Technical Efficiency of Small and Medium Manufacturing Enterprises in Vietnam

—Evidence from 2012 and 2014 Enterprise Surveys—

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Abstract

This paper examines the effect of reducing technological inefficiency through management technology transfer using data on Vietnamese SMEs manufacturing firms in 2014. Vietnam has seen increased foreign direct investment since the 2000s, which has led local firms to obtain international certification and meet the required standards of foreign-invested firms. Although the actual acquisition of international certification and improvement of management capabilities of companies are largely left to the efforts and learning of the (management of) companies, the process can be viewed as a kind of technology transfer in the context that developing countries with little experience can improve their capabilities by adapting to the standards set by developed countries. The bias-corrected DEA by Simar and Wilson (2007) was used as the method for measuring technological inefficiency. The empirical procedure estimates the standard error and confidence interval using the bootstrap method for the DEA score, which is deterministically determined by the relative evaluation of each sample. The analysis reveals that the following investment and learning activities, namely (i) having international certification; (ii) spending on advertising and publicity; and (iii) investing in expanding capacity and producing new products, are positively associated with reducing technical inefficiency in Vietnamese SMEs.

Keywords: *Organizational learning, manufacturing, technical efficiency, SMEs, Vietnam*

JEL Classification: *D22, D24, N65*

1. Introduction

The Socialist Republic of Vietnam (hereinafter referred to as Vietnam) has achieved economic growth upon the introduction of *Doi Moi* in 1986 and has been a lower middle-income country since 2010. However, despite an average economic growth rate of 6.1% between 2010 and 2017 (calculated by the authors using World Bank data, n.d.), the country's labor productivity has remained at a low level compared to neighboring countries[1]. Furthermore, it recorded negative growth in the industrial and construction sectors in 2016. ILO and ILSSA[2] (2018) point out that moving away from dependency on labor-intensive industries, such as assembly, is imperative to overcome the bottlenecks (ILO and ILSSA 2018: 26-28). In addition, GDP per capita in 2017 was 2,343.12 USD (nominal value) and slightly lower than that of neighboring Laos (2,457.31 USD, nominal value) in the same year (World Bank, n.d.).

This study focuses on private SMEs that have supported Vietnam's economic growth. We examine the effect of reducing technological inefficiencies through management technology transfer that can contribute to eliminating productivity stagnation. For the study purpose, we use firm-level data to measure technological inefficiency and analyze the factors that are correlated with its reduction (i.e. enhancing efficiency).

In Vietnam, state-owned, foreign-funded, and private enterprises have been operating under the same enterprise law[3] since 2010. However, in this analysis, the focus is placed on only private local small and medium-sized enterprises (SMEs), because large enterprises are still mainly (formerly) state-owned enterprises (SOEs) and it is difficult to identify private large enterprises in the data sets. In addition, foreign-invested enterprises (FIEs) are also not included in the analysis, because its economic environment is different from that of the local private sector. Nevertheless, private capital is the main driver of the economy in Vietnam today and, understandingly SMEs, which account for most of the private capital, will be very important for stable growth over the long term. Furthermore, it is considered that the study will provide some implications on how firms in developing countries could manage a catch-up process during the globalization process.

This study is structured as follows. First, through a review of previous studies, the environment and difficulties surrounding SMEs in Vietnam is analyzed. Then, using data from the Vietnam SME Survey 2015 (UNU-WIDER 2015), a factor analysis of technical efficiency of SMEs is conducted. In doing so, we use the dummy variables of international certification and investment objectives as explanatory variables for management capacity.

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[1] Comparing the labor productivity data for 2016, Vietnam (9,894 USD), Philippines (17,455 USD), Indonesia (23,390 USD), China (25,369 USD) and Thailand (27,101 USD) (all in 2011 real value PPP), Vietnam's labor productivity is extremely low (ILO and ILSSA, ILSSA, 2011; ILO and ILSSA, 2018, p. 27.)

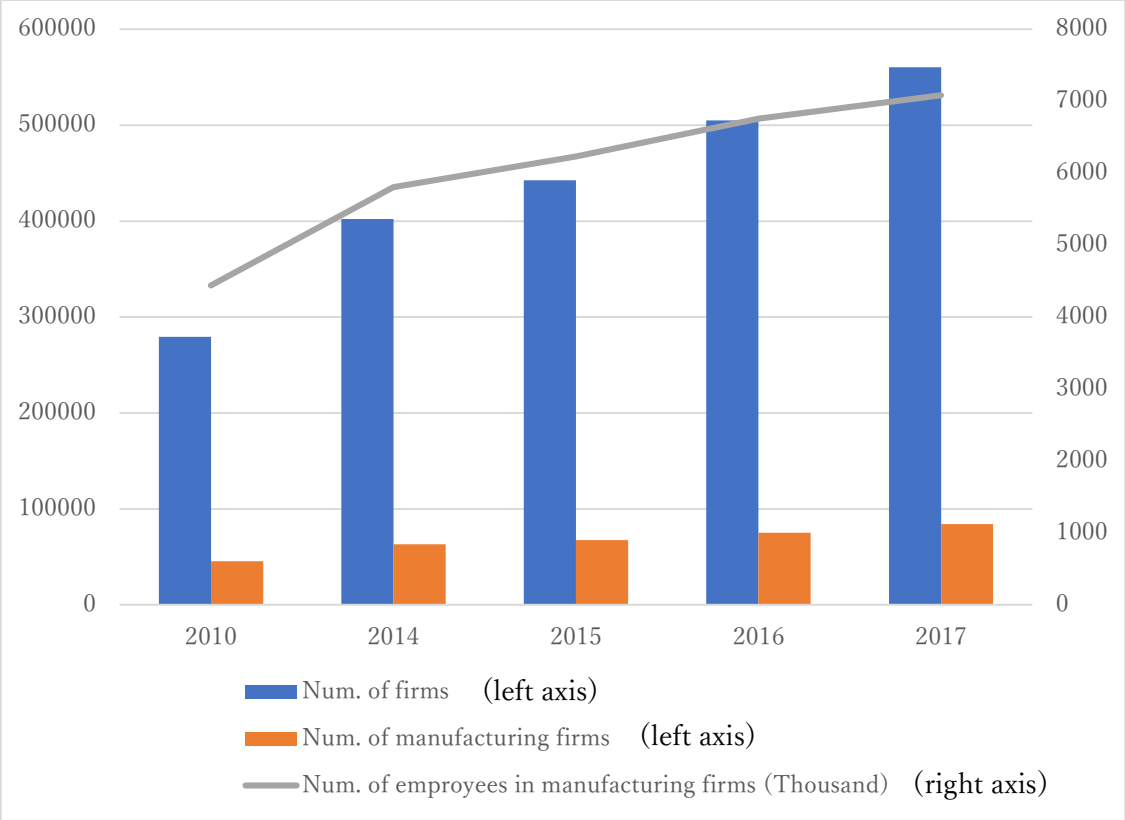
[2] ILO stands for International Labour Organization and ILSSA for Institute of Labour Science and Social Welfare, Vietnam.

[3] Socialist Republic of Vietnam (2005), 60/2005/GH11.

2. Review of Literature on Learning

The number of enterprises (left axis), manufacturing enterprises (left axis), and employees in the manufacturing industry (right axis) in Vietnam since 2010 are shown in Figure 1. This figure shows the trends since 2010. While the share of manufacturing firms in total firms has remained around 15%, the number of manufacturing employees exceeded 6.5 million in 2016, accounting for about 48% of total employment (GSO 2018).

Figure 1: Number of firms, manufacturing firms, and employees in manufacturing firms



Source: GSO (2018)

The SMEs covered in this study are defined as those with fewer than 300 employees based on the 2009 definition, but currently in Vietnam, SMEs are defined as those with fewer than 200 employees based on the Law on Supporting SMEs enacted in 2017[4].

Research on Vietnam's private sector has not only focused on institutional debates (e.g., Nguyen, Le and Bryant 2013; Tran 2015), such as private firms' export participation, challenges in ASEAN economic integration, and the formalization of household firms, etc., but it also addresses private sector-

[4] Socialist Republic of Vietnam (2009), 56/2009/ND-CP, and (2017), 04/2017/QH14.

related issues from a more micro perspective. In particular, with the advent of the Vietnamese Enterprise Surveys (VES) by the General Statistics Office (GSO) and the Vietnam SME Survey by UNU-WIDER, there has been a recent accumulation of studies targeting the manufacturing sector. These studies not only examine the effects of trade and industrial agglomeration on productivity, but the importance of innovation and management capabilities in developing countries as well, such as the impact of innovation activities and management practices, such as the improvement activities and 5S[5] and the acquisition of international certification. There are also many empirical papers that examine the importance of innovation and management capabilities in developing countries. In the Southeast Asian region, which is experiencing economic development through export-oriented industrialization along with the progress of economic globalization, it is considered extremely important for companies to acquire management capabilities that meet the required standards of developed countries.

In fact, Newman, Rand and Tarp (2012) analyze how Vietnamese local firms are exposed to the competitive environment under globalization. They analyze the characteristics of firms engaging in sector switching and its effects on the economy using VES panel data for the manufacturing sector for the period 2001-2008. Sector switching refers to changing operations from one subsector to another rather than entering or exiting firms. They find that firms that completed sector switching have higher productivity than entering and exiting firms in the subsectors before and after they do so, and that their transfer of resources contributed to the overall productivity growth of Vietnam's manufacturing sector. They also revealed that the motivation for sector switching is to gain new competitive opportunities and export destinations and showed that local firms tend to avoid industries in which foreign-invested firms are concentrated.

The study suggests that local firms are switching sectors for the proactive reason of seeking new competitive opportunities and export destinations, while at the same time avoiding industries in which foreign firms with abundant management resources are concentrated. It is suggested that local firms are choosing their competitors and trying to gain strength there. It is extremely difficult for local firms to compete with foreign firms that have sufficient resources to invest in developing countries for seeking production bases, but if local firms can supply intermediate goods as foreign companies' suppliers, they will not only have an advantage in domestic competition but may also be blessed with export opportunities.

Howard et al. (2014) examine the spillover effects of industry clusters on firm productivity using VES panel data for manufacturing industries from 2002 to 2007. Their analysis addresses the self-selection bias of estimating productivity by considering the productivity of the cluster to which the firm belongs. The results show that foreign-invested firms enjoy the most positive effect of industry clusters, and that, to some extent, local private firms obtain positive spillover effects, but not as much as foreign-

[5] 5S is initials of 5 workplace organization method originally created in Japan. Sort, Set in order, Shine (cleaning workplace), Standardize, Sustain.

invested firms. The study reveals that local private firms, which are relatively resource-constrained compared to foreign firms, do not experience the same spillover effects as foreign counterparts. However, the fact that a positive spillover effect on productivity is observed across firms in industrial clusters suggests that technology transfer among firms is taking place. The above study suggests that the competitive environment in which Vietnamese local firms are exposed to foreign firms has become severe, while aggressive local firms are willing to export and enter the competition, thereby achieving growth.

Another paper examining the learning effects of exporting is Newman et al. (2017). The authors test for self-selection bias on entry into export markets using VES from 2005 to 2012 and examine the effect of exporting on value added (productivity gain). The analysis reveals that foreign firms' entry into export markets is positively associated with an initial increase in value added, but the learning effect of exporting does not increase over time. For local private firms, the learning effect of exporting is correlated with the number of years the firm has been in the export market, indicating that the accumulation of learning (firm experience) from exporting contributes to the increase in value added.

Regarding research focusing on firm's management capability, there exist some published studies that discussed the capacity of innovation and obtaining international certification such as ISO 9001. For example, Stiglitz and Greenwald (2014) and Nübler (2014) argue that many firms in developing countries are operating below the production frontier and emphasize that moving firms closer to those with best practices (production activities on the frontier) is crucial for firm and industrial development. UNCTAD (2007) points out that learning is the very development of the capacity to use and improve technology and that capacity includes production management, quality control, repair and maintenance, and marketing. In other words, the development of management skills that meet the contemporary international standards has the potential to enhance the learning capacity of enterprises and make further learning more effective.

A study that examines the effect of management training on managers in northern Vietnam is Suzuki et al. (2014). In this study, a 10-month experiment was conducted in which managers of knit manufacturing companies were trained to improve their management capability. In addition, interviews were conducted with the managers of the participating firms. The results of the experiment revealed that demand for training was low in the initial period but gradually increased as the experiment was conducted. The study suggests that the lack of knowledge to judge the value of training is a barrier to their participation in training. The study also shows that training in improvement activities contributes to improvement of management scores and reduction of waste such as material losses, with hands-on training being particularly effective.

Although such training is considered to be a direct management technology transfer, the introduction of international certification, such as ISO 9001 (the international certification standard for quality management systems), is considered to be an effective way to create manuals on quality

management that meet the required standards without necessarily requiring help of engineers and experts from developed countries. Calza et al. (2019) and Haraguchi (2019) use the data of Vietnam SME Surveys to study the effect of introducing international certification on manufacturing firms and find that such certification has a positive effect on firm performance in Vietnam. While the acquisition of international certification and the introduction of the system itself are voluntary actions of the firms, the system itself is based on the technology of developed countries, hence, it can be considered as a kind of technology transfer.

Although there is a wealth of accumulated research on Vietnamese manufacturing firms, research on technology transfer of management involved in production is still scarce and gives rise to this study. The analysis in the next chapter examines the effect of variables representing the management involved in production of firms prior to the first period of the reduction of technical inefficiency. Albeit technical efficiency is a concept determined by relative evaluation of decision making units (firms) within a sample—unlike in total factor productivity (TFP), it can eliminate unidentifiable factors, such as institutions, that firms cannot determine themselves. In order to mitigate the shortcomings of the Data Envelopment Analysis (DEA) method in technological efficiency, this study measures technical efficiency using bias-modified DEA with the bootstrap method developed in Simar and Wilson (2007).

3. Analytical Approach, Data, Result and Discussion

3.1 Data

The data used for empirical analysis in this study are extracted from the 2013 (survey was conducted in 2012) and 2015 (survey was conducted in 2014) editions of the Vietnam SME Survey[6]. This survey series were conducted by the Central Institute for Economic Management (CIEM)—an external department of the Ministry of Planning and Investment of Vietnam (MPI), the Institute of Labor Science and Social Affairs (ILSSA)—an external department of the Ministry of Labor Invalids and Social Affairs of Vietnam (MoLISA), and the Development Economics Research Group (DERG) of the University of Copenhagen. For the purpose of this study, data from 445 SMEs with employees of between 11 and 300 people (excluding microenterprises[7]) that continued to operate between 2012 and 2014 from a total of 2,648 firms[8] are used for the empirical analysis. The variables and the descriptive statistics are presented in Table 1.A. In this analysis, we use lagged variables of one year (one-period lagged variables) for some variables that are considered unlikely to have an immediate impact of firms'

[6] In the following, unless otherwise noted, we will refer to the data as "2012 data" or "2014 data" according to the year of the survey.
[7] The majority of the sample consists of microenterprises operating as a source of cash income for households. However, to some extent, in order to focus on their characteristics as organized enterprises, microenterprises with 1-10 employees are excluded from the study.
[8] A continuous sample from the 2011 survey (Surveyed in 2010) is considered for the sample selection for the analysis.

activities in 2014—on the reduction of firms' technical inefficiency in 2014. This implies that we attempt to address the simultaneity bias by using the same variables as of 2012.

Table 1.A: Variables used and descriptive statistics

Variables	Definition	Obs.	Mean	Std. Dev.	Min	Max
Subsector dummy variables						
Food and beverage (Reference)	Dummy variable of 1 if the industry is food and beverage manufacturing and 0 otherwise	445	0.171	0.377	0	1
Textile	Dummy variable of 1 if textile manufacturing, 0 otherwise	445	0.043	0.202	0	1
Apparel	Dummy variable of 1 if you are in the sewing industry and 0 otherwise	445	0.094	0.293	0	1
Leather	Dummy variable of 1 if leather processing industry, 0 otherwise	445	0.031	0.175	0	1
Wood	Dummy variable of 1 if wood processing industry, 0 otherwise	445	0.092	0.290	0	1
Paper	Dummy variable of 1 if paper and pulp manufacturing industry, 0 otherwise	445	0.058	0.235	0	1
Publishing and printing	Dummy variable of 1 if the company is in the publishing or printing industry and 0 otherwise	445	0.031	0.175	0	1
Refining petroleum	Dummy variable of 1 if the industry is oil refinery and 0 otherwise	445	0.004	0.067	0	1
Chemical	Dummy variable of 1 if chemical manufacturing, 0 otherwise	445	0.038	0.192	0	1
Rubber	Dummy variable of 1 if the industry is plastic and rubber manufacturing and 0 otherwise	445	0.099	0.299	0	1
Nonmetal and mineral	Dummy variable of 1 if nonmetal manufacturing, 0 otherwise	445	0.072	0.259	0	1
Basic metal	Dummy variable of 1 if the industry is metal material manufacturing and 0 otherwise	445	0.011	0.106	0	1
Fabricated metal	Dummy variable of 1 if metalworking industry, 0 otherwise	445	0.110	0.313	0	1
Electrical machinery	Dummy variable of 1 if the industry is electronics and machinery manufacturing	445	0.054	0.226	0	1

	and 0 otherwise					
Motor vehicles	Dummy variable of 1 if the company is in the auto parts manufacturing industry and 0 otherwise	445	0.007	0.082	0	1
Other transport equipment	Dummy variable of 1 if other transportation equipment manufacturing, 0 otherwise	445	0.004	0.067	0	1
Other	Dummy variable of 1 if the company is a manufacturer of musical instruments, toys, accessories, etc., and 0 otherwise	445	0.074	0.262	0	1
Recycling	Dummy variable of 1 if you are in the recycling industry and 0 otherwise	445	0.004	0.067	0	1
Variables related to firm and manager characteristics						
Woman	Dummy variable of 1 if the manager is a woman, 0 otherwise	445	0.535	0.499	0	1
Age in 2014	Age of managers at the time of the survey (2014) (years old)	445	41.962	11.789	20	78
Kinh (Reference)	Dummy variable of 1 if the manager is a Kin person and 0 otherwise	445	0.948	0.222	0	1
Hoa	Dummy variable of 1 if the manager is a Chinese and 0 otherwise	445	0.047	0.212	0	1
Other ethnicity	Dummy variable of 1 if the manager is a Kinh or non-Chinese ethnicity, 0 otherwise	445	0.004	0.067	0	1
Higher education	Dummy variable of 1 if the manager has a college degree or higher, 0 otherwise	445	0.584	0.493	0	1
Firm age	Years in operation of firms at the time of the survey in 2014	445	13.820	8.029	2	59
Export dummy in 2012	Dummy variable of 1 if direct or indirect exporting in the 2012 survey, 0 otherwise	445	0.196	0.397	0	1
Investment in equipment in 2012	Dummy variable 1 if investment in machinery and equipment was made within 2 years in the 2012 survey, 0 otherwise	445	0.640	0.480	0	1
Advertisement in 2012	Dummy variable of 1 if advertising/ promotion activities were conducted in the 2012 survey and 0 otherwise	445	0.364	0.482	0	1

International certification in 2012	Dummy variable of 1 if the company had acquired international certification such as ISO 9001 in 2012, and 0 otherwise.	445	0.240	0.428	0	1
Managers share of total workforce	Ratio of managers to employees	445	0.103	0.051	0.008	0.286
Share of production workers	Unskilled production workers as a percentage of the workforce	445	0.476	0.319	0.000	0.976
Professional share of total workforce	Percentage of workers with a college degree or higher as a percentage of the workforce	445	0.072	0.086	0.000	0.533
Training for new workers in 2012	Dummy variable of 1 if new employees were trained at the time of the 2012 survey and 0 otherwise	445	0.342	0.475	0	1
Training for existing workers in 2012	Dummy variable of 1 if training was provided to employees at the time of the 2012 survey and 0 otherwise	445	0.112	0.316	0	1
Member of business association	Dummy variable of 1 if you are a member of one or more trade associations, 0 otherwise	445	0.173	0.379	0	1
Number of competitors	Number of competitors perceived by management	445	35.604	42.917	0	200
Product innovation in 2012	Dummy variable of 1 if the product innovation was made within 2 years at the time of the 2012 survey and 0 otherwise	445	0.279	0.449	0	1
Process innovation in 2012	Dummy variable of 1 if the manufacturing process was innovated within 2 years at the time of the 2012 survey and 0 otherwise	445	0.094	0.293	0	1
Region dummy variables						
Hanoi	Dummy variable of 1 if the firm is located in Hanoi and 0 otherwise	445	0.171	0.377	0	1
HCMC	Dummy variable of 1 if the firm is located in Ho Chi Minh City and 0 otherwise	445	0.351	0.478	0	1
Firm ownership variables						
Limited liability	Dummy variable of 1 if the firm is a limited liability company and 0 otherwise	445	0.587	0.493	0	1
JSC	Dummy variable of 1 if the firm is a non-state- owned joint stock company and 0 otherwise	445	0.103	0.305	0	1

Collective and cooperative	Dummy variable of 1 if the firm is a cooperative or joint venture, 0 otherwise	445	0.049	0.217	0	1
Private (Reference)	Dummy variable of 1 if the firm is a sole proprietorship and 0 otherwise	445	0.119	0.324	0	1
Household	Dummy variable of 1 if the firm is a household firm and 0 otherwise	445	0.142	0.349	0	1
Variables related to firm size, sales and costs						
Total nominal revenue	Total annual turnover (Unit: million VND) (*Production)	445	33,151	224,791	650	4,612,662
Total labor costs	Annual labor cost in million VND (*input 1)	445	2,293	2,804	173	21,840
Total assets	Amount of capital (in million VND) (*Input 2)	445	16,875	55,705	266	921,005
Total costs (intermediate, indirect, raw materials)	Annual intermediate goods cost in million VND (*input 3)	445	27,440	210,329	128	4,325,414

Source: Authors' calculations.

In this study, the following (selected) variables are obtained from the 2012 data that represent firms' activities and can contribute to the improvement of production-related management capacity as explained in the previous section (See Table 1.A for the complete list of variables).

- *'Export dummy in 2012'* (dummy variable of 1 if the firm is exporting directly or indirectly as of the 2012 survey, 0 otherwise) was used to identify firms that engage in export business. They are considered to learn through export activities and invest in appropriate machinery and equipment. They are deemed to have the management capacity to do so.
- *'Investment in equipment in 2012'* (dummy variable of 1 if the firm had invested in equipment within two years, considered at the time of the 2012 survey and 0 otherwise) was added to indicate that the firm had the management capacity to make appropriate investment in equipment.
- *'International certification in 2012'* (a dummy variable that is 1 if the firm had obtained international certification such as ISO 9001 in 2012, and 0 otherwise) was used as the variable for management technology transfer.
- The dummy variables '*Training for new workers in 2012'* (a dummy variable of 1 if the company had trained new employees at the time of the 2012 survey and 0 otherwise) and '*Training for existing workers in 2012'* (a dummy variable of 1 if the company had trained employees at the time of the 2012 survey and 0 otherwise) are used to identify firms that trained new and existing employees at the time of the 2012 survey.

- For process innovation, we use the dummy variable *'Process innovation in 2012'* (1 if the firm innovated its manufacturing process within two years at the time of the 2012 survey, 0 otherwise). The reason is that the development of the manufacturing process in the past is considered to be continuous with the management capability of the current production. The variables related to firms' innovation activities are lagged by one period.
- We also use '*Product innovation in 2012'* (a dummy variable that takes the value of 1 if the firm had product innovation within two years at the time of the 2012 survey and 0 otherwise) and '*Advertisement in 2012'* (a dummy variable that takes the value of 1 if the firm had advertisement spending within two years at the time of the 2012 survey and 0 otherwise) to indicate product innovation and advertisement spending, respectively. The dummy variable '*Advertisement in 2012'* (1 if the firm spent on advertising in 2012, 0 otherwise) is not a direct indicator of the ability of production management, but it indicates the participation in trade and intends to distinguish firms that are more competitive from firms that are less competitive. Although we cannot deny the reverse causality that more efficient firms are able to use their management resources for advertising, promotion and new product development, we attempted to mitigate this effect by taking one-year lag.
- For control variables such as characteristics of person in management, firm communication, and competitive landscape, we use variables as of the 2014 survey, namely, '*Member of business association'* (a dummy variable of 1 if the firm is a member of one or more trade associations and 0 otherwise) and *'Number of competitors'* (the number of competitors perceived by the management).
- This analysis also uses a dummy variable for the purpose of investment, classified into eight categories, to control for simple investment in machinery and equipment and investment for some purposes. With proper production-related management competence, purposeful investment in the past would help reduce inefficiencies in the firm today. In order to clarify the effect of "investment in machinery and equipment with a purpose", we also add a cross term with the purpose of investment.

Table 1.B: Breakdown of investment objectives

Objectives of investment in 2012	Frequency	Percent
Add to capacity	210	71.19
Replace old equipment	17	5.76
Improve productivity	20	6.78
Improve quality of output	13	4.41
Produce a new output	18	6.1
Safety	3	1.02
Environmental requirements	1	0.34
Other purpose	13	4.41
Total	**295**	**100**

Source: Author's calculations.

Although the analysis might face a simultaneity bias problem, which has been dealt with by using lagged variables, to some extent the ability of production-related management is an ability that companies originally possess, and it is not possible to consider all characteristics of the ability to be the result of technology transfer. The purpose of this analysis is not to clarify the causal relationship, but to clarify the correlation between the reduction of technological inefficiency and the variables that represent the management capabilities related to production.

3.2 Empirical Study Method

The empirical analysis in this study applies a two-step semi-parametric approach. First, we use DEA (a non-parametric method) to measure the technological inefficiency of firms. This method does not require a priori assumption of the specific functional form or the distribution of the error term, and thus prevents bias due to assumptions. In addition, it can eliminate factors—such as institutions—that firms cannot determine by themselves. Furthermore, it has the advantage of being able to measure technical inefficiency based on multiple input and multiple output variables without assuming profit maximization or cost minimization, so that family businesses, for example, which cannot assume profit maximization behavior, can be included in the analysis.

The DEA score, which represents the technological inefficiency of a company, is calculated based on the CCR (Charnes-Cooper-Rhodes) model (Charnes, Cooper, and Rhodes, 1978) and the BCC (Banker-Charnes-Cooper) model (Banker, Charnes, and Cooper, 1984). This analysis is based on the BCC model, which takes into account efficiency fluctuations due to changes in production scale in accordance with existing activities. In addition, since the required inputs are considered to be different across subsectors within the manufacturing industry, the inefficiency value is calculated based on the distance from the output-oriented frontier, where it is considered efficient to produce as much as possible output with the same inputs. In this method, the value 1.0 represents the most efficient value (firms located on the frontier), and the more inefficient a firm is, the larger the DEA score becomes.

Suppose n sample firms, m kinds of inputs and s kinds of outputs. $\boldsymbol{x}_0$ indicates the vector of inputs of the sample firms, and $\boldsymbol{y}_0$ indicates their vector of outputs. X indicates the $m \times n$ input matrix. Y indicates the $s \times n$ output matrix. Then, the DEA score of each firm is calculated by solving the linear programming problem below.

$$
\begin{aligned}
&\max \quad \eta \\
&s.t. \quad \boldsymbol{x}_0 \geq X\boldsymbol{\mu} \\
&\qquad \eta\boldsymbol{y}_0 \leq Y\boldsymbol{\mu} \\
&\qquad \boldsymbol{\mu} \geq \mathbf{0} \\
&\qquad \textstyle\sum \lambda_i = 1 \\
&\text{where } \boldsymbol{\lambda} = \boldsymbol{\mu}/\eta
\end{aligned}
$$

where η is the real number to maximise under the restrictions and $\boldsymbol{\mu}$ is an n-dimensional positive vector.

The second step is to estimate the determinants that reduce technical inefficiency by the regression (a parametric method) defined as follows.

$$IE_i = \beta_0 + \sum_{j=1}^{q} \beta_j z_{ij} + \varepsilon_i$$

Where IE_i is the DEA score (degree of inefficiency compared to the most efficient sampling firms) of firm i, j denotes the independent variables that have some influence on firm's technical efficiency, β is the coefficient to be estimated, and ε denotes the error term.

The DEA score in this estimation is calculated using general method that uses the STATA command 'teradial' by Badunenko and Mozharovskyi (2016). Additionally, this study follows Simar and Wilson (2007) method using the STATA command 'simarwilson' by Badunenko and Tauchmann (2018). The latter method is a better econometric method to calculate the DEA score because it can avoid and correct sampling bias by bootstrapping (see Simar and Wilson, 2007 and Badunenko and Tauchmann, 2018). The regression is performed using a truncated regression since the least DEA score is 1.0 (the most efficient) and inefficient DEA scores are larger than 1, which are positive and unlimited.

For this second stage of the estimation, in addition to the truncated regression model estimated using the DEA scores obtained by the usual method, the estimation applying the DEA scores obtained from the bootstrap method by Simar and Wilson (2007) is conducted. This is to deal with sample bias by using the bootstrap method to (1) assume that the most efficient firms in the sample and the most efficient firms in the population are different (i.e., it is assumed that firms with an efficiency value of "1.0" do not originally exist in the sample); and (2) address the problem of bias in standard errors and confidence intervals by modifying DEA scores using a parametric bootstrap method that is consistent with the assumed data generation process. In this study, the truncated regression model with DEA scores calculated by the algorithms #1 and #2[9] introduced in Simar and Wilson (2007) are also used in the estimation results along with the truncated regression model with DEA scores calculated by the usual calculation method as explained variable.

3.3 Results and Discussions

First, the descriptive statistics of the calculated DEA scores are shown in Table 2. Annual labor cost, annual intermediate goods cost, and capital amount were used for input, and annual gross sales were used for output. Table 2.2 shows that the top row is the output-oriented inefficiency index

[9] See The Badunenko and Tauchmann (2018) for more detail of this procedure.

calculated by the general method and the bottom row is the technical inefficiency modified by the method (Algorithm #2) by Simar and Wilson (2007)[10].

Table 2: Descriptive statistics of technical inefficiency (DEA score)

Technical inefficiency (DEA score)	Obs.	Mean	Std. Dev.	Min	Max
Biased	445	1.848	0.683	1.0	4.868
Simarwilson #2	445	2.056	0.817	1.112	6.472

Source: Authors' calculations

As can be seen from Table 2, the minimum value of technical inefficiency computed by Algorithm #2 (Simarwilson #2) is no longer 1.00. This is because the correction assumes that the most efficient firm is not in the sample. Even after the correction, the minimum value is about 1.11 and the mean value is about 2.06, implying that most firms in Vietnam operate close to the frontier, except for firms with relatively large technological inefficiency that could be eliminated.

The results of the second stage of the empirical analysis, i.e. the estimation with technical inefficiency calculated by this method being the explained variable, are presented in Table 3. '*sigma*' represents the estimated standard error of the cut-off regression analysis and Root Mean Square Error (RMSE) in the linear regression analysis and can be compared with the two cases under consideration. The significant coefficient of '*sigma*' implies that there is no distortion in the distribution of the samples.

In the analysis, the explained variable is the inefficiency value, which means that negative and statistically significant variables are positively correlated with the reduction of technical inefficiency of Vietnamese SMEs. In other words, it is clear that the four variables of '*International certification in 2012'*, *'Advertisement in 2012'*, '*Add to capacity'* and '*Produce a new output'* are correlated with the reduction of inefficiency value. In addition, there is no significant difference observed among the variables in (1) , (2), and (3). However, it is observed that the coefficients in (3) by Simarwilson #2 were particularly large (Table 3, column 4), and it can be interpreted that the underestimation of the effect of the variables was improved by correcting the standard errors and confidence intervals.

In this section, we (selectively) discuss the variables that are significantly correlated with the reduction of technical inefficiency. First, '*International certification in 2012'* not only has a positive effect on productivity (TFP and labour productivity), but is also significantly correlated with the reduction of firms' technological inefficiency indicated by the results of the study (for further supporting findings, see Haraguchi, 2019; Calza et al., 2019). This result suggests that the introduction of a system that allows firms to gain and own knowledge as 'formal knowledge' can improve the ability of firms in developing countries to manage their production, rather than the variable on human capital development, which did not show statistical significance. Firms that are competitive in Vietnam are operating in

[10] Since Algorithm #1 only corrects the standard error and confidence interval in the second stage estimation based on the calculated DEA score, the DEA score itself is calculated in the usual way.

relatively labour-intensive sectors. Therefore, it is more efficient for the firms to own knowledge in the form of manuals and make the general workers learn the rules written in the manuals to stabilize the overall function of the production line, rather than to provide knowledge and know-how of skill mastery to individual workers through training. In other words, it would be more efficient for a company to stabilize the entire production line by having the company itself own the knowledge in the form of manuals and having ordinary workers learn the rules written in them.

'Advertising in 2012' is a dummy variable that indicates the expenditure on advertising and promotion at the time of the 2012 survey, which includes expenditure for posting in the Yellow Pages and advertisements, participation in trade shows, and the like. At the same time the opportunities to actively market products are considered to be crucial for firms to understand market needs.

The investment variable *'Investment for equipment in 2012'* (a dummy variable indicating whether investment in machinery and equipment had been made in the last two years as of the 2012 survey) is statistically insignificant, while two of the variables indicating the purpose of investment '*Add to capacity'* and '*Produce a new output'* are significantly correlated with the reduction in technical inefficiency. In Vietnam, newly introduced machinery and equipment are often second-hand equipment imported from East Asian countries, such as Japan, Taiwan, Korea, etc. Thus, it is considered that the ability to plan and execute a purposeful investment would be more crucial and related to the reduction of technological inefficiency than the investment itself. We further conducted an analysis that included a cross-section of investment in machinery and equipment and the purpose of the investment, but the results were not significant.

The analysis shows that variables of exports, training for existing and new employees, and educational background of managers, are statistically insignificant, albeit having a negative coefficient on the reduction of firms' technical inefficiency. Plausible reasons for this could be the fact that the samples consist only of local SMEs, and hence it is difficult to find large differences in technical efficiency among firms, and that in the process of manufacturing labour-intensive products the skill of individual managers and the skill of workers are unlikely to affect the overall technical efficiency of the production.

On the other hand, one variable that is negatively correlated with the reduction of technical inefficiency in firms is the ethnicity of the manager—ethnicity other than Kinh or Chinese (Hoa). This is considered to be a result of differences in access to information and networks, customers and management depending on ethnicity, rather than the variable simply determining the superiority of the firm with respect to the reduction of technical inefficiencies.

We also find that a higher proportion of managers in the workforce is positively correlated with an increase in firms' technical inefficiency. This is because inputs include labour costs, which are considered to be a burden on the labour costs of firms with a large proportion of managers compared to firms with a small proportion of managers. Hence, the quality of labour would be a crucial issue.

Table 3: Analysis of determinants of Technical Inefficiency

Variables	(1) Biased DEA	(2) Simarwilson #1	(3) Simarwilson #2
Woman	0.193	0.193	0.295*
	(0.141)	(0.129)	(0.165)
Age of director or owner 2014	0.010	0.010*	0.012
	(0.007)	(0.006)	(0.008)
Hoa	0.275	0.275	0.357
	(0.270)	(0.247)	(0.324)
Ethnicity other	1.246*	1.246	1.802*
	(0.732)	(0.771)	(0.971)
Higher education	-0.182	-0.182	-0.235
	(0.148)	(0.133)	(0.179)
International certification in 2012	-0.416**	-0.416**	-0.446**
	(0.181)	(0.163)	(0.214)
Managers share of total workforce	3.500***	3.500***	4.010**
	(1.331)	(1.211)	(1.563)
Share of production workers	-0.108	-0.108	-0.183
	(0.211)	(0.193)	(0.250)
Professional share of total workforce	-0.519	-0.519	-1.074
	(0.854)	(0.786)	(1.020)
Firm age	-0.008	-0.008	-0.011
	(0.009)	(0.008)	(0.011)
Export dummy in 2012	-0.270	-0.270	-0.350
	(0.194)	(0.178)	(0.229)
Investment for equipment in 2012	-0.023	-0.023	0.006
	(0.172)	(0.157)	(0.199)
Business association	-0.137	-0.137	-0.208
	(0.194)	(0.176)	(0.231)
Product innovation in 2012	0.099	0.099	0.130
	(0.153)	(0.137)	(0.180)
Process innovation in 2012	0.177	0.177	0.078
	(0.248)	(0.228)	(0.290)

Number of competitors	0.002	0.002	0.002
	(0.002)	(0.001)	(0.002)
Training for existing workers in 2012	0.027	0.027	0.185
	(0.227)	(0.205)	(0.261)
Training for new workers in 2012	0.021	0.021	-0.074
	(0.150)	(0.134)	(0.176)
Advertisement in 2012	-0.369**	-0.369***	-0.446**
	(0.147)	(0.133)	(0.174)
Purpose of investment in 2012			
Add to capacity	-0.376*	-0.376**	-0.423*
	(0.194)	(0.178)	(0.225)
Replace old equipment	0.515*	0.515*	0.720*
	(0.306)	(0.292)	(0.369)
Improve productivity	-0.299	-0.299	-0.479
	(0.351)	(0.330)	(0.427)
Improve quality of output	-0.253	-0.253	-0.296
	(0.419)	(0.404)	(0.516)
Produce a new output	-0.752*	-0.752**	-1.135**
	(0.411)	(0.374)	(0.510)
Safety	-0.700	-0.700	-0.794
	(0.840)	(1.047)	(1.318)
Environmental	-1.029	-1.029	-1.147
	(1.542)	(3.999)	(5.236)
Other purpose	0.373	0.373	0.403
	(0.367)	(0.347)	(0.438)
Constant	1.029*	1.029**	0.951
	(0.531)	(0.472)	(0.615)
Sector Dummies	YES	YES	YES
Ownership Dummies	YES	YES	YES
Hanoi and HCMC Dummies	YES	YES	YES
sigma	0.851***	0.851***	1.096***
	(0.060)	(0.051)	(0.069)
Observations	422	422	445

Source: Author's calculations.
Notes: 1. Standard errors in parentheses; 2. *** p<0.01, ** p<0.05, * p<0.1

4. Concluding Remarks

This study analyses the effect of management technology transfer on reducing technical inefficiencies in developing countries, using small and medium manufacturing firms in Vietnam as a case study. The empirical analysis makes use of large (secondary) data from enterprise surveys that were conducted by government agencies. Improving the capacity of firms' management is a pressing issue in many developing countries. This is especially important when doing business with foreign firms that have entered the domestic market through exports or foreign direct investment activities, as well as in competition with domestic firms. In this study, we analysed the contribution of various variables that may indicate high management capability to reduction of technical inefficiency. In the empirical analysis, the bias is addressed by measuring the DEA score using the bootstrap method based on Simar and Wilson (2007). We also attempt to deal with simultaneity bias by setting some of the variables as of 2012 while the explained variable was technological inefficiency as of 2014 (using lagged variables).

The results of the analysis reveals that (i) obtaining international certification; (ii) having expenditure on advertising and publicity; and (iii) making investment aimed at expanding capacity and producing new products, are essential for the reduction of technical inefficiency of the firm. The result in this study (using an improved empirical procedure) reaffirms the findings in previous studies that applied other methods or procedures, and thereby contributing to literature on efficiency and technology transfer in the manufacturing in developing countries. The analytical approach and empirical procedure applied in this study offers a new aspect of analysing the factors that are correlated with the reduction of technical inefficiency in developing countries. Furthermore, the results suggest that firms' ownership of knowledge that remains in the organization regardless of the characteristics or the movement of individual employees—such as international certification, contributes to the reduction of technical inefficiency more effectively than human capital development that firms invest in—such as employee training.

However, with regard to the interpretation the effect of *expenditure on advertising* on inefficiency reduction, it is not possible to completely rule out the possibility that firms that are efficient in their activities are spending on advertising (problem of reserve causality). In addition, it is clear that the ability to plan and execute purposeful investments is more related to the reduction of technical inefficiency than simply making investment in machinery and equipment. The ability to plan and execute purposeful investment is considered to be highly dependent on the management's ability and—as a background to this—it is pointed out that investment in machinery and equipment by Vietnamese SMEs does not necessarily imply an improvement in the firm's technological level.

In conclusion, it can be said that it is extremely important to visualize the knowledge that an enterprise has in the form of a manual, such as international certification, which does not change regardless of movement employees, and that the enterprise should plan and execute investment plans in

line with the organizational target, which is a management skill regarding basic production and contributes to the reduction of technical inefficiencies. This will surely contribute to the reduction of technical inefficiencies. For SMEs in developing countries like Vietnam, it is not easy to hire the right people who can handle the consulting fees for certification and the accounting tasks that are important for financing the investment. It is hoped that the government's policy to support SMEs will include not only assistance and financing for international certification, but also investment support, including investment planning.

Notwithstanding the above findings, it is worth mentioning some limitations for further consideration and expanding this study. The main limitation of this study is that the causal relationship between technological inefficiency and individual determinants cannot be fully identified. It would be possible to enhance the findings of the study, if we could identify differences in the results between large and foreign-owned firms and small and medium-sized firms. Although it was difficult to do so in this study due to data limitations, further extension of the analysis is expected in the near future.

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