68.6	69.3	67.5	67.2	31.4	30.7	32.5	32.8
	IND	80.8	76.2	73.6	72.2	19.2	23.8	26.4	25.8
EU Countries	FRA	68.1	66.2	62.9	61.3	31.9	33.8	37.1	38.7
	GER	72.0	69.7	65.1	64.1	28.0	30.3	34.9	35.9
	ITA	70.8	69.5	66.7	66.0	29.2	30.5	33.3	34.0
Non-EU Country	UK	72.3	70.2	64.9	67.8	27.7	29.8	35.1	32.2

Source: Authors' calculation from WIOD, 2016 release.

Among APEC nations, the estimates reveal that international outsourcing has substantially higher in Canada, South Korea, and Mexico. Their FVA contents in each unit of GMY are more than 30 percent during the period. For Canada, the share is found stagnant during 2000-2014, whereas for South Korea, it has increased substantially by 6.5 percentage points in 2014 over 2000. In the US and Japan, we also see an increase in international outsourcing by 4.8 and 17.6 percentage points. China's FVA content in its GMY has increased marginally. Indonesia is the only exception in the region, shows a fall in FVA content in GMY during the period.

Non-APEC Country, India, too, has shown an increase in their international outsourcing during the period. For the EU nations, France, Germany, and Italy, the FVA contents are relatively higher (34 percent and above), reveal more increased international outsourcing. Similar is the scenario of the UK.

Based on these unit values, we have calculated the shares of DVA and FVA contents in GMX and GMY for all 18 industries at the country level. These indicators will help us to perform an inter-industry comparison in each country. However, they do not allow us to perform any cross-country comparison due to varying denominators. Nevertheless, the analysis helps us to understand the industry linkages in GVCs and their degree of international outsourcing at the country level. In the following subsection, we have analyzed the same.

Figures 2 - 4 are the graphical representations of the shares of DVA and FVA contents in GMX of the chosen countries at the industry level for the years 2000 and

2014. Figure 2 shows the DVA and FVA shares of GMX in developed APEC countries, whereas Figure 3 represents the same for developing and emerging APEC nations. Figure 4 illustrates the indicators for EU nations and the UK. The numerics of these indicators are given in Annexure, Tables A2.i and A2.ii.

Further, the shares of DVA and FVA contents in GMY estimations at the country – industry level are provided in Annexure, Tables A3.i and A3.ii for the years 2000 and 2014. These indicators are used to analyze the degree of international outsourcing at the industry level in each country.

3.2.3 Industry-level analysis:

In the APEC region, Canada, the US, and Mexico are traditional trading partners, whose majority of manufacturing trade occurs under the North American Free Trade Agreement (NAFTA). Mexico is specialized in processing trade among the three. This analysis indicates that Canada's prominent manufacturing sectors are motor vehicles, basic metals, computers, electronics and optical, and machinery. The basic metals, motor vehicles, and chemicals have shown better forward linkages with high DVA contents in GMX over time in the country. Except for the machinery sector, others have improved their backward links, too. In these industries, we find an increase in DVA and FVA contents in the GMY, indicating their higher international integration and outsourcing of the production process in GVCs. In the motor vehicle sector, domestic inputs usage has reduced along with a rise in foreign input usage. The forward linkage of the industry has diminished with no improvement in the backward link.

In the US, chemicals, motor vehicles, machinery, and transport equipment sectors are prominent in their linkage effects. The motor vehicle sector indicates a fall in forward participation with a fall in domestic inputs usage in the production process. On the contrary, the uses of foreign inputs in the production process and the backward linkages have increased in this sector. But in Mexico, in motor vehicle industries, we find a marginal fall in the links with a moderate expansion in its production process abroad during the period.

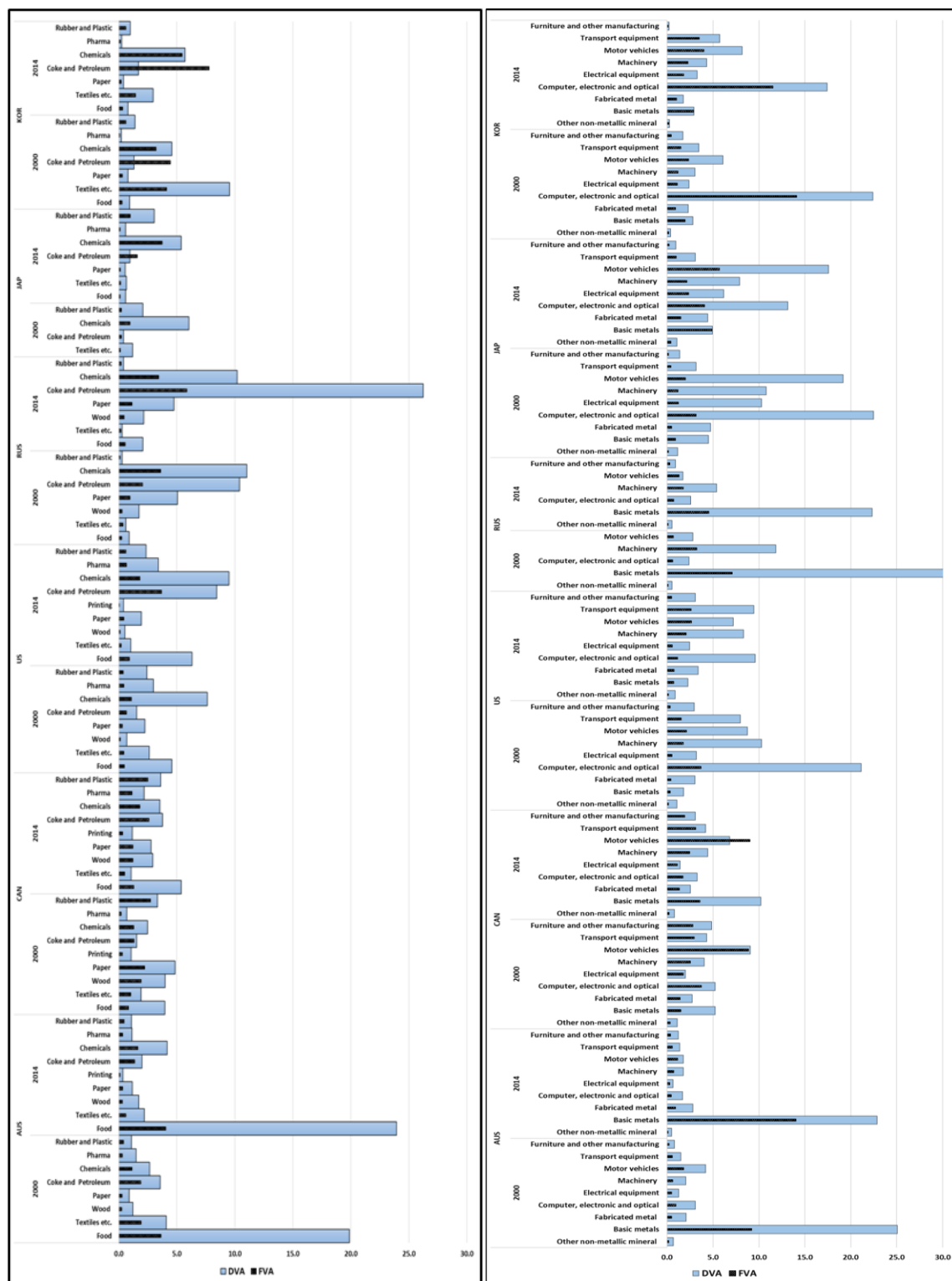
In Mexico, the computer and electronics sector is one of the prominent manufacturing sectors in terms of its shares of DVA and FVA contents in GMX and GMY. This sector has shown a falling trend in DVA and FVA shares in gross export and output, revealing Mexico's weakening position in the sectoral GVC. In the US, this sector has evidenced a substantial increase in DVA contents in GMX (2.1 percent in 2000 to 9.6 percent in 2014). But the shares of FVA contents in gross export and output have reduced in this sector, indicating its lower backward linkage and low substitution in the production process abroad.

Chemicals and transport equipment sectors in the US have exhibited an increase in the forward and backward participation in GVCs. Their DVA and FVA contents in GMY

have also increased, revealing the sectoral expansion in their domestic and foreign production processes during 2000-2014. Machinery industries in the US indicate a fall in forward participation and substitution of the production process abroad. In Mexico, this industry shows an expansion in its forward and backward participation in GVCs and its growth in domestic and foreign production processes. The other two prominent sectors in Mexico are electrical equipment and textile. The shares of DVA and FVA contents in GMX and GMY have fallen over time for these two industries. This again indicates the country's weakening performance in the sectoral GVCs.

In Australia, basic metal and food are the two leading sectors in terms of their linkages and production base. In the food sector, both forward and backward participation in GVCs has improved over time. The increase in shares of DVA and FVA in GMY indicates the sectoral expansion in the value chain. For the basic metal sector, we find a fall in DVA content in GMX, along with an increase in FVA content. It indicates an improvement in the forward linkages of the industry. The fall in DVA shares in GMY with an increase in FVA shares reveals higher substitution of production processes abroad.

Figure 2. DVA and FVA shares of GMX in APEC countries (developed) at industry level

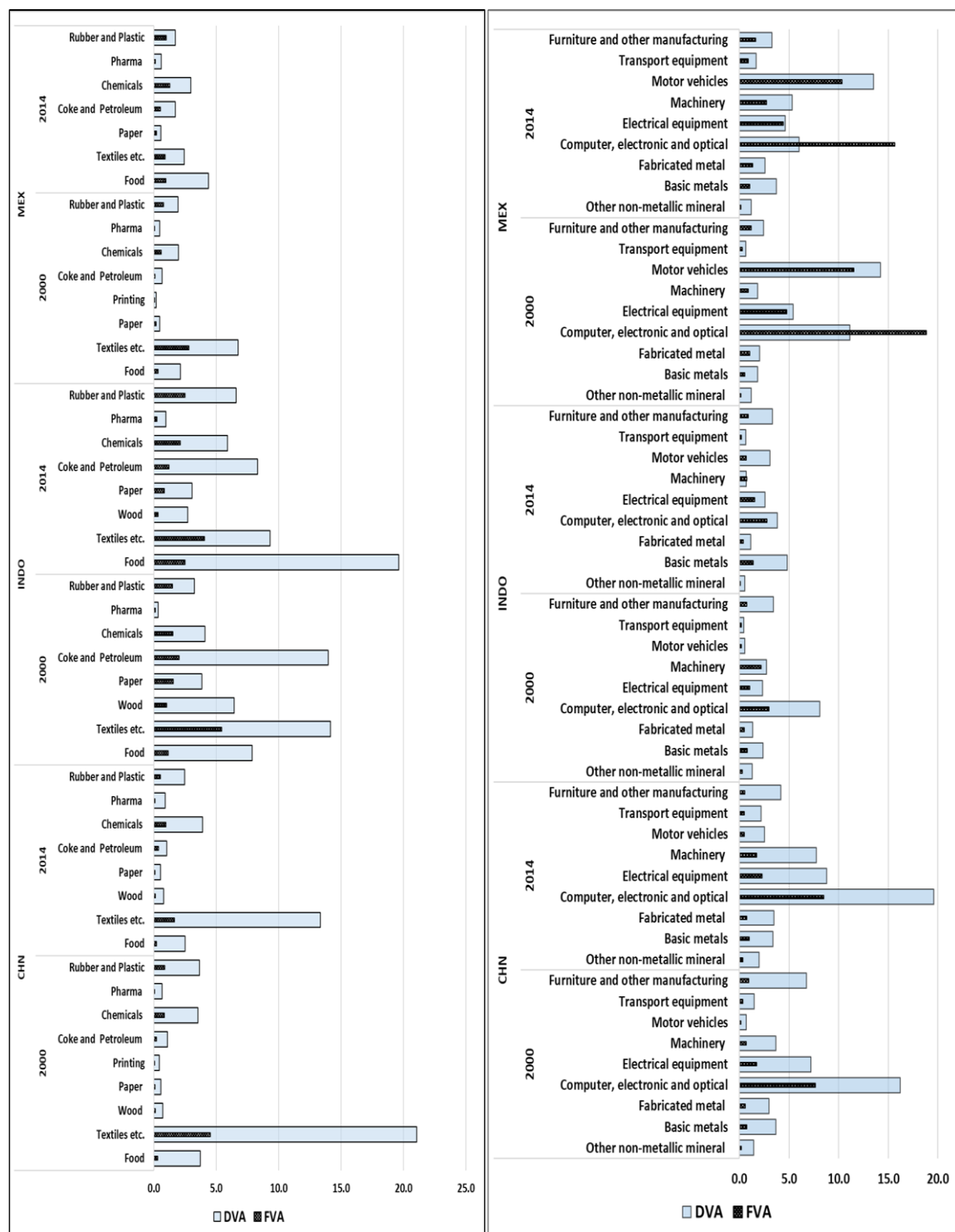


Source: Based on the Authors' calculation from WIOD, 2016 release.

Coke and petroleum, basic metal, motor vehicles, machinery, and chemicals are important sectors in Russia. Among them, coke and petroleum have shown a significant improvement in their expansion in the production base domestically and internationally. The share of DVA content in gross output has increased from 10.2 percent in 2000 to 26.2 percent in 2014. The percentage of FVA content in GMY has risen from 2 percent to 6 percent. Both the forward and backward linkages of this sector have been enhanced during the period. Basic metal, machinery, and chemicals have shown contraction in terms of their production bases (domestically and internationally) and linkages. In motor vehicles, backward participation has increased with an increase in foreign inputs' usage. Its forward linkage and domestic inputs-use have reduced during 2000-2014.

In the Asian counterparts of APEC nations, the computer, and electronics sector have shown a boom in China over Japan and South Korea. In China, the shares of DVA contents of export and output in this sector have increased substantially in this sector, indicating higher forward participation and higher substitution with domestic inputs in the production process. On the contrary, in Japan and South Korea, we see a fall in the forward participation of the sector. In South Korea, we find sectoral contraction, where both DVA and FVA shares in gross output have reduced over time. In Japan, the industry shows a substitution for the production process abroad. Among the other significant sectors, electrical equipment and machinery reveal similar conduct regarding their forward and backward participation in all three countries. In China and South Korea, both these sectors' backward and forward link in GVCs has increased. In Japan, their forward participations have reduced, but backward linkages have increased. Japanese electrical equipment and machinery sectors have substituted their production process abroad, whereas Chinese electrical equipment industries have expanded their production base domestically and internationally.

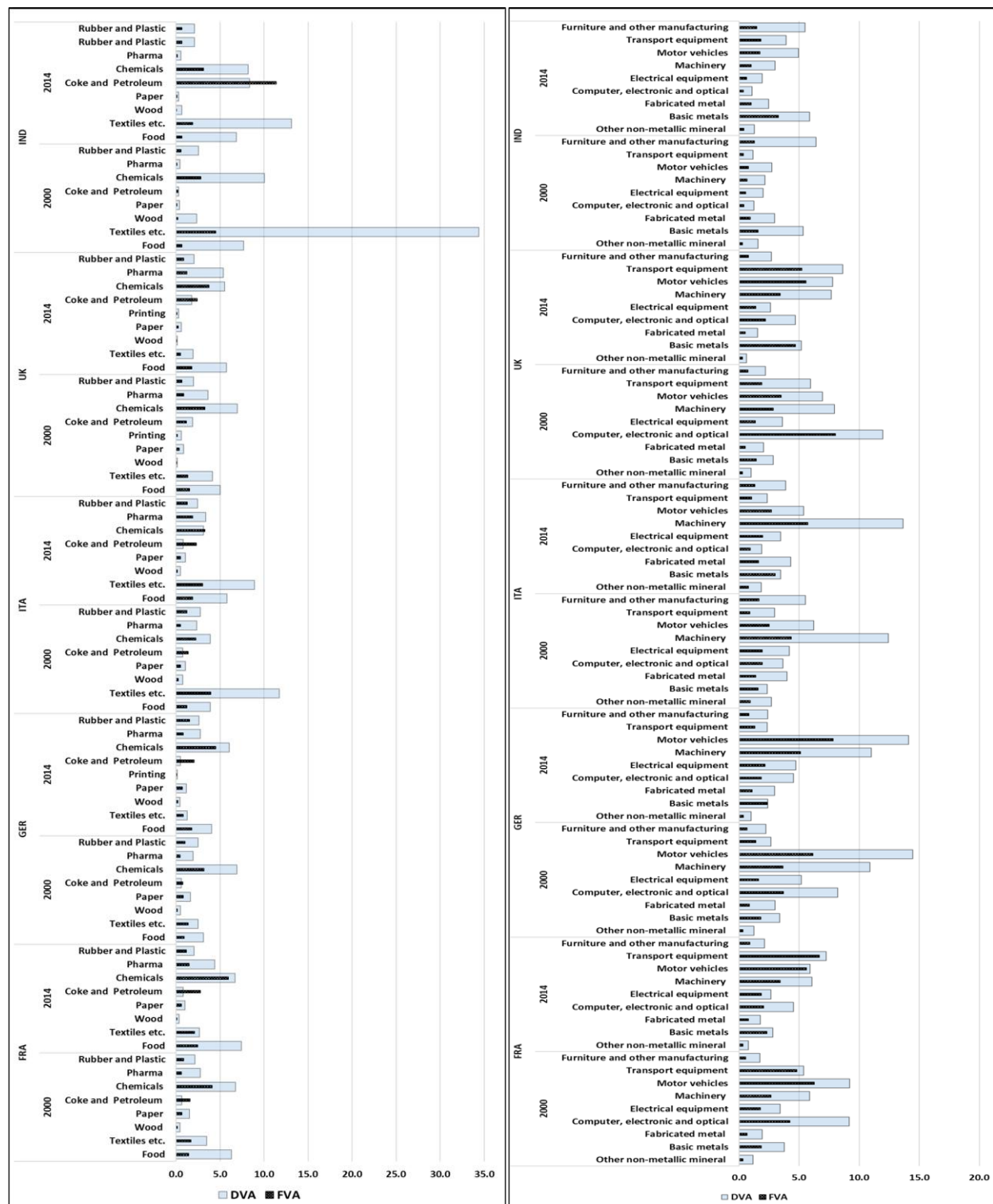
The motor vehicle sector is prominent in both Japan and South Korea. The backward participation of this sector has increased in both countries. In Japan, the forward participation has reduced marginally, but in South Korea, its forward linkage has increased substantially. The DVA and FVA shares of this sector in GMY of respective countries indicate that the industry has substituted its production process abroad in Japan. In South Korea it has expanded its production base both domestically and internationally. In South Korea, the transport equipment sector has revealed its production base expansion and its forward and backward linkages significantly during 2000-2014.

Figure 3. DVA and FVA shares of Export of APEC countries (developing and emerging) at industry level


Source: Prepared from the calculations based on WIOD 2016 release.

Indonesia is an Asian developing nation in the APEC region. India is a non-APEC member and an Asian emerging economy. In Indonesia, food and textiles are two significant sectors apart from coke and petroleum, chemicals, rubber and plastic, basic metals and computers and electronics. Apart from food and textiles, chemicals, basic metal, motor vehicles, furniture, and other manufacturing are notable manufacturing sectors in India. Indonesia's food sector has expanded its linkages (both forward and backward) and its production bases. But in India, the industry shows a stagnant growth in terms of its links and production process. The textile sector in both countries shows a falling trend in its DVA and FVA contents in GMX and GMY. Chinese and South Korean textile sectors reveal similar scenarios.

Indonesian rubber and plastic sectors show an expansion in its linkages with higher substitution in the production process abroad. In coke and petroleum, the shares of DVA and FVA contents in gross export in Indonesia have reduced, but in India, these shares have increased substantially. In India, these shares have risen from 0.2 percent to 8.3 percent and 0.2 percent to 11.4 percent, respectively, in 2014 over 2000. The DVA and FVA shares in output indicate that Indian coke and petroleum industries have substituted their production process abroad using more foreign inputs over domestic inputs during 2000-2014. The basic metal and motor vehicle industries have expanded their forward and linkages in both these countries. In India's case, in both sectors, we find higher substitutability in the production process abroad. But in Indonesia, the basic metal sector's production base has shrunk over time, and in motor vehicles, we find substitutability in the domestic production process.

Figure 4. DVA and FVA shares of Export of EU and UK and India at industry level


Source: Prepared from the calculations based on WIOD 2016 release.

As mentioned earlier, we have considered three EU member countries, viz. France, Germany, and Italy for our analysis. We have also taken the non-EU country, the United Kingdom, a major trading country of the region and has a substantial trading relationship with the countries considered in this study.

In terms of the forward and backward linkages of the manufacturing industries of the EU three countries, we find an identical pattern. Machinery, motor vehicles, computer and electronics, basic metal, electrical equipment, pharmaceuticals, chemicals, food, and textiles are the major manufacturing industries in the region.

In the machinery sector, forward participation has increased in France and Italy, and in Germany and the UK, it is constant during 2000-2014. On the contrary, the backward participation of this industry has increased in all four countries. In France and UK, the shares of the FVA contents in their GMY have increased with a reduction of DVA content-shares, signifying a substitution of the production process abroad. In Germany and Italy, both the shares in GMY have reduced, indicating a reduction in the sector's production base during 2000 – 2014.

Food and pharmaceutical sectors show similar trends in all four countries. Their shares of DVA and FVA contents in respective GMX of the states have increased overtime; reveal their higher forward and backward linkages in GVCs. In France, Germany, and Italy, it is found that the production process of the pharmaceutical sector has expanded both domestically and internationally during the period. In the UK also, we see the same expansion scenario of the pharmaceutical industry. We also visualize the domestic and international expansion of the food sector's production process in France, Italy, and the UK. But in Germany, we find a substitution of the industry's production process from domestic to abroad.

All three EU countries reveal a similar trend in electrical equipment and chemical sectors. They show lower forward participation with more robust backward participation in GVCs. In the UK, both these industries forward participation has shrunk with stagnation or marginal increase in backward linkages. The shares of DVA and FVA contents in GMY of these industries in the UK reveal the substitution of the production process abroad in chemicals and reduce electrical equipment production during 2000 – 2014.

The forward linkages of basic metals and motor vehicle sectors have narrowed down in Germany and France, whereas it has increased in the UK and Italy. These two sectors' backward linkages have expanded in all nations, except for motor vehicles in France. The domestic and foreign content shares in gross output calculations reveal that the foreign input usage in the production process has increased in basic metal industries in all four nations. The linkages and production bases of computer and electronics sectors have shrunk in the UK and all EU countries. China has come up as an emerging economy with a boom in the computer and electronics sector during the

period. The transport equipment sector is one of the prominent industries in the UK, which shows an expansion in its forward and backward participation in GVC over time. It has also been enhanced in domestic and international production base during the period. The Italian textile sector reveals sluggishness in terms of its linkages and production base during 2000–2014.

4. Conclusions and Policy Directions

Our study provides a cross-country industry-level analysis of the manufacturing sector for selected regions and nations. We have chosen two major regional blocks, viz. APEC and EU to understand the dynamics of international integration and outsourcing of the sector. Our analysis indicates growing backward linkages and global outsourcing of manufacturing in developed countries in APEC and EU regions.

The trade in intermediate manufacturing goods can be broadly categorized into 'processed intermediate goods,' and 'primary products used as intermediaries' (Kowalski Gonzalez, Ragoussis. *et al.* 2015). We have tried to segregate the 18 manufacturing sectors into these two categories, where few sectors are falling into both categories (see Annexure Table A1). Region-wise, we see that high-tech processed intermediate manufacturing like chemicals; pharmaceuticals; computer, electronics, and optical; machinery equipment, and motor vehicles have expanded in the developed countries of APEC and EU. Developing APEC has revealed higher linkages in the value chain of low-tech primary products used as intermediaries, and processed intermediate goods like food; coke and refined petroleum; basic metal; rubber and plastic, etc. Among emerging Asia, China has increased its linkages in GVCs in the high-tech industries like computer, electronics, and optical; electrical equipment, etc.

The analysis further probes us to dig deeper about the interconnectedness of the industries at a regional level. Despite the trend of increasing globalization, expanding intraregional trade indicates growing regional GVCs. Hence, mega-regional cooperation like Comprehensive and Progressive Agreement for a Trans-Pacific Partnership (CPTPP), Regional Comprehensive Economic Partnership (RCEP) would likely be more effective in enhancing the interconnectedness among nations in terms of their participation in GVCs. However, whether these mega-regional agreements will help individual countries, particularly developing and emerging nations, upgrade themselves in the value chain must be investigated further. Nevertheless, greater participation in the value chain requires more comprehensive trade facilitation measures at the country and regional level. Digitization of trade facilitation arrangements should be adopted under the preview of these mega-trade agreements to strengthen the integration of the sectors across countries in a cost-effective manner.

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