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ADB Working Paper Series

**HARNESSING FOREIGN TECHNOLOGY
TO IMPROVE FIRM PERFORMANCE:
EVIDENCE FROM PHILIPPINE
MANUFACTURING ENTERPRISES**

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Abstract

The paper examines the impact of foreign-licensed technology and identifies channels to effectively leverage such technology to improve the performance of manufacturing firms in the Philippines. Using the fixed effects approach to World Bank Enterprise Survey panel data for the Philippines covering 2009 and 2015, the paper finds no statistically significant impact of introducing foreign-licensed technology to manufacturing firms in terms of annual sales, employment, and energy intensity. Interestingly, the impact is more pronounced and significant among manufacturing firms that conduct workforce trainings, thereby improving absorptive capacity through better quality of labor. The empirical findings call for the Philippine government to bolster skills training and human capital formation initiatives, further incentivizing in-house training, to support the advancement of local absorptive capacity and better assimilate the use of foreign technologies.

Keywords: technology transfer, technology licensing, firm performance, local absorptive capacity, Philippines

JEL Classification: L24, L25, L60

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1. INTRODUCTION

Foreign technology and knowledge have played a crucial role in many emerging economies' experience of unprecedented economic growth. International diffusion of technology improves productivity along the premise of endogenous growth literature (Yasar and Morrison Paul 2008). This was particularly evident from the early technological catch-up among successful local firms in Japan and the Republic of Korea.

The People's Republic of China (PRC) also benefitted from such a strategy through its so-called technology transfer from opening the domestic market. This was introduced in the mid-1980s to gain advanced foreign technology and managerial skills especially through foreign direct investment inflows. Huang (2006) argued that the PRC's technology transfer policy has been effective in building local technological capabilities, which has propelled the country's automobile industry and, more recently, the high-speed railways industry (Takakuwa and Veza 2014). Evidence also shows the potential positive spillover effect of foreign technology transfer, especially over the long term.

International technology transfer refers to the cross-border movement of technology, largely through transnational companies, which account for approximately 80–90% of technology transfers (Posadas 1994). Transnational companies often possess commercially viable production technologies backed by adequate resources and expertise. Technology diffusion occurs upon the direct purchase or licensing of foreign capital goods and equipment, skills training of nationals, and hiring of foreign experts. Other means include the establishment of wholly owned subsidiaries of foreign companies, turnkey construction of plants and facilities, and joint ventures with local companies.

Learning from the experiences of Japan and other newly industrializing countries in Asia, the transfer and use of foreign technology in the Philippines has been generally aimed at supporting the country's path toward industrialization. Such transfer has often occurred through direct investment in majority-owned subsidiaries and licensing agreements in the use of manufacturing knowhow, patents, and trademarks (Posadas 1994). Consequently, such a practice led to the large foreign ownership now observed in modern industries, such as petroleum, chemicals, machinery, and transport equipment.

This paper attempts to examine the effectiveness of foreign technology transfer among manufacturing firms in the Philippines. Based on data availability, such transfer is limited to that obtained only through technology licensing. The other channels through which foreign technology can be transferred to local firms, such as the importation of capital goods, reverse engineering, original equipment manufacturers, labor mobility, and foreign direct investment, are beyond the scope of the study. The paper measures effectiveness in three different dimensions: (i) financial performance via sales; (ii) inclusion via employment; and (iii) sustainability via energy intensity.

To date, there is no empirical evidence on how foreign technology transfer has influenced firm-level outcomes within the Philippine context. The analysis aims to examine and understand channels and effective ways to leverage foreign technology acquired via licensing to improve the performance of manufacturing firms in the country. The findings from this study hope to contribute to generating policy-oriented insights that could help direct the country toward better industrialization.

The country exhibited deviant behavior during the 1980s, gradually falling behind its industrialization catch-up (de Dios and Williamson 2015). The deindustrialization process has been attributed to myriad factors, lagging innovation activities included. The United States Agency for International Development – Science, Technology, Research, and Innovation for Development found a high concentration of innovation among large enterprises and multinational companies in only a few industries (RTI International 2014). In a 2015 enterprise survey, Albert et al. (2017) revealed that less than half (42.9%) of firms in the country were actively engaged in innovation activities: 46% of these conducted in-house research and development activities.

Applying the fixed effects estimation approach to World Bank Enterprise Survey panel data for the Philippines covering 2009 and 2015, the paper finds no statistically significant impact of introducing foreign-licensed technology among manufacturing firms in terms of annual sales, employment, and energy intensity. Considering empirical evidence that the beneficial effect of technology transfer is conditional on firms' absorptive capacity (e.g., Elkomy, Ingham, and Read 2020; Danquah 2018), the adjusted baseline equation estimates show that the impact of foreign-licensed technology, particularly in terms of sales performance, is more pronounced if manufacturing firms that started using foreign technology conduct workforce training programs among employees, improving absorptive capacity through better quality of labor. The paper further examines but finds no evidence of region-specific heterogeneity.

The rest of the paper is structured as follows. The next section briefly discusses the available evidence on the impact of technology transfer, including technology licensing, on firm-level outcomes. Section 3 lays out in detail the data used and the empirical strategy to achieve the research objectives. Section 4 discusses the findings, while section 5 concludes and suggests policy considerations in line with the insights from the empirical findings.

2. TECHNOLOGY TRANSFER, FIRM PERFORMANCE, AND ECONOMIC DEVELOPMENT: A BRIEF REVIEW

The transfer and use of foreign technology proves to have played an invaluable role in the economic development process. Many countries incorporate the diffusion and distribution of foreign technology in various ways, including technology licensing, importing state-of-the-art capital goods, and extensive on-the-job training from foreign companies.

Such was the case for the technological catch-up evident among local firms in Japan and the Republic of Korea (Edquist and Jacobsson 1987; Amsden 1989; Wade 1990; Chang 1994). Multinational firms have greatly influenced the rapid transfer of technology even across national boundaries. The early development in the integrated circuits and automobile manufacturing, leading to the rise of Samsung and Hyundai, benefited considerably from licensing technologies from multinational companies abroad (Kim 2003).

Evidence largely shows that foreign technology transfers improve firms' productivity and efficiency, often translating to better financial performance and other relevant firm outcomes. Belderbos, Roy, and Duvivier (2012), using their dynamic productivity model, found that firms engaging in international knowledge transfer strategies have recorded higher productivity growth. Employing the same model on a large sample of Japanese manufacturing affiliates worldwide in 1996–1997 and 1999–2000, Belderbos,

Ito, and Wakasugi (2008) showed that both affiliate R&D and intra-firm technology transfer contribute to firms' productivity growth, albeit technology transfer exhibits decreasing marginal returns.

In Bangladesh, Sharma (2019) revealed that the use of foreign technology had a large positive effect on the total factor productivity of manufacturing firms. Assessing the impact of the Sino-Soviet Alliance project in the PRC during the 1950s, Giorcelli and Li (2022) found that receiving both technologically advanced capital goods and knowhow transfer under the project had large, persistent effects on plant performance and productivity. Yasar and Morrison Paul (2008), applying propensity score matching techniques to Turkish manufacturing firms, also found positive impacts of technology transfer through foreign direct investment, exporting, and importing on both total factor productivity and labor productivity.

The beneficial impact of foreign technology transfer also potentially goes beyond the receiving firms. Especially in the long run, spillover effects can be observed. Lin, Qin, and Xie (2021) found that the introduction of high-speed railway technology into the PRC has generated significant localized spillovers in nearby firms in terms of more patents, improved productivity, and higher revenue growth. The Sino-Soviet Alliance was also found to have improved industry knowledge among other companies, largely due to the program's implications for human capital development (Giorcelli and Li 2022).

While technology transfer programs and interventions have generally had a positive impact, there is also a strand of literature arguing that the observed benefits, or the lack thereof, depends on the extent and efficiency of such transfer (Mansfield et al. 1983). This may explain the heterogeneity of results across jurisdictions—e.g., only modest results were seen in sub-Saharan countries (Robinson 2009).

In other words, conditionalities need to be satisfied for technology transfers to benefit firms greatly. Analyzing Egyptian manufacturing industries for the period between 2006 and 2009, Elkomy, Ingham, and Read (2020) found that only technology-intensive industries have sufficient absorptive capacity to assimilate foreign technology effectively, especially in relation to the domestic labor force. Danquah (2018), using stochastic frontier analysis, revealed that to achieve national efficiency from technology transfer in sub-Saharan Africa, the focus should be on the development of domestic capacity to absorb technology.

Dubickis and Gaile-Sarkane (2021) also noted the importance of internal R&D and presence in foreign markets to effectively harness foreign technology. Han, Kwon, and Lee (2016) found that the growth in productivity arising from foreign technology transfer became stronger over time, R&D intensity as a proxy for absorptive capacity playing an important role in the process. Interestingly, Belderbos, Roy, and Duvivier (2012) also found that such an effect is higher among firms that combine international and domestic transfer strategies, suggesting that a diverse external technology sourcing strategy combining local knowhow with knowhow from abroad is most effective.

3. EMPIRICAL ANALYSIS

This section details the econometric framework used to gain valuable insights into the effectiveness of access to foreign-licensed technology in driving firm performance across the manufacturing industry in the Philippines. Correspondingly, empirical exercises attempt to answer the following research questions:

1. What is the impact of introducing foreign-licensed technology on firm-level outcomes across the three dimensions—financial, inclusion, and sustainability?
2. Are there significant variations in firm-level outcomes among firms adopting foreign-licensed technology? What are the major factors that significantly explain such variations?
3. Is region-specific heterogeneity evident, which could be instrumental in developing spatially oriented policies?

Subsection A describes the data used in the analysis along with the sources. Detailed discussion on the estimation strategy follows in subsection B. Limitations arising from data availability and the empirical method used are briefly noted in subsection C.

3.1 Data

World Bank Enterprise Survey

The analysis works on the available two-period (i.e., 2009 and 2015) longitudinal enterprise survey data for the Philippines, which forms part of an ongoing World Bank Group project that collects relevant economic information from firms in over 150 countries. Stratified random sampling was used to extract a nationally representative sample of firms. Three levels of stratification were used: industry, establishment size, and region. A total of 375 firms were tracked and surveyed in both periods, forming the raw panel dataset used in the paper's analysis.

Relevant firm-level characteristics and information, such as years of establishment, location, type of legal status, size, sales, employment, innovation activities, and other operation-related variables were gathered. The paper closely examines the establishment's use of a technology (excluding office software) licensed from a foreign-owned company, which suggests foreign technology transfer. Such information may involve licensing arrangements between the establishment and its parent company.

Regional Data to Test for Spatial Heterogeneity

To examine whether regional differences could help identify spatially oriented or place-based policy implications, the study merged available regional-level time variant information with the enterprise survey dataset. Human development variables such as life expectancy, mean years of schooling, and overall human development index were gathered from the Philippine Human Development Reports (2009 and 2012) published every three years by the Philippine Statistics Authority (PSA) and the Human Development Network.¹ Regional estimates of the functional literacy rate of the population aged 10–64 are gathered from the PSA estimates using the 2008 and 2019 Functional Literacy, Education and Mass Media Survey (FLEMMS).²

Labor force participation rates by region are PSA estimates derived from labor force surveys. Regional labor productivity and industries' economic contribution are derived from the PSA's Regional Accounts publication. Lastly, local government unit (LGU) public expenditure and program prioritization information is derived from the Statement of Receipts and Expenditures reports published by the Bureau of Local Government Finance. The ratio of different expenditure items, such as education,

¹ In the absence of the 2015 report, the 2012 estimates of subnational human development indices are used as a proxy. Visit <https://psa.gov.ph/human-development-index-press-releases/tables> for available information and data.

² Due to data limitation, the 2008 FLEMMS proxies for 2009, while the 2019 FLEMMS fills the missing 2015 data.

labor, employment, and economic services to the total current operating expenditure is calculated. The proportion of capital investment expenditure to total non-operating expenses is also found.

3.2 Estimation Strategy

To tackle the research questions empirically, the study implements a fixed effects estimation approach to exploit the panel feature of the dataset and address potential sources of endogeneity that may lead to biased estimates. The unobserved time-invariant characteristics among firms, such as quality of management and strength of firms' networks, may confound the relationship between the use of foreign technology and firm-level outcomes. Hence, the baseline model specification is as follows:

$$y_{it} = \alpha_0 + \alpha_i + \beta FT_{it} + \gamma X_{it} + \delta_t + \varepsilon_{it} \quad (1)$$

where y_{it} refers to the firm-level outcomes of establishment i in period t . Firm-specific intercepts, α_i , capture unobservable time-invariant firm characteristics and potentially address the omitted variable bias. The variable of interest, FT_{it} , denotes foreign technology transfer via licensing agreement. It is a binary indicator that takes the value of 1 if firm i uses foreign-licensed technology in period t and 0 otherwise. To isolate the effect of the variable of interest on respective outcome variables, a column vector of observable firm-specific characteristics, X_{it} , is added (details below). δ_t denotes period fixed effects and ε_{it} is the stochastic error term.

Dependent Variable (y_{it}): Firm-Level Outcomes

The paper measures firm performance in three dimensions: (i) financial, (ii) inclusion, and (iii) sustainability. For the financial dimension, information on annual sales generally measures the overall financial health of a firm over a given period, which can be influenced by the firm's policies and operations, including the introduction of foreign technology. The causal mechanism that links foreign technology adoption to a firm's financial performance is clear and can be expected to be more direct than the other two outcome dimensions.

Due to data limitations, the paper uses the number of permanent and full-time employees as a proxy measure of inclusion. This is generally aligned with the employment generation targets set out under the Philippine Development Plan 2017–2022 that could lead to inclusive growth. Lastly, the sustainability dimension is given by the ratio of the firm's total cost of fuel and electricity consumption to its total annual revenue. Lower values suggest a shift toward green and sustainable production, where a firm is generating revenues by consuming less energy. These two outcome dimensions can be expected to have a more indirect impact of foreign-licensed technology use, especially via financial performance and other mediating factors. Nevertheless, they are added for empirical investigation.

Variable of Interest: Foreign Technology Transfer (FT_{it})

Using the World Bank Enterprise Survey, foreign technology transfer in this paper is narrowly defined as that obtained through technology licensing. The survey asks firm respondents the following: Does this establishment at present use technology licensed from a foreign-owned company, excluding office software?³ As such, the paper

³ Note that the question is only asked among manufacturing firms. Thus, empirical analysis and the results thereof in the paper are applicable only for manufacturing firms.

measures foreign technology transfer using a dummy variable with a value of 1 if a firm uses a foreign-licensed technology and zero otherwise.

A technology license is an intellectual property right that supports production processes compliant with technical standards or specifications. Note that other channels of foreign technology transfer, such as the importation of capital goods, reverse engineering, original equipment manufacturers, labor mobility, and foreign direct investment, are not analyzed in this study. Also, relevant information describing the owner of the technology and the type and duration of the licensing agreement is not available to gain more insights.

To analyze the difference in performance between firms that adopted foreign-licensed technology in period 2 and non-adopters, the paper excludes firms that have been using foreign technology since period 1. In doing so, the remaining observations only involve 197 manufacturing firms with similar baseline characteristics as far as adoption of foreign-licensed technology is concerned. Of the 197 manufacturing firms, only 25 had introduced foreign-licensed technology by period 2 (Table 1).

Table 1: Respondent Manufacturing Firms by Size and Region and Use of Foreign Technology, 2015

	Firms Using Foreign Technology	Firms Not Using Foreign Technology	Total
<i>a. By size</i>			
Small (5–19 employees)	4 (5.7)	66 (94.3)	70
Medium (20–99 employees)	11 (14.1)	67 (85.9)	78
Large (100+ employees)	10 (20.4)	39 (79.6)	49
<i>a. By region</i>			
National Capital Region	16 (13.7)	101 (86.3)	117
Central Luzon	4 (11.1)	32 (88.9)	36
Calabarzon	4 (16.0)	21 (84.0)	25
Metro Cebu	1 (5.3)	18 (94.7)	19

Row-wise distribution in parentheses.

Source: Author's calculation using the World Bank Enterprise Survey panel dataset for the Philippines.

Table 1 shows the highest proportion of foreign technology adopters among large manufacturing firms (20.4%), followed by medium-sized manufacturing firms (14.1%). Foreign technology use among small firms is lowest, at only 5.7%. The table also shows little regional variation in the use of foreign-licensed technology among manufacturing firms located in the three biggest regions in the Philippines, while only a few manufacturing firms in Metro Cebu (5.3%) have adopted foreign technology.

Control Variables (X_{it})

Available firm-level characteristics that may confound how the adoption of foreign-licensed technology affects firm-level outcomes are added in the baseline model specification. These include the age of the firm in years (entered in a quadratic form), size, legal status, gender of the owner and top manager, share of foreign ownership, extent of participation in international trade as an exporter, main market where the firm's products are sold, and dummy variables indicating whether the establishment holds any internationally recognized quality certification, has a website, and is part of a larger firm.

3.3 Limitations

The analysis and corresponding results have limitations. Where the baseline estimation strategy is concerned, one major issue is its inability to control for possible time-variant unobservable factors simultaneously affecting the use of foreign-licensed technology and firm-level outcomes. The analysis generally assumes that the unobserved differences in firm performance between manufacturing firms that have adopted foreign-licensed technology and not are mainly time-invariant. Another limitation refers to the dataset used insofar as generalization of the results is concerned. The distribution of manufacturing firms by size and region from the dataset (Table 1) is not similar to the actual distribution based on the PSA's List of Establishments.⁴

4. DISCUSSION OF FINDINGS

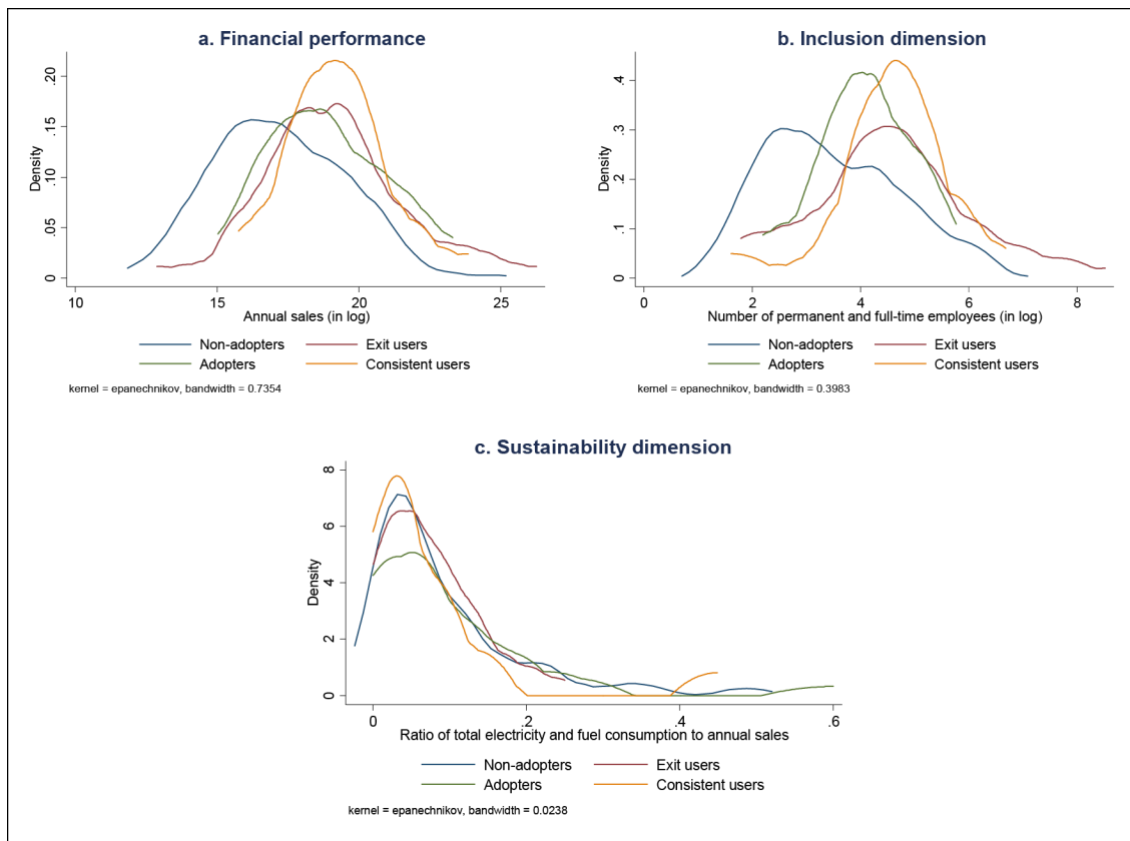
Before discussing the estimation results of Equation 1, it is worthwhile first to examine the distribution of the relevant outcome variables under study across the different groups of manufacturing firms based on their use of foreign-licensed technology. Aside from non-adopters and new adopters, which are the focus of the analysis, two other groups can be defined considering their use of foreign-licensed technology: (i) exit users, or those that use foreign-licensed technology in period 1 but no longer use it in period 2; and (ii) consistent users, or those that continue to use the technology during the second period of the survey.

This exercise provides initial insights into whether there is enough between-group variation in the outcome variables. Figure 1a illustrates the density plot of annual sales (expressed in log) in period 2 (i.e., 2015) across the different groups of manufacturing firms using an Epanechnikov kernel. It is apparent from the figure that, relative to manufacturing firms that have decided to use foreign-licensed technology in period 2, the concentration of sales (in log) values among non-adopters is lower. There is indeed a significant difference in sales performance between the two groups of firms based on the two-sample Kolmogorov-Smirnov test. However, this does not reveal the extent to which such a difference in sales performance is attributed to the introduction of foreign-licensed technology. Figure 1a also shows the concentration on higher sales values among exit users and consistent users relative to non-adopters.

The inclusion outcome across different groups of manufacturing firms in the Philippines also exhibits significant variation (Figure 1b). Like sales performance, the concentration in the values of number of full-time and permanent employees (in log) among non-adopters is lower relative to adopters and the other two groups. Aside from the introduction of foreign-licensed technology, this observation may be related to the information in Table 1 indicating that, on average, smaller firms, or those with fewer employees, have a lower foreign-licensed technology adoption rate. Lastly, Figure 1c does not establish significant differences in the distribution of sustainability indicators across the four groups of manufacturing firms, which is validated by the Kolmogorov-Smirnov test for stochastic dominance. One plausible explanation for this is that such an outcome tends to manifest more within a longer time frame than the study's coverage period.

⁴ Large manufacturing firms account for less than 1% of the total manufacturing firms in the Philippines but form 24% of the dataset. High concentration in the National Capital Region is also not reflective of the actual data.

Figure 1: Univariate Kernel Density Estimates of Different Outcome Variables by Group, 2015



Source: Author's estimates.

In the pairwise correlation matrix (see Appendix), foreign-licensed technology is positively correlated with financial and inclusion outcomes but negatively correlated, albeit weakly, with the energy intensity indicator of the sustainability outcome. The matrix also shows a positive correlation between financial and inclusion outcomes and technological absorptive capacity indicators, while a negative correlation is found with sustainability outcome. The following discussions provide deeper insights by attempting to isolate how the adoption of foreign-licensed technology influences the differences observed from the data.

4.1 Summary Statistics

Table 2 presents the basic descriptive statistics of the variables used in the analysis. Note that to arrive at a balanced panel of firms with observations involving the two periods for all the necessary variables, the effective sample size decreased to 143 manufacturing firms. The tables show little variation in terms of annual sales and number of permanent and full-time employees during the study period, while the energy intensity seemed to have declined, on average, between 2009 and 2015. Foreign-licensed technology was introduced in only 20% of the observed manufacturing firms in 2015.

Table 2: Summary Statistics of Variables Used in the Analysis—Period 1 (2009) and Period 2 (2015)

Variables	Period 1 (2009)				
	Obs.	Mean	Std. Dev.	Min	Max
Outcome variables					
Annual sales (log)	143	17.3	2.2	11.7	22.6
Number of permanent and full-time employees (log)	143	3.6	1.2	1.1	6.6
Ratio of total electricity and fuel consumption to annual sales	143	1.5	16.7	0.0	200.1
Independent variables					
Use of foreign-licensed technology (0 = No, 1 = Yes)	143	0.0	0.0	0.0	0.0
<i>Firm-level characteristics</i>					
Age (in years)	143	26.1	13.2	9.0	85.0
Firm size (1 = Small, 2 = Medium, 3 = Large)	143	1.9	0.8	1.0	3.0
Company website dummy (0 = No, 1 = Yes)	143	0.3	0.5	0.0	1.0
Female top manager dummy (0 = No, 1 = Yes)	143	0.2	0.4	0.0	1.0
Foreign ownership (%)	143	23.8	39.9	0.0	100.0
Female owner dummy (0 = No, 1 = Yes)	143	0.7	0.5	0.0	1.0
Global value chain participation	143	0.6	0.9	0.0	2.0
Main market for products (0 = Local, 1 = National, 2 = International)	143	1.8	0.8	1.0	3.0
Part of larger firm dummy (0 = No, 1 = Yes)	143	0.1	0.3	0.0	1.0
Internationally recognized quality certification dummy (0 = No, 1 = Yes)	143	0.3	0.5	0.0	1.0
Firm's legal status ^a	143	2.3	0.8	1.0	5.0
<i>Technological adaptive capacity</i>					
Formal training programs for permanent and full-time employees	143	0.4	0.5	0.0	1.0
Variables	Period 2 (2015)				
	Mean	Std. Dev.	Min	Max	
Outcome variables					
Annual sales (log)	17.5	2.3	12.6	24.5	
Number of permanent and full-time employees (log)	3.6	1.2	1.6	6.7	
Ratio of total electricity and fuel consumption to annual sales	0.1	0.1	0.0	0.6	
Independent variables					
Use of foreign-licensed technology (0 = No, 1 = Yes)	0.2	0.4	0.0	1.0	
<i>Firm-level characteristics</i>					
Age (in years)	24.8	14.4	2.0	118.0	
Firm size (1 = Small, 2 = Medium, 3 = Large)	1.9	0.8	1.0	3.0	
Company website dummy (0 = No, 1 = Yes)	0.4	0.5	0.0	1.0	
Female top manager dummy (0 = No, 1 = Yes)	0.2	0.4	0.0	1.0	
Foreign ownership (%)	17.1	35.3	0.0	100.0	
Female owner dummy (0 = No, 1 = Yes)	0.7	0.5	0.0	1.0	
Global value chain participation	0.6	0.8	0.0	2.0	
Main market for products (0 = Local, 1 = National, 2 = International)	1.9	0.7	1.0	3.0	
Part of larger firm dummy (0 = No, 1 = Yes)	0.1	0.3	0.0	1.0	
Internationally recognized quality certification dummy (0 = No, 1 = Yes)	0.3	0.5	0.0	1.0	
Firm's legal status ^a	2.3	0.5	1.0	3.0	
<i>Technological adaptive capacity</i>					
Formal training programs for permanent and full-time employees	0.5	0.5	0.0	1.0	

^a Firm's legal status (1 = publicly traded company, 2 = shareholding company with non-traded shares, 3 = sole proprietorship, 4 = partnership, 5 = limited partnership)

Obs. = observations, Std. Dev. = standard deviation

Source: Author's calculations.

Another stylized fact based on Table 2 is the increase from 30% in 2009 to 40% in 2015 in the proportion of manufacturing firms that have a digital presence through a website. Organizational changes seem to have occurred during the study period upon examining the average share of foreign ownership, which shows quite a significant drop from 23.8% in 2009 to 17.1% in 2015. There seems to have been expansion in the market among manufacturing firms: the mean value of the categorical indicator for the main market for products increased slightly from 1.8 in 2009 to 1.9 in 2015. Lastly, the indicator for technological absorptive capacity among firms—i.e., the provision of formal training for permanent and full-time employees—is observed to have increased during the period.

4.2 Introduction of Foreign-Licensed Technology and Firm Performance: Baseline Estimates

Table 3 presents the baseline results in estimating Equation 1. Broadly, the analysis finds no evidence of systematic difference between manufacturing firms that have started using foreign-licensed technology and those that do not in performance across the three dimensions. The estimated coefficients on the use of foreign technology in period 2 are found not to be statistically significant.

Note, however, that the magnitude can be considered economically relevant—i.e., the use of foreign technology in period 2 is, on average, associated with an increase of approximately 25.8% in annual sales, holding other factors constant. For the inclusion dimension, measured in terms of the number of permanent and full-time employees, the result is also not statistically significant. In terms of the sustainability dimension, the introduction of foreign technology to manufacturing firms in period 2 is found linked to higher consumption of fuel and electricity in generating revenue, albeit not statistically significant.

4.3 Outcome Heterogeneity: Technological Absorptive Capacity

The absence of statistically significant estimates of the impact of foreign-licensed technology on the performance of manufacturing firms deserves further investigation. There is evidence that the beneficial effect of technology transfer is conditional on firms' absorptive capacity. In the sub-Saharan context, Danquah (2018) found that national efficiency from technology transfer can be best achieved if there is an equivalent focus on the development of domestic capacity to absorb technology. More recently, among manufacturing firms in Egypt, Elkomy, Ingham, and Read (2020) found that the sufficient absorptive capacity among technology-intensive establishments, especially via labor force, helped them to assimilate foreign technology effectively.

To examine the applicability of such insights in the analysis involving manufacturing firms in the Philippines, available technological absorptive capacity indicators are added from the baseline Equation 1 and interacted with the foreign technology transfer indicator. Based largely on data availability, the paper uses solely information on manufacturing firms' provision of formal training programs for permanent and full-time employees as a proxy for firm-level technological absorptive capacity. Considering the mentioned literature, the hypothesis is that there are positive and statistically significant coefficient estimates before the interaction term for the financial and inclusion dimensions, but negative for the sustainability dimension.

Table 3: Adoption of Foreign Technology and Manufacturing Firm Performance: Baseline Results

	(1)	(2)	(3)
Variables	Annual Sales (log)	Number of Permanent and Full-time Employees (log)	Ratio of Total Electricity and Fuel Consumption to Annual Sales
Use of foreign-licensed technology (1 = Yes, 0 otherwise)	0.258 (0.360)	0.189 (0.196)	0.513 (4.482)
Firm-level controls			
Age of firm	-0.005 (0.024)	0.031** (0.013)	-0.149 (0.299)
Age of firm (squared)	0.000 (0.000)	-0.000*** (0.000)	0.002 (0.003)
Firm size (Base = Small firms)			
<i>Medium</i>	-0.393 (0.291)		0.927 (3.623)
<i>Large</i>	-0.645 (0.439)		0.964 (5.467)
Female top manager dummy (1 = Yes, 0 otherwise)	-0.411 (0.248)	0.088 (0.140)	-1.275 (3.091)
Female owner dummy (1 = Yes, 0 otherwise)	-0.017 (0.235)	0.281** (0.132)	4.625 (2.925)
Foreign ownership dummy (1 = Yes, 0 otherwise)	-0.000 (0.005)	-0.000 (0.003)	-0.003 (0.062)
Global value chain participation (Base = No participation)			
<i>Direct and indirect export (% of sales) less than 50%</i>	-0.635* (0.349)	-0.277 (0.195)	-0.807 (4.339)
<i>Direct and indirect export (% of sales) greater than or equal to 50%</i>	0.203 (0.533)	-0.116 (0.297)	-2.216 (6.638)
Main market for products (Base = Local, same municipality)			
<i>National, across the country</i>	0.084 (0.223)	0.267** (0.124)	-4.592 (2.775)
<i>International</i>	-0.298 (0.573)	0.553* (0.319)	-0.333 (7.138)
Firm's legal status (Base = Publicly traded companies)			
<i>Shareholding company with non-traded shares</i>	0.955** (0.417)	0.035 (0.234)	1.958 (5.190)
<i>Sole proprietorship</i>	0.156 (0.484)	-0.218 (0.272)	2.839 (6.029)
<i>Partnership</i>	-0.484 (0.629)	-0.275 (0.353)	-2.280 (7.824)
<i>Limited partnership</i>	0.369 (0.864)	-0.215 (0.478)	-0.391 (10.759)
Company website dummy (1 = Yes, 0 otherwise)	0.606** (0.258)	0.097 (0.145)	1.856 (3.205)
Part of larger firm dummy (1 = Yes, 0 otherwise)	0.233 (0.309)	-0.212 (0.174)	1.963 (3.848)
Internationally recognized quality certification dummy (1 = Yes, 0 otherwise)	-0.077 (0.316)	0.408** (0.178)	0.186 (3.933)
Constant	16.996*** (0.658)	2.757*** (0.342)	-1.300 (8.193)
Region dummies	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes
No. of observations	286	286	286
No. of firms	143	143	143
R-squared	0.218	0.256	0.085

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

Source: Author's estimates.

Table 4: Technology Transfer, Firm Performance, and Staff Training

Variables	(1) Annual Sales (log)	(2) Number of Permanent and Full-time Employees (log)	(3) Ratio of Total Electricity and Fuel Consumption to Annual Sales
Use of foreign-licensed technology (1 = Yes, 0 otherwise) [A]	-1.185* (0.606)	-0.699** (0.337)	3.706 (7.858)
Conduct of formal training programs for permanent and full-time employees (1 = Yes, 0 otherwise) [B]	0.519** (0.201)	0.239** (0.113)	-5.423** (2.610)
<i>Interaction term [A×B]</i>	1.854*** (0.697)	1.160*** (0.387)	-2.884 (9.035)
Firm-level controls			
Age of firm	0.003 (0.023)	0.035*** (0.013)	-0.194 (0.297)
Age of firm (squared)	0.000 (0.000)	-0.000*** (0.000)	0.002 (0.003)
Firm size (Base = Small firms)			
<i>Medium</i>	-0.505* (0.278)		1.530 (3.605)
<i>Large</i>	-0.651 (0.420)		1.683 (5.439)
Female top manager dummy (1 = Yes, 0 otherwise)	-0.466* (0.237)	0.061 (0.134)	-0.624 (3.076)
Female owner dummy (1 = Yes, 0 otherwise)	-0.270 (0.233)	0.000 (0.003)	6.169** (3.016)
Foreign ownership dummy (1 = Yes, 0 otherwise)	0.000 (0.005)	0.146 (0.131)	-0.000 (0.061)
Global value chain participation (Base = No participation)			
<i>Direct and indirect export (% of sales) less than 50%</i>	-0.313 (0.342)	-0.096 (0.192)	-2.452 (4.431)
<i>Direct and indirect export (% of sales) greater than or equal to 50%</i>	0.261 (0.508)	-0.081 (0.284)	-2.963 (6.580)
Main market for products (Base = Local, same municipality)			
<i>National, across the country</i>	0.105 (0.212)	0.277** (0.118)	-4.795* (2.748)
<i>International</i>	-0.338 (0.546)	0.523* (0.304)	-0.479 (7.071)
Firm's legal status (Base = Publicly traded companies)			
<i>Shareholding company with non-traded shares</i>	0.989** (0.396)	0.049 (0.223)	1.819 (5.137)
<i>Sole proprietorship</i>	0.238 (0.461)	-0.169 (0.260)	2.247 (5.973)
<i>Partnership</i>	-0.680 (0.607)	-0.343 (0.342)	0.362 (7.866)
<i>Limited partnership</i>	0.574 (0.824)	-0.137 (0.456)	-2.297 (10.685)
Company website dummy (1 = Yes, 0 otherwise)	0.475* (0.248)	0.017 (0.140)	2.224 (3.219)
Part of larger firm dummy (1 = Yes, 0 otherwise)	0.372 (0.298)	-0.150 (0.167)	0.651 (3.857)
Internationally recognized quality certification dummy (1 = Yes, 0 otherwise)	-0.117 (0.300)	0.389** (0.169)	0.446 (3.894)
Constant	16.782*** (0.631)	2.635*** (0.331)	0.970 (8.181)
Region dummies	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes
No. of observations	286	286	286
No. of firms	143	143	143
R-squared	0.306	0.336	0.119

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

Source: Author's estimates.

Table 4 shows that the beneficial effect of foreign-licensed technology in terms of sales performance and quality employment creation is indeed more pronounced if manufacturing firms that start using foreign technology possess sufficient absorptive capacity, especially through quality of labor. Columns 1 and 2 suggest that the use of foreign technology alone can be associated with lower sales performance and job creation without the complementary support for production workers, especially through training. Based on the estimates, if foreign technology is manned by skilled workers, annual sales and the number of permanent and full-time employees could potentially be higher by around 67% and 26%, respectively, relative to firms that have introduced foreign technology yet lack skilled manpower.

Meanwhile, results remain ambiguous for the sustainability dimension. While the coefficient of foreign-licensed technology complemented by skilled workforce is negative—i.e., the energy intensity is, on average, lower among those that have introduced foreign technology in their production and are active in providing training for their employees—it is not statistically significant. It may be that the short period used in the analysis failed to capture such significant difference, considering that sustainability is more of a long run objective.

4.4 Outcome Heterogeneity: Regional Characteristics

The paper also investigates whether outcome heterogeneity exists due to selected regional characteristics where firms locate or operate. It is expected that the impact of foreign technology on firm performance can also be influenced by how supportive the respective region's infrastructure, regulatory environment, and policy and program priorities are. Hence, like the adjustment done in the baseline equation to accommodate firms' technological absorptive capacity, several regional time-varying characteristics are also added based largely on data availability (Table 5).

It is intuitive that the availability of human capital with sufficient skills could lend support to how firms harness their adoption of foreign technology and generate revenues and better performance. As such, human capital-related variables are used, such as life expectancy, mean years of schooling, and literacy rate. It also matters that the public expenditure priorities where firms operate are supportive of their foreign technology adoption. For example, improving the region's human capital through higher education and labor and employment budget allocations may benefit firms' foreign technology adoption by catering to their skilled worker needs.

Table 5: Key Descriptive Statistics of Regional Data, 2009 and 2015

Variables	2009		2015	
	Mean	Std. Dev.	Mean	Std. Dev.
Life expectancy (in years)	71.58	1.06	72.59	1.08
Mean years of schooling	9.25	1.12	9.68	1.01
Human Development Index	0.65	0.12	0.69	0.10
Functional literacy rate (%)	91.55	3.40	92.48	3.70
Labor force participation rate (%)	62.78	1.78	63.73	2.66
Labor productivity (in thousands)	227.08	158.45	290.13	200.56
Industry GVA, % of regional GDP	32.91	11.23	32.16	12.72
Education, % of total current operating expenditure	7.89	4.89	6.97	4.63
Labor and employment, % of total current operating expenditure	0.12	0.14	0.13	0.14
Economic services, % of total current operating expenditure	16.96	3.31	16.69	1.71
Capital investment, % of total non-operating expenses	77.89	5.47	68.38	17.03

GVA = gross value added, GDP = gross domestic product.

Source: Author's calculation.

Table 6 presents the estimates of adjusted baseline Equation 1 incorporating available regional-level information to assess the regional heterogeneity of outcomes. Note that the estimation incorporates firm-level controls, not shown for brevity. The empirical exercises find no statistically significant results supporting the hypothesis that there is outcome heterogeneity based on regional differences. One possible explanation for this is that the sample regions from the dataset have comparable characteristics, considering that economic developments are largely concentrated among these regions. Small standard deviations in many of the regional characteristics used in the analysis are obvious from Table 5. Also, there is not enough variation in regional characteristics within the periods under study. Estimations are also done with the other two firm outcomes—inclusion and sustainability—and generate similar findings; thus they are not included in the discussion.

Table 6: Technology Transfer, Regional Characteristics, and Firm Financial Outcome

Variables	Life Expectancy (in years)	Mean Years of Schooling	Human Development Index	Functional Literacy Rate (%)	Labor Force Participation Rate (%)	Labor Productivity (in '000s)
Use of foreign-licensed technology (1 = Yes, 0 otherwise) [A]	8.318 (32.512)	2.646 (4.896)	1.858 (3.392)	0.617 (0.950)	4.350 (28.749)	-6.153 (18.598)
Regional characteristics [B]	0.042 (0.206)	0.057 (0.158)	0.527 (1.486)	0.000 (0.000)	0.024 (0.150)	0.016 (0.125)
<i>Interaction term [A×B]</i>	-0.110 (0.443)	-0.227 (0.464)	-2.057 (4.342)	-0.000 (0.000)	-0.043 (0.304)	0.102 (0.297)
Constant	13.908 (15.033)	16.379*** (1.793)	16.567*** (1.348)	16.969*** (0.735)	14.789 (14.082)	15.944** (7.799)
Firm-level controls	Yes	Yes	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	286	286	286	286	286	286
No. of firms	143	143	143	143	143	143
R-squared	0.219	0.220	0.220	0.220	0.219	0.219

Variables	Industry GVA, % of Regional GDP	Education, % of Total Current Operating Expenditure	Labor and Employment, % of Total Current Operating Expenditure	Economic Services, % of Total Current Operating Expenditure	Capital Investment, % of Total Non-operating Expenses
Use of foreign-licensed technology (1 = Yes, 0 otherwise) [A]	-0.247 (0.937)	0.699 (1.003)	0.558 (0.802)	-0.816 (3.709)	0.550 (4.743)
Regional characteristics [B]	-0.001 (0.010)	0.005 (0.032)	-0.362 (0.795)	0.000 (0.071)	-0.006 (0.015)
<i>Interaction term [A×B]</i>	0.017 (0.030)	-0.040 (0.086)	-1.145 (2.899)	0.070 (0.240)	-0.003 (0.060)
Constant	16.973*** (0.701)	16.904*** (0.793)	16.969*** (0.661)	16.991*** (1.208)	17.473*** (1.359)
Firm-level controls	Yes	Yes	Yes	Yes	Yes
Period fixed effects	Yes	Yes	Yes	Yes	Yes
No. of observations	286	286	286	286	286
No. of firms	143	143	143	143	143
R-squared	0.220	0.220	0.222	0.219	0.219

Note: Column headings are the regional-level characteristics in the adjusted baseline equation. Firm-level controls include age of firm in years (entered in a quadratic form), size, legal status, gender of the owner and top manager, share of foreign ownership, extent of participation in international trade as an exporter, main market where the firm's products are sold, internationally recognized quality certification dummy, website dummy, and dummy variable indicating whether the establishment is part of a larger firm.

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

Source: Author's estimates.

5. CONCLUSION AND POLICY IMPLICATIONS

For emerging economies to reach the same level of development as their developed country peers in effective ways involves a great many innovation initiatives. While in-house innovation can be considered progress in leaps and bounds, there is also evidence and experience that acquiring new knowledge and technology from external parties, especially foreign ones, fosters a similar development path.

Foreign technology transfer, largely through multinational companies, has made innovating and upgrading faster. The early technological catch-up among successful local firms in Japan and the Republic of Korea serves as a great example. Evidence also suggests that foreign technology transfer facilitates positive spillover among local firms, especially in the long run.

Apart from addressing the empirical gap on how foreign technology transfer has influenced firm-level outcomes within the Philippine context, the paper hopes to contribute to generating policy-oriented insights that could help direct the country again toward better industrialization. In particular, the paper aims to assess effective ways to leverage foreign technology acquired via licensing to improve the performance of manufacturing firms in the country.

Using World Bank Enterprise Survey panel data for the Philippines covering 2009 and 2015, the empirical findings do not support a direct positive impact of introducing foreign-licensed technology to manufacturing firms in terms of annual sales, employment, and energy intensity. The introduction of foreign technology per se has no statistically significant impact on firm-level outcomes.

Such technology transfer must coincide with initiatives within the country to build technological and innovation capabilities able to absorb knowledge spillovers from external sources, and the findings from this paper are consistent with this policy narrative. The results reveal that the impact of foreign-licensed technology is more pronounced if manufacturing firms that start using foreign technology possess sufficient absorptive capacity, which in this paper is indicated by the manufacturing firms conducting relevant formal training among their employees and ultimately improving the quality of the labor.

In line with the empirical findings, the Philippine government should bolster skills training and human capital formation initiatives to help advance the local absorptive capacity of manufacturing firms and better assimilate the use of foreign technologies throughout their operations. These efforts should be central to the country's ongoing Comprehensive National Industrial Strategy, which gears innovation, new technologies, and knowledge toward greater integration across different industries. In the medium to long run, investment in training and skills development should be incentivized while ramping up the budget allocation toward the public education system, especially at the tertiary and vocational levels. These short- to medium-term policy actions are deemed critical to prompt firms' upgrade to more complex, skillful, and knowledge-intensive activities, and add more value to local production.

APPENDIX

Pairwise Correlation Matrix of Variables Used in the Analysis

Variables	Annual Sales (log)	Number of Permanent and Full-time Employees (log)	Ratio of Total Electricity and Fuel Consumption to Annual Sales	Use of Foreign-licensed Technology (0 = No, 1 = Yes)	Age (in years)	Firm Size (1 = Small, 2 = Medium, 3 = Large)	Company Website Dummy (0 = No, 1 = Yes)	Female Top Manager Dummy (0 = No, 1 = Yes)	Foreign Ownership Dummy (0 = No, 1 = Yes)
Annual sales (log)	1.00								
Number of permanent and full-time employees (log)	0.73	1.00							
Ratio of total electricity and fuel consumption to annual sales	-0.12	-0.08	1.00						
Use of foreign-licensed technology (0 = No, 1 = Yes)	0.29	0.16	-0.1	1.00					
Age (in years)	0.11	0.07	-0.10	0.11	1.00				
Firm size (1 = Small, 2 = Medium, 3 = Large)	0.53	0.66	-0.02	0.16	0.12	1.00			
Company website dummy (0 = No, 1 = Yes)	0.43	0.42	0.05	0.20	0.11	0.27	1.00		
Female top manager dummy (0 = No, 1 = Yes)	-0.26	-0.21	0.02	-0.07	-0.02	-0.15	-0.05	1.00	
Foreign ownership dummy (0 = No, 1 = Yes)	0.33	0.37	0.08	-0.01	-0.14	0.38	0.14	-0.07	1.00
Female owner dummy (0 = No, 1 = Yes)	0.03	-0.03	0.03	0.14	0.14	-0.01	0.03	0.18	-0.24
Global value chain participation	0.26	0.43	0.08	0.08	0.02	0.41	0.12	-0.08	0.54
Main market for products (0 = Local, 1 = National, 2 = International)	0.34	0.48	0.07	0.10	-0.05	0.36	0.17	-0.10	0.45
Part of larger firm dummy (0 = No, 1 = Yes)	0.18	0.14	0.03	0.32	0.13	0.19	0.18	0.01	0.23
Internationally recognized quality certification dummy (0 = No, 1 = Yes)	0.46	0.54	-0.04	0.21	0.03	0.25	0.39	-0.08	0.27
Firm's legal status	-0.42	-0.38	0.00	-0.14	0.00	-0.33	-0.27	0.26	-0.32
Formal training programs for permanent and full-time employees	0.28	0.37	-0.10	0.19	-0.17	0.24	0.28	-0.09	0.18
Spending on formal research and development activities	0.26	0.25	-0.01	0.27	0.08	0.20	0.30	0.04	0.02

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Appendix table continued

Variables	Female Owner Dummy (0 = No, 1 = Yes)	Global Value Chain Participation	Main Market for Products (0 = Local, 1 = National, 2 = International)	Part of Larger Firm Dummy (0 = No, 1 = Yes)	Internationally-recognized Quality Certification Dummy (0 = No, 1 = Yes)	Formal Training Programs for Permanent Employees and Full-time Development Activities	Spending on Formal Research and Development Activities
Annual sales (log)							
Number of permanent and full-time employees (log)							
Ratio of total electricity and fuel consumption to annual sales							
Use of foreign-licensed technology (0 = No, 1 = Yes)							
Age (in years)							
Firm size (1 = Small, 2 = Medium, 3 = Large)							
Company website dummy (0 = No, 1 = Yes)							
Female top manager dummy (0 = No, 1 = Yes)							
Foreign ownership dummy (0 = No, 1 = Yes)							
Female owner dummy (0 = No, 1 = Yes)	1.00						
Global value chain participation	-0.17	1.00					
Main market for products (0 = Local, 1 = National, 2 = International)	-0.08	0.76	1.00				
Part of larger firm dummy (0 = No, 1 = Yes)	-0.06	0.29	0.27	1.00			
Internationally recognized quality certification dummy (0 = No, 1 = Yes)	0.04	0.23	0.29	0.22	1.00		
Firm's legal status	-0.18	-0.24	-0.36	-0.15	-0.32	1.00	
Formal training programs for permanent and full-time employees	0.11	0.08	0.07	0.06	0.29	-0.16	1.00
Spending on formal research and development activities	0.04	0.08	0.11	0.16	0.15	-0.03	1.00

Source: Author's calculations.

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