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## In-house R&D, technology transfer, and firms' performance

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**ADB Working Paper Series**

**IN-HOUSE R&D, TECHNOLOGY  
TRANSFER, AND FIRMS' PERFORMANCE**

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**Abstract**

This study examines the individual and joint impact of technology transfer and in-house R&D on firms' productivity and export performance. We utilize a specially designed survey module on firms' technology competitiveness in Vietnamese manufacturing, which allows us to identify various forms of technology transfer directly at firm-level. We find that technology transfer exhibits a positive impact on firms' exports. The estimated coefficients on both export participation (the extensive margin) and export share (the intensive margin) are positive and significant. In terms of productivity, our result suggests the presence of vertical spillover. Technology transfer along the supply chain is associated with higher productivity—the coefficient is strongest in terms of significance level and magnitude. A long-term relationship with business partners along the supply chain can enhance the effectiveness of technology transfer, thus improving productivity. This finding suggests the potential effectiveness of policies to further enhance linkages between upstream and downstream firms, through which technology transfer can be promoted. Other forms of technology transfer, however, do not show robust impact on productivity. With regard to R&D, we find weak evidence of R&D impact. Only estimated coefficients on export participation are significant. Finally, the joint impact of R&D and technology transfer only shows on exports through firms who purchase embodied technology through goods or equipment.

**Keywords:** research and development, technology transfer, firms' heterogeneity, trade, productivity

**JEL Classification:** O3, F23

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## 1. INTRODUCTION

The development gap across countries can largely be explained by differences in productivity (Hsieh and Klenow 2009; Waugh 2010), which, in turn, is driven by innovation and technological progress. The importance of innovation activities in boosting productivity has been well documented in both theory and empirical research (Aghion and Howitt 1998; O'Mahony and Vecchi 2009). As such, promoting the utilization of advanced technology can accelerate productivity growth and narrow the technology gap with the global frontier (Fu, Pietrobelli, and Soete 2011).

To catch up with the advanced technology in developed countries, firms in developing countries have two avenues: in-house R&D and technology transfer (Hou and Mohnen 2013). The former is reflected in the expenditure spent on the development, design, and improvement of a firm's products. The latter refers to the acquisition of technology from external sources, such as the purchase of capital goods, technology licensing from research institutes and other firms, or through linkages with input suppliers or customers.

Both venues have been shown to boost productivity and enhance the competitiveness of countries and firms. Pieri, Vecchi and Venturini (2018) discuss two channels through which R&D can promote productivity. The input accumulation channel emphasizes the role of capital deepening, as well as the productivity-enhancing effect of investment in knowledge assets—that is, innovation. The second channel is through technology spillover, in which knowledge diffusion occurs across firms. Empirically, the meta-regression analysis by Ugur et al. (2016) shows, on average, positive estimates for the rate-of-return to R&D.

Despite its indisputable positive growth-enhancing effect, R&D may be infeasible for firms in developing countries with limited financial and human resources. R&D projects are expensive: physical and human capital requirements are demanding, and success is not guaranteed. Therefore, instead of pursuing heavy investment in R&D, these firms may opt for technology that has already been developed elsewhere through the second avenue—technology transfer. Tariff reduction has facilitated this effort by reducing the cost of imported machinery and equipment. Furthermore, foreign direct investment (FDI) liberalization has brought foreign firms with superior technology to the domestic markets. The expected technology spillover from multinational enterprises to domestic firms through the diffusion of advanced technology is one key rationale for FDI attraction policy.<sup>1</sup>

Attractive as it may sound, technology spillover from external sources does not occur automatically. The effectiveness of technology transfer depends on the absorptive capacity of recipient firms—that is, the ability to identify, assimilate, and commercially apply the knowledge created abroad (Cohen and Levinthal 1990). The concept of absorptive capacity and its role in generating productivity spillovers has been widely discussed in the literature on FDI impact on firms. The intuition is straightforward: Firms with the cognitive capacities to internalize the knowledge shared by external technology sources, such as from multinational enterprises, are more likely to enhance performance when exposed to new technologies. In a pioneering study on FDI and absorptive capacity, Girma (2005) finds a nonlinear threshold associated with the firm's absorptive capacity. Firms who are unable to utilize knowledge from their foreign

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<sup>1</sup> For studies on FDI spillover, see, for example, Javorcik (2004); Sari et al. (2016); Motohashi and Yuan (2010); Lu, Tao, and Zhu (2017); Bwalya (2006).

counterparts lose the competition, thus experiencing negligible or even negative FDI spillovers.

Given both the advantages and disadvantages of each innovation path—R&D versus technology transfer—the question for an individual firm is whether to invest in in-house R&D as the key source of innovation, or rely on external sources, or both. Existing literature linking R&D and technology transfer proposes two directions. If foreign technology and indigenous R&D generate similar benefits for the firm, and their effects on firm performance are independent, firms would consider these two avenues as substitutes. Firms will allocate the resources accordingly—an increase in in-house R&D is accompanied by a decrease in technology transfer.

Nevertheless, to the extent that R&D stimulates learning, and thus enhances absorptive capacity, in-house R&D can play a complementary role to technology transfer. In other words, larger investments in R&D improve the efficacy of technology transfer (Hu, Jefferson, and Jinchang 2005). Understanding the effect of the interaction of R&D with technology transfer on firms' performance facilitates the formulation of innovation strategies to enhance firms' effective technology adoption.

Against this backdrop, this research aims to examine both the individual and joint impact of in-house R&D and technology transfer on the performance of Vietnamese manufacturing firms. Our study addresses two questions. First, we ask whether R&D and technology transfer per se enhance firms' productivity and exports. Second, we examine whether in-house R&D, as a form of enhancing absorptive capacity, facilitates the effectiveness of technology transfer. If a complementary relationship is observed, we expect the interaction between R&D and technology transfer to exert positive impacts on firms' performance, and vice versa.

To answer these questions, we utilize the Viet Nam Enterprise Survey (VES) matched with the Technology Competitiveness Survey (TCS), covering the 2009–2014 period. One key advantage of the TCS data is the availability of information on firm-level technology transfer and supply linkages. This information is usually not available in studies on technology spillovers and firms' performance, and thus is proxied by industry-level indicators.<sup>2</sup> Using industry-level variables, in turn, masks substantial heterogeneity at firm-level. Employing firms' information allows us to measure the direct technology linkages among firms along the supply chain instead of relying on the indirect technology spillover measured at industry-level. As such, we can explicitly control for firm heterogeneity and delve further into the potential differential impact of technology and R&D on firms with diverse characteristics.

The rest of our paper is organized as follows. Section 2 explains two key data sources we use and our empirical setting. Section 3 discusses firms' perception of technology transfer and R&D observed from our data. Section 4 presents baseline estimates. Section 5 proceeds with robustness tests. Section 6 concludes and discusses policy implications.

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<sup>2</sup> See, for example, Konings (2001); Javorcik (2004); Le and Pomfret (2011); Lu, Tao, and Zhu (2017).

## 2. EMPIRICAL STRATEGY

### 2.1 Data

#### 2.1.1 Viet Nam Enterprise Survey

The Viet Nam Enterprise Survey (VES) is provided by Viet Nam's General Statistics Office. Data have been collected annually since 2000, and the VES is by far the most comprehensive data set available on Vietnamese firms; it is the main source of firm-level statistics in the formal agriculture, industry, and service sectors. The VES includes a general questionnaire covering basic statistics at the firm-level, including ownership, assets and liability, employment, sales, labor costs, capital stock, and industry code from January to December of a particular year. A consistent and unique tax code is assigned to each firm, which allows us to track the firm across years.

#### 2.1.2 The Viet Nam Technology and Competitiveness Survey (TCS)

The VES data is supplemented with a specialized module on technology adoption at the firm-level covering the 2009–2014 period. The TCS is a joint product between the General Statistics Office of Viet Nam, the Central Institute for Economic Management and the Department of Economics, Copenhagen University.

The TCS gathers detailed information on the utilization of technology, supply chain linkages, research and development, and technology transfer. Approximately 7,000 firms are selected for the survey from around 52,000 manufacturing firms in the VES. The TCS survey is administered simultaneously using the same discipline as the VES. These data can be matched with the master data from VES using the unique firm ID.

We follow the definition of technology transfer as specified in the TCS, which includes the following activities: purchasing technology presented in goods (e.g., machine, equipment); purchasing technology or machine and equipment from research institutes and other enterprises; utilizing technology or machine and equipment from other enterprises in the same group/corporation; and utilizing technology or machines and equipment provided by a supplier or main customer under a long-term contract (3 years and over).

We construct our major variables as follows. We use information from the question "How relevant are the following transfer channels as sources of technology for your enterprise?" to construct our firms' perception of the relevance of each technology transfer channel. There are five technology transfer channels: (i) purchase of embodied technology (e.g., in goods, machinery, or equipment); (ii) purchase of technology from research institutions or external firms; (iii) use of technology provided by other firms within the group (e.g., shareholder(s)); (iv) use of technology provided by firms outside the group (e.g., suppliers or customers); (v) skills and experience of new employees.

The relevance of each technology transfer channel is reported from 0 (not at all) to 10 (very relevant). Our technology channel variables are constructed as binary variables, which take the value of one if a firm reports the specific channel is very relevant (i.e., the firm chooses 10 in their response) and zero otherwise. Since there is no consensus on whether the threshold value should be used to construct variables on technology transfer channels, in our opinion, if a firm uses a specific technology transfer channel, their response should be very relevant rather than other values.



Technology transfer with input supplier and customers is constructed from two questions for 2009 and four questions for 2010–2014. In the 2010–2014 questionnaires, the questions are “Do any of these relationships with domestic suppliers result in technology transfer from the supplier to your enterprise?”; “Do any of these relationships with foreign suppliers result in technology transfer from the supplier to your enterprise?”; “Do any of these relationships [i.e., these contracting relationships with your Vietnamese customers] result in technology transfer from the customer to your enterprise?”; and “Do any of these relationships [i.e., these contracting relationships with your international customers outside Viet Nam] result in technology transfer from the customer to your enterprise?” In the 2009 questionnaire, there are only two questions for input suppliers and for customers (i.e., it does not distinguish foreign and domestic suppliers and customers). This variable takes the value of one if firms reported that their relationship with either input suppliers and customers resulted in technical transfer and zero otherwise.

The R&D variable is constructed from the question: “Does your enterprise undertake research and development (R&D) activities in order to develop new technologies?” R&D variable takes value of one if the firm reported that they have R&D activities and zero otherwise. In-house R&D activities are constructed from firms’ answer to question: “Where are these R&D activities performed?” “In-house R&D activities’ is also a binary variable, which takes the value of one if firms reported that their R&D activities were performed in-house or both in-house and out-of-house, and zero otherwise.

The data set also provides information on the share of exports in total revenue. We use this information to construct export-related variables. Exporting firms are defined as firms with a positive export share. Export share is equal to the share of exports in total revenue.

In this paper, we adopt the Wooldridge (2009) approach to measure total factor productivity (TFP), using the whole sample from the VES 2006–2014. We use the industrial producer price to convert labor cost, material cost, capital costs, value added, and revenue to the 2010 price. All the price and costs are converted to the 2010 USD.

## 2.2 Methodology

We follow Hu, Jefferson, and Jinchang (2005) to estimate the performance of firms as a function of firms’ in-house R&D, technology transfer, and their interaction term. Industry fixed effects and time fixed effects are also included. Our regression equation is as follow:

$$Y_{it} = \beta_0 + \beta_1 techtransfer_{it} + \beta_2 RD_{it} + \beta_3 RDtechtransfer_{it} + \beta X_{it} + u_{it} \quad (1)$$

where  $i$  and  $t$  denote firm and time, respectively.  $Y_{it}$  represents firms’ performance variables, including TFP, export status dummy, and export value.  $Techtransfer_{it}$  represents modes of technology transfer used in our study as explained earlier.

We include in  $X_{it}$  a set of firm characteristics—firm size, ownership, and 2-digit industry fixed effects, firm and year fixed effects.

We expect a positive relationship between technology transfer and R&D on firms' performance individually. As for the joint impact of R&D and technology transfer ( $\beta_3$ ), a positive coefficient implies complementarity between R&D and technology transfer. In other words, the performance-enhancing effect of technology transfer is expected to increase with R&D intensity, suggesting an absorptive capacity argument is in place. To the extent that R&D results in better learning skills, we expect evidence of a complementary relationship.

## 2.3 Robustness Check

One may be concerned with our definition of technology transfer. We are conservative in the sense that only firms who report technology transfer as “very relevant,” that is, firms choosing 10 in the response scale, are coded as 1 in our empirical model, while firms choosing 1 to 9 are all classified as firms without technology transfer. As the responses are perception-based, differences between “relevant” (9) and “very relevant” (10) can be subtle. To account for this possible sensitivity in the response, we redefine firms with technology transfer as those who report the relevance scales of 8–10 and estimate equation (1).

## 3. TECHNOLOGY TRANSFER AND R&D—STYLIZED FACTS

This section presents preliminary observations about firms' perceptions towards technology transfer and their engagement in R&D. Table 1 demonstrates the percentage of firms who consider technology transfer as “very relevant” to their performance by year. Overall, firms regard technology transfer as a potentially important activity—from 21% to 34% of firms have ranked at least one technology transfer approach as very relevant. Among the six channels of technology transfer, having contracts with buyers and suppliers is considered the most important, followed by the purchase of embodied technology. Up to 22% and 17% of the firms give a score of 10 to the former and the latter, respectively. To the extent that firms expect technology transfer to improve their performance, this observation is consistent with existing studies on the positive technology spillover effects through vertical linkages and through the utilization of advanced technology.

**Table 1: Technology Transfer (TT) by Year**

	All	2009	2010	2011	2012	2013	2014
Self-reported relevance of TT approach							
TT through Purchase of embodied technology	17%	17%	18%	17%	16%	15%	15%
TT through Purchase of technology from research institutions or external firms	7%	5%	8%	7%	8%	8%	8%
TT through Use of technology provided by other firms within group	6%	5%	7%	7%	6%	6%	7%
TT through Use of technology provided by firms outside group	8%	4%	9%	9%	8%	8%	9%
TT through Skills and experience of new employees	10%	0%	14%	15%	10%	9%	8%
Having at least one “most relevant” TT approach	30%	21%	34%	33%	30%	30%	30%
TT through Contract with suppliers and buyers	22%	14%	28%	35%	20%	18%	15%

Source: Authors' calculation.

Table 2 presents a more detailed picture of firms' perception of technology transfer based on the relevance scale from 0 to 10. Responses concentrate on the two extremes—either 0 or 10—and the middle value 5. Approximately 25% to 40% of firms consider technology transfer as being of no relevance to their business. Around 10% of the firms view technology transfer as somewhat relevant. On the right extreme, technology transfer through purchase of embodied technology is regarded as the most relevant form among the five types, with up to 17% of firms giving this form a 10-point score on the relevance scale.

**Table 2: Firms' Perception of Technology Transfer (TT), by Relevance Scale<sup>a</sup>**

	Degree of Relevance										
	(0: no relevance; 10; very much relevant); unit %										
	0	1	2	3	4	5	6	7	8	9	10
All firms											
TT through Purchase of embodied technology	26	8	4	4	5	12	6	5	8	5	17
TT through Purchase of technology from research institutions or external firms	33	10	5	6	6	13	7	5	5	3	7
TT through Use of technology provided by another firm within group	41	9	5	5	5	11	6	4	5	3	6
TT through Use of technology provided by firms outside group	36	8	5	5	6	12	6	5	6	3	8
TT through skills and experience of new employees	24	9	5	6	6	14	8	6	7	4	12

<sup>a</sup> The 6th form of technology transfer, i.e., linkages with suppliers and buyers, is not perception-based, thus we do not include the response in this table. Similarly, R&D statistics is not presented in this table.

Source: Authors' calculation.

The importance of technology transfer varies not only across forms of technology transfer per se, but also on firms' characteristics. Table 3 illustrates firm heterogeneity in terms of size, ownership, and trade status. For the perception-based responses (columns 2 to 6), the differences are less pronounced. Consistent with findings from Table 2, the dominant source of technology transfer is the purchase of embodied technology. However, we observe clearer heterogeneity regarding firms' technology transfer with suppliers or customers (column 7). State-owned enterprises (SOEs)—followed by joint ventures, larger firms, and firms who are active in both exports and imports, are more likely to have technology transfer contracts with partners along the supply chain.

A similar pattern is observed for R&D activities (columns 8 and 9). Nevertheless, compared to technology transfer, R&D—especially in-house R&D—is less popular among firms, arguably due to the higher monetary costs and more demanding human resources.

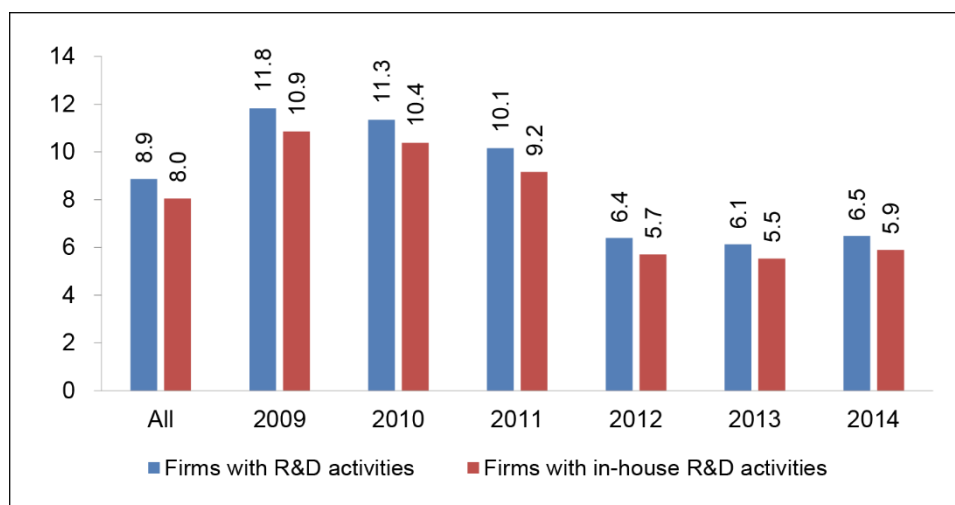
As we are interested in the interaction between technology transfer and R&D, next we examine the prevalence of R&D activities among firms who consider technology transfer as very relevant. Figure 1 depicts the findings. Approximately 9% of these firms conduct R&D activities, even though the ratio fluctuates across the years. The majority of R&D activities are conducted in-house. Combined with the statistics in Table 3, it seems that firms with technology transfer are also more likely to engage in R&D, suggesting a complementary relationship between these two forms of innovation.

**Table 3: Technology Transfer and R&D by Firm Characteristics**

	Type of Technical Transfer (Relevance Perspective)								
	At Least a TT	Purchase of Embodied Technology	Purchase of Technology from Research Institutions or External Firms	Use of Technology Provided by Another Firm within Group	Use of Technology Provided by Firms Outside Group	Skills and Experience of New Employees	TT with Suppliers/Customers	R&D Activity	In-house R&D Activities
<i>Firm ownership</i>									
Cooperative/Partnership	31	18	7	3	5	13	19	5	4
State-owned enterprises (SOEs) or SOEs with 50% state equity	34	19	7	9	7	9	37	23	23
Equitized firms (States<50%)	28	17	7	5	8	9	22	9	9
LTD/Joint Stocks Companies	31	18	8	4	8	10	22	9	8
FDI 100% foreign	31	13	7	13	9	9	24	7	6
FDI – joint venture	30	17	7	9	8	8	29	16	15
<i>By firm size</i>									
less than 10 employees	29	17	6	7	11	4	14	4	3
at least 10 and less than 20 employees	29	17	7	6	10	4	16	5	5
at least 20 and less than 50 employees	28	16	7	7	9	5	19	6	6
at least 50 and less than 250 employees	30	17	8	8	9	7	25	11	10
at least 250 employees	33	17	8	10	10	10	31	14	13
<i>GVC status</i>									
No import and export activities	29	17	7	4	7	10	19	7	6
Only import or export activities	30	16	8	6	8	10	25	12	11
Both import and export activities	32	15	8	11	9	9	28	11	10

Source: Authors' calculation.

**Figure 1: Technology Transfer Firms with R&D Activities, by Year (%)**



Source: Authors' calculation from the TCS.

Table 4 presents the descriptive statistics of the variables in our model.

**Table 4: Descriptive Statistics**

		Mean	Sta. Dev.	Min	Max
TFP (in log)	40,366	1.20	0.82	-6.91	5.24
TFP (in '1000 USD)	40,366	4.74	5.86	.001001	188.26
Share of TFP in real value added	40,366	0.04	0.05	0.00	0.30
Having export activities	40,366	0.35	0.48	0	1
Share of exports in total revenue	40,366	0.23	0.39	0	1
Export value (in 1000USD)	40,366	1,139.91	5,203.21	0.01	165,699
Have in-house R&D activities	40,366	0.08	0.27	0	1
Having at least one "most relevant" technology transfer (TT) approach	40,366	0.30	0.46	0	1
TT through Purchase of embodied technology	40,366	0.17	0.37	0	1
TT through Purchase of technology from research institutions or external firms	40,366	0.07	0.26	0	1
TT through Use of technology provided by another firm within group	40,366	0.06	0.24	0	1
TT through Use of technology provided by firms outside group	40,366	0.08	0.27	0	1
TT through Skills and experience of new employees	40,366	0.10	0.29	0	1
TT through Contract with suppliers and buyers	40,366	0.22	0.42	0	1
Used imported inputs	40,366	0.31	0.46	0	1
Labor	40,366	167	401.00	1	13,116
Size class					
less than 10 employees	40,366	0.07	0.25	0	1
at least 10 and less than 20 employees	40,366	0.13	0.34	0	1
at least 20 and less than 50 employees	40,366	0.27	0.44	0	1
at least 50 and less than 250 employees	40,366	0.36	0.48	0	1
at least 250 employees	40,366	0.18	0.39	0	1
Firm types					
Cooperative/Partnership	40,366	0.02199	0.14666	0	1
SOEs or SOEs with > 50% state equity	40,366	0.00323	0.05674	0	1
Equitized firms (<50% state equity)	40,366	0.43849	0.49621	0	1
LTD/Joint Stocks Corp.	40,366	0.30756	0.46149	0	1
FDI 100% foreign investment	40,366	0.20525	0.40389	0	1
FDI – joint venture	40,366	0.02348	0.15143	0	1

Source: Authors' calculation.

## 4. EMPIRICAL RESULTS

We start our analysis by examining the impact of technology transfer and R&D separately on firms' performance. Table 5 reports the results for TFP. Contrary to our expectation, we do not find any significant impact of R&D on firms' TFP.<sup>3</sup> In terms of technology transfer, our result suggests the presence of vertical spillover. Technology transfer along the supply chain is associated with higher productivity—the coefficient is strongest in terms of significance level and magnitude. A long-term relationship with business partners along the supply chain can enhance the effectiveness of technology transfer, thus improving productivity.

<sup>3</sup> Since our R&D variable is a dummy variable, it cannot capture the intensity of R&D. If R&D activities are carried out on a limited scale, the productivity impact may be negligible.

**Table 5: R&D and Technology Transfer on Firm's Productivity – Individual Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(8)
In-house RD	-0.004 [0.010]	-0.004 [0.010]	-0.003 [0.010]	-0.004 [0.010]	-0.003 [0.010]	-0.004 [0.010]	-0.006 [0.010]
At least one type of transfer (except TT with suppliers/buyers)	0.011* [0.006]						
Purchase of embodied technology		0.004 [0.007]					
Purchase of technology from research institutions or external firms			-0.006 [0.010]				
Use of technology provided by another firm within group				0.002 [0.011]			
Use of technology provided by firms outside group					-0.009 [0.010]		
Skills and experience of new employees						0.000 [0.009]	
TT with suppliers and buyers							0.020*** [0.007]
VSIC 2-digit _cons	Yes 1.596*** [0.158]	Yes 1.596*** [0.158]	Yes 1.595*** [0.158]	Yes 1.595*** [0.158]	Yes 1.596*** [0.158]	Yes 1.595*** [0.158]	Yes 1.593*** [0.158]
N	40366	40366	40366	40366	40366	40366	40366
Firm size							
less than 10 employees	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
at least 10 and less	-0.058*** [0.014]	-0.059*** [0.014]	-0.059*** [0.014]	-0.059*** [0.014]	-0.059*** [0.014]	-0.059*** [0.014]	-0.059*** [0.014]
at least 20 and less	-0.205*** [0.016]	-0.205*** [0.016]	-0.205*** [0.016]	-0.205*** [0.016]	-0.205*** [0.016]	-0.205*** [0.016]	-0.205*** [0.016]
at least 50 and less	-0.358*** [0.018]	-0.358*** [0.018]	-0.357*** [0.018]	-0.358*** [0.018]	-0.358*** [0.018]	-0.358*** [0.018]	-0.358*** [0.018]
at least 250 employees	-0.490*** [0.023]	-0.490*** [0.023]	-0.489*** [0.023]	-0.490*** [0.023]	-0.490*** [0.023]	-0.490*** [0.023]	-0.491*** [0.023]
Firm type							
Cooperative/Partnership	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
SOEs or SOEs with > 50% state equity	0.223 [0.162]	0.223 [0.162]	0.223 [0.162]	0.224 [0.162]	0.224 [0.162]	0.224 [0.162]	0.228 [0.162]
Equitized firms (<50% state equity)	0.011 [0.138]	0.012 [0.138]	0.013 [0.138]	0.013 [0.138]	0.013 [0.138]	0.013 [0.138]	0.015 [0.138]
LTD/Joint Stocks Corp.	-0.043 [0.138]	-0.042 [0.138]	-0.041 [0.138]	-0.041 [0.138]	-0.041 [0.138]	-0.041 [0.138]	-0.039 [0.138]
FDI 100% foreign investment	0.315* [0.161]	0.318** [0.161]	0.320** [0.161]	0.319** [0.161]	0.321** [0.161]	0.320** [0.161]	0.321** [0.161]
FDI – joint venture	0.200 [0.159]	0.202 [0.159]	0.203 [0.159]	0.203 [0.159]	0.204 [0.159]	0.203 [0.159]	0.204 [0.159]

Standard errors in brackets = \* p<0.1, \*\* p<0.05, \*\*\* p<0.01.

Note: Dependent variable: TFP. Year fixed effects are included.

Source: Authors' calculation.

Turning to exports, both technology transfer and R&D are positively associated with export participation (Table 6). It is possible that technology transfer and R&D improve firms' innovation capacity, through which export is promoted. All forms of technology transfer except for "the use of technology provided by other firms within the group" are significant. Similarly to the results with TFP, the coefficient on technology transfer with suppliers and buyers is largest in magnitude compared to the other types.

**Table 6: R&D and Technology Transfer on Firm's Export Participation  
– Individual Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
In-house RD	0.011* [0.006]	0.012** [0.006]	0.012** [0.006]	0.012** [0.006]	0.012** [0.006]	0.012** [0.006]	0.010* [0.006]
At least a type of transfer (except TT with suppliers/buyers)	0.013*** [0.003]						
Purchase of embodied technology		0.009** [0.004]					
Purchase of technology from research institutions or external firms			0.013** [0.006]				
Use of technology provided by another firm within group				-0.006 [0.006]			
Use of technology provided by firms outside group					0.012** [0.005]		
Skills and experience of new employees						0.012** [0.005]	
TT with suppliers and buyers							0.016*** [0.004]
TFP	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]
Used input import	0.118*** [0.005]	0.118*** [0.005]	0.118*** [0.005]	0.118*** [0.005]	0.118*** [0.005]	0.118*** [0.005]	0.118*** [0.005]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	0.169* [0.088]	0.169* [0.088]	0.169* [0.088]	0.169* [0.088]	0.168* [0.088]	0.168* [0.088]	0.167* [0.088]
N	40366	40366	40366	40366	40366	40366	40366
Firm size							
less than 10 employees	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
at least 10 and less	0.018** [0.008]	0.018** [0.008]	0.018** [0.008]	0.018** [0.008]	0.018** [0.008]	0.018** [0.008]	0.018** [0.008]
at least 20 and less	0.043*** [0.009]	0.043*** [0.009]	0.043*** [0.009]	0.043*** [0.009]	0.043*** [0.009]	0.043*** [0.009]	0.043*** [0.009]
at least 50 and less	0.064*** [0.010]	0.065*** [0.010]	0.064*** [0.010]	0.065*** [0.010]	0.065*** [0.010]	0.065*** [0.010]	0.064*** [0.010]
at least 250 employees	0.095*** [0.013]	0.096*** [0.013]	0.095*** [0.013]	0.096*** [0.013]	0.095*** [0.013]	0.095*** [0.013]	0.094*** [0.013]
Firm type							
Cooperative/Partnership	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
SOEs or SOEs with > 50% state equity	0.002 [0.090]	0.001 [0.090]	0.003 [0.090]	0.003 [0.090]	0.002 [0.090]	0.003 [0.090]	0.006 [0.090]
Equitized firms (<50% state equity)	-0.037 [0.077]	-0.037 [0.077]	-0.035 [0.077]	-0.035 [0.077]	-0.035 [0.077]	-0.034 [0.077]	-0.033 [0.077]
LTD/Joint Stocks Corp.	-0.067 [0.077]	-0.067 [0.077]	-0.065 [0.077]	-0.065 [0.077]	-0.065 [0.077]	-0.064 [0.077]	-0.063 [0.077]
FDI 100% foreign investment	0.012 [0.090]	0.014 [0.090]	0.017 [0.090]	0.019 [0.090]	0.016 [0.090]	0.018 [0.090]	0.019 [0.090]
FDI – joint venture	-0.016 [0.089]	-0.015 [0.089]	-0.011 [0.089]	-0.011 [0.089]	-0.013 [0.089]	-0.011 [0.089]	-0.011 [0.089]

Standard errors in brackets = \* p<0.1, \*\* p<0.05, \*\*\* p<0.01.

Note: Dependent variable: Export dummy. Year fixed effects are included.

Source: Authors' calculation.

Following the literature, we include in this regression not only the key variables of interests as defined in Section 2, but also the use of imported intermediate inputs as a potential form of embedded technology relevant to export. For example, Feng, Li and Swenson (2016) find that firms who expand their range or expenditure of imported intermediate inputs also increase export volume, and that this relationship is stronger for firms operating in high-R&D-intensity industries. Consistent with previous studies, we also find a robust relationship between the use of imported intermediates and export participation. The magnitude of estimated coefficients is also larger than that on technology transfer and R&D.

Table 7 complements the analysis in Table 6 by looking at the intensive margin of export—that is, the export share over total revenue. Interestingly, R&D no longer shows significant impact, suggesting the potential effect of R&D on fixed costs rather than variable costs. Technology transfer remains positively significant with larger magnitude compared to results from Table 6. Again, the use of imported intermediates exerts the most significant impact on export share.

**Table 7: R&D and Technology Transfer on Firm's Export Share  
– Individual Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
In-house RD	0.058 [0.064]	0.061 [0.064]	0.064 [0.064]	0.069 [0.064]	0.063 [0.064]	0.062 [0.064]	0.052 [0.065]
At least one type of transfer (except TT with suppliers/buyers)	0.162*** [0.036]						
Purchase of embodied technology		0.159*** [0.045]					
Purchase of technology from research institutions or external firms			0.113* [0.061]				
Use of technology provided by another firm within group				-0.096 [0.068]			
Use of technology provided by firms outside group					0.188*** [0.059]		
Skills and experience of new employees						0.160*** [0.055]	
TT with suppliers and buyers							0.131*** [0.041]
TFP	0.248*** [0.036]	0.249*** [0.036]	0.250*** [0.036]	0.250*** [0.036]	0.250*** [0.036]	0.250*** [0.036]	0.248*** [0.036]
Use input import	1.309*** [0.057]	1.310*** [0.057]	1.312*** [0.057]	1.313*** [0.057]	1.312*** [0.057]	1.313*** [0.057]	1.307*** [0.057]
VSIC 2-digit	yes	yes	yes	yes	yes	yes	yes
No. of observations (firm-year)	40,149	40,149	40,149	40,149	40,149	40,149	40,149

Standard errors in brackets = \* p<0.1, \*\* p<0.05, \*\*\* p<0.01.

Note: Dependent variable: Export intensity, measured as the ratio of export to total revenue. Firm size, firm ownership and year fixed effects are included.

Source: Authors' calculation.

In the next step, we examine the interaction between R&D and technology transfer on firms' performance. Table 8, 9, and 10 report the results for TFP, export participation, and export share, respectively.

We do not detect any significant joint impact of R&D and technology transfer on productivity. This observation mirrors the results from Table 5, in which the individual impact of R&D and technology transfer is insignificant in most specifications.



**Table 8: R&D and Technology Transfer on Firm's Productivity – Joint Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	At Least One Type of Transfer (Except TT with Suppliers/ Buyers)	Purchase of Embodied Technology	Purchase of Technology from Research Institutions or External Firms	Use of Technology Provided by Another Firm Within Group	Use of Technology Provided by Firms Outside Group	Skills and Experience of New Employees	With Suppliers and Buyers
In-house RD: Yes / Tech Transfer: Yes	0.009 [0.015]	-0.012 [0.019]	-0.003 [0.027]	0.009 [0.029]	-0.027 [0.030]	-0.040 [0.025]	0.003 [0.014]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	1.596*** [0.160]	1.595*** [0.160]	1.595*** [0.160]	1.596*** [0.160]	1.595*** [0.160]	1.595*** [0.160]	1.593*** [0.159]
No. of observations (firm-year)	40,366	40,366	40,366	40,366	40,366	40,366	40,366

Standard errors in brackets = \* p<0.1, \*\* p<0.05, \*\*\* p<0.01.

Note: Dependent variable: Firm's TFP. Firm size, firm ownership and year fixed effects are included. Reference group: firms without technology transfer and R&D.

Source: Authors' calculation.

Turning to export performance, the estimates in Table 9 show a certain level of complementarity between these two innovation forces. Compared to firms without R&D and technology transfer, firms who undertake both activities, especially R&D firms who purchase embodied technology (column 2) and firms with linkages along the supply chain (column 7) have a higher probability of exporting compared to firms who only have technology transfer.

**Table 9: R&D and Technology Transfer on Export Status – Joint Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	At Least One Type of Transfer (Except TT with Suppliers/ Buyers)	Purchase of Embodied Technology	Purchase of Technology from Research Institutions or External Firms	Use of Technology Provided by Another Firm Within Group	Use of Technology Provided by Firms Outside Group	Skills and Experience of New Employees	With Suppliers and Buyers
In-house RD: Yes / Tech Transfer: Yes	0.028*** [0.010]	0.030** [0.015]	0.015 [0.019]	-0.000 [0.021]	0.004 [0.016]	0.003 [0.016]	0.022** [0.010]
TFP	0.013*** [0.004]	0.013*** [0.004]	0.013*** [0.004]	0.013*** [0.004]	0.013*** [0.004]	0.013*** [0.004]	0.013*** [0.004]
Used input import	0.118*** [0.008]	0.118*** [0.008]	0.118*** [0.008]	0.118*** [0.008]	0.118*** [0.008]	0.118*** [0.008]	0.118*** [0.008]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	0.170*** [0.052]	0.170*** [0.052]	0.169*** [0.052]	0.168*** [0.052]	0.168*** [0.052]	0.167*** [0.052]	0.167*** [0.053]
No. of observations (firm-year)	40,366	40,366	40,366	40,366	40,366	40,366	40,366

Standard errors in brackets = \* p<0.1, \*\* p<0.05, \*\*\* p<0.01.

Note: Dependent variable: Firm's TFP. Firm size, firm ownership and year fixed effects are included. Reference group: firms without technology transfer and R&D.

Source: Authors' calculation.

Similarly to findings from Table 9, Table 10 shows that technology transfer, especially through the purchase of embodied technology, is highly correlated with export intensity. R&D firms who purchased embodied technology are most likely to exports compared to R&D firms engaging in other forms of technology transfer. Utilization of imported intermediates remains robust, as the estimated coefficients are both large in magnitude and statistically significant.

**Table 10: R&D and Technology Transfer on Export Intensity – Joint Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	At Least One Type of Transfer (Except TT with Suppliers/Buyers)	Purchase of Embodied Technology	Purchase of Technology from Research Institutions or External Firms	Use of Technology Provided by Another Firm Within Group	Use of Technology Provided by Firms Outside Group	Skills and Experience of New Employees	With Suppliers and Buyers
In-house RD: Yes / Tech Transfer: Yes	0.193* [0.113]	0.262* [0.149]	0.068 [0.181]	0.129 [0.224]	0.259 [0.181]	-0.013 [0.160]	0.060 [0.107]
TFP	0.248*** [0.040]	0.249*** [0.040]	0.250*** [0.040]	0.250*** [0.040]	0.250*** [0.040]	0.249*** [0.040]	0.247*** [0.040]
Used input import	1.309*** [0.087]	1.310*** [0.087]	1.312*** [0.087]	1.313*** [0.087]	1.312*** [0.087]	1.313*** [0.087]	1.308*** [0.087]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-3.601*** [0.682]	-3.588*** [0.683]	-3.601*** [0.678]	-3.599*** [0.679]	-3.613*** [0.678]	-3.620*** [0.678]	-3.624*** [0.681]
No. of observations (firm-year)	40,149	40,149	40,149	40149	40149	40149	40149

Standard errors in brackets = \* p<0.1, \*\* p<0.05, \*\*\* p<0.01.

Note: Dependent variable: Firm's export intensity, measured as the ratio of export value over total revenue. Firm size, firm ownership and year fixed effects are included. Reference group: firms without technology transfer and R&D.

Source: Authors' calculation.

## 5. ROBUSTNESS CHECK

Table 11 to Table 13 present the results for our robustness check. We assign the value 1 to the technology transfer dummy if the responses range from 8 to 10 on the relevance scale, and 0 otherwise. Our key findings remain unchanged.

**Table 11: Robustness Check – R&D and Technology Transfer on Firm's Productivity – Individual Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
In-house RD	-0.004 [0.010]	-0.004 [0.010]	-0.004 [0.010]	-0.003 [0.010]	-0.003 [0.010]	-0.003 [0.010]	-0.006 [0.010]
At least one type of transfer (except TT with suppliers/buyers)	0.011* [0.006]						
Purchase of embodied technology		0.012** [0.006]					
Purchase of technology from research institutions or external firms			0.002 [0.007]				
Use of technology provided by another firm within group				-0.005 [0.008]			
Use of technology provided by firms outside group					-0.012* [0.007]		
Skills and experience of new employees						-0.009 [0.007]	
TT With suppliers and buyers							0.020*** [0.007]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	1.592*** [0.160]	1.593*** [0.160]	1.595*** [0.160]	1.596*** [0.160]	1.595*** [0.160]	1.597*** [0.161]	1.593*** [0.160]
No. of observations (firm-year)	40,366	40,366	40,366	40,366	40,366	40,366	40,366

Source: Authors' calculation.

**Table 12: Robustness Check – R&D and Technology Transfer on Firm's Export Status – Individual Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
In-house RD	0.012*	0.012*	0.012*	0.012*	0.012*	0.012*	0.010
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
At least one type of transfer (except TT with suppliers/buyers)	0.008**						
	[0.003]						
Purchase of embodied technology		0.002					
		[0.004]					
Purchase of technology from research institutions or external firms			0.007				
			[0.005]				
Use of technology provided by another firm within group				-0.003			
				[0.005]			
Use of technology provided by firms outside group					0.008*		
					[0.004]		
Skills and experience of new employees						0.008*	
						[0.004]	
TT With suppliers and buyers							0.016***
							[0.004]
TFP	0.013***	0.013***	0.013***	0.013***	0.014***	0.013***	0.013***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Used input import	0.118***	0.118***	0.118***	0.118***	0.118***	0.118***	0.118***
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	0.166***	0.168***	0.168***	0.169***	0.169***	0.167***	0.167***
	[0.052]	[0.052]	[0.052]	[0.052]	[0.052]	[0.052]	[0.053]
No. of observations (firm-year)	40,366	40,366	40,366	40,366	40,366	40,366	40,366

Source: Authors' calculation.

**Table 13: Robustness Check – R&D and Technology Transfer on Firm's Export Intensity – Individual Impact**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
In-house RD	0.062	0.066	0.066	0.069	0.065	0.064	0.052
	[0.075]	[0.075]	[0.075]	[0.075]	[0.075]	[0.075]	[0.075]
At least one type of transfer (except TT with suppliers/buyers)	0.067*						
	[0.036]						
Purchase of embodied technology		0.027					
		[0.041]					
Purchase of technology from research institutions or external firms			0.034				
			[0.050]				
Use of technology provided by another firm within group				-0.059			
				[0.058]			
Use of technology provided by firms outside group					0.079*		
					[0.047]		
Skills and experience of new employees						0.076*	
						[0.045]	
TT with suppliers and buyers							0.131***
							[0.046]
TFP	0.249***	0.249***	0.250***	0.250***	0.250***	0.250***	0.248***
	[0.040]	[0.040]	[0.040]	[0.040]	[0.040]	[0.040]	[0.040]
Used input import	1.310***	1.312***	1.312***	1.312***	1.311***	1.312***	1.307***
	[0.087]	[0.087]	[0.087]	[0.087]	[0.087]	[0.087]	[0.087]
VSIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-3.621***	-3.609***	-3.607***	-3.598***	-3.603***	-3.616***	-3.617***
	[0.679]	[0.679]	[0.679]	[0.679]	[0.679]	[0.678]	[0.681]
No. of observations (firm-year)	40,149	40,149	40,149	40,149	40,149	40,149	40,149

Source: Authors' calculation.

## 6. CONCLUSION

We study the individual and joint impact of technology transfer and R&D on firms' productivity and export margins. Our results suggest a significant association between technology transfer and firms' extensive and intensive margins of export. However, not all forms of technology transfer are performance-enhancing. Our results show a differential impact of various modes of technology transfer, with the relationship with suppliers and buyers, together with the purchase of embodied technology, being the most robust. This finding strengthens two common findings in other research on technology and firms' performance. The first is the existence of vertical spillover where firms providing or receiving inputs from their business partners are more likely to exchange knowledge and improve their own technology adoption. The second is export promotion and productivity enhancement through the adoption of imported technology. The individual impact of R&D on firms' performance, on the contrary, is somehow limited, except for export participation. Nevertheless, conducting technology transfer in parallel with R&D can further encourage firms to enter the export market and enhance export intensity rather than undertaking only one activity. To the extent that firms' own R&D contributes to better absorptive capacity, R&D and technology transfer are complementary.

Our result informs policymakers of a potential channel through which the effectiveness of technology transfer could be affected. Since a complementary relationship between technology transfer and R&D exists, R&D grants should be encouraged, particularly for firms who both invest in R&D and acquire foreign technology. In addition, policies aiming at enhancing inter-firm linkages along the supply chain should also be considered.

Our study has several limitations. For the perception-based technology transfer, we cannot capture whether, in practice, firms receive technology transfer or not. As a consequence, our estimated results for these forms of technology transfer should be interpreted with caution. In addition, we cannot measure R&D intensity. It could be possible that R&D, albeit being present, is still limited in terms of scale among Vietnamese firms, which could be one reason we observe insignificant results for estimates with R&D. We leave these issues for further studies with a more detailed data set.

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