A Portrait of Firms Participating in Global Value Chains*

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February 2017

Abstract

This paper presents new stylized facts on developing-nation firms that both import and export, drawing on data from the World Bank's Enterprise Surveys. Using a sample of 124 developing nations, I show that such two-way trading firms, a proxy for global value chains (GVC) participation, are more likely to run training programs, use foreign-licensed technology, possess quality certifications, and communicate with customers and suppliers via the internet. Using the same sample, I also show that local suppliers, i.e. non-trading domestic firms, are more likely to engage in internet-based communication, and hold quality certificates and licences to foreign technology for stronger downstream input-output linkages with two-way trading firms. Overall, these results suggest that the fragmentation of production processes, both internationally and domestically, have significantly affected firms' characteristics in developing and emerging economies.

Keywords: global value chains, firm heterogeneity, technology adoption

*I would like to thank Richard Baldwin and Céline Carrère for their constant advice and support. I also thank conference participants at the 24^{th} IIOA conference.

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1 Introduction

The last two decades have witnessed a dramatic change in international trade and production patterns. Nowadays, a large fraction of world trade and production are structured around so-called Global Value Chains (GVC) where stages of a single production process are dispersed internationally. As a result, three-quarter of world trade consists of intermediate and capital goods (OECD, 2015). This means that most trade concerns the movement of inputs across countries. As to the implications for firms, Antras (2015) points out that trading in GVC differs from traditional trade in four ways: i) customization of production, ii) sequential production decision going from the buyer to the suppliers, iii) high contracting costs, and iv) global matching of goods, services, production teams and ideas. It is natural, therefore, to expect that firms that engage with GVC display different characteristics from those that do not.

Few empirical researchers have looked into whether GVC-linked firms do indeed present different characteristics. The work that has been done focuses on firm characteristics that are suggested by Melitz-like theory, for example firm size and productivity (Bernard et al., 2012), rather than theories more explicitly linked to GVC participation. An exception is Seker (2012), showing that two-ways traders in developing countries are the most innovative, in terms of product and process innovation, than any other group of firms.

The main contribution of this paper is to use Antras-like theoretical insights to guide an empirical search for characteristics that are associated with GVC participation. The paper presents, I believe for the first time, a set of stylized facts on two-way trading firms that is based on firm-level evidence from the World Bank's Enterprise Surveys. These surveys are harmonized in order to construct a cross-section dataset on a wide set of developing and emerging economies for the period 2006 – 2015. The resulting dataset reports information on an array of technological and organizational choices taken within the firm. This allows me to compare groups of firms along a novel set of measures on technology adoption and knowledge creation (hereafter technology-linked activities), which are ultimately related to firms' ability to produce and trade predictable, reliable and on time intermediate and final goods within fragmented and dispersed supply chains.

Specifically, following Teece (1977), I distinguish between two basic forms of technology: the "hardware" or physical items, such as tooling, equipment and blue prints; and the "know-how" or information that must be acquired if this hardware is to be used effectively. The former is measured by whether the firm uses foreign-licensed technology, internationally recognized quality certification, or internet for communicating with customers and suppliers. The latter by whether the firm has run any training program in the past year.

The empirical analysis is divided in two parts. The first part relates the intensity of firms' technology-linked activities to their trade status, the idea being that firms engaged in two-way trade of goods must share a common set of characteristics related to technology and knowledge. For instance, the use of a foreign-licensed technology and the use of internet for communicating with customers and suppliers are relevant for efficiently and predictably incorporating intermediate inputs in a final good. In addition, the use of internationally recognized

quality certifications is used as an assurance about the level of quality of the goods exported, especially for intermediate inputs. Finally, running a training program may suggest that the firm is investing more in their employees given the complexity of tasks required in GVC.

Based on the framework proposed by Bernard et al. (2007), I find that two-way traders of goods share significantly higher probabilities to engage in the four technology-linked activities than any other group of firms. These results are confirmed by reducing the sample of firms to foreign-owned firms, exporters-only or importers-only. Whether this is due to a positive selection or to a transfer of technology among firms participating in GVC, it is not in the scope of this paper.

The second part of the empirical analysis extends these results by looking at firms operating in domestic supply chains in developing and emerging economies. According to international organizations, the fragmentation of production processes offers important development opportunities to low income countries (UNCTAD (2013), OECD (2015) and Taglioni and Winkler (2016)). While recent macro evidence points to the beneficial role of GVC for developing nations industrial development (Kummritz (2016) and Constantinescu et al. (2017)), the literature has not provided firm-level evidence studying the mechanisms at work. As I do not have firm-level data on domestic transactions, I use national input-output (IO) tables and the sector of the firms in my sample to identify supply chain linkages indirectly. I focus on these linkages since domestic IO linkages should, like international trade linkages, be associated with the four technology-linked activities.

Using the same cross-section dataset, this paper finds that upstream suppliers are more likely to use foreign-licensed technology, quality certification and internet for communicating with customers and suppliers for stronger downstream IO linkages with two-way traders. This relationship is stronger for local suppliers (non-trading domestic-owned firms), suggesting that the results may be driven by an actual transfer of technology rather than a positive selection[1]. In addition, my findings suggest that these conjectured transfers to local suppliers may occur from both domestic- and foreign-owned two-way traders.

The paper is organized as follow. Section 2 proposes a brief survey of two related strands of empirical literature about the complementarities between trade and technology adoption, and foreign direct investment (FDI) spillovers. Section 3 describes the data and variables of interest. Section 4.1 describes novel stylized facts on two-way traders of goods. Section 4.2 studies the relationship between upstream suppliers and IO linkages with two-way traders in downstream sectors. Section 5 concludes.

[1]These results are based on correlations and do not allow to discern whether this is due to an actual transfer of technology or a selection by firms participating in GVC of upstream supplier with the "right" characteristics to work with. However, this latter channel is less likely since local suppliers, by definition, do not trade and as shown in this paper non-trading firms are the least likely group of firms to share the four technology-linked activities.

2 Literature review

This paper extends the literature on firm heterogeneity providing novel firm-level stylized facts on two-way traders of goods. The theoretical literature on trade and firm heterogeneity is based on the Melitz (2003)'s model, which argues that only the most productive firms are able to overcome the fixed cost to export. However, my paper suggests that firms' productivity is not the fulcrum behind firms' decision to integrate in GVC[2]. Instead, this paper shifts the interest to technology and knowledge, suggesting that manufacturing firms must share a common set of technologies and know-how in order to participate in GVC.

The competitive environment in many manufacturing sectors and demanding customers leave no room for error in the production of final goods. Close to zero defects and delivery on time require sophisticated process design, supply chain management software, high-speed telecoms networks, and effective transport and logistics services. A day of delay in exporting has a tariff equivalent of 1 percent or more for time-sensitive products (Hummels et al., 2007). Slow and unpredictable land transport keeps most of Sub-Saharan Africa out of the electronics value chain (Christ and Ferrantino, 2011).

It is natural, therefore, to expect that firms that engage with GVC are different from those that do not. These GVC-related characteristics may be acquired either in-house investing in technology and know-how or through the help and assistance from a GVC leading firm[3].

The former channel is pointed out in many empirical firm-level studies, showing the positive impact of innovation on exports[4]. In addition, Boler et al. (2015) show several stylized facts highlighting the complementarity between R&D and international outsourcing. However, the literature has not studied the relationship of both importing and exporting on technology adoption. In addition, once firms are integrated in GVC, the exposure to international markets may bring several advantages (higher revenues and better quality inputs) which may lead firms to invest further in technology and know-how. Empirical work by Bustos (2011) and Lileeva and Trefler (2010) show that trade integration can induce exporters to upgrade technology.

The latter channel is, instead, highlighted by the literature on FDI spillovers. According

[2]Additional analysis shows that two-way traders in developing countries are more import and export intensive, bigger both in terms of number of employees and total sales, pay higher average wages, more capital and skill intensive and older. Instead, they do not have significantly higher labor productivity than exporter-only and importer-only.

[3]This new mechanism, related to firms' participation in GVC, is that technology may be transferred by the firm leading the GVC (hereafter GVC leading firm) which strives to minimize efficiency costs involved with the production and incorporation of inputs in final goods along the supply chain. Bernard et al. (2016) call these firms "Global firms". The GVC leading firm is most likely to be a multinational enterprise (MNE), dictating the technological standards to their network of suppliers. According to UNCTAD (2013), 80 per cent of global trade is somehow linked to a MNE. For instance, a global manufacturing producer as Toyota uses third parties intermediate inputs, handing over the production of leather seats, steering wheel, tires, etc. to local suppliers. Toyota transfers its technology to the local suppliers in order to maintain the quality standards necessary to assemble the intermediate inputs in the final product (Baldwin and Lopez-Gonzalez (2015)).

[4]Using survey data specifically designed to measure innovation activity, the positive relationship between innovation and export has been tested for direct proxies of product and process innovation (Cassiman and Golovko (2011) and Van Beveren and Vandenbussche (2010) as well as for broader set of variables, including measures of innovation inputs like R&D expenditures (Damijan et al. (2010) and Ganotakis and Love (2012).

to Javorcik (2008)[5], sharing information about new technologies or business practices (such as quality control processes or inventory management techniques) to suppliers reduces input costs, increases input quality, and thus benefits multinationals. In addition, the same paper points out that MNEs often offer assistance to their suppliers, such as personnel training, advance payment, leasing of machinery and help with quality assurance and organization of production line.

The second part of the empirical analysis, about the functioning of domestic value chains, takes inspiration from the literature on FDI spillovers. The past fifteen years have witnessed the proliferation of firm-level studies on the impact of FDI on the efficiency of domestic firms in the host country. The results are mixed, and suggest that the postulated spillover effects often do not materialize automatically in developing nations. There are many transmission channels to take into consideration and MNEs have different incentives in sharing their know-how and technology with domestic firms. Evidence supporting the presence of FDI spillovers to upstream sectors in developing nations have been found in Javorcik (2004) and Blalock and Gertler (2008). In addition, as suggested by Javorcik (2008), firms operating in GVC receive higher pressure from MNEs which impose higher standards for product quality, technological content, or on-time delivery (Javorcik, 2008). MNEs thus may induce local producers in upstream sectors to make improvements. In addition to these findings, the results of this paper suggest that spillovers may be amplified in a GVC-setting, given the need to integrate locally produced inputs into a global production network.

[5]In the Czech Republic, more than a quarter of all suppliers surveyed (49 of 190) report that multinationals required them to make specific improvements. Specifically, to the question "which are the types of changes required from multinational?", the most frequent requirements were improvements to the quality assurance process, acquisition of a quality certification (such as an ISO 9000), improvements to the timeliness of deliveries, use of a new technology, or purchase of new equipment. In addition, the survey data reveals that local suppliers in order to receive a contract from a multinational undertake improvements on their own. Thirty-six percent of Czech suppliers reported making improvements with the explicit purpose of finding a multinational customer. These improvements included investing in new machinery and equipment, improving product quality, conducting staff training increasing production volume, reducing the share of defective units produced, and reorganizing manufacturing lines. Finally, forty percent of Czech companies with ISO 9000 certification reported obtaining it in order to be able to supply multinational companies.

3 Definitions and Data Description

The dataset is built on the World Bank's Enterprise Surveys[6]. The cross-sectional dataset is built on 199 surveys for 124 developing and emerging economies, covering the years from 2006 to 2015[7]. Even though some firms were surveyed in more than one year the time dimension is not considered in the empirical analyses. There are more than 54'000 manufacturing firms[8] with information on both ownership and trading status (Table 1). The dataset covers all the 2-digit manufacturing industries listed by ISIC rev 3.1 (from 15 to 37)[9].

Table 2 shows that firms which are not trading are the largest group and account for 40 per cent of the sample. Among trading firms, two-way traders represent 19 per cent of the sample[10]. Interesting, importer-only is the largest group among trading firms, and exporter-only[11] the smallest, accounting for 36 per cent and 5 per cent respectively. This may due to the fact that fixed costs in joining international markets are lower for importing than for exporting in developing and emerging economies.

The analysis also aims to identify foreign-owned firms (or foreign affiliates), i.e. firms having more or equal than 10 per cent of foreign ownership. There are 5'648 foreign-owned firms with information about their trading status, accounting for more than 10 per cent of the sample. They span all manufacturing sectors and there are 120 countries with at least one foreign firm. As shown in Table 2, almost 50 per cent of foreign-owned firms are both importing and exporting and 85 per cent are engaged in the international markets; with the share of exporter-only and importer-only which is similar between domestic- and foreign-owned companies.

Table 3 shows the share of adoption by trade orientation and ownership of the technology-linked activities identified in this paper: whether the firm has run any training program in the previous year, uses technology licensed from a foreign company, internationally recognized quality certification, and website and emails to communicate with clients and suppliers[12]. In particular, the table highlights two findings: first, the presence of a hierarchy of adoption in these practices, with trading firms characterized by higher shares than non-traders; second, the hierarchy being consistent across domestic- and foreign-owned firms, with larger shares for the former.

[6]For more information see http://www.enterprisesurveys.org/Data.

[7]I use only the survey after 2006 since they use stratified sampling and contain weights based on this information. Instead, prior surveys are likely to contain no information regarding weights. In addition, all surveys included in the standardized dataset follow the global standardized methodology.

[8]Formal (registered) companies with 5 or more employees are targeted for interview. Firms with 100 per cent government/state ownership are not eligible for interview. Although, in the surveys the unit of observation is plant, I always refer to firm throughout the paper.

[9]For more information about the firms distribution by country, year or sector see Annex tables.

[10]This category also includes firms operating in special economic zones involved in processing trade. However, the group of firms exporting and importing all their sales and intermediate inputs, respectively, accounts for only 1 percent of the sample.

[11]This definition includes only direct exporters, excluding indirect exporters.

[12]The four technology-linked activities can be considered as pro-development, since they are positively associated with measures of competitiveness (as shown in Table A6 in the annex).

4 Results

This section describes two set of results on the relationship between firm trading status and the four technology-linked activities identified in this paper. I first present a novel set of stylized facts on two-way traders of goods. Second, I show how the four technology-linked activities are more likely to be associated with domestic suppliers with stronger input-output linkages with two-way traders in downstream sectors.

4.1 Stylized facts on technology-linked activities and trading status

This section provides evidence supporting the fact that firms engaged in two-way trade of goods (a proxy for GVC participation) share a variety of technologies related to firms' ability to reduce mistakes, avoid delays and keep a minimum level of quality in trading intermediate and final goods. First, I present a comparison on the technology-linked activities between two-way traders, exporter-only, importer-only and non-trading firms. Second, I test whether the propensity to adopt these technologies depends on firms' ownership status by looking within the sample of foreign-owned firms (i.e. foreign affiliates). Third, I replicate the first exercise within the sample of exporter-only and importer-only. In addition, as a robustness check I use a propensity score matching estimator.

The first analysis focuses on the relationship between firms' trading status and the four technology-linked activities. Following Bernard et al. (2007), the estimation results are based on this specification:

$$\begin{aligned} Y_{ijs} =& \beta_0 + \beta_1 Import\&Export_{ijs} + \beta_2 Import - only_{ijs} + \beta_3 Export - only_{ijs} \\ &+ \beta_4 Foreign_{ijs} + \beta_5 lnEmpl_{ijs} + \delta_j + \delta_s + \varepsilon_{ijs}, \end{aligned} \tag{1}$$

where i denotes the firm, j the industry and s the survey. Y_{ijs} is a dummy variable and denotes one of the following activity: whether the firm run a training program in the past year, use foreign-licensed technology, quality certification or internet for communicating with clients and suppliers. The variable *Import&Export* equals 1 if the firm is a two-way trader, *Export-only* equals 1 if the firm is only exporting, *Import-only* equals 1 if the firm is only importing, *Foreign* equals 1 if the firm has a foreign ownership higher or equal than 10 per cent. In addition the specification uses industry and survey fixed effects, and control for firms' level of employment. Even though some countries are surveyed over time, this analysis does not exploit the time variation in the data, not allowing to draw any conclusion about causality[13]. Survey fixed effects

[13]Based on the literature, two main channels may drive the results: a positive selection of the most "fitted" firms; and, the exposure to international markets thanks to importing better quality inputs, a "learning-by-doing" mechanism, or by exploiting economies of scale firms make higher revenues which may be re-invested in new technology and know-how. Finally, a novel channel is that the GVC leading firm may provide help and assistance to their suppliers directly transferring the technology and know-how.

is equivalent to country-year fixed effects, allowing to isolate potential differences across surveys in GVC participation and technology adoption. Industry fixed effects account for differences in factors such as the level of competition, technology use, market demand, and trade intensity. The results are based on a logit method and average marginal effects of the discrete differences in probability are reported. In other words, the coefficient of *Export&Import* indicates the difference in probability for Y_{ijs} being equal to 1 between two-way traders and non-trading firms. For instance, two-way traders are 14 per cent more likely to run training programs than non-trading firms, which is almost two times higher than exporter- and importer-only. All the estimation results are based on robust standard errors clustered by survey and industry.

The results for the four left-hand side variables are shown in Table 4, column by column. The focus is on how trading status affects the dependent variable. Overall, the results suggest that two-way traders are the most likely to engage in the four technology-linked activities. The difference between two-way traders and the other trading firms changes activity by activity: two-way traders are more than twice more likely than exporter-only to use foreign licensed technology, and than importer-only to use quality certifications and internet to communicate with customers and suppliers.

In addition at the bottom of the table, for each specification, an analysis of whether traders significantly differ from each other in the use of each activity is presented. The p-value results show that two-way traders perform significantly better than exporters-only and importer-only in all measures. The results in Table 4 can be summarized in:

Fact 1: developing nation two-way traders of goods are significantly more likely to engage in technology-linked activities, showing higher probabilities to run training programs, use foreign-licensed technology, possess quality certifications, and communicate with customers and suppliers via the internet than any other group of firms[14].

Fact 1 suggests that two-way traders are engaged in activities that are GVC-link. Table 4 also points out that the technology adoption link is more intense for foreign owned companies, coherently with the idea that a parent company might be more willing to transfer knowledge to its subsidiaries than to unrelated firms. The next set of regressions uses exclusively foreign-owned firms who presumably have access to the parent company's technologies even if transferring the technology is costly as per Keller and Yeaple (2013). The analysis looks for differences among foreign-owned companies according to their trading status, namely whether they are two-way, importer-only, or exporter-only. The hypothesis is that the parent company would invest in technology and know-how only when it is strictly required by the tasks performed by its subsidiary. The results in Table 5 shed light on the hypothesis.

[14]Consistent results are presented in the Annex, where Table A4 shows that including additional controls, such as firm's labor productivity, skill intensity, capital intensity, average wage and age does not affect the previous results. Since adding further controls reduce the sample size without increasing the R-squared, the remaining analysis in this section focused on the reduced specification without additional controls.

Fact 2: among foreign-owned firms[15], two-way traders are more likely to run training programs, and to use foreign-licensed technology, quality certification and the internet for communicating with suppliers and customers than non-trading firms.

Note to start with that two-way traders and importer-only foreign affiliates must incorporate foreign intermediate inputs into their production functions and so, as confirmed in Table 5 (column 2) they are both more likely to use a foreign-licensed technology. Second, column 3 shows that two-way traders and exporter-only have the same probability to use an internationally recognized quality certification, coherently with the logic that two-way traders and exporter-only have to guarantee a minimum level of quality in order to sell their products to foreign firms or final customers. Third, column 1 shows that two-way traders are the most likely to run training programs, suggesting that firms participating in GVC have more incentives to invest in training their staff given the complexity of tasks they are required to perform.
An additional perspective on Facts 1 can be added by focusing only on firms that export (25 per cent of the sample of all firms) and testing for whether two-way traders are more likely to engage in the technology-linked activities than firms who export without also importing. Table 6 shows that two-way traders are significantly more likely to have the four technology-linked activities, with the probability being higher for running training programs and using foreign-licensed technology. For instance, two-way traders are 8 per cent more likely than exporter-only to run training programs.
Table 7 shows similar results for the set of all firms that import (here the distinction is between firms that only import and those that both import and export). This sample covers 55 per cent of the firms. Table 7 shows that two-way traders are also more likely than importer-only to engage in the four technology-linked measures. The finding in Tables 6 and 7 can be summarized in:

Fact 3: two-way traders are more likely than exporter-only and importer-only to run training programs, communicate with customers and suppliers via internet, and hold foreign-licensed technologies and quality certifications.

In order to check the robustness of Fact 3, I implement a matching strategy, where the "treatment group" includes all two-way traders and the "control group" exporter-only (or importer-only). The estimated average treatment effects shown in Table 8 and 9 confirm Fact 3. In this exercise the firms are matched within survey and by sector, ownership status, level of employment, level of sales, labor productivity, age, average wage[16], share of exported sales (or share of imported inputs) and skill intensity[17]. The propensity score matching (PSM) technique aims to control for selection bias by restricting the comparison to differences within selected pairs of firms with similar observable characteristics. The minimum number of matches required is

[15]The results are consistent using the 50 per cent threshold of foreign control.
[16]Measured as labor costs per employee.
[17]Measured as the share of non-production workers over total workers.

set to 10 and the maximum difference in probability between matched subjects (i.e. caliper) is set to 0.1.

4.2 Stylized facts on technology-linked activities and domestic suppliers

Facts 1 to 3 relate the intensity of firms' technology-linked activities to their trade status, the idea being that firms engaged in two-way trade (a proxy for GVC participation) have to share a common set of technologies to use or supply intermediate inputs. A second approach to gauge the linkages is to look at input-output linkages between two-way trading firms and domestic suppliers. The notion being that input-output (IO) linkages should, like trade linkages, being associated with the four technology-linked activities studied in this paper. However, it is important to acknowledge that due to data limitation this analysis is not able to discern whether knowledge and technology are transferred or whether there is a positive selection by downstream two-way traders of local suppliers with the "right" characteristics to work with (proxied by the four technology-linked activities).

The empirical analysis is based on the same cross-sectional dataset from the World Bank's Enterprise Surveys and national IO tables from the OECD-TiVA database. First, I test whether developing country firms are more likely to use the four technology-linked activities for stronger IO linkages with two-way traders. Second, I identify whether this relationship depends upon the ownership status of the two-way traders, in order to verify whether foreign-owned companies may have lower propensities in engaging in local sourcing or supplying.

To associate technology-linked activities of firms with the GVC participation of their customers and suppliers, I rely on indicators based on information from IO tables. To this end, the empirical analysis builds on the methodology used in Javorcik (2004). As a first step, a proxy for horizontal presence of two-way traders is calculated as the weighted share of sales in sector j and survey s produced by two-way traders.

$$GVC - Horizontal_{js} = \frac{\sum_{\forall i \in j} GVC_{ijs} * Y_{ijs}}{\sum_{\forall i \in j} Y_{ijs}},$$

where GVC_{ijs} equals 1 if the firm i is a two-way trader and Y_{ijs} is firm i's sales.

GVC - Upstream captures the extent of potential contacts between upstream suppliers and two-way traders in downstream sectors. It is defined as the proportion of output produced by an upstream sector and supplied to downstream sectors weighted by the share of sales accounted by two-way traders to total sales in the downstream sector.

$$GVC - Upstream_{js} = \sum_{k \neq j} s_{jks} * GVC - Horizontal_{ks},$$

where s_{ijs} is the proportion of sector j's intermediate inputs supplied to sector k taken from national input-output tables when available, otherwise the indicator is based on US input-output tables. A further assumption is that when the year is not available (OECD's input-output tables are available until 2011) the 2011 input-output tables are used[18]. The analysis focuses on 14 manufacturing sectors which are aggregated from the 16 starting sectors[19]. The proportion is calculated excluding output supplied for final consumption and intermediate inputs to primary and services sectors. The greater the presence of firms participating in GVC in sectors supplied by industry j and the larger the share of intermediate inputs supplied to industries participating in GVC, the higher the value of the variable.

Finally, the *GVC – Downstream* variable is defined as the weighted share of output supplied by two-way traders in upstream sectors to firms in downstream sector j. Thus, the following indicator is used:

$$GVC - Downstream_{js} = \sum_{m \neq j} t_{jms} * GVC - Horizontal_{ms}.$$

Where t_{jms} is the share of intermediate inputs purchased by industry j from industry m in total inputs sourced by sector j. These spillover variables are used in the following specification:

$$\begin{aligned} Y_{ijs} = \beta_0 + \beta_1 GVC - Horizontal_{js} + \beta_2 GVC - Upstream_{js} + \\ \beta_3 GVC - Downstream_{js} + \beta_4 lnEmpl_{ijs} + \delta_j + \delta_s + \varepsilon_{ijs}, \end{aligned} \tag{2}$$

where i denotes the firm operating in sector j and survey s. The dependent variable Y_{ijs} stands for one of the following measures: use of training programs in the past year, foreign-licensed technology, quality certification and the internet for communicating with clients and suppliers. *Empl* denotes the firm's level of employment.

The specification is estimated using the logit model with robust standard errors clustered by survey and industry. The coefficients reported are the marginal effects at mean values. The estimation is performed on the full sample and on the sample of domestic suppliers, i.e.

[18] A radical change in relationships between sectors is not likely to happen in the short run.

[19] For a list of sectors see Annex Table A7.

domestic-owned non-trading firms[20]. It is important to acknowledge that due to the lack of time variation the analysis is based on cross-correlations that suffer of an omitted variable bias, such as firm specific characteristics.

The coefficient of interest is β_2, which is expected to be positive and significant. In other words, I expect that firms in sectors that supply larger share of inputs to sectors participating in GVC are more likely to engage in technology-linked activities. However, according to Bustos (2011), higher demand for upstream inputs would increase local suppliers' revenues leading to investments in technologies and personnel. In other words, the postulated spillovers may be due to local suppliers exploiting economies of scale, instead of actual transfer of technology and know-how from GVC. In order to solve for this problem I control for firms' sales growth calculated over the previous three years.

In Table 11, the first set of regressions (on the left) includes all firms, instead, the second set (on the right) only local suppliers[21]. Focusing on non-trading domestic-owned firms emphasizes the hypothesis of a transfer of technology and knowledge rather than a positive selection because this group of firms, as shown in the first part of the paper, is the least likely to engage in the four technology-linked activities. Table 11[22] shows evidence consistent with the existence of positive spillovers from two-way traders to upstream suppliers for two out of four technology-linked activities, with the correlation being stronger for local suppliers. The results suggest that firms participating in GVC may transfer to upstream suppliers foreign-licensed technologies and the use of internet to communicate with customers and suppliers. Specifically, a 10-percentage point increase in share of downstream two-way traders (from an average of 14 per cent) is associated with a 1 per cent increase in probability to use foreign-licensed technology by upstream local suppliers. About the use of internet, a 10-percentage point increase (from an average of 14 per cent) is associated with a 2 per cent increase in probability for upstream local suppliers. The magnitude of these effects is rather small; however, this analysis is affected by many confounding factors since it is based on a sample of 124 countries.

However, the findings on training programs are more mixed. While the negative coefficient suggests that firms supplying intermediate inputs to downstream two-way traders are less likely to train their staff, the positive coefficient of *GVC-Horizontal* suggest possible transfers of knowledge between firms within the same sector. Finally, coherently with the literature on FDI spillovers, there is not any significant spillover occurring through downstream linkages.

I turn now to test if the evidence for the four technology-linked measures depends upon the ownership status of the two-way traders. The spillover variables are thus divided by ownership, distinguishing whether the previous results come from the presence of domestic-owned or foreign-owned firms participating in GVC . Since I am interested in domestic suppliers, I focus my attention only on upstream linkages. As a result, the specification tested becomes the following:

[20]This group of firms may include non-trading parent companies, even though it is not likely.

[21]The sample of non-trading domestic firms covers 119 countries, 14 manufacturing sectors, from 2006 to 2015.

[22]The results of the econometric analysis using spillover measures based on number of employees, instead of sales, are qualitatively and quantitatively similar.

$$
\begin{aligned}
Y_{ijs} =& \beta_0 + \beta_1 GVC - Up - Foreign_{js} + \beta_2 GVC - Up - Domestic_{js} \\
&+ \beta_3 GVC - Horizontal_{js} + \beta_4 GVC - Downstream_{js} + \beta_5 lnEmpl_{ijs} \\
&+ \delta_j + \delta_s + \varepsilon_{ijs}
\end{aligned} \tag{3}
$$

Table 12 shows that the coefficients of the upstream spillover variable are not significant for foreign-owned two-way traders. This suggests that foreign firms in GVC have lower propensities to engage in local sourcing. This can be explained by the fact that foreign affiliates are more likely to be dependent on the global sourcing policies of their parent companies and thus they may have less freedom in choosing their own suppliers. Disentangling the spillovers coming from domestic two-way traders increases the magnitude of the coefficients: a 10-percentage point increase in share of domestic firms participating in GVC (from an average of 8 per cent) is associated with 1 and 3 per cent increase in probability to use a foreign-licensed technology and internet by local suppliers, respectively. In addition, a 10-percentage point increase in presence of domestic firm participating in GVC is associated with 2 per cent higher probability to use an internationally recognized quality certificate by local suppliers; instead, it decreases their probability of running a training program by 2 per cent.

However, linkages between firms participating in GVC and upstream suppliers may also occur within the same sector. For instance, a Toyota's subsidiary in Thailand may outsource the production of leather seats, steering wheel, tires, etc. to local suppliers; those local suppliers would belong to the same 2-digit (ISIC rev. 3) sector as the Toyota's subsidiary. In the next analysis, I thus consider an augmented spillover variable calculated as the sum between *GVC – Upstream* and *GVC – Horizontal*. The resulting measure should be interpreted as a lower bound of the extent of potential contact because *GVC – Horizontal* also includes the direct competitors of the Toyota's subsidiary. This implies that the positive transfer to local suppliers may be offset by mechanisms put in place by firms participating in GVC in order to prevent leakage and transfer of knowledge and technologies to local competitors.

Table 13 confirms the previous results about the transfer of technologies from GVC to upstream suppliers. The coefficients of the augmented upstream spillover variable are lower than before, confirming the idea that firms participating in GVC prevent the transfer of technologies to direct local competitors.

Finally, Table 14 shows that the transfer of technologies may also come from foreign affiliates participating in GVC. Overall, these results confirm the previous conclusions, suggesting that domestic suppliers have to share a common set of technologies in order to supply intermediate inputs to firms participating in GVC.

5 Conclusions

This paper presents a novel set of stylized facts on two-way traders in goods for a wide set of developing and emerging economies, using data from the World Bank's Enterprise Surveys. The paper main contribution is to extend the literature on firm heterogeneity and trade by relating the intensity of firms' technology-linked activities to their trading status, the idea being that firms engaged in two-way trade (a proxy for GVC participation) are more likely to share a common set of technologies and knowledge.

The first part of the empirical analysis finds that manufacturing two-way traders are more likely to run training programs, use foreign-licensed technology, quality certification and internet for communicating with suppliers and customers than any other group of firms. Whether this evidence is due to a positive selection or to a transfer of technology among firms participating in GVC, it is not in the scope of this paper. However, I see these stylized facts as a starting point for future research aimed at incorporating GVC into traditional heterogeneous firms models.

The second part of the empirical analysis extends the previous results by looking at the characteristics of domestic suppliers for different input-output linkages with two-way traders. This analysis is based on national IO linkages between two-way trading firms and domestic suppliers. The underlying idea is that IO linkages should, like trade linkages, be associated with some specific technology and knowledge (as proxied by the four technology-linked activities). I find that upstream suppliers are more likely to use foreign-licensed technology, internationally recognized quality certification and internet for communicating with customers and suppliers for higher downstream IO linkages with two-way traders. The relationship is stronger for local suppliers, suggesting that the results may be driven by an actual transfer of technology rather than a positive selection. In addition, these conjectured transfers may occur from both domestic- and foreign-owned two-way traders, suggesting that the way a country integrates in GVC (promoting FDI versus trade) is not important for the upgrading of the local suppliers[23]. Overall, these results suggest that the fragmentation of production processes, both domestically and internationally, have significantly affected firms' characteristics and may be facilitating the transfer of technology and knowledge to developing and emerging economies.

[23]The related literature on firms' boundaries emphasizes that firms in order to minimize production costs have to answer a two-dimensional decision problem: whether to source intermediate inputs from within the firm or not, i.e. the vertical integration decision; and whether to locate an economic activity in the country of origin or abroad, i.e. the offshoring decision (see, for example, Antras (2014)); Antras and Yeaple (2014), for an overview). Although the literature has identified two distinct sets of necessities for firms that countries are asked to address: connecting factories and protecting assets. It has largely left opened the question of which are the implications of such trade-offs for local firms.

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Tables

Table 1: Description of main variables

Variable	*Description*	*Obs.*	*Mean*	*Std Dev.*
Imp & Exp	= 1 if the firm exports and imports	54164	0.19	0.40
Import only	= 1 if the firm only imports	54462	0.36	0.48
Export only	= 1 if the firm only exports	62859	0.07	0.25
None	= 1 if the firm does not trade	63709	0.34	0.47
Foreign	= 1 if foreign ownership >= 10%	62641	0.10	0.30
Training	= 1 if the firm runs training programs in the previous year	58999	0.38	0.49
For tech	= 1 if the firm uses technology licensed from a foreign-owned company	60229	0.15	0.36
Quality cert	= 1 if the firm has an internationally-recognized quality certification	61816	0.28	0.45
Internet	= 1 if the firm communicates with clients and suppliers via email or website	63491	0.73	0.44

Table 2: Firms distribution by trade orientation and ownership status

All manufacturing firms	*Obs.*	*Mean*	*Std. Dev.*
Importer & exporter	54164	0.19	0.40
Only importer	54164	0.36	0.48
Only exporter	54164	0.05	0.22
None	54164	0.40	0.49
Only foreign affiliates (>10% foreign ownership)			
Importer & exporter	5648	0.47	0.50
Only importer	5648	0.33	0.47
Only exporter	5648	0.06	0.23
None	5648	0.14	0.35
Only domestic firms			
Importer & exporter	47793	0.16	0.37
Only importer	47793	0.36	0.48
Only exporter	47793	0.05	0.22
None	47793	0.43	0.49

Table 3: Technology-linked activities by trade orientation and ownership status

All firms	**Non-trader**	**Only importer**	**Only exporter**	**Importer & exporter**
Training	0.26	0.38	0.50	0.61
Foreign technology	0.09	0.16	0.19	0.27
Quality certification	0.17	0.20	0.51	0.53
Internet	0.54	0.76	0.92	0.96
Foreign affiliates				
Training	0.33	0.50	0.56	0.67
Foreign technology	0.21	0.35	0.36	0.41
Quality certification	0.31	0.39	0.60	0.62
Internet	0.66	0.86	0.89	0.96
Domestic firms				
Training	0.26	0.37	0.49	0.58
Foreign technology	0.08	0.14	0.17	0.22
Quality certification	0.17	0.18	0.50	0.50
Internet	0.53	0.75	0.92	0.96

Table 4: Trade orientation and technology adoption: all manufacturing firms

LOGIT	Training	Foreign tech	Quality certif	Internet
Export & Import	0.140***	0.0799***	0.138***	0.182***
	(0.00750)	(0.00657)	(0.00588)	(0.00807)
Export-only	0.0779***	0.0309***	0.117***	0.149***
	(0.0104)	(0.00919)	(0.00856)	(0.0120)
Import-only	0.0792***	0.0696***	0.0489***	0.0737***
	(0.00595)	(0.00549)	(0.00489)	(0.00389)
Foreign	0.0390***	0.0965***	0.0742***	0.0491***
	(0.00672)	(0.00472)	(0.00593)	(0.00731)
Observations	50,398	52,492	51,778	52,378
Pseudo R^2	0.224	0.143	0.308	0.460
p-Values for Tests on Marginal Effects				
Export&Import = Export-only	0.00	0.00	0.01	0.02
Export&Import = Import-only	0.00	0.03	0.00	0.00

Note: Marginal effects of the discrete difference in probability are reported. Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

Table 5: Trade orientation and technology adoption: only foreign affiliates

LOGIT	Training	Foreign tech	Quality certif	Internet
Export & Import	0.160***	0.148***	0.153***	0.126***
	(0.0205)	(0.0254)	(0.0210)	(0.0155)
Export-only	0.0939***	0.0250	0.172***	0.102***
	(0.0300)	(0.0359)	(0.0320)	(0.0220)
Import-only	0.105***	0.141***	0.0780***	0.0799***
	(0.0204)	(0.0227)	(0.0213)	(0.0111)
Observations	5,441	5,432	5,346	4,129
Pseudo R^2	0.241	0.121	0.257	0.358
p-Values for Tests on Marginal Effects				
Export&Import = Export-only	0.01	0.00	0.50	0.30
Export&Import = Import-only	0.00	0.66	0.00	0.00

Note: Marginal effects of the discrete difference in probability are reported. Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

Table 6: Two-way traders versus exporter-only

LOGIT	Training	Foreign tech	Quality certif	Internet
Export&Import	0.0771***	0.0776***	0.0489***	0.0272***
	(0.0117)	(0.0116)	(0.0104)	(0.00575)
Foreign	0.0382***	0.131***	0.0663***	0.00525
	(0.0107)	(0.0105)	(0.0111)	(0.00746)
Observations	12,453	12,849	12,598	9,375
Pseudo R^2	0.188	0.117	0.235	0.317

Note: Marginal effects of the discrete difference in probability are reported. Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

Table 7: Two-way traders versus importer-only

LOGIT	Training	Foreign tech	Quality certif	Internet
Export&Import	0.0591***	0.0214***	0.107***	0.0905***
	(0.00665)	(0.00569)	(0.00553)	(0.00634)
Foreign	0.0452***	0.119***	0.0750***	0.0392***
	(0.00834)	(0.00638)	(0.00708)	(0.00747)
Observations	28,032	28,877	28,344	28,059
Pseudo R^2	0.200	0.125	0.290	0.420

Note: Marginal effects of the discrete difference in probability are reported. Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

Table 8: Propensity score matching: only exporting firms

PSM	Training	Foreign lic.	Quality certif.	Internet
ATE: Export&Import (1 vs0)	0.115***	0.0547***	0.0167	0.0166***
	(0.00787)	(0.0110)	(0.0167)	(0.00407)
Observations	9,364	9,865	9,588	9,909

Note: Firms are matched within survey, by sector, share of foreign control, share of exported sales, level of sales, level of employment, age, labor productivity and skill intensity. At least 10 matches per observation are required. The maximum difference between matched subjects is set to 0.1.

Table 9: Propensity score matching: only importing firms

PSM	Training	Foreign lic.	Quality certif.	Internet
ATE: Export&Import (1 vs0)	0.0654***	0.0361***	0.103***	0.0898***
	(0.0118)	(0.00911)	(0.00909)	(0.00841)
Observations	17,839	18,843	18,381	18,965

Note: Firms are matched within survey, by sector, share of foreign control, share of exported sales, level of sales, level of employment, age, labor productivity and skill intensity. At least 10 matches per observation are required. The maximum difference between matched subjects is set to 0.1.

Table 10: GVC-related spillover variables by sector, average across surveys

Sectors	Isic	GVC - Up	GVC - Up - For	GVC - Up - Dom	GVC - Horiz	GVC - Down
1	C15T16	3%	1%	2%	37%	11%
2	C17T19	14%	5%	9%	54%	22%
3	C20	17%	5%	11%	24%	14%
4	C21T22	13%	5%	8%	24%	11%
5	C23	19%	7%	12%	42%	11%
6	C24	19%	6%	12%	50%	11%
7	C25	31%	13%	18%	43%	32%
8	C26	17%	7%	10%	28%	18%
9	C27	19%	6%	12%	22%	12%
10	C28	29%	12%	17%	38%	25%
11	C29	25%	10%	14%	44%	24%
12	C30T33	16%	5%	11%	41%	16%
13	C34T35	6%	2%	4%	34%	19%
14	C36T37	21%	8%	12%	27%	26%

Table 11: GVC-related spillovers and technology-linked activities

	Training		**Foreign lic.**		**Quality cert.**		**Internet**	
	All firms	Domestic	All firms	Domestic	All firms	Domestic	All firms	Domestic
GVC - Upstream	-0.00112**	-0.00150**	0.000313*	0.000582**	0.000443	0.000193	0.00109***	0.00245**
	(0.000508)	(0.000602)	(0.000190)	(0.000296)	(0.000476)	(0.000438)	(0.000407)	(0.00109)
GVC - Horizontal	0.000352**	0.000312	6.62e-05	0.000126	0.000355***	6.26e-05	0.000143	0.000146
	(0.000156)	(0.000230)	(6.86e-05)	(0.000101)	(0.000106)	(0.000105)	(9.92e-05)	(0.000270)
GVC - Downstream	0.000382	0.000680	0.000197	0.000206	0.000272	7.35e-05	-9.35e-05	-0.000535
	(0.000405)	(0.000569)	(0.000198)	(0.000296)	(0.000433)	(0.000466)	(0.000447)	(0.00119)
Observations	44,262	14,138	45,713	15,362	60,989	19,210	61,767	20,028
Pseudo R^2	0.202	0.232	0.118	0.256	0.276	0.313	0.423	0.414

Note: Marginal effects at means are reported. Robust standard errors clustered by survey and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions control for employment, last three years sales growth rate, 2-digit industry and survey fixed effects.

Table 12: GVC-related spillovers by ownership status and technology-linked activities

	Training		**Foreign lic.**		**Quality cert.**		**Internet**	
	All firms	Domestic	All firms	Domestic	All firms	Domestic	All firms	Domestic
GVC - Up - Foreign	-0.000377	-0.000716	0.000366	8.78e-05	-0.000403	-0.00138*	0.000679	0.00142
	(0.000739)	(0.000826)	(0.000307)	(0.000434)	(0.000649)	(0.000744)	(0.000494)	(0.00129)
GVC - UP - Domestic	-0.00178***	-0.00230***	0.000253	0.000979**	0.00104*	0.00187**	0.00143***	0.00351**
	(0.000633)	(0.000875)	(0.000255)	(0.000400)	(0.000533)	(0.000909)	(0.000512)	(0.00138)
Observations	44,262	14,138	45,713	15,362	60,989	19,844	61,767	20,028
Pseudo R^2	0.202	0.232	0.118	0.256	0.276	0.313	0.423	0.414

Note: Marginal effects at means are reported. Robust standard errors clustered by survey and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions control for employment, last three years sales growth rate, 2-digit industry and survey fixed effects.

Table 13: Augmented upstream spillovers and technology-linked activities

	Training		**Foreign lic.**		**Quality cert.**		**Internet**	
	All firms	Domestic	All firms	Domestic	All firms	Domestic	All firms	Domestic
GVC - Upstream	0.000225	0.000606	0.000216*	0.000252	0.000515***	0.000122	0.000422**	0.000952**
	(0.000275)	(0.000412)	(0.000121)	(0.000164)	(0.000192)	(0.000179)	(0.000166)	(0.000440)
Observations	44,262	14,138	45,713	15,362	61,031	19,214	61,810	20,032

Note: Marginal effects at means are reported. Robust standard errors clustered by survey and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions control for employment, last three years sales growth rate, 2-digit industry and survey fixed effects.

Table 14: Augmented upstream spillovers by ownership status and technology-linked activities

	Training		**Foreign lic.**		**Quality cert.**		**Internet**	
	All firms	Domestic	All firms	Domestic	All firms	Domestic	All firms	Domestic
GVC - Up - Foreign	0.000375	0.000263	0.000577***	0.000279	0.000459*	0.000109	0.000510***	0.00129**
	(0.000313)	(0.000428)	(0.000149)	(0.000212)	(0.000251)	(0.000204)	(0.000196)	(0.000534)
GVC - Up - Domestic	0.000185	0.00109*	-0.000145	0.000266	0.000563**	0.000174	0.000320	0.000604
	(0.000387)	(0.000644)	(0.000158)	(0.000199)	(0.000261)	(0.000173)	(0.000237)	(0.000608)
Observations	44,262	14,138	45,713	15,362	61,031	19,214	61,810	20,032

Note: Marginal effects at means are reported. Robust standard errors clustered by survey and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions control for employment, last three years sales growth rate, 2-digit industry and survey fixed effects.

Annex

The following tables describe the distribution of the firms by ISIC 2-digit code, year and country.

Table A1: Number of firms by ISIC 2-digit code rev.3

ISIC rev. 3	No. firms	%
15	13,050	20.5
16	234	0.4
17	4,896	7.7
18	7,113	11.2
19	1,509	2.4
20	2,108	3.3
21	889	1.4
22	2,362	3.7
23	158	0.3
24	5,191	8.2
25	3,516	5.5
26	4,506	7.1
27	1,828	2.9
28	5,248	8.2
29	3,557	5.6
30	40	0.1
31	1,771	2.8
32	339	0.5
33	389	0.6
34	1,156	1.8
35	282	0.4
36	3,428	5.4
37	139	0.2
Total	63,570	100

Table A2: Number of firms by year

Year	No. firms	%
2006	8,637	13.56
2007	6,758	10.61
2008	2,071	3.25
2009	9,397	14.75
2010	8,035	12.61
2011	1,652	2.59
2012	3,154	4.95
2013	13,591	21.33
2014	10,331	16.22
2015	83	0.13
Total	63,709	100

Table A3: Number of firms by country

Country name	No. firms	%	Country name	No. firms	%
Afghanistan	262	0.4	Lithuania	208	0.3
Albania	222	0.4	Madagascar	467	0.7
Angola	291	0.5	Malawi	268	0.4
Antigua and Barbuda	34	0.1	Mali	461	0.7
Argentina	1,449	2.3	Mauritania	132	0.2
Armenia	224	0.4	Mauritius	216	0.3
Azerbaijan	241	0.4	Mexico	2,298	3.6
Bahamas	42	0.1	Micronesia	9	0.0
Bangladesh	2,471	3.9	Moldova	218	0.3
Barbados	71	0.1	Mongolia	245	0.4
Belarus	221	0.4	Montenegro	88	0.1
Belize	72	0.1	Morocco	187	0.3
Benin	72	0.1	Mozambique	341	0.5
Bhutan	177	0.3	Myanmar	353	0.6
Bolivia	525	0.8	Namibia	287	0.5
Bosnia and Herzegovina	242	0.4	Nepal	379	0.6
Botswana	199	0.3	Nicaragua	584	0.9
Brazil	1,483	2.3	Niger	62	0.1
Bulgaria	846	1.3	Nigeria	2,375	3.7
Burkina Faso	95	0.2	Pakistan	1,870	2.9
Burundi	162	0.3	Panama	359	0.6
Cameroon	106	0.2	Paraguay	551	0.9
Cape Verde	68	0.1	Peru	1,120	1.8
Central African Republic	37	0.1	Philippines	981	1.5
Chad	60	0.1	Poland	330	0.5
Chile	1,420	2.2	Romania	365	0.6
China	1,686	2.7	Russia	2,077	3.3
Colombia	1,342	2.1	Rwanda	140	0.2
Costa Rica	322	0.5	Samoa	27	0.0
Croatia	532	0.8	Senegal	508	0.8
Czech Republic	215	0.3	Serbia	253	0.4
Cote d'Ivoire	204	0.3	Slovak Republic	187	0.3
DRC	514	0.8	Slovenia	190	0.3
Djibouti	62	0.1	South Africa	680	1.1
Dominica	28	0.0	South Sudan	89	0.1
Dominican Republic	122	0.2	Sri Lanka	362	0.6
Ecuador	485	0.8	St Kitts and Nevis	29	0.1
Egypt	2,015	3.2	St Lucia	63	0.1
El Salvador	741	1.2	St Vincentand Grenadines	49	0.1
Eritrea	93	0.2	Sudan	84	0.1
Estonia	175	0.3	Suriname	75	0.1
Ethiopia	321	0.5	Swaziland	70	0.1
Fiji	48	0.1	Sweden	337	0.5
Fyr Macedonia	251	0.4	Tajikistan	238	0.4
Gambia	33	0.1	Tanzania	713	1.1
Georgia	233	0.4	Timor Leste	63	0.1
Ghana	669	1.1	Togo	35	0.1
Grenada	25	0.0	Tonga	54	0.1
Guatemala	790	1.2	Trinidad and Tobago	117	0.2
Guinea	135	0.2	Tunisia	329	0.5
Guinea Bissau	50	0.1	Turkey	1,989	3.1
Guyana	71	0.1	Uganda	685	1.1
Honduras	556	0.9	Ukraine	1,316	2.1
Hungary	214	0.3	Uruguay	742	1.2
India	7,163	11.2	Uzbekistan	256	0.4
Indonesia	1,183	1.9	Vanuatu	15	0.0
Iraq	475	0.8	Venezuela	85	0.1
Israel	201	0.3	Vietnam	772	1.2
Jamaica	121	0.2	West Bank and Gaza	158	0.3
Jordan	335	0.5	Yemen	368	0.6
Kazakhstan	386	0.6	Zambia	668	1.1
Kenya	810	1.3	Zimbabwe	376	0.6
Kosovo	174	0.3	Total	63,709	100.0
Kyrgyz Republic	197	0.3			
Lao PDR	243	0.4			
Latvia	210	0.3			
Lebanon	239	0.4			

Table A4 replicates the results in Table 4 with additional controls: age of the firm; firm's labor productivity (in log), measured as output per worker; a measure of skill intensity calculated as the share of non-production workers over total workers; a measure of capital intensity (in log) computed as total assets (net book value of machinery, equipment, land and buildings) per worker; and, a measure of average wage (in log) as total labor cost per worker.

Table A4: Trade orientation and technology-linked activities: additional controls

LOGIT	Training	Foreign tech	Quality certif	Internet
Export & Import	0.116***	0.0784***	0.112***	0.152***
	(0.00980)	(0.00870)	(0.00792)	(0.00926)
Export-only	0.0616***	0.0389***	0.103***	0.130***
	(0.0137)	(0.0109)	(0.0108)	(0.0138)
Import-only	0.0605***	0.0644***	0.0336***	0.0554***
	(0.00788)	(0.00719)	(0.00639)	(0.00469)
Foreign	0.0175**	0.0841***	0.0541***	0.0303***
	(0.00857)	(0.00587)	(0.00737)	(0.00803)
Labor productivity	0.0170***	0.0116***	0.0215***	0.0210***
	(0.00271)	(0.00197)	(0.00241)	(0.00203)
Skill intensity	0.103***	0.0497***	0.0510***	0.107***
	(0.0177)	(0.0104)	(0.0112)	(0.0188)
Capital intensity	0.00458**	0.00335**	0.00911***	0.0111***
	(0.00195)	(0.00139)	(0.00157)	(0.00134)
Average wage	0.00859***	0.00739***	0.0109***	0.0141***
	(0.00307)	(0.00252)	(0.00289)	(0.00249)
Age	8.09e-05	-0.000503***	0.000378***	-7.88e-05
	(0.000164)	(0.000128)	(0.000137)	(0.000154)
Observations	29,237	31,526	30,879	30,759
Pseudo R^2	0.237	0.153	0.322	0.497
p-Values for Tests on Marginal Effects				
Export&Import = Export-only	0.00	0.00	0.36	0.15
Export&Import = Import-only	0.00	0.02	0.00	0.00

Note: Marginal effects of the discrete difference in probability are reported. Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

Table A5 provides the OLS results of the specification in equation 1, allowing for a comparison with the estimates of the logit model in Table 4. The OLS coefficients are similar to the logit model, importantly the hierarchy of the GVC-related technology is consistent between the two methods, except for the last column.

Table A5: Trade orientation and technology-linked activities: OLS results

OLS	Training	Foreign tech	Quality certif	Internet
Export & Import	0.156***	0.0792***	0.198***	0.144***
	(0.00866)	(0.00722)	(0.00826)	(0.00853)
Export-only	0.0762***	0.0161*	0.150***	0.165***
	(0.0118)	(0.00964)	(0.0114)	(0.0122)
Import-only	0.0758***	0.0556***	0.0441***	0.128***
	(0.00633)	(0.00470)	(0.00454)	(0.00637)
Foreign	0.0429***	0.152***	0.114***	0.0268***
	(0.00722)	(0.00820)	(0.00822)	(0.00659)
Observations	50,474	52,690	51,910	53,159
R-squared	0.263	0.127	0.315	0.437
p-Values for Tests on Marginal Effects				
Export&Import = Export-only	0.00	0.00	0.00	0.03
Export&Import = Import-only	0.00	0.00	0.00	0.02

Note: Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

Table A6 shows that the four technology-linked activities, identified in this paper, are ultimately related to firms' performances. Firms using training programs, foreign-licensed technology, quality certification and internet to communicate with customers and suppliers have significantly higher labor productivity[24], pay higher wages, are more capital and skill intensive, and import and export more. Each specification uses industry and country-year fixed effects, and control for firms' level of employment. All the estimation results are based on robust standard errors clustered by country-year and industry.

Table A6: Trade orientation and technology-linked activities: OLS results

OLS	Labor Productivity	Avg Wage	Capital Intensity	Skill Intensity	Export Share	Import Share
Training	0.158***	0.108***	0.147***	0.0193***	0.543*	2.876***
	(0.0155)	(0.0130)	(0.0338)	(0.00217)	(0.287)	(0.383)
Foreign Technology	0.196***	0.117***	0.155***	0.0120***	0.0105	6.025***
	(0.0196)	(0.0174)	(0.0349)	(0.00250)	(0.369)	(0.463)
Quality Certification	0.278***	0.199***	0.263***	0.0115***	4.036***	0.706
	(0.0177)	(0.0160)	(0.0336)	(0.00211)	(0.436)	(0.448)
Internet	0.492***	0.316***	0.534***	0.0345***	3.680***	9.225***
	(0.0241)	(0.0192)	(0.0391)	(0.00319)	(0.568)	(0.566)
Foreign	0.316***	0.203***	0.301***	0.0177***	11.49***	10.38***
	(0.0255)	(0.0248)	(0.0388)	(0.00347)	(0.691)	(0.646)
Observations	42,866	47,632	34,931	52,129	54,054	48,639
R-squared	0.788	0.821	0.647	0.141	0.236	0.294

Note: Robust standard errors clustered by country-year and industry are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The regressions include log firm employment, 2-digit industry and country-year fixed effects.

[24]Labor productivity is calculated as value added per employee, where value added is the difference between sales and cost of raw materials and intermediate goods used in production.

Table A7: Sectors used in deriving the spillover variables

Sectors	Isic	Description
1	C15T16	Food products, beverages and tobacco
2	C17T19	Textiles, textile products, leather and footwear
3	C20	Wood and products of wood and cork
4	C21T22	Pulp, paper, paper products, printing and publishing
5	C23	Coke, refined petroleum products and nuclear fuel
6	C24	Chemicals and chemical products
7	C25	Rubber and plastics products
8	C26	Other non-metallic mineral products
9	C27	Basic metals
10	C28	Fabricated metal products
11	C29	Machinery and equipment, nec
12	C30T33	Electrical and Optical Equipment
13	C34T35	Transport equipment
14	C36T37	Manufacturing nec; recycling