GLOBAL VALUE CHAINS, A DEVELOPMENT PARADIGM? EVIDENCE FROM THE INDIAN EXPERIENCE

Abstract

Global Value Chains (GVCs) have gained prominence amongst policymakers as a means for developing countries to transition into industrial hubs. This study seeks to evaluate how participating in GVCs have impacted Indian firms and whether this will eventually result in the emergence of a strong manufacturing sector as expected. Unlike majority of the extant empirical GVC literature which is at the country level, this study opts for firms as the primary unit of analysis. Using a rich firm level panel dataset of Indian manufacturing firms, we aim to explore the impact of GVC participation on three important categories of firm level outcomes: *i)* productivity, *ii)* exports and imports, and *iii)* in-house innovation activity. These outcomes give us a clearer idea about whether participation in a GVC automatically translates into a robust manufacturing sector. To correct self-selection bias, we employ propensity score matching (PSM) which allows *a* 'like – for like' comparison. Robust to alternate specifications and subsamples, our estimates indicate that though there exists a positive impact of GVC participation on productivity of firms, the impact on domestic innovation and importing behaviour of the firm is varied. Notably, lack of a significant impact on technology transfer, coupled with a decline in domestic innovation efforts indicate a challenge to sustained manufacturing growth if the current nature of engagement persists. By focussing on GVC engagement at the firm level, this study contributes to the firm level GVC literature and the literature on the role of GVCs as an industrial policy in achieving development goals. These findings have great relevance for policymakers as they provide a finer understanding of both the firm level and the broader sectoral impact resulting due to firms integrating in the global economy. These insights can aid in policy formulation that should not be limited to encouraging mere participation of firms in the international market but also but also on designing suitable intervention that mitigate the possible adverse consequences.

Keywords: Global Value Chain, Productivity, Indian Manufacturing

JEL codes: F14, F15, F63, L60, O12

INTRODUCTION

In today's world, global value chains (referred to GVCs hereafter) are integral to any discussion on international trade and investment policy. GVCs lies at an intersection of trade, investment, and development. In a GVC[1], production is sliced across international boundaries for efficiency and gains from each region's comparative advantage. A rapid decline in trade barriers and communication costs has led to a proliferation of GVCs, both simple and complex, especially in the manufacturing sector. GVC in manufacturing involves fragmentation of production into tasks such as procurement of raw materials mined from country *A*, parts and components made in country *B*, which are then assembled in factories in country *C* as per the design and technology provided by a lead firm, which is usually a MNE situated in a developed country *D*. The concept of a value chain was introduced by Porter (1985) - "the full range of interrelated activities required to bring a product from its conception to its end use and beyond[2]." This value chain becomes a GVC when these stages lie across economic territories. All major global brands like Nike, Apple, Walmart are all part of some or the other GVC.

International trade and GVCs have become exceedingly enmeshed, especially for trade in goods. Production is fragmented across international regions, resulting in trade across borders. GVCs have fueled the rapid growth in international trade in goods, with more than 50% of world trade being linked to some or the other GVC (WDR, 2020). Trade in goods is no longer the classic Ricardian exchange of wheat for cloth. Trade in parts and components has replaced trade in final goods. As per the WTO Report (2013), intermediate goods comprise over 50% of exports and 60% of imports in Asia since 2000.

GVC led industrialisation

Over the past few decades, there have been several shifts in the industrialisation strategies prescribed for the industrial development of emerging and developing economies. The export-led industrialisation model replaced the socialist import substitution industrialization (ISI) and infant industry protection model. after the rapid success experienced by the East Asian economies. Since then, export led development has been propagated as the primary model of industrial development. Despite the global financial crisis of 2008, the popularity of the role exports in achieving a higher growth trajectory has persisted.

[1] GVC linked trade is referred to as trade in value added, trade in parts and components, production sharing, offshoring, vertical integration etc. in the literature.
[2] https://www.globalvaluechains.org/about/gvc-intro/

With the emergence of GVCs, countries with a deficient capital base do not have to wait long periods to become exporting hubs to catch up with the wealthier nations. They now have the option to industrialise faster by specializing in some fragment of the value chain instead of developing the entire chain from scratch. Therefore, it would not be wrong to say that GVC led industrialisation has emerged as a new development paradigm for emerging economies (Taglioni & Winkler, 2016). The growing acceptance of GVC as a development paradigm beyond academic circles is also evident by the increasing importance it has received from international development organisations (IDO) such as WTO, IMF, ILO, World Bank, etc. Flagship publications, conferences, and annual meetings of these international bodies have been dedicated to the role of GVCs and their impact on various facets of the host economies. In this regard, the Chapter 5 of Economic Survey, 2019 - 2020 released by the Ministry of Finance, Government of India (GOI), recommends "that trade policy should actively enable large scale participation in Global value chains of network products to achieve faster export growth that create well-paid jobs for a rapidly growing young workforce like ours" (Economic Survey, 2019).

Why manufacturing matters

Can GVCs be labelled as the new development paradigm? The answer to this question can be understood from the pivotal role occupied by the manufacturing sector in the development and growth literature. Manufacturing has been termed as the traditional '*engine of growth'* in multiple seminal works (Lewis, 1954; Kaldor, 1966 etc.). Rodrik (2009) is of the view that a structural transformation, i.e. shift from "low productivity" (traditional) to "high productivity" (modern) activities, is the only way to ensure that poor countries experience accelerated growth and catch up with their rich counterparts. Convergence theorists have anointed manufacturing sector as the 'ladder' that can bring about this structural transformation. It has also been shown that countries facing de-industrialisation have been unable to raise their incomes. (Rodrik, 2016; Rodrik, 2013). Manufacturing sector is critical, as in the history of the world, there exists very few examples of nations that have gone on to become economic superpowers despite bypassing the manufacturing sector completely.

RESEARCH QUESTION

Against this backdrop, this paper aims to evaluate *the firm-level outcomes resulting from its participation in a GVC. Does joining a GVC eventually help improve the manufacturing sector's growth?* We address this question at the firm level, as importance has shifted from countries and sectors to firms as the primary unit of analysis in the international trade and GVC literature (Bernard et al., 2018; Antràs

& Yeaple, 2014). We analyse the outcomes once a firm decides to be a part of a GVC. However, the choice of these firm-level outcomes are not limited to indicators of firm performance or profitability but those that drive the overall sector's growth and eventually fuel national output. To summarise, this paper examines the firm-level outcomes that provide insights into whether GVC participation is the proverbial silver bullet to obtain a robust manufacturing sector.

THEORETICAL BACKGROUND AND REVIEW OF LITERATURE

GVC firms are also called *two-way traders,* as they import intermediate goods and then export them in the finished or unfinished stage. The literature that deals with the consequences and outcomes of GVC integration can be viewed as an extension of the extant strand of literature that examines the impact of firms' participation in international markets.

Firm Heterogeneity in International Trade

International trade theory has undergone a change, with firms taking centre stage compared to countries and sectors, as was the case earlier (Bernard et al., 2018). This change was deemed necessary as a large volume of empirical literature, based on real world data, showed different results than the theoretical models. In the early 1980s, concepts of increasing returns to scale, imperfect competition and product differentiation were added to traditional trade general equilibrium models which were then popularly named *'new trade theory'*. Thus, an element of industrial organisation was incorporated into traditional trade theory (Markusen, 2002). However, even these so called 'new' trade theories assumed away firm heterogeneity within each sector. Eventually, this led to the development of '*new' new trade theory* models that incorporated firm-level heterogeneity (Baldwin, 2005).

Studies that empirically estimated the association between exports and firm-level productivity encouraged trade economists to incorporate firm-level heterogeneity in their models. Consequently, there was a rapid increase in scholarly work that incorporated firm heterogeneity (Melitz, 2003; Helpman et al., 2004; Baldwin, 2005; Bernard et al., 2007). However, the Melitz (2003) firm heterogeneity model is the most pioneering work in this strand of literature. These theoretical models used the results obtained from real-world empirical studies on exporting and firm outcomes and incorporated those findings into trade theory. These models provided the foundation for several testable hypotheses for future researchers to add to the theoretical and empirical international trade literature.

GVC research – a background

GVC research presents a confluence of micro (firm), meso (industry), and macro (country) factors. The MNE firm, state, local firms, and industrial policy are critical actors in this framework. It goes beyond the performance outcome of private firms (unlike in the International Business literature). It aims to bridge the link between firm performance and the larger picture of policy relevance (Gereffi, 2019). Therefore, it presents a fertile ground for interdisciplinary research in various domains such as international economics, industrial organisation, international management, and development. GVC analysis can be linked with several earlier theoretical traditions. All these theories essentially deal with modernisation with the creation of a hierarchical and interdependent 'core' and 'periphery' (Gereffi, 2018, pp. 2–5). However, any further theoretical discussion is beyond the scope of this paper. Contemporary GVC research in mainstream economics is conducted at the country or the sectoral level using the Trade in Value added data or the Multi-Region Input Output (MRIO) tables. However, there has also been a steady rise in the number of firm-level studies in the GVC literature, which utilise detailed firm-level micro surveys to get a clearer idea of the impact of GVC at a firm level. (For a detailed discussion, refer to the literature review section.)

GVC activity of firms

Participating in the international market can have positive and negative effects on the domestic firms of a host economy (refer to Wagner, 2007 for review). In the same manner, it may seem intuitive that the participation of a domestic firm in a GVC would lead to several consequences due to access to new markets, improved technology, and cheaper raw materials. As a result, several cross-country and sectoral-level studies have tried to estimate the extent of gains from GVC participation (if any) (For review, refer to Amador & Cabral, 2016; Criscuolo & Timmis, 2017). At the macro level, the most frequently used indicator of GVC participation at the country level is the share of foreign value added (FVA) and domestic value added (DVA) in a country's gross exports. These are calculated using global input output tables. For this purpose, the widely used databases are World Input-Output tables (WIOD), Trade in value added (TiVA) by OECD and Eora global supply chain database by University of Sydney. In contrast, compared to studies at the country level, GVC research at the firm level to empirically verify the consequences of participation are relatively few in number. This strand of firm-level studies relies on theoretical principles and foundations similar to those that explain the difference between exporters and non–exporters. Here, the focus shifts from exporters and non-exporters to GVC and non-GVC firms. The extant

literature linked to the consequences and factors affecting GVC participation of firms are mostly based in the developed world. (Baldwin & Yan, 2014 for Canadian firms) or in Latin American and East Asian economies for developing countries. (Del Prete et al., 2017 for North African firms; Montalbano et al., 2018 for Latin American and Caribbean firms) with some based in China (Lu et al., 2018). Firm-level studies based out of emerging economies like India, albeit increasing in recent years, are relatively scarce despite the vast scope to study the impact of GVC integration. The following section briefly reviews the related literature based on India.

INDIA-BASED STUDIES

As discussed in the previous section, there is a steady rise in work that study various dimensions of GVC participation and its implications. However, similar studies of the consequences of GVC participation set in the Indian context are a relatively recent phenomenon (the next section provides a brief review). Most studies in this domain have been published after 2020, with only a few making significant contributions. Given the relatively nascent stage of research in this vital area, ample scope exists for a deep dive into this critical albeit underexplored domain.

The following section briefly reviews the firm-level studies based on Indian firms.

Determinants of GVC participation

Most of the work published regarding the factors that determine a firm's decision to participate in a GVC is by Reddy et al. (2022, 2021a, 2021b, 2020). Reddy et al. (2022) examine the relationship between the growing servicification of manufacturing firms and their GVC participation and exit. Further, Reddy & Sasidharan (2021a) and Reddy et al. (2021b) estimate the role of financial constraints and firm level innovation in the GVC participation of firms respectively. The effect is studied separately for high-tech and low-tech firms.

Consequence of GVC participation

Mallick & Yang (2013) empirically estimate the evidence for self-selection vs learning by exporting for firms that participate in the export market. The study examines how productivity varies for a firm post entry in the exporting market and whether its exit from the market is caused due to a decline in productivity. Banga (2022a, 2022b, 2023) has published several papers on the various firm-level outcomes of participation in a GVC network. Few papers have examined the impact of GVC participation on firm-level productivity in the form of Total Factor Productivity (TFP) (Banga, 2022a; Reddy & Sasidharan, 2024). Both studies conclude that GVC embeddedness positively impacts firm-level TFP. Banga (2022a) also adds that the nature of the value chain's

governance also determines the impact on firm TFP. Firm age and firm liquidity are also important determinants. Banga (2022b) empirically examines the role of digital capabilities as the driver of product upgradation in GVC firms using product-level data. Digitally capable GVC firms have increased product upgradation. Banga (2023) finds that linking into a GVC significantly improves product sophistication. This may be true due to the 'learning by exporting' effect.

GAPS IN LITERATURE

It is evident from the previous section that there is an overall shortage of firm-level studies on the impact of GVC participation on Indian firms, particularly within the manufacturing sector. Given the crucial role the manufacturing sector plays in attaining the development goals of a nation, this study focuses exclusively on this sector. Most studies on the consequences of firm level GVC participation primarily focus on a singular outcome, like a cause-and-effect story, with little or no emphasis on the larger picture. Against this background, we aim to fill this gap in the extant literature. Concerning productivity outcomes and the methodology used, this study aligns itself most with Banga (2022a) albeit using a slightly different time period and sample. However, we also analyse a host of other firm-level outcomes to get a comprehensive idea of the impact on the overall sector. Furthermore, this study does not limit itself to analyzing the productivity impact of GVC participation alone. We take an additional step by incorporating how FDI moderates this relationship, which is a novel contribution to GVC productivity literature. Therefore, to summarise, the objective of this study is to explore the impact of GVC participation on several firm-level outcomes, instead of a singular outcome. By taking this approach, we aim to gain a clearer understanding of whether GVC participation contributes to increased growth of the Indian manufacturing sector.

FIRM LEVEL OUTCOMES

Given its importance on the growth of a sector, we focus on the following three broad categories of firm level outcomes - Productivity Impact, Domestic Innovation efforts and international activities of the firm. The following section explains each outcome and the theoretical basis that drives our empirical approach.

1) PRODUCTIVITY IMPACT (TFP)

One of the primary outcomes we are interested in is the impact on productivity or total factor productivity (TFP) that firms experience as they become a part of a GVC. Productivity is one of the principal drivers of growth in the economic growth literature (Jorgenson,1991). Several studies

(e.g., Hall & Jones 1999; Easterly & Levine ,2002 etc.) have highlighted that total factor productivity (TFP) can explain the differences in per capita income across countries more than traditional drivers of growth such as capital accumulation. (Narula & Driffield, 2012).

The impact that international trade and liberalisation have on aggregate productivity has always been a critical area of interest for researchers (Bøler et al., 2015). Several theoretical and empirical papers have highlighted intermediate input trade liberalisation cause significant productivity gains (see Amiti & Konings, 2007; Kasahara & Rodrigue, 2008, Goldberg et al., 2010; and Topalova & Khandelwal, 2011). Compared to other outcomes, more literature exists on the relationship between GVC participation and productivity. These can be grouped into cross country sectoral level analysis using input-output tables (see Constantinescu et al., 2019; Pahl & Timmer, 2020), qualitative analysis using case studies of a particular industry or firm (Miroudot et al., 2013) and lastly studies employing firm micro surveys (see Baldwin & Yan, 2014 for Canadian firms). Regarding studies based in India, recently, some scholars have examined the productivity gains associated with GVC participation for Indian firms (manufacturing and in general) (Banga, 2022a; Reddy & Sasidharan, 2023). Concerning the impact on firm level productivity, this study also adds to this existing body of work.

Participating in a GVC can impact a firm's productivity via several channels. These are primarily similar to the ones documented in FDI spillover literature. However, unlike spillovers from FDI on the host economy firms, which is an externality, this productivity gain is a direct outcome of a firm's decision to participate in a GVC. The most obvious is the lowering of costs due to access to cheaper intermediate inputs, which drives down the cost of production. Hyper specialisation allows firms to focus on a few tasks they are good at and exit from tasks they do not have competency in, thereby benefitting from economies of scale. GVCs result in the improved capability of firms as they have access to updated technology, managerial practices and stringent quality checks enforced by the lead firm. Productivity gains can also occur through the diffusion of knowledge to employees by exposing them to the latest techniques, training and upskilling. Moreover, gains in productivity can also force inefficient firms to exit the market, improving the existing firms' market share.

1.1) MODERATING ROLE OF FDI

MNE led development has traditionally been synonymous with FDI led development. However, in the contemporary context, FDI is no longer the sole mode of interaction with firms with foreign markets due to growing importance of non-equity modes of transaction. Therefore, FDI led

development and MNE assisted development can been seen as distinct from each other (Narula & Dunning, 2010). Incoming FDI resulting in a "spillover" on the host economy's firm is an area that is well documented. Its sensitive nature makes it one of the most contentious topics in academic as well as policy circles (Narula & Driffield, 2012). Extant literature has studied the impact of FDI on a whole host of variables like domestic firm productivity, technology transfer, participation in the exporting markets, etc. (*for detailed review*, refer to Görg & Greenaway, 2004; Crespo & Fontoura, 2007; Rojec & Knell, 2018). However, the literature on this topic is mainly inconclusive, as the results are very context specific. With this background, as an extension to our initial specification examining the impact of GVC participation on TFP, we also check the moderating effect of incoming FDI on this relationship. The productivity impact of inward FDI on firms of the host economy has been well documented in the extant literature. The established channel of this spillover is through backward integration, i.e., firms that act as suppliers to these MNE firms (Javorick, 2004; Blalock & Gertler, 2008). Since GVC firms in India are also essentially supplier firms to the offshore located FDI firm or through arm's length trade, therefore, this study also aims to assess whether incoming FDI enhances or diminishes the productivity effect of GVC participation.

2) DOMESTIC INNOVATION (in-house R&D activity)

The world is rapidly moving towards a knowledge-based economy, which makes innovation and the investment to enhance technological capacity a vital determinant for a firm's survival. This is important not only from the point of view of a firm. Technological capacity is an essential influence on a nation's competitiveness in the international market, determining its future growth prospects (Kumar & Aggarwal, 2005). R&D is an important driver of future productivity growth and an important factor that helps a country unleash the endogenous growth process and achieve higher per capita income (Shepherd, 2017). In India, the main drivers of R&D have been publicly funded research institutions, with the private sector usually taking a backseat. This trend has become more pronounced after the opening up of the Indian economy after the 1990s due to reliance on imports.

Against this background, the second crucial firm-level outcome we analyse is the impact on domestic innovation efforts of firms due to participation in GVCs. Despite the long gestational lag, higher sunk costs, and greater uncertainty, private sector efforts for R&D are essential along with those of the public sector. Private R&D expenditure is recognised as a crucial driver of economic growth in the micro and macroeconomic literature. (see Baumol, 2002; Jones, 2002; Ortega-Argilés et al., 2010).

Private R&D investment undertaken by corporate firms is not just essential for innovation in production; it is vital for enhancing the firm's ability to absorb and assimilate gains from interaction with the global market, which can translate into future productivity gains. (Bhattacharya et al., 2021). R&D is also an indication of process upgradation within a GVC. Upgrading need not be limited to product upgrading but can also be an improvement in the processes by using improved technology and means of production. Firm-level literature exists on how international sourcing of intermediate goods can act as a conduit for further innovation. In some developed countries like Denmark, offshoring frees labour to be assigned to innovation-linked tasks (WDR, 2020). There also exist studies based in the developed world that are of the view that R&D and international outsourcing are, in fact, complementary (Bøler et al. (2015) in Norway).

However, the impact on firm-level R&D due to GVC integration on firms from developing countries may be contrary to the impact in the developed world. GVC is characterised by a geographic segregation of pre-production tasks like R&D design and the actual production and post-sale services (Buciuni & Pisano, 2021). As a relatively recent entrant into the GVC system, India primarily attracts labour-intensive manufacturing due to the availability of surplus labour in which there is limited scope for innovation. Therefore, we expect that participation in GVC may act as a detriment to local innovation, indicating a lack of upgradation and, therefore, presenting a limited scope of gains via the innovation channel.

3) INTERNATIONAL ACTIVITY OF FIRMS

Next, we proceed to study the international activities of a GVC firm in some detail. The three main categories of international activities of a firm we study are – exporting intensity, import of capital goods and import of raw materials by a firm. Similar to the linkages in FDI, importing intermediate goods by GVC firms implies backward participation as there is value addition in the firms' export from the imported inputs. Additionally, exporting by GVC firms is an indicator of forward participation in a GVC (Antras, 2020).

3.1) EXPORTING INTENSITY

The popularity of export-led development as a step to rapid growth, has made exports of firms a vital area of research, primarily due to its links with productivity (for a brief review, refer to Wagner, 2007). Given how recent research has shifted its focus from just exporting to what one is exporting. Ideally, the more relevant question to be explored would have been whether the GVC participation of a firm leads to upgradation in its export basket (for e.g. Harding & Javorcik (2012)

in the case of FDI). However, such an exercise is beyond the scope of the current study due to data limitations. Nevertheless, even though it may seem intuitive, it is a useful exercise to empirically validate whether GVC participation increases the exporting intensity of firms. In this study, we have taken the combined value of exports of goods and services together, as it is commonly observed that services can be embedded into manufactured output (e.g. software) or vice versa, i.e., services embedded in the products sold (e.g. post-sale services). We expect a greater increase in the exporting intensity of GVC firms compared to non-GVC firms as, by definition, it leads to greater participation in the world market.

3.2) IMPORT OF CAPITAL GOODS and RAW MATERIAL

A firm's technological activity is not limited to innovation via R&D. At the firm level, there are three main channels of technological acquisition: domestic in house R&D, purchasing technology through licensing and royalty payments to foreign firms (disembodied technology), and import of capital goods (embodied technology).

R&D is a costly exercise with several risks involved. Therefore, in developing countries where capital is scarce, the principal way of acquiring capital is via imports – either embodied or disembodied imports (Kumar & Aggarwal, 2005). The idea of innovation in emerging economies may differ from that in the developed world as it is mainly about process innovation rather than product innovation (Shepherd, 2017). Growing trade liberalization has made it much cheaper for a firm to import technology rather than innovate it, also called as '*innovation by imitation'*. Some innovation may be needed to absorb the technology as per the local requirements.

Importing capital goods (embodied technology) leads to domestic productivity gains in two ways. They have a direct impact due to their role in the production process and impact indirectly through the practice of 'reverse engineering', which is commonly observed in firms from emerging markets (Connolly, 2003).

We aim to explore if GVC participation leads to an increase in the import of capital goods, as it is an essential factor that improves domestic output through the abovementioned channels. This analysis aims to understand better whether participation in a GVC leads to improvement in the technological profile of the firm in terms of the import of embodied technology. It is said that robust inter firm relationships make GVC an ideal vehicle for technological transfer along the chain. There exists a common interest to share technology and learnings (WDR, 2020). Typically, Indian firms prefer the route of technology imports compared to R&D for acquiring technology.

As explained in the above section, we expect a decline in the in-house R&D activities, therefore we expect to see a rise in imported technology as a compensation for this decline. This is plausible as GVC integration can lead to greater import of capital goods from lead firms.

As the next step, post analyzing the impact on the import of technology, we study a firm's dependence on imported raw materials as well. Does the nature of imported goods for GVC comprise of importing only intermediate goods and raw materials with no significant improvement in the technological profile? To answer this, we will also analyse the impact on the import of raw materials as another outcome of GVC participation of firms.

Raw materials are the inputs (commodities, parts or substances) used in a product's manufacturing, transformation or assembly process. The inputs a factory purchases, have gone through some prior processing, basically intermediate goods.

Finally, drawing on this background from the extant literature, Table 1 summarises the various firm-level outcomes this study focusses on and their expected direction of relationship.

Table 1: Summary of outcomes and expected direction of relationship

	Outcome	**Expected direction of relationship**
Productivity Impact	**TFP**	Positive
	TFP*	Positive
Domestic Innovation efforts	**R&D efforts**	Negative
International Activity of Firms	**Exporting intensity**	Positive
	Import of Capital goods	Positive
	Import of Raw Material	Positive

*Note: * refers to the combined influence of GVC participation and incoming FDI on TFP*

METHODOLOGY

Data Source and Variables

The data for firm-level factors are obtained from the PROWESS database maintained by the Centre for Monitoring Indian Economy (CMIE). The CMIE-PROWESS database is one of India's largest and most popular firm-level databases. It comprises firm-level financial information on sales, compensation of employees, capital used, R&D expenditure, exports, imports, ownership details and other critical variables compiled from audited annual reports. The firms in the database are publicly listed and unlisted companies in India. Most of the firms in this database are private or affiliated with a business group, with a smaller subset of foreign or government owned. The firms covered by the PROWESS database account for over 75% of corporate taxes and over 95% of excise duty collected by the Government of India (De & Nagaraj, 2014). However, Prowess cannot be considered as a census of all the companies operating in India.

Furthermore, firms in the prowess database represent about 50% of India's exports and nearly 60% of imports. This database is used extensively for firm-level studies based in the Indian context (Topalova & Khandelwal, 2011; De Loecker et al., 2016; Stiebale & Vencappa, 2018). These studies primarily use the CMIE Prowess database instead of the Annual Survey of India (ASI) published by GOI. The reason is that the Prowess database comprises a panel of firms, which makes tracking firms over time easier, whereas ASI is a cross-sectional survey of firms, which makes it impossible to monitor the changes in a particular firm over a period of time.

For incoming greenfield FDI, we use the CapEx database maintained by the Centre for Monitoring Indian Economy Pvt. Ltd (CMIE). Some recent literature that studies facets of different investment categories (public, private or foreign investment) have used this database (Chakrabarti et al., 2017; Bahal et al., 2018). The CMIE CapEx database includes all capital projects in India that are above the investment level of INR 10 million (approximately USD 120,300). CapEx compiles project level data on "investment projects that involve setting up 'new capacities' from domestic and foreign sources from public, private and foreign investors. The database has details of two categories of investment 'New Unit' and 'Substantial expansion'. A new unit implies starting a unit from scratch, equivalent to a greenfield investment. It also captures other variables of interest, such as cost, industry, ownership type, the status of completion, stalled/shelved projects, etc. Most studies in India utilise total FDI equity inflow data available at the sectoral level from the Reserve Bank of India (RBI) Bulletin or the FDI newsletters from the Department for

Promotion of Industry and Internal Trade[3](DPIIT). However, this can lead to overestimation, as FDI equity inflow may not always translate into actual tangible investment at the ground level.

Dataset creation

Although the firm-level and investment data from our databases is available at the five-digit 2008 National Industry Classification (NIC) level, we aggregate firms at the two-digit NIC code level due to relatively few firms in such a granular grouping (Topalova & Khandelwal, 2011). This study focuses on the manufacturing sector per the NIC 2008 classification. This corresponds to 22 industries, i.e., from NIC 2008 code 10 to 32. Table A1 in the appendix consists of all the NIC codes and industry names which are a part of our sample. We create a detailed firm level panel data using the following steps. In the beginning, we extract data for the subset of all manufacturing firms available in the CMIE Prowess database **for the period of 2001 to 2020**[4]. We observe that the firm level data contains industry codes not part of the that are manufacturing sector as per the NIC 2008 codes (10 to 32). As our study pertains to GVC participation in the manufacturing sector, we apply an additional filter for firms with 2-digit industry codes from 10 to 32. As part of our data cleaning process, we remove duplicates and exclude observations with missing and negative values of sales.

In the CapEx database, we initially begin with the sample of foreign capital investment dataset. We aggregate FDI investment at 2 digit NIC 2008 industry-year level for all completed projected from 2003 to 2019. We use only those projects whose status is "completed", and the type of unit is "New Unit", indicating a greenfield foreign investment. For the industry where the foreign investment is missing in a year, we assume there is no inward FDI in that particular year, i.e., it takes the value zero. We merge this dataset with the firm level dataset to obtain our final sample dataset.

As our sample size is relatively small, we winsorise the variables at 1% or 0.1% to reduce the impact of outlier values without losing out on observations. The final unmatched sample comprises an unbalanced panel of 15,597 firm-year observations and 2,272 firms from 2001 to 2020[5]. Due to changes in the reporting format of financial statements, certain important variables can be calculated only from 2012 onwards. This limits the time period of our estimation sample from

[3] https://dpiit.gov.in/publications/fdi-statistics. Total FDI equity inflow includes FDI inflows received through FIPB, RBI's Automatic route and the acquisition of existing shares

[4] Years correspond to financial years not annual year

[5] The number of observations will reduce in the matched sample post the PSM exercise

2012 to 2020[6]. This truncated version of the unmatched sample comprises 8,216 firm- year observations and 1,831 firms for the time period 2012 to 2020. The time period chosen does not exceed 2020 as there was major supply chain disruption due to the pandemic in 2020. Additionally, the Production Linked Incentive (PLI) scheme was notified by the Indian Government in April 2020 which would have had an impact on GVC participation[7].

INDEPENDENT VARIABLE

GVC firm identification

In this study, our main variable of interest is the identification of a firm that is part of a global network of production and trade, i.e., a GVC. Based on recent literature, we identify firms involved/participating in GVC as two-way traders, i.e., the ones who import intermediate goods (raw materials, stores and spares) and export intermediate and final goods (Baldwin & Yan, 2014; Banga, 2017). Therefore, a firm's participation in a GVC is captured using a dummy variable which takes the value of 1 if it is a two-way trader, i.e., it undertakes both imports and exports at the same time period (Baldwin & Lopez-Gonzalez, 2015; Antras, 2020; World Bank, 2020). Thus, two-way trading firms, which is an indication of production fragmentation, are categorised as GVC firms. (Del Prete et al., 2017; Ehab & Zaki, 2021; Reddy et al., 2021). Consequently, all one-way traders and firms who do not participate in the international market (via import and export) and serve the domestic market are categorised as non-GVC firms. This aligns with the identification criteria for GVC participation at a firm level, followed by recent studies in the Indian context using the PROWESS database (Banga, 2022; Reddy et al.,2022). Estimating an industry or country's extent of participation in GVC would have been possible through value-added trade data. However, such data is not available at the firm level for India.

TFP CALCULATION

One of the important variables in this analysis is the firm level total factor productivity (TFP). Although the origin of TFP analysis can be tracked to the seminal work by Solow (1957), there is a recent surge in empirical and theoretical studies using TFP due to both greater data availability and methodological improvements (Van Beveren, 2012). TFP is a complex measure to estimate,

[6] Since April 2012, Indian companies present their financial data in the new disclosure format given in the Schedule VI of The Companies Act, 1956, which is in accordance with the IFRS requirements. Due to this change in the reporting format, the leverage variable (long term debt/current asset) can be calculated from 2011 onwards. Hence, the sample time period after leverage is added as a control changes from 2001-2020 to 2012-2020. We have incorporated both versions (with and without leverage as control)

[7] PLI Scheme details: https://www.meity.gov.in/writereaddata/files/PLI%20booklet__english.pdf

given the wide range of input variables required for its calculation (Yang & Mallick, 2010). The traditional OLS method of calculating TFP via the Cobb-Douglas production function suffers from the problem of simultaneity bias due to ex ante and ex post productivity shocks. These productivity shocks may determine how much input is used by a firm. This leads to biased estimates of productivity. To overcome this simultaneity issue, the standard procedure in literature is the estimation of TFP using one of the non-parametric methods (Olley & Pakes, 1996; Levinsohn & Petrin, 2003; Ackerberg et al., 2006). The most popular measure in the firm level productivity literature is the TFP estimate by Levinsohn & Petrin (2003). In this study, we use the LP method in our main specification and subsequently introduce the ACF method as an additional robustness check. In the LP approach, a firm's energy inputs are used as a proxy for these productivity shocks. The LP method is an improvement on the Olly Pakes method, which uses investment as the proxy for them. Despite the limitations of the TFP estimate using the LP and other similar measures[8], we still use it as it is the best that is available to us and is the standard practise in the TFP literature. We utilise the '*levpet'* Stata package developed by Petrin et al. (2004), which provides us with the TFP estimate using the LP approach. As the *levpet* package also starts with the Cobb Douglas production function, before estimating TFP, we need to calculate several firm level factors as inputs for the command. We follow the standard way of calculating these as in the firm-level literature on productivity utilising the PROWESS database.

Real Value Added (output): TFP can be estimated using sales or value added. The standard estimation prefers using value added due to double counting issues. Therefore, we use real value added as the firm's output. We follow the variable construction used by De & Nagaraj (2014). Firstly, gross output is calculated by adjusting firm level sales for changes in inventory and purchase of finished goods. Gross output is then subtracted from all intermediate inputs (nominal values), sum of raw material, stores and spares, fuel and energy, etc., to obtain nominal Gross value added (GVA). To obtain real value-added, we deflate nominal GVA with WPI series for the manufacturing sector at 2011 prices[9]

Labor: The data on the number of workers in a firm is not well populated in Prowess as it is not mandated by law for firms to disclose their number of employees. Therefore, using the standard practice followed in the literature that calculates TFP (De & Nagaraj, 2014; Rath, 2018), we use the Annual Survey of Industries (ASI) data published by the Government of India. Since ASI also

[8] TFP measure using semiparametric techniques suffer from limitations strict underlying assumptions, price and quantity biases (for detailed review refer Van Beveren (2012).

[9] Obtained from the Office of the Economic Advisor, Ministry of Commerce and Industry, GOI (https://eaindustry.nic.in/download_data_1112.asp)

reports industry details, we calculate the average wage rate at the industry level by dividing total emoluments by total employees for each industry.

$$Industry\ wage\ rate = \frac{Total\ emoluments}{Total\ persons\ engaged}$$

This data is merged with the prowess data at the 2-digit industry level. The compensation to employees (salaries and wages plus other social security benefits) reported by each firm is divided by this average wage rate at the industry level, which was calculated using ASI data to obtain firm level labour estimates.

$$No\ of\ employee\ (labour\ estimate) = \frac{Compensation\ to\ employees\ (firm\ )}{Industry\ wage\ rate}$$

Capital: A firm's capital stock is constructed using the method followed by Balakrishnan et al., (2000) which is based on Srivastava (1996) with some modifications. The value of capital as recorded in a firm's balance sheets, that is the gross fixed asset, is at historical costs, which is to be converted into current prices. Therefore, an adjustment in the capital stock estimation at the firm level is required. For this purpose, we calculate a revaluation factor (r^f) following Kato (2009) and Srivastava (1996). This r^f converts capital in the base year to values in the current prices. Once capital stock is estimated for the base year, following the perpetual inventory mechanism (PIM), we can estimate the capital stock for all points of time. As per PIM, capital stock for every time period is the sum of the capital stock of all the previous periods with an annual economic depreciation rate of 7%. To obtain the real capital values, the nominal value of capital is deflated using the implicit price deflator for fixed capital formation constructed using the gross capital formation (GCF) series[10].Details of the calculation of the r^f and capital stock estimates is included in the Appendix. For additional details, refer to the methodology followed by Topalova & Khandelwal (2011).

Intermediate Goods: Intermediate good is the sum of raw materials, fuel and energy, and depreciation. The nominal value is then deflated by Fuel and Power WPI for fuel and power expenditure and overall WPI for depreciation and raw material, respectively, to obtain the corresponding real value.

Summary Statistics of all the important variables used in the study is provided in Table 2. Table A2 in the appendix details the construction and the references for all the other variables used in the study.

[10] GCF series obtained from the NSO NAS. Implicit price deflator=GFCF at current prices/GFCF at constant prices

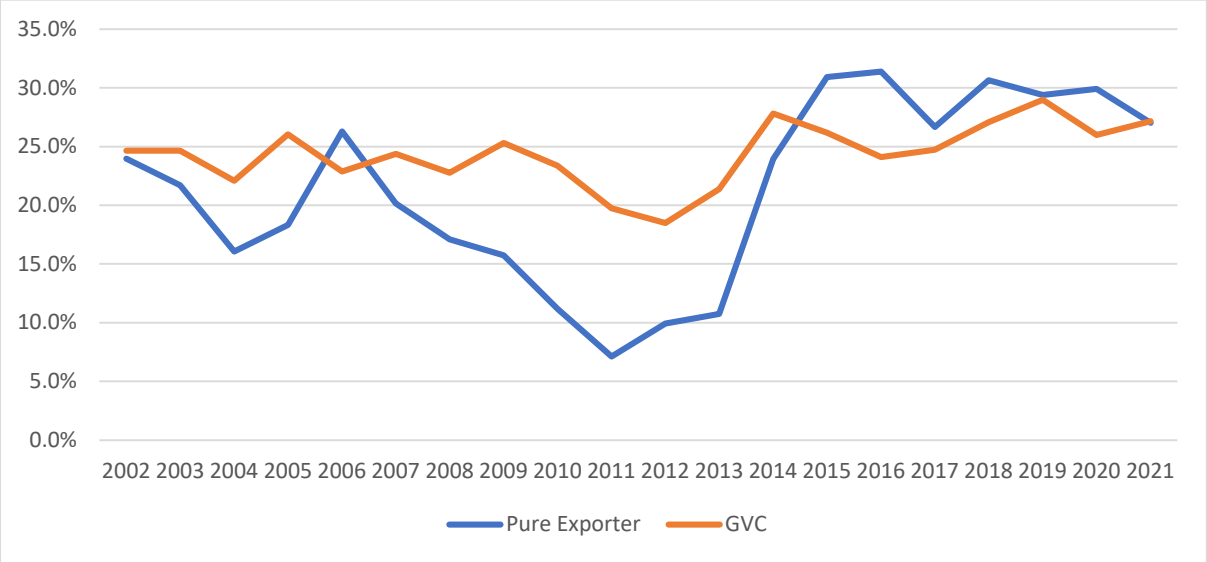
DESCRIPTIVE STATISTICS

Table 2: Summary Statistics

Variable	#	Mean	Std. Dev.	Min	Max
GVC Status	8,216	0.30	0.46	0.0	1
Firm Age	8,216	38.28	20.34	10	143
Firm Size	8,216	8.74	1.78	2.53	16.27
TFP (LP method)	8,216	0.53	0.45	0	9.34
TFP (ACF method)	8,216	0.22	0.19	0	4.14
Import of capital goods/Sales	856	0.02	0.03	0	0.28
Leverage Ratio	8,015	0.14	0.16	0	0.92
Imported Raw material/Total raw material purchased	8,195	3.57	12.13	0	75.84
R&D/Sales	8,216	0.00	0.02	0	0.21
Technology intensity (Industry)	8,216	0.48	0.50	0	1
Industry competition	8,216	0.90	0.11	0	0.97
Inward greenfield FDI (Industry)	8,216	6841.25	12776.52	0	73600

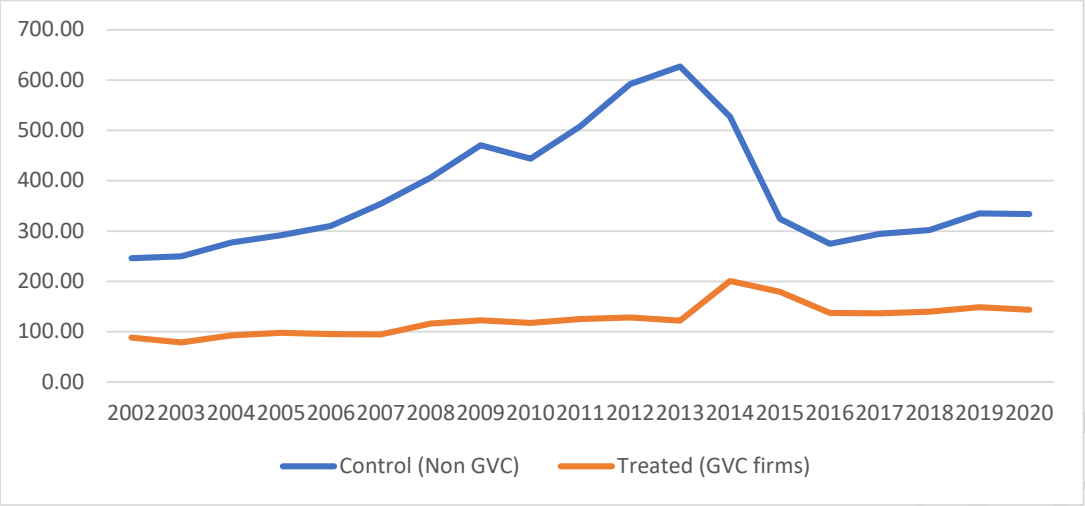
Note: This is based on the unmatched sample

Figure 1: Trend of exports earnings as a percentage of sales for GVC and Exporting firms



Note: This is based on the full unmatched sample. Source: Own calculations

Figure 2: Trend of Real Sales for GVC and Non GVC firms



Note: This is based on the full unmatched sample. Source: Own calculations

ESTIMATION STRATEGY

Propensity Score Matching (PSM)

In order to assess the outcome of a firm in terms of GVC participation, it would be best to compare the outcome of a firm once it is part of a GVC with the outcome if it had not joined a GVC (Baldwin & Yan, 2014). Propensity score matching (PSM), a quasi-experimental technique introduced by the seminal work of Rosenbaum & Rubin (1983), creates a counterfactual group to compare the outcome of the treated firm (GVC firm) with the outcomes of the control group firms (non-GVC firm). This estimation approach is the most useful for carrying out a '*like for like*' comparison between the treated (GVC firms) and untreated (non-GVC firms) groups in the estimate sample. This estimation technique was popularised in firm level literature by Wagner (2002) to study the causal impact of exporting on variables like firm size and productivity of labour. A similar technique of creating a counterfactual control group was used by Mallick & Yang (2013) to compare the productivity differentials in exporter and non-exporter firms. The systemic differences between GVC and non-GVC firms are accounted for by creating a synthetic control group. Moreover, there is a scope of selection bias as inherently productive firms may self-select themselves to participate in a GVC.

Observational data suffers from this problem, and any inference made on the outcome may be erroneous as the treatment group may systematically differ from the control group. Thus, comparing these two groups without intervention can result in biased outcomes. This is why it is essential to take some steps to balance out the kinds of observations that are available in the treatment and control groups. These issues of self-selection can be addressed by the PSM method,

wherein an artificial group is created as the control group. PSM ensures that both groups (GVC firms and non-GVC firms) are balanced in terms of important characteristics. This ensures that any observed effects can be attributed to the treatment itself rather than pre-existing differences between groups. In our case, each treated firm is matched with a firm in the control group, which is similar to that of the treatment firm, except that it was treated (became a part of GVC).

STEP 1: DEFINING THE TREATMENT AND CONTROL GROUP

In this study, we consider the act of a firm entering a GVC as the treatment. For example, if a firm has joined a GVC in the time period *t*, then from *t+1,* it is considered a treated firm even if the export and import data of subsequent years for that firm is missing, i.e., which indicates that it may have temporarily exited the GVC. However, we do not consider this to be an exit[11]. Once a firm enters a GVC, it is considered part of the treatment group, as the missing data may be due to a lack of data reporting The control group consists of the firms that have not entered a GVC even once in the entire time period of the analysis. This definition is similar to the one used by Banga (2022a) and Goldar & Banga (2020). This definition avoids complicating the participation of GVC with entries and exits from GVC, which can be studied in detail as a separate phenomenon.

STEP 2: PROPENSITY SCORE ESTIMATION and MATCHING

To begin with, we obtain the propensity score by choosing factors based on which a firm becomes a part of the GVC. We utilise the user written Stata command of *psmatch2,* popularly used in several studies (latest version being Leuven & Sianesi (2018). The first step is to run a probit estimation by choosing the appropriate variables. Caliendo & Kopeinig (2008) recommend that selected variables to match treatment (GVC firms) and control group (non-GVC firms) should be such that they impact both the decision to participate in GVC as well the outcome variable of interest. We also ensure that the lagged variables are selected instead of contemporaneous to ensure they are exogenous to the treatment (GVC participation in this case). We keep the number of variables selected to the minimum to avoid over parametrisation of the model (Caliendo & Kopeinig, 2008). The propensity score is calculated as the predicted probability of a firm participating in a GVC using a probit estimation. For obtaining the propensity scores, we choose the lagged value of firm specific attributes *size, age, gross value added and the* current value of firm ownership characteristics like *foreign ownership and group affiliation* along with industry and year dummies, based on existing

[11] Topalova & Khandelwal (2011) are of the view that the prowess dataset may not be suitable to study entry and exit of firm as it is not a census of Indian manufacturing firms

literature of variables that determine participation as well have an impact on firm TFP, R&D and export and import behaviour.

$$\boldsymbol{Pr\,(GVC = 1)}$$
$$\boldsymbol{= \emptyset\left(firm\ size_{it-1}, firm\ real\ GVA_{it-1}, firm\ age_{it-1}, foreign\ firm_{it}, group_{it}, \alpha_j, \alpha_t\right)} \quad \textbf{(1)}$$

Using the propensity score, obtained by the estimation of equation (1) we match the firms that have made the transition into a GVC firm with firms which have never participated in a GVC, i.e., never been a GVC firm These two steps are done using the psmatch2 command. As is done by Mallick & Yang (2013), we also utilise the common support option, which drops observations (both treated and control) that lie outside the common overlapping range of propensity score to ensure comparable units in both groups. This improves matching quality. Post matching, we conduct post-matching tests to ensure the covariates are balanced across the treatment and control groups. This is done via the *pstest* command in Stata which is part of the psmatch2 package used above.

Since in this study, we try to evaluate numerous outcomes of the treatment (GVC participation in this case), we run the PSM command multiple times with varying outcome variables; therefore, the matched sample for each outcome is different.

Table 3: Comparison of GVC and Non GVC firms

Variables	Non GVC Firms	Mean	GVC Firms	Mean	MeanDiff
GVC Status	3726	0	3726	1	-1
Firm Age	3726	36.07	3726	36.36	-0.292
Firm Size	3726	8.44	3726	8.37	0.070*
TFP (LP method)	3726	0.50	3726	0.52	-0.019**
TFP (ACF method)	3726	0.22	3726	0.22	-0.003
Import of capital goods/Sales	88	0.02	1266	0.02	-0.003
Leverage	2859	0.14	2922	0.13	0.011***
Imported Raw material/Total raw material purchased	3719	0.88	3690	11.96	-11.081***
R&D/Sales	3726	0.01	3726	0.00	0.001***
Technology intensity of industry	3726	0.52	3726	0.53	-0.009
Industry competition	3726	0.90	3726	0.89	0.001
Inward greenfield FDI	3726	6717.33	3726	6652.46	64.87

Source: Based on the matched Sample (for TFP)

EMPIRICAL FRAMEWORK

PSM – FE

After the creation of the treatment and control groups, we estimate a fixed effect model to account for the unobservable heterogeneity on the matched sample obtained. In order to study the impact of GVC participation on firm level outcomes, we begin by the baseline specification which estimates the following equation using the following model:

$$(\boldsymbol{firm\ outcome})_{ijt} = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}(\boldsymbol{GVC\ status})_{it} + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\varepsilon_{ijt}} \qquad (2)$$

Equation (2) represents a panel fixed effect model. The dependent variable is the firm specific outcome (firm level TFP, R & D efforts, import of capital goods and import of raw materials) for the firm *i*, belonging to industry *j* in the time period *t*. GVC status is a dummy variable (also treatment variable) which indicates whether the firm is a GVC firm. It takes the value of 1 if a firm is a GVC firm. As explained in the previous section, the switch from a non-GVC firm to a GVC firm can occur anytime within the time period. Once a firm becomes a part of a GVC, we treat it as a GVC firm throughout. $\boldsymbol{Z_{t-1}}$ refers to a lagged vector of firm and industry level controls lagged at *t-1* time period to ensure exogeneity. Unobserved heterogeneity may lead to inconsistent estimates. Therefore, the specification includes firm level fixed effects (γ_i) to account for any unobserved heterogeneity at the firm level which does not change over time and time fixed effects (γ_t), which capture any general increase in a firm level outcome over time due to any general policy change at the overall level. We also include an additional industry – time fixed effect γ_{jt} to account for trends in the composition of share of an industry over time.

Estimation of Firm Level Outcomes

Although equation (2) gives us the general baseline equation, we estimate in equations (3) to (8) give the exact specification of the equations we estimate in the following section. The equations indicate the exact firm level outcomes we estimate using this empirical framework. The main variable of interest across all the equations is the GVC status of a firm (treated vs control). Each of these estimations requires matching command to be run separately, as the outcome variable will vary. However, the matching algorithm and the variables selected for the propensity score estimation in all these estimations are kept consistent throughout[12].

[12] However, different matching commands result in different estimate sample sizes.

Productivity Impact

$$(\boldsymbol{TFP})_{ijt} = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}(\boldsymbol{GVC\ status})_{it} + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\varepsilon_{ijt}} \quad (3)$$

$$(\boldsymbol{TFP})_{ijt} = \boldsymbol{\delta_o} + \boldsymbol{\delta_1}(\boldsymbol{GVC\ status_{it}} * \boldsymbol{Incoming\ FDI_{jt}}) + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\varepsilon_{ijt}} \quad (4)$$

In order to estimate the impact of GVC participation on a firm's TFP, we estimate the model specified in Equation (3). Which is the same as equation (2) in terms of specification. The outcome variable of interest is firm level productivity. We use the standard Levinsohn – Petrin (LP) method as a measure for TFP. We also use the Ackerberg Caves and Frazer (ACF) measure of TFP as an additional robustness check. Equation (4) incorporates the moderating role of incoming greenfield FDI on the relationship between TFP and GVC status. For this purpose, the interaction term between these two variables is introduced in the specification. $\boldsymbol{Incoming\ FDI_{jt}}$ is a continuous variable that measures the incoming greenfield FDI in industry *j* at time period *t*.

In house Innovation efforts

$$(\boldsymbol{R\&D\ efforts})_{ijt} = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}(\boldsymbol{GVC\ status})_{it} + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\varepsilon_{ijt}} \quad (5)$$

Equation (5) estimates the impact of GVC status on firms' domestic innovation efforts. $(\boldsymbol{R\&D\ efforts})_{ijt}$ is taken as (R&D expenditure/Sales) of firm *i* in industry *j* for time period *t*. As per the Companies Act,1956, there is no mandatory disclosure for R&D expense if it is less than 1% of the total turnover. For companies that do not report any R&D expenses, we assume that they do not make any, as the amount would be negligible anyway, which is a reasonable assumption to make.

International activity – Exporting and Importing Decisions

$$(\boldsymbol{Export\ earnings\ /\ Sales})_{ijt} = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}(\boldsymbol{GVC\ status})_{it} + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\mu_{ijt}} \quad (6)$$

$$(\boldsymbol{Import\ of\ CG\ /\ Sales})_{ijt} = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}(\boldsymbol{GVC\ status})_{it} + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\epsilon_{ijt}} \quad (7)$$

$$(\boldsymbol{Imported\ Raw\ Mat\ /\ Total\ Raw\ mat\ purchased})_{ijt} = \boldsymbol{\beta_o} + \boldsymbol{\beta_1}(\boldsymbol{GVC\ status})_{it} + \boldsymbol{Z_{t-1}} + \boldsymbol{\gamma_i} + \boldsymbol{\gamma_t} + \boldsymbol{\gamma_{jt}} + \boldsymbol{\varepsilon_{ijt}} \quad (8)$$

Equation (6) estimates the impact of GVC status on the exporting activity of firms. Exporting intensity is taken as (Exports earnings/Sales) of firm *i* in industry *j* for time period *t*. The Prowess database includes detailed information about the category of imports – import of finished goods, intermediate goods and capital goods. We make use of import of capital good as a proxy for import of embodied technology. Although, Prowess does not specify the country of origin of the import, it is reasonable to assume that its source will be an advanced economy in which a lead firm of the GVC is situated. In equations (7) and (8), importing activity undertaken by a firm is broken down into the import of capital goods and the import of raw materials. In equation (7), the import of capital goods is expressed as a share of sales for firm *i* in industry *j* for the time period *t*. However,

in equation (8), the import of raw material is captured as a share of imported raw material in the total raw materials purchased by firm *i* in industry *j* for time period *t*[13].

[13] This variable gives us a better indication of the dependence of a firm on imported raw material

RESULTS

In this section, we report the findings obtained after estimating the Equation 3 to 8. The tables comprise the estimates of our main variable of interest (i.e., GVC status) on the matched sample obtained after the PSM procedure. This captures the effect of GVC participation on firm level outcomes such as TFP, domestic innovation efforts and the export and importing activities of the firm.

I) TFP impact

The results from estimating equation 3 are presented in Table 4

Table 4: PSM – FE model: Productivity impact of GVC participation

		No Controls	+ controls	+leverage	+ industry - year FE	Unmatched
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	TFP (LP)	TFP (LP)	TFP (LP)	TFP (LP)	TFP (LP)	TFP (LP)
GVC status	0.019**	0.037**	0.051***	0.032	0.049**	0.016
	(0.009)	(0.016)	(0.020)	(0.024)	(0.024)	(0.019)
Firm Age t-1			0.019**	0.005**	0.031	0.046
			(0.008)	(0.002)	(0.054)	(0.160)
Firm Size t-1			-0.013	0.032***	0.029**	-0.014
			(0.009)	(0.012)	(0.012)	(0.010)
Leverage t-1				-0.170***	-0.176***	-0.223***
				(0.037)	(0.037)	(0.031)
Industry competition			-0.007	0.158*	0.492	0.587
			(0.075)	(0.083)	(1.499)	(5.547)
FIRM FE	NO	YES	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES	YES	YES
INDUSTRY - YEAR FE	NO	NO	NO	NO	YES	YES
Constant	0.356***	0.204***	-0.141	-0.104	-1.381	-1.655
	(0.107)	(0.061)	(0.318)	(0.112)	(3.250)	(11.361)
Observations	7,452	7,452	6,312	4,777	4,777	8,216
R-squared	0.008	0.064	0.062	0.061	0.149	0.200
Number of firms		1,967	1,786	1,542	1,542	1,831

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 reports the results obtained by estimating equation 3 that modelled TFP as an outcome of GVC participation. Columns (1) to (5) represent estimates obtained using the matched sample using the PSM procedure explained in the previous section. Column (1) reports the estimates of

the effect of GVC participation on firm level productivity (TFP) from a simple bivariate model that takes care of year effects only. The opening up of the economy and increasing waves of globalisation imply a general increase in firms entering GVC and a general improvement in firm productivity, which makes it important to control for the effects of time. Column (2) eliminates firm specific fixed effects without adding any controls in the specification. Column (3) includes time varying lagged firm and industry level control variables. To some extent, the lagged value of firm-level controls also accounts for reverse causality. As explained previously, due to a change in the reporting format, the variable leverage (long term debt/ current assets) can be calculated only from 2012 onwards, even though the main sample is from 2001. As the financial health of a firm is a crucial control variable that impacts both the firm joining GVC and its productivity, we introduce it as a separate control in Column (4).

Meanwhile, the specifications in columns (2) to (4) have accounted for unobserved firm and time-varying heterogeneity. We introduce industry - year effects to account for changes that occur at the industry level over time. For instance, a particular industry may grow rapidly over time due to favourable policy decisions. We keep Column (5) as our final specification. Our estimates remain robust and significant throughout, indicating a positive and significant relationship between GVC participation and TFP. As per the estimates in the full specification in Column (5), GVC firms have approximately 5% higher TFP than firms not part of a GVC.

Further, the estimates in columns (1) to (5) represent the matched sample, which takes care of self-selection problem. For the sake of comparison, Column (6) includes the estimates for the final specification using the entire unmatched sample, which is insignificant. It can be seen that due to matching, the positive and significant effect on TFP is captured.

I A) The moderating role of FDI

As the next step in our analysis, we test the moderating influence of incoming greenfield FDI at the industry level on the TFP gain due to a firm's participation in GVC. The Table 5 reports the estimates of Equation (4), which studies the moderating role of FDI.

Table 5: PSM – FE model: Moderating Role of FDI on productivity

	Matched sample	+ind - year
Dependent Variable: TFP(LP)		
	(1)	(2)
GVC status	0.024	0.041*

	(0.024)	(0.024)
Inward greenfield FDI (norm)	-0.000	0.023
	(0.000)	(0.279)
GVC Status X Inward greenfield FDI	0.001***	0.001***
	(0.001)	(0.001)
CONTROLS	YES	YES
FIRM FE	YES	YES
YEAR FE	YES	YES
INDUSTRY - YEAR FE	NO	YES
Constant	-0.128	-2.087
	(0.112)	(8.806)
Observations	4,777	4,777
R-squared	0.065	0.151
Number of firms	1,542	1,542

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Normalised FDI = FDI/1000

Columns (1) and (2) report the estimates of the full specification along with the addition of the interaction term. The positive and significant interaction terms suggest that firms that belong to industries receiving higher incoming FDI experience more gains in terms of TFP by participating in a GVC. In other words, inward FDI acts as a complement to the productivity gains experienced by a firm due to GVC participation. Incoming FDI augments a firm's "productivity premium" when it participates in a GVC.

II) Domestic in-house R&D efforts

The next outcome we analyse is the impact of GVC participation on the domestic innovation efforts of firms. The outcome variable is R&D intensity, which is the ratio of R&D expenses of a firm / Sales. Table 6 reports the results obtained after estimating equation 5.

Table 6: PSM – FE model: In house innovation

	OLS +year effect+ no controls	FIRM FE + year FE +NO CONTROLS	+ controls	+leverage	+all controls + industry - year FE
	(1)	(2)	(3)	(4)	(5)
Dependent Variable: Domestic Innovation intensity = R&D/ Sales					
GVC status	-0.001***	-0.001	-0.001	-0.003***	-0.003***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Firm Age t-1			0.000	0.000	-0.000
			(0.000)	(0.000)	(0.001)
Firm Size t-1			0.001***	0.001*	0.001
			(0.000)	(0.000)	(0.000)
Leverage t-1				0.002	0.002
				(0.001)	(0.001)

TFP t-1			0.001*	0.002***	0.002***
			(0.000)	(0.001)	(0.001)
Industry competition			0.000	-0.001	-0.012
			(0.002)	(0.003)	(0.031)
FIRM FE	NO	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES	YES
INDUSTRY - YEAR FE	NO	NO	NO	NO	YES
Constant	0.002	0.001	-0.010	-0.002	0.028
	(0.006)	(0.003)	(0.007)	(0.004)	(0.082)
Observations	7,134	7,134	7,134	5,555	5,555
R-squared	0.004	0.011	0.015	0.007	0.038
Number of firms		1,895	1,895	1,660	1,660

The table follows the same order of specifications with sequential introductions of a host of firm and industry level controls for the matched sample as in Table 4. We observe that the estimates from Columns (1) to (5) indicate a negative relationship between GVC participation and domestic R&D efforts by firms. The estimates of our full specification in column (5) are negative and highly significant, which implies a decline in R&D efforts by firms once they become a part of GVC. These results align with our initial argument that R&D efforts by GVC firms in India will be impacted negatively due to the geographical separation of pre-production activities like R&D and design from the actual production. R &D is costly. Therefore, GVC firms can spend less on R&D, as they mainly act as per the directives of the lead firms, usually located in an advanced economy. The estimates obtained across specifications are small but highly significant in the same direction, which gives us confidence in our estimates.

III) INTERNATIONAL MARKET ACTIVITIES

Exporting and Importing Behavior

We analyse the impact of GVC participation on the international activity of the firm. International activity includes the importing and exporting behaviour of the firm. Table 7 reports the estimates of equations 6 to 8, corresponding to full specification columns 4 and 5 of Table 4. The table selectively reports only the estimates for the full specification to compare the impact on exporting and importing outcomes.

Table 7:

Dependent Variable:	***Import Raw mat***		***Import of CG***		***EXPORTS***	
	+leverage	+all controls + industry - year FE	+leverage	+all controls + industry - year FE	+leverage	+all controls + industry - year FE
	(1)	(2)	(3)	(4)	(5)	(6)
GVC status	0.195***	0.193***	-0.012	-0.008	0.211***	0.219***
	(0.013)	(0.013)	(0.014)	(0.021)	(0.020)	(0.021)
Firm Age t-1	-0.011***	-0.030	0.007**	0.050***	-0.007***	-0.041
	(0.001)	(0.029)	(0.003)	(0.014)	(0.002)	(0.035)
Firm Size t-1	-0.001	-0.004	-0.048**	-0.028	-0.021**	-0.027***
	(0.006)	(0.006)	(0.019)	(0.021)	(0.010)	(0.010)
TFP t-1	-0.015	-0.015	0.018	0.038	-0.013	-0.022
	(0.009)	(0.010)	(0.022)	(0.029)	(0.014)	(0.014)
Leverage t-1	-0.016	-0.021	0.092	-0.143	-0.026	-0.033
	(0.022)	(0.022)	(0.057)	(0.086)	(0.032)	(0.033)
Industry competition	0.136***	-0.487	-0.042	2.491***	0.021	-0.231
	(0.047)	(0.587)	(0.091)	(0.776)	(0.071)	(0.752)
FIRM FE	YES	YES	YES	YES	YES	YES
YEAR FE	YES	YES	YES	YES	YES	YES
INDUSTRY - YEAR FE	NO	YES	NO	YES	NO	YES
Constant	0.239***	1.587	0.206*	-3.562***	0.375***	1.999
	(0.064)	(1.600)	(0.124)	(1.149)	(0.100)	(1.990)
Observations	5,501	5,501	266	266	5,555	5,555
R-squared	0.113	0.185	0.224	0.874	0.057	0.095
Number of firms	1,653	1,653	143	143	1,660	1,660

Columns (1) to (4) report the estimates indicating the impact of GVC participation on imports of a firm. Columns (5) and (6) study the impact on exporting behaviour. Imports indicate the backward participation of a firm within a GVC. Within the importing behaviour of a firm, the comparison of the nature of imports i.e., importing raw material vis a vis import of capital goods gives us greater insight into the nature of technology building activities undertaken by the firm. Firstly, columns (1) and (2) indicate the impact of GVC participation on the import of raw materials, whereas columns (3) and (4) show the effect on import of capital goods of a firm[14]. As evident in columns (1) and (2), there is a positive and highly significant increase in raw material imports of GVC firms compared to non-GVC firms. As per the full specification, a GVC firm's import of raw materials is almost 19% higher than a non-GVC firm. These findings align with our expectations as GVC firms undertake imports of raw materials and intermediate goods. This result, although seemingly intuitive, coupled with the estimates of import of capital goods that is a proxy for technological activity by firms, reveals an interesting paradox. Columns (3) and (4)

[14] Prowess does not provide any breakdown of export data in terms of exports of final goods vs intermediate goods. Thus, in this analysis 'exports' is a summation of exports of goods and exports of services

indicate that the GVC participation has no significant impact on capital goods imports. However, what is equally interesting is the direction of relationship. Though statistically insignificant, the estimates are negative. In a way, these contrasting results validate that GVC firms in emerging countries like India are primarily active in low-technology manufacturing activities such as assembling of products, which involve low levels of technology transfer from the lead firm. Exporting indicates forward participation in a GVC framework Further, as shown in columns (5) and (6), GVC participation indicates a positive and highly significant impact on a firm's exports. Using the final specification, we can conclude that a GVC firm's exports exceed the non-GVC firms by approximately 22%. This result is in line with our expectations, as GVC firms will have greater export market participation compared to non GVC firms. Due to data constraints regarding the nature and destination of exports, we would not like to draw any further insights.

ROBUSTNESS CHECKS

To build confidence in our estimates, we subject them to several robustness checks based on alternate specifications and estimation samples. Table 8 contains the estimates from these robustness checks on the complete specification in columns (4) and (5) of the Table 4.

Table 8: PSM – FE model: Robustness Checks

	Matched Sample	Unmatched Sample	
	(1)	(2)	(3)
VARIABLES	TFP (ACF)	TFP (LP)	TFP(LP)
GVC status (dummy)	0.019**		
	(0.009)		
GVC integration		0.168*	0.154*
		(0.097)	(0.086)
FIRM CONTROLS t-1	YES	YES	YES
INDUSTRY CONTROLS	YES	YES	YES
FIRM FE	YES	YES	YES
YEAR FE	YES	YES	YES
INDUSTRY - YEAR FE	YES	NO	YES
Constant	-0.524	-0.165	-0.708
	(0.742)	(0.180)	(2.840)
Observations	4,777	1,706	1,706
R-squared	0.112	0.046	0.415
Number of firms	1,542	666	666

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Alternate estimate of TFP

Despite being popularly used in literature, the TFP measure estimated by Levinsohn Petrin (LP) was later critiqued and improved, primarily by Ackerberg et al. (2006), which will henceforth be referred to as TFP ACF. They argued that TFP may not be identified separately from labour productivity as the former is a deterministic function of the latter. Therefore, we estimate the full specification in Column (5), which is included in Table (4). Table 8, column (1) reports the estimates with the ACF measure of TFP. We observe that the estimates remain robust to this alternate specification.

Alternate measure of GVC integration

The dummy variable indicating GVC participation status does not entirely capture the extent of embeddedness of a firm in a GVC. For this purpose, as is used in firm GVC participation literature, we use the measure in Tucci (2005), which is a firm-level modification of Hummels et al.'s (2001) country-level Vertical Specialization (VS) measure. We modify this measure to make it suitable for firm level data, as has been done in recent studies (Reddy & Sasidharan, 2021b; Banga, 2022b). For the sample of identified GVC manufacturing firms in India, the magnitude of GVC embeddedness for firm *i* at time *t* is measured as follows:

$$VS_{it} = \frac{import\ of\ raw\ materials, stores\ and\ spares_{it}}{expenditure\ on\ raw\ materials, stores\ and\ spares_{it}} \times \left(\frac{Export_{it}}{Sales_{it}}\right)$$

This measure incorporates a firm's backward and forward linkages in a GVC. The measure VS_{it} takes the maximum value of 1 if a firm utilises all imported intermediate inputs and then sells whatever it produces in the international market through exports. This indicates perfect GVC integration of that firm. Import of intermediate inputs is standardised by total expenditure on inputs to take care of the effect of the firm size. For the non-GVC firms, we take this measure to be zero to avoid losing observations.

We use this measure of GVC integration as our main independent variable instead of GVC status and estimate the full specification in Columns (4) and (5). We run this regression on the unmatched sample[15]. Despite not accounting for self-selection bias, our main variable of interest, the coefficient of the impact of GVC integration on firm level TFP, remains stable both in direction and significance.

Our results have been tested for robustness to ensure they are valid and hold for alternate estimations and subsamples. For our main result, which studied the productivity impact of GVC participation, we used different measures for TFP and GVC integration. We found that our results remain stable both in direction and significance. The absolute value of the beta coefficients also remains mostly stable despite these inclusions. We have subjected our other results to a host of similar robustness checks, and the results were broadly similar. Therefore, we can conclude with a reasonable degree of confidence that our estimates correctly capture the impact of GVC participation on firm level outcomes.

[15] The variable of GVC integration is linked to that of GVC identification. The matched sample is linked to the creation of the treatment group, which differs albeit slightly from plain identification as a GVC firm.

To summarise our results obtained, Table 9 presents an extended version of the Table YY to incorporate the actual direction of relationship we obtain after our estimation. Most outcomes are as per our expectations apart from the impact on import of capital goods which indicate a low level of technology transfer from lead firms in GVC framework.

Table 9: The firm level outcomes along with its expected and actual relationship signs

	Outcome	Expected Relationship	Actual Relationship
Productivity Impact	**TFP**	Positive	Positive
	TFP*	Positive	Positive
Domestic Innovation efforts	**R&D**	Negative	Negative
International Activity of Firms	**Exporting intensity**	Positive	Positive
	Import of Capital goods	Positive	Negative and insignificant
	Import of Raw Material	Positive	Positive

*Note: * refers to the combined influence of GVC participation and incoming FDI on TFP*

CONCLUSION, CAVEATS AND SCOPE OF FUTURE RESEARCH

This study explores the firm level outcomes resulting from the participation of a firm in a GVC specifically in the manufacturing sector. We select three important categories of firm level outcomes - i) productivity impact, ii) exports and importing behavior of the firm, and iii) in-house domestic innovation activity. These outcomes are chosen as they give an indication of transformative potential of GVCs to unleash sectoral growth and thereby accelerate national growth. Most studies that deal with firm level implications of GVC participation focus on a singular outcome. This is where we aim to fill the gap in extant literature by focussing on the broader picture using micro level outcomes.

We make use of a firm level unbalanced panel of 15,597 observations and 2,272 manufacturing firms from 2001 to 2020 with our final specification being for period from 2012 to 2020 due to data reporting issues. Our results incorporate estimates from both these subsamples with the 2012 -2020 subsample being our final estimation. To address concerns of self – selection that is inherent in such studies, we employ propensity score matching. Our findings suggest that GVC participation increases the productivity of a firm by 5%. This can be attributed to cheaper inputs and other positive spillovers from the lead firm. Using the CMIE Capex database, we additionally confirm a positive complementary effect of incoming FDI on this productivity premium. The estimates also reveal a significant, albeit expected, decline in the R&D expense of the firm which

is in line with theory. Examining the importing and exporting of firms, we note a significant jump of approximately 19% in import of raw material and intermediate goods, but surprisingly, do not find any significant impact on technology transfer via import of capital goods. These two findings signal a potential weakening of manufacturing sector in the future if current nature of engagement of Indian firms within these networks persists. Mere participation in a GVC does not automatically translate into a strong and thriving manufacturing sector and highlights the requirement for suitable policy interventions to ensure technology transfer and upgradation within the value chain even at the process level if not at the product level. These results are in alignment with Pahl & Timmer's (2020*) 'mixed blessing'* hypothesis which was at the country level. Our estimates are subjected to a several robustness checks which provide additional confidence in our findings.

Our study suffers from known limitations The GVC participation indicator used in the current literature may be too simplistic, and there may be a need for additional criteria over and above the two-way trader definition. Dovis & Zaki (2020) recommend a stricter definition of a GVC firm which involves quality certification by international bodies etc. Secondly, Prowess does not distinguish between finished goods exports and intermediate goods exports, nor does it include the destination of the exports and the extent of value addition at the firm level. These additional details would help to get a deeper insight into the nature of engagement of a firm in a value chain. Thirdly, some variables used in this study such as R&D expenses and import of capital good are lumpy in nature, leading to some measurement issues. However, these variables are commonly used in most firm level studies using prowess without any additional treatment. Most of the firms in PROWESS are listed private firms. In contrast, it is known that several MSME and unorganised sector firms have non-equity relationships with MNE s which are part of GVC's via subcontracting and outsourcing. All these limitations represent interesting possibilities for future research in this area.

In conclusion, our empirical investigation into firm-level outcomes, provide valuable insights into the mechanisms by which participation in GVCs can drive overall sectoral growth and ultimately the national output. Thus, our findings give a clearer understanding of the implications of GVC participation especially for manufacturing firms. These findings can aid policymakers and stakeholders in crafting suitable policies that will enable India to correctly leverage the true potential of gainful integration into the world economy via a GVC.

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APPENDIX

Table A1: Manufacturing industries and NIC codes used in the analysis

NIC CODE	INDUSTRY NAME
10	MANUFACTURE OF FOOD PRODUCTS
11	MANUFACTURE OF BEVERAGES
12	MANUFACTURE OF TOBACCO PRODUCTS
13	MANUFACTURE OF TEXTILES
14	MANUFACTURE OF WEARING APPAREL
15	MANUFACTURE OF LEATHER AND RELATED PRODUCTS
16	MANUFACTURE OF WOOD AND OF PRODUCTS OF WOOD AND CORK
17	MANUFACTURE OF PAPER AND PAPER PRODUCTS
18	PRINTING AND REPRODUCTION OF RECORDED MEDIA
19	MANUFACTURE OF COKE AND REFINED PETROLEUM PRODUCTS
20	MANUFACTURE OF CHEMICALS AND CHEMICAL PRODUCTS
21	MANUFACTURE OF PHARMACEUTICALS, MEDICINAL CHEMICAL AND BOTANICAL PRODUCTS
22	MANUFACTURE OF RUBBER AND PLASTICS PRODUCTS
23	MANUFACTURE OF OTHER NON-METALLIC MINERAL PRODUCTS
24	MANUFACTURE OF BASIC METALS
25	MANUFACTURE OF FABRICATED METAL PRODUCTS, EXCEPT MACHINERY AND EQUIPMENT
26	MANUFACTURE OF COMPUTER, ELECTRONIC AND OPTICAL PRODUCTS
27	MANUFACTURE OF ELECTRICAL EQUIPMENT
28	MANUFACTURE OF MACHINERY AND EQUIPMENT
29	MANUFACTURE OF MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS
30	MANUFACTURE OF OTHER TRANSPORT EQUIPMENT
31	MANUFACTURE OF FURNITURE
32	OTHER MANUFACTURING

Source: National Industrial Classification (NIC) 2008

Table A2: Variable definition and Source

VARIABLE	DESCRIPTION	REFERENCE
VS index/ GVC integration	(import of Raw Material (RM) store & spares (SS) /Expenditure on RM SS)*(Export/Sales)	Reddy, K., & Sasidharan, S. (2021). Financial constraints and global value chain participation: Firm-level evidence from India. The Journal of International Trade & Economic Development, 30(5), 739-765.
GVC identifier dummy	dummy variable which takes the value 1 if the firm is simultaneously importing intermediates (RM, SS, and capital goods and services) and exporting at a given point of time	Banga, K. (2022). Digital technologies and product upgrading in global value chains: Empirical evidence from Indian manufacturing firms. The European Journal of Development Research, 34(1), 77-102. Reddy, K., Sasidharan, S., & Thangavelu, S. (2022). Does servicification of manufacturing increase the GVC activities of firms? Case of India. The World Economy
Deflated sales / Nominal output	Sales adjusted for inventory = Sales - purchase of finished goods +increase in inventory - decrease in inventory	De, P. K., & Nagaraj, P. (2014). Productivity and firm size in India. Small Business Economics, 42(4), 891-907.
Nominal Gross Value Added (GVA)	Nominal output - expenditure on RM, SS	De, P. K., & Nagaraj, P. (2014). Productivity and firm size in India. Small Business Economics, 42(4), 891-907.
Inward greenfield FDI	Completed greenfield projects at 2 digit NIC code level	CMIE CapEx database
Industry competition	1 - Herfindahl index (HHI). HHI = square of market share of firms in that industry	Giroud, X., & Mueller, H. M. (2011). Corporate governance, product market competition, and equity prices. the Journal of Finance, 66(2), 563-600.
firm age	Reporting year - incorporation year	
RnD intensity	R n D expense/ Sales	
Subcontracting intensity	Purchase of finished goods/Value of inputs and power and fuel	Ramaswamy, K. V. (2021). Do Size-dependent Tax Incentives Discourage Plant Size Expansion? Evidence from Panel Data in Indian Manufacturing. Margin: The Journal of Applied Economic Research, 15(4), 395-417.
Outsourcing intensity	(Outsourced industrial jobs (Including Mfg.) + outsourced professional jobs)/ sales	Sahu, S. K., & Roy, I. (2018). Determinants of Outsourcing in the Automobile Sector in India. Indian Journal of Industrial Relations, 54(1), 37-53.
Firm size	log(total assets)	De, P. K., & Nagaraj, P. (2014). Productivity and firm size in India. Small Business Economics, 42(4), 891-907.
Foreign ownership dummy	takes the value 1 if foreign promoters equity share (%) >10	RBI definition
Business group dummy	1 0 dummy if firm is part of business group	CMIE prowess definition
Low tech vs high tech industry dummy	Technology intensive industries are as follows: NIC code – 20, 21, 26, 27, 28, 29, 30 & 32. Low-tech industries are as follows: NIC code – 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 25 & 31.	Reddy, K., Sasidharan, S., & Thangavelu, S. (2022). Does servicification of manufacturing increase the GVC activities of firms? Case of India. The World Economy. Refer to Table A3