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**Global Value Networks:
Case Study of the Indian Auto Industry**

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Abstract

Much of international trade today happens through Global Value Chains (GVCs) wherein companies restructure and relocate their operations across geographies to leverage locational advantages and realize greater returns and efficiency in their production processes. Within these GVCs, there are global value networks that exist across countries for a given industry, which help highlight the relative position of a country and the corresponding importance of other countries in a country's industry. This paper attempts to map the global value network for the Indian automotive industry. It provides a descriptive analysis of the industry's flow of value and the relative standing of India's partner countries in these flows, using network analysis. We analyse GVC trends in this industry for India by charting the overall as well as segment-wise flow of value in the international market. We then map the domestic network of firms as well as the foreign partners to identify central nodes, important sub-groups, and influential geographies. Our network analysis indicates that in terms of geographies, India's firm-level linkages with the Western world are more robust with strong bi-directional flow of final goods and components while corresponding connections with Asian counterparts show greater one-way dependence. In terms of segments, we find that although India is a strong player in the components manufacturing space, its firms are mostly present in the lower value-added segments which face tough competition from their Asian counterparts. India's presence is weak in the higher value-added segments (Tier-1), where the scope for domestic value addition is high, indicating limitations regarding innovation and cost-effective manufacturing and export of critical components. We infer that the dominance of small and medium enterprises in India's automotive industry and their constraints in terms of scale, low levels of investment, poor research and development, and mediocre technology have manifested themselves in the Indian industry's global performance. Our study points to several areas for further research including understanding the role of trade agreements, FDI flows, domestic and external barriers, and the capacitation of MSMEs to enable GVC participation and movement up the value chain in sectors such as the automotive industry.

Keywords: Global Value Chains, Networks, Automotive Industry, Trade

JEL Classification: F1, F2, L1, L6

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1. Introduction

Global Value Chains (GVC) are the present modus operandi of international trade. Cross-border flow of goods, services, investment, and technology occurs through these complex conduits which span across the globe and make every end-product a result of international efforts. Liberalization accompanied by technological revolution paved the way for globalized production and provided the opportunity to firms to explore and exploit locational comparative advantages. Hence, companies could restructure and relocate their operations to geographies that offered them the highest returns for their overall investment through outsourcing or offshoring. This has resulted in cognate value chains (or rather value networks) traversing the globe and accounting for around 80% of global trade as per WTO figures in 2015-16 (intra-firm or inter-firm, regional or global in nature).

When geographically mapped, these flows can be clearly visualized as intricately woven “global value networks” (contrary to the belief of being linear chains). The interactions of procurement, production and distribution occur between the firms as nodes and the transactions as edges. With varied actors spread across the world operating and collaborating within and across segments of a value chain, GVCs present a complex synthesis of engaging outsourced production activities (including operations and services) , global corporate governance, and cross-country division of labour to capture value in international markets. Hence GVCs can actually be scrutinized by employing network analysis to understand the interrelationships of such transactions and strategies of value addition to a product or service.

Mapping the global value network for a sector helps analyse the relative position of a country within the sectoral GVC. It also helps identify the corresponding importance of other nations in a country’s specific sector. Network tools like “centrality measures” reflect the degree of connectivity (both direct and indirect) and the level of influence partner nations have in the country’s domestic value addition in the sector. When mapped over a period of time, this approach to examining GVCs can present an interesting tale of evolution of a particular economy with respect to its status in sectoral GVCs as well as the perceptible changes that might have occurred with respect to the geography of economic activity.

In terms of connectedness and interdependence, the Automotive and Electronics sectors present some of the most complicated and sophisticated production networks. The Indian Automotive

and Electronics sectors are no different, as evidenced by the high Grubel-Llyod index² of 0.69 and 0.72 respectively. This paper attempts to provide a descriptive analysis of the Indian Automotive Sector in terms of value addition and network indicators. In this paper, we have tried to understand the flow of value in India's Automotive Sector and the relative standing of its partner nations in domestic value addition in the auto sector. We first analyse the GVC trends in the Indian automotive industry by charting the flow of value in the international market, both overall and segment wise. We then map the Indian automotive network that includes the domestic network of firms as well as the foreign partners. This has been done with the objective of analysing the Indian auto network in an integrated manner with respect to identifying central nodes, important sub-groups, influential geographies etc.

The outline of the paper is as follows – Section 2 briefly describes pertinent literature on GVCs and Networks followed by Section 3 that maps the various facets of the Indian Automotive Sector. Section 4 provides a brief network analysis of the Indian Automotive Sector from a domestic as well as international standpoint. Section 5 concludes with the proposed road ahead as to how network analysis can be effectively used for identifying as well as resolving some of the major challenges faced by Indian firms to enhance their participation in Automotive GVCs.

2. Literature Review

Global Value Chains have gained importance as a topic of research since the early 1990s primarily due to two major paradigm shifts in the literature on International Trade, namely (a) the concept of “value added” trade (instead of “gross” trade) (Johnson and Noguera (2012), Fally (2012); Antràs et al. (2012); Koopman et al. (2014)) and (b) the rise in trade of intermediates signalling the fragmentation of the production line (Feenstra (1998); Hummels et al. (2001), Antràs and Helpman (2004); Baldwin and Venables (2013)).

However, the phenomena of “network” rather than “chain” to underline the complexity of interactions among global players of GVCs, is still nascent (Coe and Hess, 2007). In the networks and trade literature, the gains from networking have been broadly associated with lowering of information costs (thus improving information channels within and across borders) and transactions costs by exploiting the positive externalities generated through agglomeration (Tremblay, 2000; Kumar & Van Dissel, 1996). Firms gain from pooling of complementary

² Grubel-Llyod index measures the extent of intra-industry trade in a sector. An index value of 1 means extremely well-connected sector due to high levels of intra-industry transactions while a value of 0 means no intra-industry trade. The transactions involved in calculating the index value are oblivious to location.

resources like labour and infrastructure. More importantly, there is greater scope for collaboration and thereby increased learning-based innovation (Kogut, 2000; Roome 2001).

Outlining different types of networks in terms of production structures, simultaneity of tasks and governance formats has repercussions for diffusion in the network (Serrano et. Al. (2003); Baldwin and Venables (2013); De Benedictis et.al. (2014)). For instance, identifying central hubs has become paramount in the era of economic shocks as this could provide valuable information to both firms and policy makers for designing mitigating measures. Some such measures outlined in the literature include moderating the vulnerability of firms to input shocks by diversifying the range of suppliers (OECD, 2013) or through extra inventories (Kahn, 1987; Alessandria et al., 2011).

Traditional network analysis tools are being increasingly customized to account for economic relationships among countries and regions (Wang et al. (2013); Koopman et al. (2014); Chor et.al. (2019)). Centrality metrics provide profound insights into both direct and indirect ties between firms, sectors and nations that ultimately have an impact on the overall productivity and efficiency of economies. Recent studies have computed centrality metrics for determining the nature of economic networks of nations, interconnectedness of sectors, and degree of clustering within sectors (Cerina et al. (2015), Gourdon et al. (2016), Amador and Cabral (2017)).

Such studies on the Indian economy are rare or non-existent. Our effort through this paper is to map one of the most vibrant sectors of the Indian economy – automotives and to examine it through the lens of network analysis in order to better understand its structure, degree of dependence on foreign inputs and extent of integration with the foreign markets. We also attempt to analyse the possible macro-level (industry-level and nation-level) reasons for the findings, by using micro-level (firm-level) data. This could show us the way forward in policy making against the backdrop of two contesting views regarding increased participation in GVCs – better productivity and increased competitiveness of firms vis-à-vis greater exposure to vagaries of the international market in the form of negative economic shocks and contagion effects. Such an analysis is also very relevant at a time when the Indian government has stated its objective of enhancing India's GVC participation, although some of its recent measures to increase self-reliance and substitute for imports, seem antithetical to this goal.

3. Approach and Methodology

3.1 Choice of sector

The Indian Automotive sector was chosen for this study primarily because of its significance in the Indian economy in terms of contribution to GDP (and output) as well as its capacity for employment and growth. The Automotive sector in India (automobiles and auto components) contributed 7.1% to the national GDP in 2019-20 while employing 35 million directly and indirectly. It accounted for 4.3% of India's exports and a massive 40% of global R&D. Additionally, the Indian market is expected to be the 3rd largest automotive market by volume by 2026.³

Despite its good performance domestically and a cornucopia of prospects globally, India's presence in Auto GVCs was not significant, as suggested by the figures in 2015-16. Using the degree of Domestic Value Added (DVA) as an indicator for GVC participation where higher amount of value-added activities to the chain domestically reflects the country's contribution to the sectors' GVC, India only clocked 68% contribution of value added domestically to gross exports. As the spread of Value Chains for Automotives is quite wide and intense internationally, India stands to gain immensely by enhancing its participation.⁴

3.2 Data Sources and Methodology for Network Mapping

To map the global value network of the Indian auto sector, comprehensive information regarding transaction partners at the firm-level was essential. This included not only the buyer and supplier data for the domestic network of auto firms but also information about the foreign trading partners. The year 2015 was specifically chosen for two principal reasons – (a) the OECD Trade in Value Added (TiVA) database has updated data till 2015 which was a critical source for cross verifying gross flows in value-added and (b) 2015 was a record setting year for the Indian automobile industry in terms of production and sales before the pace was hindered by macro events like stringent pollution control norms, reduced research and development (R&D) allocation for the auto industry in the Union Budget and demonetization in the country. Thus 2015 was a year of expansive value-added activities, both domestically and internationally, for the Indian auto industry.

³ The Automotive sector in India (automobiles and auto components) contributed 10.4% to the national GDP in 2015-16 while employing 19 million directly and indirectly. Additionally, the Indian market was the 4th largest automotive market by volume in 2015 and was projected to be a top-3 market by the end of the decade

⁴ Domestic value added share of gross exports (EXGR DVASH) is defined as domestic value added in gross exports (EXGR DVA) by industry *i* divided by total gross exports of industry *i*, in %. It is a 'DVA intensity measure' and reflects how much value-added is generated by an industry per unit of its total gross exports.

For mapping the domestic network of auto industry in India, the data was sourced from relevant industry associations, i.e., Society of Automobile Manufacturers (SIAM) and Automotive Component Manufacturers' Association of India (ACMA) and company reports (wherever available). SIAM is the apex industry body of principal vehicle and vehicular engine manufacturers and ACMA is the apex body of the auto components industry that represents nearly 85% of the industry by turnover in India. These directories contain the particulars of nearly 800, member auto firms – Company Names, Location details, Management details, Contact information, Products Manufactured, Customers, etc.

For particulars of overseas partners, detailed firm-level daily transactions data for Indian importers and exporters, collected by Indian Customs from all major seaports and airports in India was sourced. This dataset comprises of Indian firms and product trade data at the HS 8-digit level for calendar year 2015 that includes data on date of transaction, name of Indian importer (or exporter), details of Indian importer (or exporter) like address, Indian exit port, name and other details of International supplier (or customer), source (or destination) port and country, quantity and value of imports (or exports) etc. in standardized format.

This rich data was then mapped into an unweighted directed network with firms as nodes and buyer (or supplier) relationship as incoming (or outgoing) edges using the software Gephi (see Section 4). Different maps for the domestic and international network of Indian auto firms were also plotted for more in-depth analysis of the patterns of value flow.

For preliminary examination using network analysis tools, network density was scrutinised for the entire grid of auto firms. Network density explains the inter-connectedness of firms and depicts the degree of dyadic connections in the sector. Additionally, node centrality⁵(particularly eigen vector centrality⁶) was determined that helps explain how influential or tightly clustered a node's neighbours are, thereby defining the relative importance of the node itself.

⁵ Node centrality is a measure in network analysis which defines the importance of a node and the various facets of the node's position

⁶ Eigenvector Centrality measure, or the Bonacich centrality associates a node's centrality to the node's neighbours' characteristics, directly referring to how important or influential the node is within a network

4. Mapping the Indian Automotive Network

4.1 *Brief description of the Indian Automotive sector and Value Chain*

As per the Society of Indian Automobile Manufacturers (SIAM)'s statistics in 2015, the **Indian Automotive Industry** was the 7th largest in the world. The industry accounted for 10.4 per cent of the country's Gross Domestic Product (GDP). India was also the 4th largest automotive market by volume in 2015 and was predicted to rise to the third position by the end of the decade. The average annual production had touched nearly 24 Million vehicles, of which 3.6 Million units were exported.⁷

In India, automotive manufacturing is concentrated around the four major metropolises of the country: Delhi, Mumbai, Kolkata and Chennai. As the basic tendency of the Auto industry is for agglomeration, regional concentrations have developed around these cities fuelled by the establishment of major industrial hubs such as Gurgaon-Manesar in suburban Delhi, the manufacturing corridor extending from Mumbai to Pune in western India and the manufacturing belt from Chennai to Bangalore in southern India.⁸

The manufacturing value chain of the automotive sector comprises of various segments like

- Original Equipment Manufacturers (OEMs) - owners of the brand, final assemblers and drivers of design and innovation; for instance, Maruti, Mahindra, Tata, Volvo, Hero, Honda, TVS
- Components Manufacturers/Assemblers (Tier-1) - manufacturers of sub-systems and critical components like powerline, brake system etc. and direct suppliers to OEMs
- Sub-Components Manufacturers/Assemblers (Tier -2, Tier - 3) – generic manufacturers of components and sub-components like Piston Rings, Engine Valves, sheet metal
- Raw Materials Suppliers – suppliers of basic manufacturing raw materials like metal, plastic, glass etc.

The performance of Indian and India-based companies in all the segments of the Auto value Chain was quite impressive in 2015-16. From the OEMs' standpoint, India continued to be the largest tractor and motorcycle manufacturer, second-largest two-wheeler manufacturer and fifth largest commercial vehicle manufacturer in the world. It had 13 per cent market share in

⁷ Society of Indian Automobile Manufacturers (SIAM) Statistics, (<http://www.siamindia.com/statistics.aspx?mpgid=8&pgidtrail=13>)

⁸ Dash (2019), Ph.D. thesis

the Passenger Vehicle (PV) segment and around 31 per cent of small cars sold globally were manufactured in India in 2015-16.⁹

In the components segment too, the performance was encouraging in 2015. The automobile components industry comprising of nearly 850 firms in the organized sector and several more in the unorganized sector contributed 25.6% to India's manufacturing GDP, 3.8% to India's overall GDP and employment (direct and indirect) to 1.5 million people in 2015-16.¹⁰

While gross production statistics portray a healthy manufacturing story for the Indian automotive sector, we are more interested in looking at the "value-added" angle of the story. Value addition provides a much better indication of the industry's productivity performance especially in the presence of offshoring. India's value-addition had been consistently going up but there is still room to increase its value add in foreign final demand, which implies that the industry has good scope for growth in the coming years.

Table 1: Performance of India's Automotive Industry

PERFORMANCE OF INDIAN AUTOMOTIVE INDUSTRY (in USD Millions)											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production (Gross)	46 765.7	53 036.7	63 282.7	66 403.7	80 417.7	101 341.2	118 792.9	112 237.1	101 213.8	116 429.7	119 210.2
Value Added	14 083.9	15 597.0	18 641.7	16 395.5	21 611.1	26 384.6	30 480.9	29 609.1	25 456.1	31 113.0	37 746.7
DVA in Foreign Final Demand	1 305.0	1 456.6	1 809.6	2 446.5	2 624.4	3 929.3	4 121.7	4 169.1	5 142.1	6 725.2	7 035.9

Source: TiVA Database, 2018 (www.stats.oecd.org) (Data Extracted on 30 Sept 2020)

4.2. Mapping the Domestic Automotive Network of India

The domestic network of Indian auto firms demonstrates all the classic characteristics that are associated with the global automotive industry.¹¹ Some of these traits include –

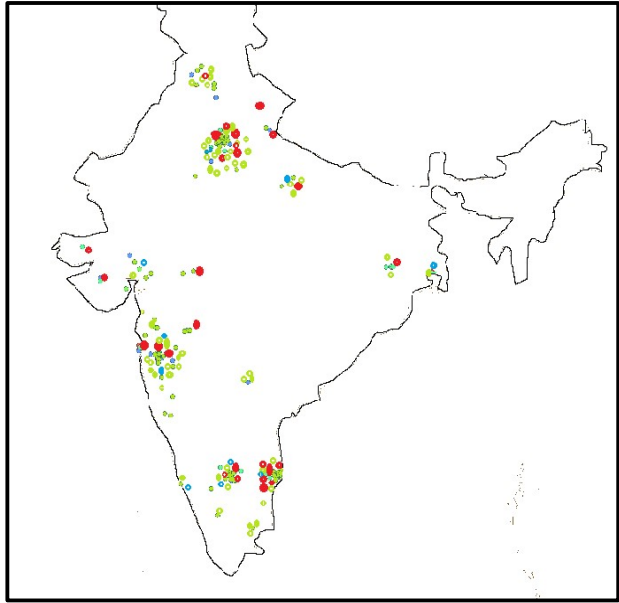
⁹ Make in India: Sector Survey – Automobiles (<http://www.makeinindia.com/article/-/v/make-in-india-sector-survey-automobile>)

¹⁰ Make in India Sector Survey – Automobile Components (<http://www.makeinindia.com/article/-/v/make-in-india-sector-survey-automobile-components>)

¹¹Dash (2019)

- Agglomeration around four major centres with dense offshoots nearby - four major clusters located in four corners of the country
- Highly fragmented and scattered components (Tier-2, Tier-3) manufacturing with extremely localized clientele (Tier-1, OEMs)
- Modular Production with standardized designs and common platforms across brands with the goal of cost minimization, efficiency maximization and highest return for investment in lower value-added activities
- Largely indigenous base of suppliers developed by the OEMs organically with the sub-text (this holds for most of the foreign OEMs as well)

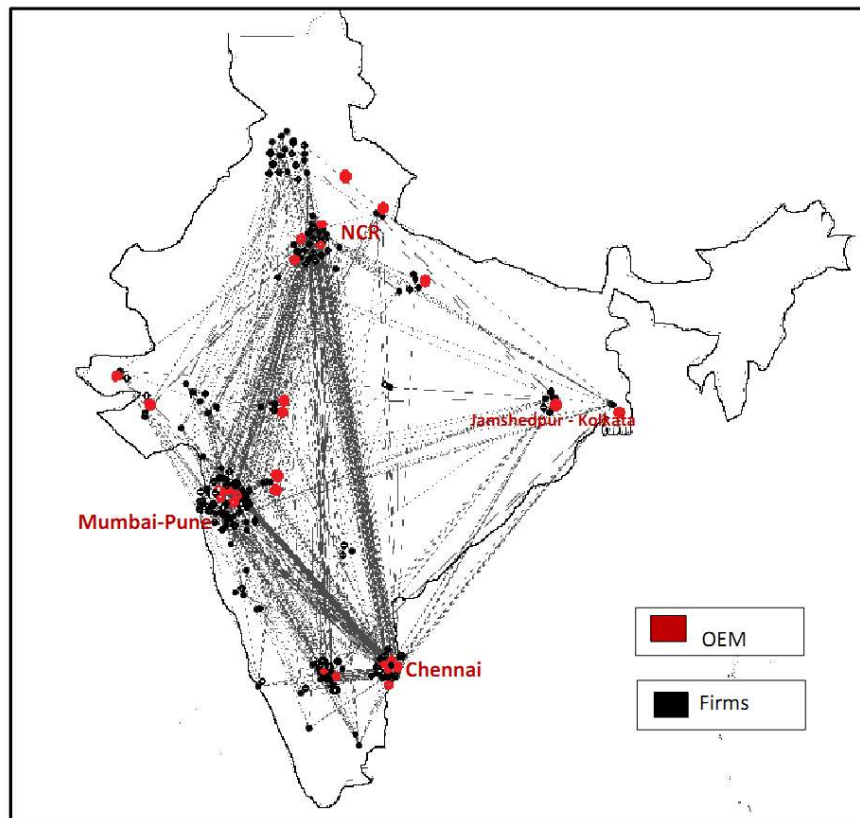
Figure 1: Major Auto Clusters in India



Source: Authors' conceptualization using Gephi

Though each cluster is home to several major OEMs which have developed their respective dedicated local supplier base, a significant amount of inter-regional trading also takes place as evidenced by the network map of the auto firms (Figure 2).

Figure 2: Domestic network of Indian Auto firms



Source: Authors' representation using Gephi

The buyer supplier network of several firms (especially OEMs) spans multiple clusters probably due to these reasons –

- (a) clusters generally have specialized components manufacturing; for instance, the Southern cluster has emerged to be extremely popular for manufacturing auto components for two-wheelers apart from four wheelers (around 19 items in the Tier-2 and Tier-1 categories account for more than 50% of the components manufactured here)¹²
- (b) OEMs tend to develop the supplier base for their critical components first while sourcing other elements from other locations in a cost-effective manner, whether generic or specialized. Cost efficiency remains a crucial criterion for sourcing patterns.
- (c) Vehicle manufacturers often tend to diversify their supplier base in order to mitigate risks arising from local conditions. For instance, firms located at the same centre are under the purview of identical legislations or regulations (state/local government). Similarly, business culture, labour issues, physical and institutional infrastructure are also common to locations.

¹² Tamil Nadu Industrial Development Corporation (TIDCO) (2015)

Hence, they tend to tap into the resource pool of other regions and compensate for their local barriers.

4.3. Mapping the Origin and Destination of Value added in Gross Imports and Exports

As per the gross trade figures, the top sourcing markets and destination markets for the year 2015-16 were identified as below (Table):

Table 2: Imports and Exports in the Automotive Sector for 2015-16

SEGMENT	Top 5 EXPORT DESTINATION (Value of Exports)	Top 5 IMPORT SOURCES (Value of Imports)
Automotive	1. Mexico (US \$ 1037 million) 2. South Africa (US \$566.40 million) 3. UK (US \$316.25 million) 4. Italy (US \$ 312.4 million) 5. Sri Lanka (US \$305 million)	1. Germany (US \$83.52 million) 2. U K (US \$38.55 million) 3. Italy (US \$14.98 million) 4. Hungary (US \$14.12 million) 5. Sweden (US \$9.88 million)
Auto Components	1. US (US \$ 1026.36 million) 2. Turkey (US \$ 418.98 million) 3. Mexico (US \$ 194.05 million) 4. Germany (US \$193.45 million) 5. Thailand (Us \$ 185.56 million)	1. Germany (US \$723.23 million) 2. Korea RP (US \$651.2 million) 3. China P RP (US \$638.36 million) 4. Japan (US \$479.47 million) 5. Thailand (US \$354.82 million)

Source: Ministry of Commerce and Industry, Government of India

The international sourcing pattern exhibits certain classic patterns, not uncommon to the Automotive sector –

- Follow Sourcing: Foreign OEMs tend to favour single suppliers across different markets, often for critical components. This results in the supplier following the OEM to wherever the latter sets up shop; for instance, Hyundai’s suppliers almost always follow it to foreign markets.
- Follow Design: OEMs tend to use a common design for multiple markets, albeit under different brand names; for example, Ford sold its “Ikon” sedan under different names in different markets – Ford Ikon in India, Ford Fiesta sedan in South America and China.

4.3.1 Mapping Value Added in Imports

The auto industry in India has always been heavily reliant on imports, although this dependence has started witnessing a slowing trend since the start of this decade (since 2011). While the gross figures for imports for the sector might portray a simplistic picture of the flow of goods and suffer from errors like double counting, the value-added trade figures depict the intricacies of flow of goods in a value chain much better (Table 3).

The Value Added (VA) by the Rest of the World in India's Automotive sector follows the imports tale and shows a slowdown in this decade. While 2012 appears to be an outlier in terms of enhanced foreign VA, it was mostly due to a myriad of unexpected internal issues faced by the firms like recalls and labour issues (e.g. violence in Maruti Suzuki plants in Manesar, Haryana against management, Labour Union strikes in Hyundai's Chennai, Tamil Nadu plants etc.). Foreign Value Added in Domestic Final Demand of India in the auto sector has remained fairly consistent in this decade.

Table 3: Foreign Value Added in the Indian Automotive Sector

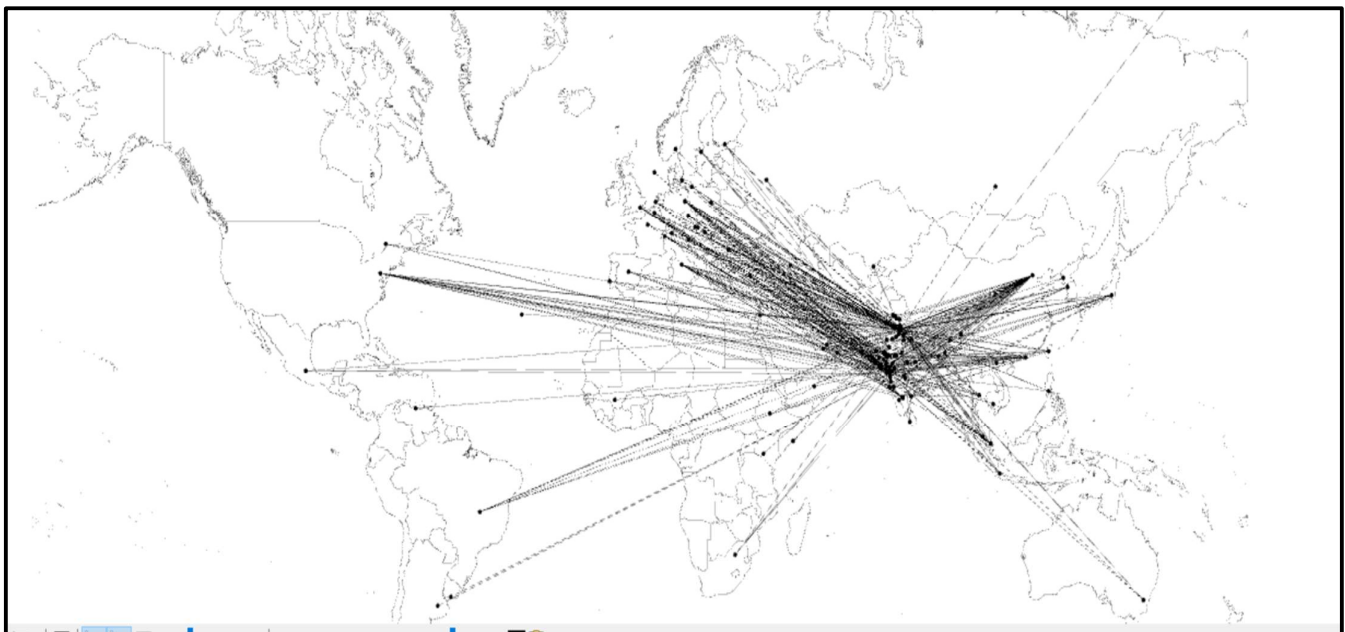
FOREIGN VALUE ADDED IN INDIAN AUTOMOTIVE SECTOR (in USD Millions)											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
VA by World	8 293.9	13 086.4	13 492.4	21 788.7	17 595.6	20 251.7	18 419.5	28 276.3	21 281.3	18 879.5	20 607.0
VA by World-Intermediates	1 391.5	2 123.8	2 033.1	4 018.0	3 116.4	3 066.0	2 097.7	1 806.3	1 399.6	1 641.6	2 488.9
VA by World- Final Goods	6 902.4	10 962.6	11 459.3	17 770.6	14 479.2	17 185.7	16 321.8	26 470.0	19 881.7	17 237.9	18 118.1
Foreign VA in Domestic Final Demand	4 106.9	6 042.3	6 279.1	9 614.6	7 718.6	8 705.6	8 485.9	11 488.4	9 072.3	8 180.3	9 902.8

Source: TiVA Database, 2018 (www.stats.oecd.org) (Data Extracted on 30 Sept 2020)

Mapping the source of this foreign value addition (Figure 3) presented some interesting insights into geographic patterns of sourcing. Global auto manufacturing has evolved into industrial hubs over the decades, as a result of which imports of automotive inputs are usually confined to certain locations. It is to be noted here that the data represented in this map is at the firm-level, so effectively depicts the micro-level flow of value from auto firms in other nations to firms in India. Some valuable particulars that can be gleaned from this value-map visualization are:

- The East and South East Asian regions were the foremost sources of foreign value added in India’s automotive manufacturing. China along with Hong Kong and Taiwan, Japan, Thailand, and South Korea witnessed a high volume of trade across segments of the auto value chain.
- Germany remained the top source of foreign value addition in dollar terms. In the European region, Italy was a close second in terms of source of value of imports.
- A notable number of firms had transactions with their sister-companies in other locations. There was no significant variation across different segments of the value chain, indicating there might be some degree of “arms-length” trading taking place.

Figure 3: Origin of Foreign Value Added in the Indian Automotive Sector



Source: Authors’ representation using Gephi

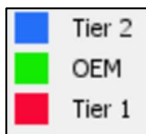
The mapping of segment-wise location of foreign value-addition of the Indian auto industry (Figure 4) offered more insights into the micro-level trade. Some distinctive traits that presented themselves are –

- In the OEM segment, major sources of value addition in Indian auto manufacturing were Thailand and Germany followed closely by Italy, South Korea and Japan. These countries have been traditionally considered world-class in critical components manufacturing and

have well established strong historical background of well-known brand names. In addition, several foreign OEMs that have presence in India belong to these nations.

- Tier -1 manufacturing witnessed large volumes as well as high dollar value imports from Europe, namely from countries like Austria, Denmark, Finland, Belgium, and Italy.
- Indonesia and China also had a notable presence in this segment (Tier- 1), albeit the dollar value of their transactions was low. The other noteworthy countries in this segment were Kenya and Venezuela which were the source of significant dollar value of transactions.
- Tier 2 and Tier – 3 segments had lot more dispersed origin of value addition that included substantial presence of the Asian region (China, Hong Kong, Taiwan, Japan, South Korea, Singapore). Turkey and UAE were also sources of imports for this segment.
- Other notable countries adding value to Indian sub-components manufacturing (Tier-2 and Tier-3) included Belgium, Denmark, UK, Spain and France in Europe, USA and Mexico in North America and Australia.
- For firms importing from multiple locations, the preferred venues for sourcing sensitive and critical components were found to be firms in the European region like Germany, France, and UK. The more generic components and larger volumes which were mostly used in Tier-2 and Tier-3 sub-component manufacturing, were mostly sourced from the Asian countries

Figure 4: Origin of Foreign Value Addition in the Indian Automotive Sector, value segment-wise



Source: Authors' representation using Gephi

Using network analysis tools on these maps, we calculated the degree centrality¹³ and the eigen-vector centrality¹⁴ scores to determine the relative importance of these locations of foreign value addition. At an aggregated (nation) level –

- China had the highest in-degree centrality reflecting the high volume of trade (number of transactions) that Indian auto firms had with their Chinese counterparts. This in-degree score went up significantly if firms in Hong Kong and Taiwan were also identified as Chinese firms.
- Germany and Italy came close behind China with very high in-degree centrality scores as well. They were followed by USA and Japan.
- In terms of relative importance, Germany and China had close high eigen-vector centrality scores indicating the high level of influence these nations have on the auto sector, not only in India but also globally.

¹³ Degree Centrality measures how a node is connected to others (number of connections a node has).

¹⁴ Eigenvector Centrality measures a node's centrality to the node's neighbours' characteristics, directly referring to how important, central, influential or tightly clustered are a node's neighbours.

- USA, Italy, and Japan were the countries with the next high eigen-vector centrality scores proving their prominent position in India's auto sector.
- Surprisingly, UAE also had a considerably high eigen-vector centrality score (as opposed to a moderate in-degree centrality score) signifying that its importance was probably due to its inter-connections to other important hubs as opposed to a high level (or value) of direct trade with Indian firms.

4.3.2 Mapping the Value Added in Exports

India's performance as an automotives exporter has been good with a steady rise throughout the past two decades. While in gross terms, India's auto exports breached the \$10 billion mark in 2010, in terms of value addition in the final demand of foreign nations, India has a lot of scope for improvement. The potential to improve further certainly exists as showcased by the constant growth in the sector's share of domestic value added (DVA) in gross exports (Table 4)

Table 4: Domestic Value Added by India in the Automotive Sector

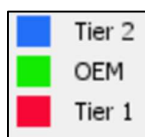
VALUE ADDED BY INDIA IN GROSS EXPORTS AUTOMOTIVE SECTOR (in USD Millions)											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
VA by India in Gross Exports of World	4 726.7	5 699.4	7 260.8	9 688.4	8 390.6	13 360.4	15 427.0	15 765.2	18 585.6	21 573.4	19 428.9
DVA Content of Gross Exports	2 503.1	2 846.7	3 634.3	5 227.0	5 348.7	8 287.9	9 061.6	9 623.8	11 904.0	14 524.0	12 953.9
FVA Content of Gross Exports	851.4	1 086.3	1 416.6	2 803.5	2 233.8	3 967.4	4 597.0	4 567.6	5 572.1	6 008.2	4 637.3
DVA in Foreign Final Demand	1 305.0	1 456.6	1 809.6	2 446.5	2 624.4	3 929.3	4 121.7	4 169.1	5 142.1	6 725.2	7 035.9

Source: TiVA Database, 2018 (www.stats.oecd.org) (Data Extracted on 30 Sept 2020)

Visualizing the firm-level transactions of auto and auto components manufacturers in international markets, the geographic dispersion revealed some interesting features (Figure 5). The map for value-added exports appeared more scattered and denser because firms in India had interactivity with almost all international markets across continents. Some of the most prominent trends that could be observed in exports of India's value addition were -

- For the OEM segment, the Americas were the most favoured destination. USA and Mexico in North America were the top recipients of India's domestic value addition in OEMs followed by Colombia, Chile, and the Caribbean islands in this region.
- Germany received the highest amount of India's domestic VA in the OEM segment amongst the European nations, both in terms of dollar value as well as volume.
- In the Asian region, South East Asian nations like Vietnam and Middle East nations like Turkey, Kuwait and UAE were preferred destinations. Additionally, immediate neighbours of India were also top targets that included Sri Lanka, Nepal, and Bangladesh.
- In terms of volume of trade, several countries of the African region featured prominently as recipients of India's value addition in the OEM segment. These included Egypt, Kenya, Nigeria, and Tanzania.
- In the Tier-1 segment, Germany and Italy were the two most important ports of call for value addition by India, across all components in this segment, followed by Colombia.
- Neighbouring countries of India again had a large volume of trade in value added in this segment with Nepal and Bangladesh at the top.
- In the sub-components manufacturing (Tier-2 and Tier-3), USA and Colombia witnessed very high volumes as well as dollar value worth of exports of India's DVA. This was followed closely by countries in Europe that included Germany, Belgium, Italy, and Sweden.
- In Asia, Sri Lanka, Japan, and Bangladesh were top recipients of India's DVA in this segment. Amongst the African nations, Egypt, Kenya, and Mozambique were the top destinations of certain sub-components.

Figure 6: Destinations of India's Domestic Value Added in the Automotive Sector



Source: Authors' representation using Gephi

The network analysis of the exports of value added by India reveals some interesting insights into the locational diffusion of India's DVA –

- The US had the highest out-degree centrality score indicating the high volume of trade that both nations had in the auto sector. It was followed closely by Germany.
- Asian giants, China, Japan, and Thailand followed their western counterparts next with high scores of out-degree centrality.
- In terms of relative importance (as indicated by the eigen-vector centrality score), the US, Germany and Italy were the top-most valuable partners. This was reflective of the high volume of trade as well as high dollar value worth of trade these nations enjoy with India.
- The Asian region came next in terms of significance with China, UAE and Thailand emerging as the most preferred collaborators. These nations were important not only because they had direct trade linkages with Indian firms but were also important hubs for the auto sector of other nations.

- Surprisingly, Brazil had quite a high out-degree score as well as eigen-vector centrality score indicating Indian firms had strong linkages with their Brazilian counterpart. Though the country did not feature as a top destination in the gross value-added terms, it was certainly a vital central hub for India's exports of DVA.

5. Summary of Results

India's automotive manufacturing sector has made a noteworthy contribution to global value added in the automotive industry and has considerable ties with certain nations and regions. Network analysis of sources and destinations of India's value-added trade has helped shed light on these linkages in a more focussed manner. Three regions cumulatively accounted for almost 85% of value addition in India's automotive industry (both as sources and destinations, as well as across segments).

Key takeaways from the network analysis of India's value-added maps for the Automotive industry are summarized below –

- North America was the strongest trading bloc for auto firms in India with USA being a focal point for imports as well as exports of value addition in and by India. With the addition of Mexico and Canada, this regional bloc had very high centrality scores both for the number of transactions by Indian firms and for the net dollar value worth. Hence, it might be a worthwhile endeavour to negotiate some form of trade agreement with the US and/or its neighbours (such as the ongoing discussions for a bilateral agreement between India and Canada) to enable firms in India to do better business with their counterparts in this region.
- The European Union (including the UK) was the next major trading partner for India in terms of value addition, with Germany, UK and Italy leading the group. However, these nations mostly remained the top-most sources of foreign value addition in India's manufacturing implying a trade balance in their favour. Their importance, as underlined by the eigenvector centrality, stemmed from both high dollar value transactions as well as from being the home to some of the world's best-known auto brands across segments. India needs to tilt the scale in its favour by making its presence better known in the segments where it excels (for instance, small passenger cars completely built units (CBUs)) and in segments where it holds the potential to be far more aggressive (for instance in the components manufacturing). The proposed India-EU Broad Based Trade and Investment

Agreement needs to be tweaked in that respect, for instance lowering tariffs for super-luxury automobile CBUs from Europe (which are not manufactured domestically) while maintaining higher tariffs in other vehicle segments, imposing binding knowledge transfer regulations with lowering of tariffs in auto components etc. Tariffs on OEMs have, however, been a bone of contention in these trade negotiations.

- Firms in East and South East Asia were the third major trading cohort for their Indian counterparts, albeit with some disparate leanings. India's dependence on foreign value added (FVA) by countries like Thailand, China, and Japan had only grown over the recent years with Indian firms losing out on developing world class manufacturing capabilities especially in non-critical components like glass and metal parts, brakes, clutches etc. due to import substitution. India exported to these nations mostly in the OEM segment, which was high in terms of dollar value worth but net value added by India reduced because of the presence of high FVA from these countries in the gross exports of India. This indicates that regional trade agreements with nations in this region might not have helped Indian firms in the manner envisioned and might even have led to higher one-way trade.¹⁵

India's firm-level linkages with the western world seemed to be more robust due to the presence of strong bi-directional flow of final goods and components while corresponding connections with their Asian counterparts did not seem as vibrant probably due to a greater one-way dependence of value addition. There are several areas that need to be probed more deeply given these findings; for instance, the impact of trade agreements on the domestic auto industry and whether such agreements have caused lop-sided trade relations with neighbouring trading blocs. Secondly, the pattern of investment flows within the auto industry and whether it mirrored the inter-relationships shown by nations in manufacturing and trade can also be an interesting area for further investigation. Additionally, figuring out the possible barriers to entry in foreign markets like meeting quality standards and product specifications in manufacturing, raising adequate capital (and/or credit) for large scale manufacturing, overcoming trade-related barriers etc. is a vital area of study for enhancing India's presence in auto GVCs. Finally, figuring out a solution to the key conundrum of balancing higher GVC participation with greater self-reliance on domestic manufacturing will help resolve a major challenge for Indian policy makers. The recent announcement of India's ambitious Atma

¹⁵ EXGR FVA (c,i) presents the foreign value added embodied in the exports by domestic industry i in country/region c. In other words, it measures the extent of imports used in the exports of a country's industry.

Nirbhar Bharat Abhiyan includes several measures to help revive the MSME sector through stimulus packages, collateral-free automatic loans, reduced tax rates and liquidity infusion. These initiatives can address both the development of indigenous manufacturing capabilities while also helping Indian firms to integrate into GVCs by empowering the MSMEs and linking them to lead firms, both foreign and domestic.

6. Conclusion and Future Work

The story of the Indian automotive sector in 2015 presents an excellent case study in the country's participation in sectoral GVCs. That particular year highlights the rudimentary challenge faced by India with regard to GVC participation, i.e., why despite the industry's excellent performance in terms of manufacturing output, its presence in GVCs remained limited. Why did the participation of Indian firms in Automotive GVCs remain a tale of aspiration?

Delving deeper into the auto industry in 2015 helped answer this question to a certain extent. While India continued to be a strong player in the components manufacturing space, it was mostly so in the lower value-added segments which are not only subject to tough competition (Indian firms faced a tough contest from their Asian counterparts) but also operate mostly on very thin margins.

India's presence was yet to be strongly felt in the higher value-added sections, where the scope for domestic value addition is usually very high. India's insubstantial presence (low centrality scores) in the lucrative Tier-1 manufacturing space was a bit of concern as it did not reflect well on its ability to innovate, manufacture critical components cost-effectively and deliver to competitive markets. Since a majority of the Indian firms are small and medium enterprises, their handicap stemming from low investment, poor research and development (R&D) and mediocre technology has manifested itself in the industry's global performance.

However, moving forward, the prospects may be brighter for Indian auto firms to enhance their capabilities and their participation in GVCs. Firstly, India's domestic market can be a strong driver of demand in the backdrop of a rising well-to-do middle-class population, robust infrastructural development, and easier access to finance. Secondly, according to latest news reports and industry experts, certain central countries like China and Thailand, which are large exporters of components, are facing several constraints in terms of capacity, labour and IPR issues; Indian firms could very well fill this vacuum. Thirdly, Indian OEMs have gradually

built international reputations and have established themselves as global brands; firms in their entire value chain can very well take advantage of this fact and upgrade themselves to international standards. Finally, at this time, when many MNCs are looking to diversify their supply chains and to relocate investments from China, there may be a window of opportunity for India to attract more investment in this sector and for Indian automotive firms to tie up with larger firms, thus enabling increased GVC participation in this sector. The associated gains in terms of technology transfer, quality, standards, employment, and exports, could be significant, provided ease of doing business related issues are addressed.

The use of network analysis tools like the centrality scores has helped us elucidate the linkages across segments and geographic locations and has made visualization clearer than would have otherwise been possible with only gross or value-added trade statistics. This is particularly indispensable in analysing transfer phenomena like flow of investments or transmission of shocks. For instance, firms, and countries that are identified as “hubs” due to a high centrality score (resulting from a high number of immediate and secondary connections) influence the cumulative performance of the network due to their disproportionate influence. Similarly, a shock to a specific firm or nation spreads to firms in other countries through the buyer-supplier global value network.

Network analysis approach to GVCs also helps visualize the diffusion of procedural and technological advancements. Central characters play a crucial role in dissemination of knowledge that helps all the other players of the network in upgrading along the value chain. Further research using network analysis can help understand how this diffusion process works and how production networks can enable entry and upgrading in the value chain. The findings of such research can help us to better understand the macro as well as firm-level measures that would be needed to improve the performance of Indian firms in their sectoral global value chains.

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