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GLOBAL VALUE CHAINS AND TECHNOLOGY TRANSFER: NEW EVIDENCE FROM DEVELOPING COUNTRIES[a]

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Abstract

This paper uses the World Bank's Enterprise Surveys as a sample of 18 developing and emerging economies to investigate the causal relationship between global value chains and the transfer of technology to manufacturing firms in developing nations. It focuses on one specific channel for technology transfer, namely the licensing of foreign technology. By using a propensity score matching difference-in-differences technique, I show that there is a positive and causal impact of being involved in complex international activities (i.e. being a two-way trader) on the licensing of technology. Importantly, domestic firms becoming two-way traders are more likely to acquire foreign-licensed technology than domestic firms starting to either export or import. These findings suggest that the complexity associated with the trading activity determines whether or not foreign technology is licensed.

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1. Introduction

The last decades have witnessed a dramatic change in international trade and production patterns. Twenty-first century trade and production are structured around so-called global value chains (GVCs) where stages of a single production process are dispersed internationally. It is often argued that GVCs have offered a new path towards industrial development, since firms from high-technology nations combine their firm-specific managerial, technical and marketing know-how with low wages from developing nations (Baldwin 2016). However, little is known about the implications of GVCs for firms of developing nations.

Most trade concerns the movement of inputs between and across countries. According to the OECD (2015), three-quarters of world trade involves intermediate and capital goods. The increasing importance of input trade has been accompanied by a parallel increase in the customization of products (Antràs and Staiger, 2012). As a result, to minimize the transaction costs involved with the production and incorporation of inputs into final goods, intellectual property rights and know-how may be transferred from the firm leading the supply chain (hereafter "the buyer") to its suppliers.[3] As Baldwin and Lopez-Gonzalez (2015) states "When Toyota makes car parts in Thailand, they do not rely on local know-how; they bring Toyota technology, Toyota management, Toyota logistics and any other bits of know-how needed since the Thai-made parts have to fit seamlessly into the company's production network."

According to Antràs and Staiger (2012), intermediate input purchases tend to be associated with significant lock-in effects for both buyers and sellers. For example, differentiated intermediate inputs are frequently customized to meet the needs of their intended buyers and hence embody a disproportionate amount of relationship-specific investments (Nunn, 2007), which may be hard to recoup when transacting with various parties. Moreover, offshoring often involves the costly search for suitable foreign suppliers or foreign buyers, which makes separations costly and thereby provides another source of lock-in. The competitive pressure imposed on firms participating in a supply chain is especially important

[3] This paper is also closely related to the empirical literature on foreign direct investment (FDI) which shows that multinational enterprises transfer their technology and methods to their operations in destination markets (e.g. Javorcik, 2004; Keller and Yeaple, 2009). This literature argues that sharing information about new technologies or business practices to domestic suppliers reduces input costs, increases input quality, and thus benefits multinationals supply chain activities.

for developing nation firms. Rigo (2017) argues that the fragmentation of production processes has significantly affected manufacturing firms in developing nations, showing that a common set of technologies and capabilities correlate with firms' participation in complex international activities.

In the empirical literature, international trade has long been considered to be a channel of technology transfer. Several studies have shown the positive impact of innovation on export and import activities (e.g. Bøler, Moxnes, and Ulltveit-Moe, 2015). In addition, exposure to international markets may bring several advantages (higher revenues and better quality inputs) which may lead firms to invest further in upgrading their technology (Bustos, 2011; Lileeva and Trefler, 2010). Moreover, firms that export are expected to absorb new knowledge from foreign markets and buyers. However, learning by exporting is far from guaranteed, and is conditional on several factors. For instance, such learning tends to occur more when firms are exporting to advanced economies (De Loecker 2007), when they are exporting multiple products to multiple destinations (Masso and Vahter 2015), or when firms are involved in knowledge-intensive activities (Benkovskis et al. 2018).

This paper argues that supply chains may unlock the transfer of technology, especially for firms in developing nations. In particular, this paper extends the existing literature by investigating the causal link between participating in complex international activities and licensing of foreign technologies to firms in developing and emerging economies. This analysis differs from the existing literature in three respects. First, I examine the implications of international trade on a completely unexplored channel of technology transfer, namely foreign licensing (i.e. the lending of intellectual property rights between firms located in different countries). Second, I study a large set of developing and emerging economies, covering all continents of the world, which give me confidence in the generalizability of my findings. Third, my analysis focuses on the direction of causality by combining a propensity score matching (PSM) technique with a difference-in-differences (diff-in-diff) approach.

The empirical analysis is based on a sample of 3,340 manufacturing firms from the World Bank's Enterprise Surveys. These surveys are harmonized to construct a two-year panel data set for 18 developing and emerging economies covering the period 2006-2017. The main goal of the empirical analysis is to disentangle correlation and causality in the context of international trade and technology adoption. I thus use propensity-score matching (PSM) to

assess the causal effect of trading internationally on technology licensing. The matching technique creates for each firm participating in a GVC (treatment group) a synthetic counterfactual (control group). It does so by pairing up each firm that will start a complex trading activity (i.e. two-way trading) in the future with a domestic plant or a simple trader (exporter-only or importer-only) with very similar observable characteristics. I then use the PSM diff-in-diff technique. The causal effect of participation in GVCs is hence inferred from the average divergence in the probability for using foreign-licensed technology between firms involved in complex trading activity and their matched control firms. This strategy allows controlling for observable and unobservable time-invariant firm characteristics.

My analysis shows that there is a positive and causal impact of being involved in complex trading activity on the licensing of foreign technology. Importantly, domestic firms becoming two-way traders are more likely to acquire a foreign-licensed technology than domestic firms starting to either export or import. This suggests that the complexity associated with the trading status determines the licensing of a foreign technology.

These findings matter for policy. There is a lack of consensus on the role and the upgrading processes of firms within GVCs (OECD, 2013; UNCTAD, 2013; and Taglioni and Winkler, 2016). A prevalent worry is that manufacturing firms in developing countries become stuck in labour-intensive low-value added operations, such as product assembly. The findings of this paper suggest that GVC participation can enhance firms' learning possibilities, by introducing foreign technology.

The paper is structured as follows: the next section (section 2) presents the data and discusses some measurement issues; section 3 lays out the empirical strategy and describes the results; and section 4 summarizes its conclusions.

2. Data

This paper is based on a sample of 3,340 manufacturing firms[4] from the World Bank's Enterprise Surveys.[5] These surveys are harmonized to construct a two-year panel data set for 18 developing and emerging economies covering the period 2006–2017. Firms in

[4] 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 them as firms throughout the paper.

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

different countries are evaluated in different time periods, with an average time span between the two surveys of 4 years.[6] The object of my analysis is to identify whether or not foreign technology is transferred to firms participating in a global supply chain. This exercise entails two main challenges: to measure technology transfer and to identify firms participating in GVCs.

First, the transfer of technology is measured by whether the firm uses a foreign-licensed technology.[7] The World Bank's Enterprise Surveys define a technology license as the intellectual property right necessary to create and market a product that complies with a technical standard or specification.[8] For instance, a buyer licenses its technology to a foreign supplier to use a consistent production process or specialized equipment to manufacture a product.[9] In practice, a global manufacturer of photovoltaic panels licenses the process for depositing silicon on its solar panels to a Chinese company. However, the surveys do not provide any further information on either the duration or type of the agreement.

Table 1 breaks down foreign-licensed technology according to trade orientation. The table highlights the presence of a hierarchy in the adoption of foreign-licensed technology, with trading firms characterized by higher shares than non-traders. Among trading firms, those involved in complex activities (i.e. two-way traders) use foreign technology more intensively. However, Table 2 shows that while two-way traders are more likely than domestic firms to use a foreign-licensed technology, they are not significantly more likely to do so than firms involved in "simple" international activities.[10]

[6] See table A1 in the appendix for the list of surveys.

[7] According to the World Intellectual Property Organization (WIPO), licensed production must constitute a partnership between an intellectual property owner and a licensee who is authorized to use such rights under certain conditions. The licensee is manufacturing a product for which it has been granted production rights under specific conditions, while the licensor retains ownership of the intellectual property thereof. In some cases, the licensor will supply the necessary technical data, prototypes, and/or machine tools to the licensee. Licensing agreements determine the form and scope of compensation to the intellectual property owner, which usually takes the form of a flat licensing fee or a running royalty payment derived from a share of the licensee's revenue.

[8] The question in the survey is the following: "Does this establishment at present use technology licensed from a foreign-owned company, excluding office software?"

[9] This agreement is defined by a written contract between a buyer and a supplier which allows the buyer to outsource the production of a product without high financial and legal risks.

[10] Rigo (2017) find that, for a larger sample of developing and emerging economies, two-way traders are the most likely group of firms to possess foreign-licensed technologies.

Table 1. Break-down of firms by trading status and foreign technology

Foreign technology	Domestic	Importer-only	Exporter-only	Two-way
NO	0.92	0.84	0.79	0.75
YES	0.08	0.16	0.21	0.25

Table 2. Correlation with foreign-licensed technology

VARIABLES	Foreign tech
Two-way trader	0.101***
	(0.0145)
Importer-only	0.0921***
	(0.0123)
Exporter-only	0.0896***
	(0.0195)
Empl (log)	0.0379***
	(0.00323)
Foreign (dummy)	0.0930***
	(0.0114)
Observations	6,518
R-squared	0.126
	p-Values
Exp&Imp = Exp	0.55
Exp&Imp = Imp	0.45

Robust standard errors in parentheses. The analysis controls for industry and country-year fixed effects.
*** p<0.01, ** p<0.05, * p<0.1

Second, few empirical studies have distinguished between GVC firms and non-GVC firms. So far, studies have identified GVC firms as traders (exporter-only, importer-only or two-way traders) with a quality certification (Del Prete, Giovannetti, and Marvasi, 2016; and Nadvi, 2008). This definition is based on the idea that global standards reduce transaction costs across firms by ensuring the codifiability of information. However, this definition is overly general because it also includes firms producing everything domestically and do no offshore any stage of their production process(es). This paper's *condition sine qua non* to participate in GVCs is to be a two-way trader (i.e. exporting and importing at the same time) because this is the only category that includes all firms with internationally fragmented production

processes.[11] Importantly, my definition sets apart a GVC firm that imports and exports, from a frim that is part of a value chain that involves a single international transaction, such as an import or export of intermediate goods. My definition follows the macro literature which has emphasized that a GVC is defined as involving production sharing between two or more countries (Baldwin and Lopez-Gonzalez, 2015; Koopman, Wang, and Wie, 2014; Wang et al. 2017). Obviously, this definition does not account for many firms that indirectly participate in GVCs (i.e., exporters-only, importers-only and domestic firms that supply or use inputs which are part of a GVC).[12] However, I exclude these indirect participants because importing and exporting at the same time has economic implications that are qualitatively distinct from being engaged in only one activity (Rigo, 2017; Bernard et al., 2007).[13]

In my sample[14], 21 per cent of firms are engaged in two-way trading (importing and exporting at the same time), indicating that trading firms in developing countries are highly involved in complex fragmented activities. Instead, exporters-only and importers-only account for 5 and 35 per cent of the sample, respectively. Finally, domestic firms (non-traders) made up the remaining 39 per cent of firms.

To implement my empirical strategy, I then identify two groups of firms: i) the "switchers", which are firms engaging in complex international activities (i.e. two-way traders) during the period of analysis (treated group); and ii) firms that are not two-way traders (control group). Not considered in the analysis are the two following additional categories of firms: the "quitters", which are firms that cease to be engaged in two-way trading; and firms that are always two-way traders during the period. Table 3 shows the proportion of "switchers" in the total number of firms by country.[15] Table 4 complements this overview by showing the

[11] A limitation of this definition is that some two-way traders are not participating in GVCs. For instance, firms importing raw materials and exporting final goods, without offshoring (or being offshored) stages of their production processes across national boundaries. Unfortunately, I cannot identify this type of firm because in the data I do not observe the industry classification of imports. However, I believe that these firms represent a minority in developing countries.

[12] For instance, a firm that import some intermediate inputs, processed and sold them domestically to another firm that eventually export them is indirectly participating in GVCs.

[13] Rigo (2017) shows that the probability of having a quality certification is not significantly different between exporters-only and two-way traders. This fact confirms the importance of quality standards in reducing the transaction costs entailed in the exports of goods. However, according to my definition of GVC, firms are also required to deal with at least one foreign supplier (contrary to exporters-only). As a result, GVC firms face an additional layer of organizational complexity than exporters-only since they must also incorporate foreign inputs into their production process.

[14] The following shares are based on the pooled sample of firms.

[15] These statistics are based on the final year. In other words, the first row of Table 2 indicates that 25 firms became two-way traders.

number of "switchers" by industry. The missing industries are not considered in the analysis because they do not have any switcher(s).

Table 3. Number of switchers by country

Country	No. firms	No. switchers
Argentina	177	25
Bangladesh	110	32
Chile	210	25
Colombia	156	16
Ethiopia	108	11
Indonesia	325	8
Mexico	124	20
Myanmar	133	5
Nigeria	205	41
Peru	124	16
Philippines	188	20
Senegal	108	3
Uganda	105	6
Ukraine	85	6
Uruguay	109	6
Vietnam	148	16
Zambia	74	2
Zimbabwe	136	26

Table 4. Number of switchers by industry

ISIC rev. 3.1	No. firms	No. switchers
15	668	42
17	224	32
18	443	61
19	58	10
24	246	35
25	136	21
26	170	16
28	182	18
29	108	14
36	100	11

3. Empirical Strategy and Results

The empirical analysis aims to shed light on whether firms acquire foreign-licensed technology before or after joining "complex" international activities (i.e. becoming a two-way trader).

3.1 Matching strategy

To implement the PSM, I need to model the probability of joining a GVC. I do so by estimating a logit model of a firm becoming a two-way trader with firm characteristics as explanatory variables. All explanatory variables are included at the initial year and thus refer to the pre-treatment period.

This analysis is implemented by estimating the following specification:

$$Switch_{ijs} = \beta_0 + \beta_1 X_{ijs} + \delta_j + \sigma_s + \varepsilon_{ijs}$$

where *i* denotes the firm, *j* the industry and *s* the survey (i.e. country-year). $Switch_{ijs}$ is a dummy variable indicating firms becoming two-way traders from one year to another. X_{ijs} includes the following firm-level measures: labour productivity (value added per worker), average wage (labour costs per worker), skilled labour share (non-production workers over total workers), employment growth (last three years growth rate), age, a dummy indicating if the firm is a two-way trader, a dummy for exporters-only, a dummy for importers-only and a dummy which equals 1 if the firm has a foreign ownership higher than or equal to 10 per cent. In addition, the specification uses industry and survey fixed effects. Survey fixed effects is equivalent to country-year fixed effects, allowing for the isolation of potential differences across surveys in GVC participation and industrial development. Industry fixed effects account for differences across industries such as the level of competition, technology use, market demand, and trade intensity. The results are based on a logit method (for binary outcomes).[16] All of the estimation results are based on robust standard errors.

Table 5 presents the coefficients of my model. While most firm-level variables are not significant, the probability of becoming a two-way trader is determined by size and by being an exporter or an importer. In addition, the share of foreign ownership and average wage positively correlate with the probability of joining GVCs.

The predicted probability of joining a GVC resulting from the model in Table 5 forms the basis of the matching procedure. The matching is performed at the initial period, before receiving the treatment, and firms are also matched within the same country and the same sector. This eliminates the possibility that difference in foreign-technology adoption across

[16] The average marginal effects of the discrete differences in probability are reported. For instance, in Table 5 the coefficient of *Exporter* indicates the difference in probability between exporters-only and domestic firms.

countries and sectors influence the estimated effects. In conclusion, the propensity score relies on the following determinants: ownership status, trade status, level of employment, age, skill intensity and employment growth. In choosing the minimum number of matches required, there is a trade-off between bias (higher number higher bias) and variance (higher number lower variance) (Caliendo and Kopeinig, 2008). I decide to give more importance to bias by requiring at least one match.

Table 5. Matching strategy

	Pr(Switch)	Pr(Switch)	Pr(Switch)
Employment	0.0485***	0.0495***	0.0468***
	(0.00590)	(0.00592)	(0.00600)
Labor Prod (log)	0.00981	0.00834	0.0103
	(0.00704)	(0.00700)	(0.00717)
Skilled labor share	0.0151	0.0243	0.00770
	(0.0421)	(0.0416)	(0.0428)
Average wage	0.0138*	0.0132*	0.0134*
	(0.00720)	(0.00726)	(0.00764)
Age	-0.00450	-0.00269	-0.00322
	(0.00982)	(0.00980)	(0.0101)
Foreign owned	0.0294		0.0222
	(0.0231)		(0.0237)
Importer	0.0306*		0.0345*
	(0.0175)		(0.0180)
Exporter	0.124***		0.125***
	(0.0254)		(0.0261)
Employment growth			0.00921
			(0.0183)
Foreign control share		0.000584*	
		(0.000302)	
Exported sales share		0.00173***	
		(0.000373)	
Imported input share		0.000205	
		(0.000218)	
N	1,719	1,719	1,647
Pseudo R2	0.219	0.223	0.223

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

3.2 Average Treatment effect on Treated (ATT)

The aim of this section is to estimate the causal effect of joining a GVC on the probability of using a foreign-licensed technology. This effect is defined as

$$ATT = E(Y_1 - Y_0|GVC = 1) = E(Y_1|GVC = 1) - E(Y_0|GVC = 1)$$

which is the difference between the probability of having a foreign-licensed technology for firms joining GVCs (first term) and the analogous outcome of the same firms had they not started participating in GVCs (second term). Logically, the latter outcome cannot be observed and I rely on a matching technique to construct the missing counterfactual (Rosenbaum and Rubin, 1983). The underlying assumption for the validity of the matching procedure is that, conditional on a set of observable characteristics, treatment status and potential outcomes are independent. Under these assumptions,

$$E[Y_1|X] = E[Y_1|X, GVC = 1] = E[Y_1|X, GVC = 0]$$
$$E[Y_0|X] = E[Y_0|X, GVC = 0] = E[Y_0|X, GVC = 1]$$

These imply that

$ATT = E[Y_1 - Y_0|X, GVC = 1] =$

$= (E[Y_1|X, GVC = 1] - E[Y_0|X, GVC = 0]) - (E[Y_0|X, GVC = 1] - E[Y_0|X, GVC = 0]) =$

$= (E[Y_1|X, GVC = 1] - E[Y_0|X, GVC = 0]),$

where the second difference in the equation represents the selection bias, which is assumed to be zero conditional on X. I am then left with only the causal effect.

The combination of PSM and a diff-in-diff approach means that my empirical strategy looks for divergence in the paths of probability in having foreign-licensed technology between the treated firms and the matched control firms that have similar characteristics in the initial year. The advantage of focusing on firms observed before and after becoming two-way traders is that differencing over time allows us to eliminate the influence of all observable and unobservable time invariant firms' characteristics (e.g. quality of management). My dependent variables are dummies and so, by taking the first-difference, I want to compare the firms that have acquired licensed technology from one year to another, with firms that never had any foreign-licensed technology. Consequently, I exclude all firms that did have foreign technology in both years and the firms that "lost" such technology from one year to another.

Table 6 presents the results of the PSM diff-in-diff estimation.[17] In particular, in column (1) firms are matched within country and sector; column (2) firms are matched within country and sector, and by level of employment and FDI dummy; column (3) firms are matched within country and sector, and by level of employment, FDI dummy, exporter dummy and importer dummy; column (4) firms are matched within country and sector, and by level of employment, FDI dummy, exporter dummy, importer dummy, skill intensity, age, and labour productivity; and column (5) firms are matched within country and sector, and by level of employment, FDI dummy, exporter dummy, importer dummy, skill intensity, age, labour productivity, and employment growth.[18]

Table 6. ATT – All firms

	(1)	(2)	(3)	(4)	(5)
ATT	0.135***	0.100***	0.123***	0.0926**	0.183***
	(0.0310)	(0.0358)	(0.0346)	(0.0425)	(0.0387)
No. matched pairs	224	223	223	162	153

Average Treatment effect on Treated (ATT).
*** p<0.01, ** p<0.05, * p<0.1

Table 6 confirms my prediction, showing that there is a positive and causal impact of being involved in complex international activities (i.e. being a two-way trader) on the licensing of foreign-licensed technology.[19] In column (5), containing the full set of matching variables, the ATT is equal to 0.183, indicating that firms after joining GVCs have a 18 per cent higher probability of using foreign-licensed technology. This effect is statistically significant at the 1 per cent level. This finding holds by setting the maximum difference in probability between matched pairs of firms (i.e. caliper) at 10 per cent.[20]

3.3 Robustness check

To further increase confidence in my results, in this section I replicate the PSM diff-in-diff estimation in two different samples: first, I exclude all domestic firms from the control

[17] This procedure is implemented in Stata using the command *teffects psmatch*.
[18] The results stay consistent by also controlling for capital intensity. However, the number of observations drops by more than half to 93 matched pairs.
[19] The results are consistent by requiring at least 3 or 5 matches for each treated firm, see Table A2 and A3 in the Appendix.
[20] See Appendix, Table A4.

group, to compare treated firms with firms involved in "simple" international activities; and, second, I consider domestic firms becoming two-way traders as treated firms, and domestic firms becoming either exporter-only or importer-only as control firms. These analyses allow me to test whether the complexity of a firm's involvement in international markets affects my findings.

Regarding the first analysis, the PSM procedure looks for a match only within the sample of trading firms. In particular, in column (1) firms are matched within country and sector; column (2) firms are matched within country and sector, and by level of employment and FDI dummy; column (3) firms are matched within country and sector, and by level of employment, FDI dummy, skill intensity, age, and labour productivity; and column (4) firms are matched within country and sector, and by level of employment, FDI dummy, skill intensity, age, labour productivity and employment growth.

The results in Table 7 are consistent with the previous conclusion (in Table 6), suggesting that my findings are not driven by the composition of the control group. This implies that while treated firms are not different compared to exporter-only and importer-only before starting to become engaged in complex international activities (as shown in Table 4), they are more likely to then use foreign-licensed technology.

Table 7. ATT – only international traders

	(1)	(2)	(3)	(4)
ATT	0.132***	0.0881**	0.148***	0.0784
	(0.0311)	(0.0410)	(0.0483)	(0.0582)
No. matched pairs	224	223	162	153

Average Treatment effect on Treated (ATT).
*** p<0.01, ** p<0.05, * p<0.1

Regarding the second analysis, I compare domestic firms becoming two-way traders with domestic firms becoming either exporter-only or importer-only. In particular, in column (1) firms are matched within country and sector; in column (2) firms are matched within country and sector, and by level of employment and FDI dummy; in column (3) firms are matched within country and sector, and by level of employment, FDI dummy, skill intensity, age, and labour productivity; and in column (4) firms are matched within country and

sector, and by level of employment, FDI dummy, skill intensity, age, labour productivity, and employment growth.

The results in Table 8 show that domestic firms becoming two-way traders are more likely to acquire foreign-licensed technology than domestic firms starting to either export or import. This finding suggests that the complexity associated with the trading activity determines the licensing of foreign technology to manufacturing firms in developing nations.

Table 8. ATT – only domestic firms in time t

	(1)	(2)	(3)	(4)
ATT	0.151**	0.160**	0.227*	0.200***
	(0.0680)	(0.0742)	(0.122)	(0.0486)
No. matched pairs	71	71	43	40

Average Treatment effect on Treated (ATT).
*** p<0.01, ** p<0.05, * p<0.1

4. Conclusions

It is often argued that GVCs have offered a new path towards industrial development, since firms from high-technology nations may combine their firm-specific managerial, technical and marketing know-how with low wages from developing nations. However, little is known about the role of GVCs on manufacturing firms in developing nations.

This study aims to shed some light on this issue by examining the casual relationship between GVC participation and technology transfer to developing nations. I identify causality by controlling for the possible endogeneity of a firm's trading status, by combining a PSM technique with a diff-in-diff approach. This analysis differs from the existing literature in three respects. First, I examine the implications of international trade on a completely unexplored channel of technology transfer, namely foreign licensing (i.e. the lending of intellectual property rights between firms located in different countries). Second, I study a large set of developing and emerging economies, covering all continents of the world, which give me confidence in the generalizability of my findings. Third, my analysis focuses on the direction of causality.

This paper shows that there is a positive and causal impact of being involved in complex trading activity on the licensing of foreign technology. Importantly, domestic firms becoming two-way traders are more likely to acquire a foreign-licensed technology than domestic firms starting to either export or import. This suggests that the complexity associated with the trading status determines the licensing of a foreign technology.

Many developing countries strive to participate in GVCs in the hope of stimulating economic growth through knowledge transfer. The findings of this paper suggest that GVC participation can enhance developing nation firms' learning possibilities by introducing foreign technology. This is crucial for the success of a country, since knowledge diffusion is a powerful engine of growth and is a crucial factor in explaining global income distribution.

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Appendix

Table A1. Number of firms by country and year

Country	2006	2007	2008	2009	2010	2011	2013	2014	2015	2016
Argentina	306	0	0	0	306	0	0	0	0	0
Bangladesh	0	207	0	0	0	207	0	0	0	0
Chile	277	0	0	0	277	0	0	0	0	0
Colombia	188	0	0	0	188	0	0	0	0	0
Ethiopia	0	0	0	0	0	117	0	0	117	0
Indonesia	0	0	0	378	0	0	0	0	378	0
Mexico	143	0	0	0	143	0	0	0	0	0
Myanmar	0	0	0	0	0	0	0	149	0	149
Nigeria	0	107	0	106	0	0	0	213	0	0
Peru	189	0	0	0	189	0	0	0	0	0
Philippines	0	0	0	256	0	0	0	0	256	0
Senegal	0	118	0	0	0	0	0	118	0	0
Uganda	119	0	0	0	0	0	119	0	0	0
Ukraine	0	0	98	0	0	0	98	0	0	0
Uruguay	145	0	0	0	145	0	0	0	0	0
Vietnam	0	0	0	192	0	0	0	0	192	0
Zambia	0	88	0	0	0	0	88	0	0	0
Zimbabwe	0	0	0	0	0	156	0	0	0	156
Total	1,367	520	98	932	1,248	480	305	480	943	305

Table A2. ATT at least 3 matches

	(1)	(2)	(3)	(4)	(5)
ATT	0.138***	0.0873***	0.112***	0.105***	0.137***
	(0.0304)	(0.0305)	(0.0302)	(0.0314)	(0.0290)

Average Treatment effect on Treated (ATT).
*** p<0.01, ** p<0.05, * p<0.1

Table A3. ATT at least 5 matches

	(1)	(2)	(3)	(4)	(5)
ATT	0.140***	0.0912***	0.119***	0.104***	0.135***
	(0.0295)	(0.0305)	(0.0276)	(0.0299)	(0.0248)

Average Treatment effect on Treated (ATT).
*** p<0.01, ** p<0.05, * p<0.1

Table A4. ATT with caliper 0.1

	(1)	(2)	(3)	(4)	(5)
ATT	0.135***	0.124***	0.136***	0.0823**	0.117***
	(0.0310)	(0.0317)	(0.0370)	(0.0374)	(0.0429)

Average Treatment effect on Treated (ATT); one match; caliper 0.1
*** p<0.01, ** p<0.05, * p<0.1