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Sources of the performance of manufacturing firms: evidence from Vietnam

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ABSTRACT

We used stochastic frontier analysis (SFA) to investigate the cost efficiency and productivity of the manufacturing sector in Vietnam from 2010 to 2016 to determine the sources of their performance. Our findings suggest that it is important for the country and its regions to create a competitive environment for the development of their local manufacturing firms. We also found that larger firms, those with a longer history and those that are more export-oriented tend to outperform their counterparts. We suggest that the sampled firms should focus more on research and development and technological implementation to shift towards a capital-intensive state and thus enhance their productivity.

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1. Introduction

A significant body of literature suggests that the manufacturing sector has a strategic role in economic development. For example, Tybout (2000) argued that the manufacturing sector is a leading dimension of modernisation and skilled job creation, and also has other positive spill-over impacts. Mijiyawa (2017) suggested that it is the key for innovation and technology diffusion. Additionally, manufacturing firms can also be seen as important consumers of banking, transport, insurance and even agriculture (Mijiyawa, 2017). Although global manufacturing growth is expected to remain stable, there is some evidence of a slowdown in the manufacturing output of developing and emerging countries (United Nations Industrial Development Organization (UNIDO), 2018). Therefore, examining and improving the efficiency of manufacturing firms has become an essential condition for further development in developing and emerging countries.

Vietnam is an interesting case for our study because its economic development and achievements over the last few decades have been attributed to the exponential growth of business enterprises in the private sector (Central Institute for Economic Management (CIEM), 2016). Since the implementation of *Doi Moi* (renovation) in 1986, a wide range of market-oriented economic and industrial policies has been adopted, including import substitution and export-oriented policies, and the development of resource- and labour-intensive industries, especially in the manufacturing sector. As a result, the country's

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gross GDP increased 30-fold in 25 years (1986–2011) and the GDP growth rate continued to grow by 6% on average from 2010 to 2016 (World Bank, 2017). In 2017, there were about 631,000 active enterprises in Vietnam, 126,859 of which were newly established, which consequently created more than a million additional jobs for the economy. Relatively, the manufacturing sector only accounted for 14.9% in terms of the number of firms but contributed 20.2% in terms of total assets and 38.3% in terms of total net turnover (General Statistics Office (GSO), 2017). This development, however, is still hindered by the constrained environment including credit and financial constraints and stringent regulations (CIEM, 2016), especially for privately owned manufacturing firms (Giang, Nguyen, Van, & Thieu, 2015; Van Thang & Freeman, 2009). It is therefore important to analyse the efficiency and productivity of the Vietnamese manufacturing sector in response to the impacts of environmental factors in order to understand and improve its competitiveness to become an integral part of the global economy.

Frontier analysis, including Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA), has been used extensively to examine the technical efficiency and performance of manufacturing firms in many countries. This includes studies in the US (Shen, Dunn, & Shen, 2007), Spain (Martin-Marcos & Suarez-Galvez, 2000), Italy (Becchetti & Sierra, 2003), African countries (Lundvall & Battese, 2000; Söderbom & Teal, 2004), Indonesia (Suyanto & Bloch, 2009) and Vietnam (Huang & Yang, 2016; Vu, 2016). To the best of our knowledge, there is no study on the cost efficiency of manufacturing firms, which is relatively important, since it is often easier and more practical for firms to reduce their costs rather than to increase their sales, especially in a highly competitive environment.[1] Additionally, firms' total factor productivity (TFP) and its changes over time have also not been widely addressed, since it is difficult to build up a panel of data for the same sample of firms across different times through surveys. Nevertheless, the longitudinal Annual Survey on Enterprises conducted by the General Statistics Office (GSO) of Vietnam (General Statistics Office (GSO), 2016) allows us to do so.

This article investigates the cost efficiency, economies of scale, technical progress and TFP growth of 7633 Vietnamese firms operating in the manufacturing sector from 2010 to 2016. These measures are examined simultaneously regarding the impact of key determinants such as firm type, firm age, the proportion of female employees and export-related activities. To do so, we use a time-variant translog stochastic cost frontier model following Battese and Coelli (1995) and Kumbhakar and Lovell (2003), among others.

The rest of the article is structured as follows. Section 2 provides a brief review of the relevant studies on the efficiency and productivity of manufacturing firms. Section 3 explains the methods used in this study as well as describing our data. Section 4 discusses the empirical results and Section 5 concludes.

2. Literature review

Managers are familiar with the use of ratios such as returns over assets, returns over equity or cost:income for measuring firms' performance. When it comes to the case of multiple outputs and/or multiple inputs, there is an increasing trend to use frontier analysis to measure the multi-dimensional efficiency and performance of firms via two popular methods: parametric and nonparametric approaches. Each approach has advantages and shortcomings compared with the other. SFA, which takes the parametric approach, is often chosen if the sample is big enough so that hypothesis test(s) regarding the efficiency measurements can be performed. This method requires an a priori production function form for the analysis and therefore is more suitable for studies of the manufacturing sector.

The earliest study that applied SFA to analyse the efficiency of manufacturing was that of Meeusen and van Den Broeck (1977). This study used the 1962 census data of 4838 French manufacturing firms and found that the average technical efficiency scores of those firms were moderate at about 0.849. The study then analysed each of the 10, two-digit industries, especially in terms of yearly production volumes, to conclude that larger firms tended to have higher technical efficiency levels than smaller firms.

Taking a slightly different view, Alison and Mayes (1991) looked at 151 sub-industries of the manufacturing sector in the United Kingdom to understand efficiency at the industry level. They argued that the average (in)efficiency of those sub-industries was about 0.320, suggesting that the UK manufacturing sector performed at only 68% of its optimum capacity. Along the same lines, data on the US, Canadian, Australian, Korean and Japanese sub-industries have also been examined (Caves, 1992). These studies found that efficiency in the manufacturing and industrial sectors is affected by five sets of factors: competition, organisation (e.g. size and ownership), structural heterogeneity (e.g. capital intensity, material intensity and scale diversity), dynamic disturbances (e.g. research and development, technological growth) and public policy (e.g. regulations and policy).

Similar studies on manufacturing firms have also been conducted in many countries. In line with Meeusen and van Den Broeck (1977), Hossain and Karunaratne (2004) found that for the Bangladeshi manufacturing sector, the scale of operation appeared to be an important determinant of technical inefficiency, whereas export activities had a significant impact on reducing inefficiency, especially over time. Meanwhile, Rijkers, Söderbom, and Loening (2010) argued that there are differences between the efficiency and productivity of Ethiopian manufacturing firms operating in rural and urban areas. Part A of Table 1 presents some SFA results on the efficiency and productivity of manufacturing firms as well as their determinants as presented in the literature.

In terms of the Vietnamese manufacturing sector, the number of studies using frontier analysis, especially SFA, is still limited. More importantly, the estimated efficiency measurements found in earlier studies for Vietnamese manufacturing firms varied considerably, with the average technical efficiency scores ranging from 0.497 to 0.940 (see Part B, Table 1). This can be related to the differences in the variables, model selection and the period of observation. For example, earlier studies such as Vu (2003) started with only 164 firms operating in the 1997–1998 period, resulting in 328 observations, whereas a recent study by Pham, Dao, and Reilly (2010) used a dataset of 10,759 firms for the year 2003 only. It is also important to note that Table 1 only reports SFA studies on the technical efficiency but not the cost efficiency of manufacturing firms. This may be because of the difficulty of collecting input price information, especially for materials, which is required for cost efficiency analysis in both SFA and DEA.

Table 1. Selected SFA studies on technical efficiency of manufacturing firms.

Study	Country	Period	Number of observations	Average efficiency	Determinants of efficiency
Part A. Studies using data from other countries					
Meeusen and van Den Broeck (1977)	France	1962	4838 firms	0.849	SIZE(+)
	UK	1977	151 industries	0.680	
Lundvall and Battese (2000)	Kenya	1993–1995	235 firms	0.740	SIZE(+)
Hossain and Karunaratne (2004)	Bangladesh	1978–1994	25 industries	0.548	EX(+);
Söderbom and Teal (2004)	Ghana	1991–1997	143 firms	0.530	
Charoenrat et al. (2013)	Thailand	2007	56,444 firms	0.54	SIZE(+); AGE(+); CITY(+); SOE(–)
Hailu and Tanaka (2015)	Ethiopia	2000–2009	1639 firms	0.205–0.740	
Part B. Studies using data from Vietnam					
Vu (2003)	Vietnam	1997–1998	164 firms	0.788–0.789	EX(+); CITY(–)
Nguyen, Giang, and Bach (2007)	Vietnam	2000–2003	1492 firms	0.372–0.575	SIZE(+); AGE(–)
Pham et al. (2010)	Vietnam	2002	10,759 firms	0.458–0.635	SOE(+); FOE(–); FERATIO(–); EX(+)
Chu and Kalirajan (2011)	Vietnam	2000–2003	328 firms	0.550–0.638	EX(+)
Vu (2016)	Vietnam	2009–2013	31,889 observations	0.557	SIZE(+); AGE(+); EX(+)
Huang and Yang (2016)	Vietnam	2000–2008	7625 firms	Not reported	SIZE(+); FOE(+); EX(+)
Vu, Holmes, Tran, and Lim (2016)	Vietnam	2009	1664 firms	Not reported	SIZE (+), POE(+), SOE(+)
Le et al. (2018)	Vietnam	2008	2655 firms	0.920	

EX: the firm is involved in export activities; SOE: the firm is publicly owned; FOE: the firm has foreign ownership; POE: the firm is privately owned; SIZE: firm size; AGE: firm age; CITY: the firm operates in an urban or municipial area; FERATIO: the proportion of female employees out of the total number employed by the firm; (+): positive and significant association; (–): negative and significant association.

3. Methodology

3.1. The SFA model

Traditional SFA studies based on the production function could not measure how firms manage their usage of inputs, because they used data on input quantities only but not input prices. One way to incorporate the input prices into efficiency and productivity measurements is to use the cost function. Kumbhakar and Lovell (2003) explained that a time-variant translog[2] form of the cost function for an average firm in the sample can be expressed as shown in Equation (1) below. Note that in Equation (1), the standard homogeneity and symmetry restrictions (Kumbhakar & Lovell, 2003) are imposed to ensure that the cost function is well behaved, whereas the firm and time subscripts are suppressed for ease of exposition:

$$\ln C = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln w_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{ij} \ln w_i \ln w_j + \beta \ln y + \sum_{m=1}^{3} \gamma_m \ln w_m \ln y + \omega_t t + \frac{1}{2}\omega_{tt} t^2 + \sum_{p=1}^{3} \omega_p t \ln w_p + \varphi t \ln y + v + u; \tag{1}$$

$$u = \delta_0 + \delta_k z_k + \epsilon. \tag{2}$$

Equation (1) summarises a cost function that uses the three input prices (w_i, $i = 1,\ldots,3$) of the three (hidden) inputs (x_i, $i = 1,\ldots,3$) to produce a single output. Specifically, we argue that any manufacturing firm uses labour (x_1), total assets (x_2) and capital (x_3) to produce total revenue (y), and these variables will contribute to the total cost (C) of the firm. It is noted that in Equation (1), the deviations of an individual small or medium enterprise from the cost frontier (i.e. the regression's residuals) are then decomposed into the random noise (v) and non-negative inefficiency (u) components, in which u is simultaneously affected by environmental factors z_k (Battese & Coelli, 1995; Kumbhakar & Lovell, 2003), as represented in Equation (2). Consequently, Equation (2) examines the impacts of environmental variables z_k on the inefficiency component u, for which a positive association between z_k and u indicates a negative association between z_k and the cost efficiency estimates and vice versa. More details on the total cost (C), inputs (x_i), output (y) and environment variables (z_k) are given in the following section.

For a particular firm, its cost efficiency score can be estimated by using Battese and Coelli's (1988) definition:

$$\mathrm{CE}_i = \exp(-u_i) \tag{3}$$

Kumbhakar and Lovell (2003) also applied the differentiating method and Shepherd's lemma to further estimate TFP change (*TFPCH*) as the sum of change in cost efficiency (*CECH*), technical change (*TECH*)[3] and a scale effect component (*SCALE*), for the case of balanced panel data. Those components are expressed in Equations (4)–(7) below. Note that previous studies on the manufacturing sector, including ones about Vietnam, could not analyse *TFPCH* because of data limitation.

$$TFPCH = CECH + TECH + SCALE \tag{4}$$

$$CECH = \frac{CE_{t+1}}{CE_t} \tag{5}$$

$$TECH = -\frac{\partial \ln C}{\partial t} = -\omega_t - \omega_{tt}t - \sum_{p=1}^{3} \omega_p \ln w_p - \varphi \ln y \tag{6}$$

$$SCALE = \left(1 - \frac{\partial \ln C}{\partial \ln y}\right)\dot{y} = \left(1 - \beta - \sum_{m=1}^{3} \gamma_m \ln w_m - \varphi t\right)\dot{y} \tag{7}$$

where $\dot{y}$ measures the rate of changes in the output y . The negative sign of *TECH* in Equation (5) reflects that an inward shift of the cost frontier (i.e. cost reduction) over time positively contributes to overall TFP growth. In contrast, *CECH* and *SCALE* made positive contributions towards TFP growth.

3.2. Data and variable selection

There are two important sources for our data. Firstly, firm-level data were extracted from annual surveys on the nation's business enterprises conducted by the General Statistics Office of Vietnam (GSO). These surveys collected both financial and non-financial information from a large number of enterprises to support decision-makers and government agencies in management, policy-making, socio-economic planning and business promotion (General Statistics Office (GSO), 2018).[4] For example, the latest survey in 2017 provided data on nearly 400 variables for more than 76,000 firms that operated in 2016. Secondly, information on the competitive environment at the provincial level was collected through annual surveys conducted by the Vietnam Chamber of Commerce and Industry and the US Agency for International Development in Vietnam. These surveys represent the opinions of more than 11,500 enterprises regarding the local governance and business environment in 63 cities and provinces in Vietnam (Vietnam Chamber of Commerce and Industry (VCCI) & United States Agency for International Development in Vietnam (USAID), 2018). After matching and cleaning missing observations or variables from the two datasets, we ended up with a balanced panel data of 7633 manufacturing firms that operated consistently for the period of 2010–2016, yielding 53,431 observations. A summary of those variables (pooled data from the period 2010–2016) is presented in Table 2, where monetary values are presented in million Vietnam Dong (VND) at 2010 prices (i.e. 1 USD ≈ 19,500 VND as of 31 December 2010). Particularly, one can see from Table 1 that the number of state-owned enterprises (SOE) accounted for only about 6% of the sample, whereas the figures for privately owned enterprises (POE) and foreign-owned enterprises (FOE) were 55% and 39%, respectively. The firms employ female labour as about 44% of their total employees and nearly two-thirds of the firms are involved in exporting activities and/or located in industrial parks. Less than one-third of our sample is located in the big five municipalities in Vietnam.

The variables in Table 2 were selected on the basis of the information available and the current literature. First, the total cost (*C*) consists of all actual financial expenses related to the operation of the firms, including salary and wages, material and intermediary costs, and other operating costs such as administration and sales (Kotey & O'Donnell, 2002; Ngo & Tripe, 2016). Second, most studies on manufacturing firms

Table 2. Descriptive statistics.

Variables	Means	Definitions
Total Cost		
C	373,095.00	Total cost = labour cost + operating cost + materials cost (million VND)
Inputs		
x_1	384.55	Number of employees (thousand persons)
x_2	10.45	Value of total assets (million VND)
x_3	1677.23	Materials (= material costs/w_3)
Input Prices		
w_1	48.88	Labour cost divided by x_1
w_2	3923.91	Operating cost divided by x_2
w_3	130.85	Materials price index, extracted from the General Statistics Office's annual yearbooks
Output		
y	295,377.50	Total revenue (million Vietnamese Dong)
Environmental Variables		
PCI	59.59	Provincial Competitiveness Index, measuring the competitive environment that firm operates in (ranges from 0 to 100)
AGE	11.61	Firm's age (in years)
SIZE	10.72	Logarithmic value of the firm's total assets
SOE	0.06	= 1 if the firm is a central or local state company, collective enterprise or joint stock company with state capital of more than 50%
POE	0.55	= 1 if the firm is a private enterprise or joint stock company with state capital of less than 50%
FOE	0.39	= 1 if the firm is 100% foreign-owned or is a joint venture with foreign capital
FERATIO	0.44	The ratio of female employees to total employees
EX	0.61	= 1 if the firm is involved in exporting activities
IZONE	0.64	= 1 if the firm is located inside an industrial zone
CITY	0.27	= 1 if the firm is located in a municipality in Vietnam (including Hanoi, Ho Chi Minh City, Hai Phong, Da Nang and Can Tho)

separate inputs into three categories: labour, capital and materials (Mijiyawa, 2017; Pilar, Marta, & Antonio, 2018; Rijkers et al., 2010). In this study, these inputs are, respectively, proxied by the number of employees (x_1), the value of total assets (x_2) and the amount of materials (x_3). It is noted that the input prices of labour (w_1) and capital (w_2) can be easily computed from their costs and quantities, which are reported in the surveys; however, information on the quantity of materials is often unavailable. Consequently, it is difficult to measure the input price of materials, which hinders the use of cost efficiency analysis for manufacturing firms. One can argue that firms are likely to face the same input prices; hence, we can assume that the input price of materials is equal to unity for all firms. This assumption has a limitation when it comes to panel data where input prices can vary over time; therefore, we follow the approach of Kotey and O'Donnell (2002) in using the material price index, provided in the Annual Yearbooks of the GSO, as a better alternative. Third, following Pham et al. (2010), and Le, Xuan-Binh, and Nghiem (2018), we use total revenue as the final output of the firms. Finally, yet importantly, the environmental variables are the ones that have been found to have significant impacts on technical efficiency (see Table 1), as here we would like to examine their impacts on the cost efficiency of Vietnamese manufacturing firms. Importantly, we add in two more factors, PCI and IZONE, to examine the role of local competitiveness[5] and (local) industrial zones as an environment supporting cost efficiency. This is in line with previous efficiency studies, although these did not focus on the manufacturing sectors or use SFA. For example, Nickell (1996) argued that competition may positively influence the efforts of managers and employees, which, in turn, leads to better firm performance. However, Lai, Hsu, Lin, Chen, and Lin (2014) and Yang, Motohashi, and Chen (2009) suggested that firms operating in industrial parks tend to be more innovative and hence more efficient than their counterparts.

4. Results and discussion

4.1. Cost frontier estimates

We first report the parameter estimates of the cost frontier of Vietnamese manufacturing firms in Table 3. The model statistics section of Table 3 shows that the model provides a robust and reliable estimation of the parameters because the generalised likelihood ratio (LR) test returns a statistic of 1242 with a p-value of less than 0.001, which confirms that the translog model is better than a basic Cobb–Douglas model in terms of our specific sample. Importantly, the significant differences from zero of δ_u and λ indicate that inefficiency exists in the Vietnamese manufacturing sector (more details on those parameters are in Kumbhakar & Lovell, 2003).

We also observe that price of labour ($\ln w_1$) is the most important factor in the total costs of the firm (C). Although the price of capital ($\ln w_2$) is not significantly associated with total costs, its quadratic value ($\ln w_2 \ln w_2$) shows a significant but negative association. This indicates that the relationship between w_2 and C follows an inverse U-shape, suggesting that economies of scale exist in the Vietnamese manufacturing sector. Consequently, we suggest that those firms should be more capital-intensive instead of labour-intensive in order to reduce the costs. This is in line with previous studies on the manufacturing sector, especially in developing economies, such as in Thailand

Table 3. Parameter estimates of the cost frontier.

	Coefficient	Standard error
Equation (1): Cost frontier		
Constant	−5.8405	6.5011
$\ln w_1$	−0.3679***	0.0872
$\ln w_2$	0.0394	0.0297
$\ln w_3$	2.5901	2.8275
$\ln w_1 \ln w_1$	0.0084***	0.0017
$\ln w_1 \ln w_2$	0.0048***	0.0006
$\ln w_1 \ln w_3$	0.0830***	0.0187
$\ln w_2 \ln w_2$	−0.0051***	0.0002
$\ln w_2 \ln w_3$	−0.0018	0.0064
$\ln w_3 \ln w_3$	−0.5094	0.6109
$\ln y$	1.0521***	0.0301
$\ln w_1 \ln y$	−0.0055***	0.0005
$\ln w_2 \ln y$	−0.0008***	0.0002
$\ln w_3 \ln y$	−0.0152*	0.0064
t	−0.1943	0.1680
t^2	0.0025	0.0031
$t \ln w_1$	−0.0032**	0.0011
$t \ln w_2$	−0.0006	0.0004
$t \ln w_3$	0.0393	0.0340
$t \ln y$	−0.0008**	0.0004
Model statistics		
δ_u	0.0196***	
δ_v	0.1547***	
λ	0.1265***	
LR statistic	1242.00***	

LR, likelihood ratio. *, ** and *** indicate significant differences at $P < 0.01$, $P < 0.05$ and $P < 0.001$ respectively.

(Charoenrat, Harvie, & Amornkitvikai, 2013), Bangladesh (Hossain & Karunaratne, 2004) or African countries (Mijiyawa, 2017).

It is not a surprise to see that the more output (and revenues) a firm produces via ln*y*, the more costs it will need to pay, since this relationship has been found in many other cost studies (e.g. Ngo & Tripe, 2017; Nguyen, Nghiem, Roca, & Sharma, 2016). It does not mean that Vietnamese manufacturing firms should reduce their outputs and revenues; however, this finding provides a different view on the cost efficiency aspect compared with the technical efficiency aspect. In particular, although technical efficiency studies focus on how to maximise the outputs (e.g. Huang & Yang, 2016; Le et al., 2018; Vu, 2016), we argue that it needs to be balanced with the costs involved.

4.2. Cost efficiency estimates

The average cost efficiency score of Vietnamese manufacturing firms for the whole period 2010–2016 is moderate (about 0.684), as reported in Table 4. This figure is consistent with the previous results of Chu and Kalirajan (2011), Pham et al. (2010) and Vu (2003) (see Table 1 in Section 2 above). However, it is important to emphasise again that it represents the efficiency of the firms in terms of managing and minimising their costs rather than in terms of maximising outputs (i.e. technical efficiency), as examined by the abovementioned studies. The results therefore provide a different view of the performance of those firms.

According to Table 4, there is evidence that Vietnamese manufacturing firms performed differently depending on characteristics such as ownership status (i.e. SOE, POE and FOE), municipalities (i.e. CITY) or trade activities (i.e. EX). We further illustrate the differences in cost efficiency across the Vietnamese provinces and regions, especially for the five municipalities, in Figure 1. The significance roles of those factors are further examined in the following section.

4.3. Determinants of cost efficiency

Table 5 presents the relationships among environmental factors such as size, age and municipality status on the firms' cost efficiency. For our sample, it can be seen that SIZE,

Table 4. Cost efficiency of Vietnamese manufacturing firms by group.

Year		2010	2011	2012	2013	2014	2015	2016	Average
SOE	= 0 (7178 obs)	0.672	0.681	0.683	0.685	0.687	0.689	0.691	0.684
	= 1 (455 obs)	0.684	0.690	0.692	0.693	0.694	0.696	0.697	0.692
POE	= 0 (3405 obs)	0.692	0.700	0.702	0.703	0.705	0.707	0.709	0.702
	= 1 (4228 obs)	0.657	0.666	0.669	0.671	0.673	0.676	0.678	0.670
FOE	= 0 (4683 obs)	0.659	0.668	0.671	0.673	0.675	0.677	0.680	0.672
	= 1 (2950 obs)	0.693	0.702	0.703	0.705	0.707	0.708	0.710	0.704
EX	= 0 (4131 obs)	0.654	0.653	0.656	0.657	0.660	0.660	0.661	0.657
	= 1 (3502 obs)	0.694	0.698	0.700	0.701	0.703	0.705	0.707	0.702
IZONE	= 0 (5159 obs)	0.663	0.670	0.687	0.686	0.684	0.690	0.681	0.675
	= 1 (2474 obs)	0.691	0.700	0.683	0.685	0.688	0.689	0.708	0.690
CITY	= 0 (5557 obs)	0.670	0.679	0.681	0.683	0.685	0.687	0.689	0.682
	= 1 (2076 obs)	0.679	0.687	0.689	0.692	0.693	0.695	0.697	0.690

The numbers of observations (obs) in each group are average values for the whole period. Yearly number may vary, except for those on ownership (i.e. SOE, POE and FOE). See Table 2 for definitions of the variables.

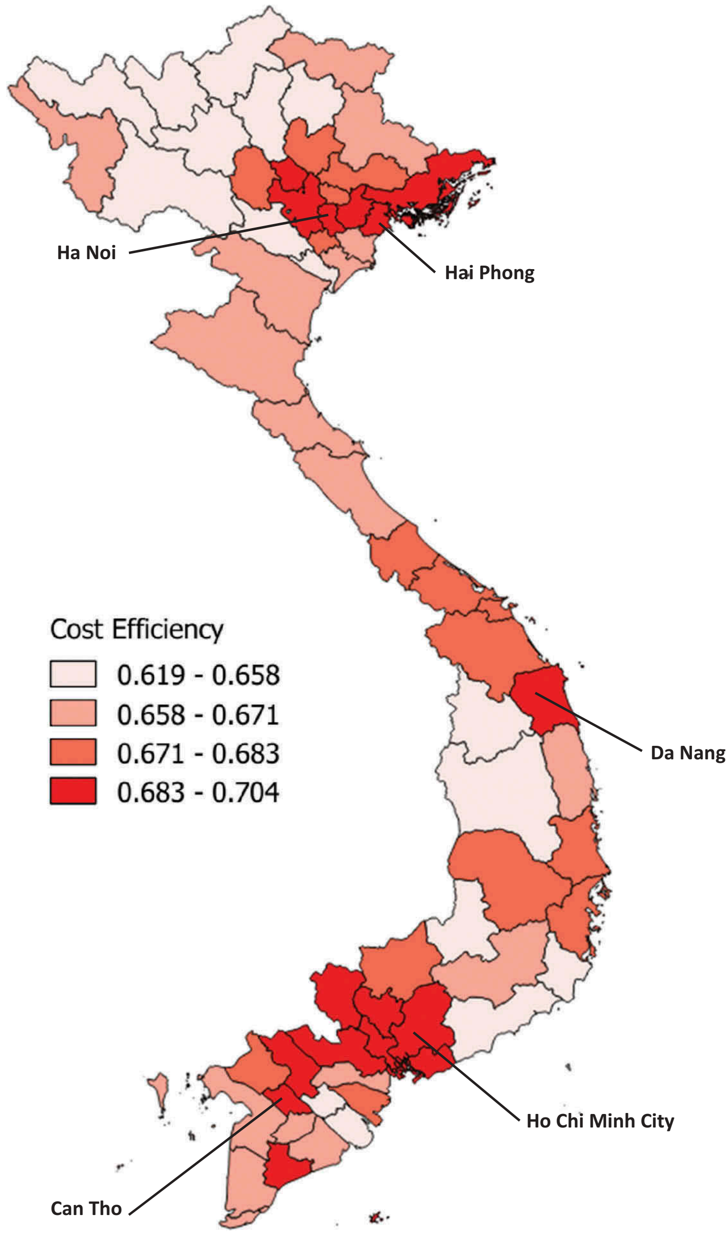

Figure 1. Cost efficiency of Vietnamese manufacturing firms by province and the five municipalities.

PCI and AGE are negatively and significantly associated with the inefficiency components, suggesting that experienced and bigger firms operating in a better provincial competitive environment tend to perform better than their counterparts in terms of cost management. Although the findings on the impacts of SIZE and AGE are in line with the literature (e.g. Bačić, Bakarić, & Sunčana, 2018; Charoenrat et al., 2013; Huang & Yang, 2016; Vu, 2016), the additional findings from the PCI support the argument that competition generates an efficient allocation of resources (Nickell, 1996), here in terms

Table 5. Parameter estimates of the inefficiency equation.

	Coefficient	Standard error
*Equation (2): **Inefficiency function***		
Constant	0.6992***	0.0590
SIZE	−0.0254***	0.0008
PCI	−0.0004**	0.0002
AGE	−0.0004***	0.0001
FERATIO	0.0028	0.0030
SOE	−0.0016	0.0031
FOE	−0.0191***	0.0017
EX	−0.0147***	0.0018
IZONE	0.0008	0.0017
CITY	0.0024	0.0017

SIZE, the natural logarithm of the firms' total assets; PCI, the Provincial Competitiveness Index; AGE, the firm's age (in years); FERATO, the ratio of female employees to total employees; SOE, a dummy variable that takes a value of 1 if a firm is a central or local state company, collective enterprise or joint stock company with state capital of more than 50%, and 0 otherwise; FOE, a dummy variable that takes a value of 1 if a firm is 100% foreign-owned or is a joint venture with foreign capital, and 0 otherwise; EX, a dummy variable that takes a value of 1 if a firm is involved in exporting activities; IZONE, a dummy variable that takes a value of 1 if the firm is located inside an industrial zone; CITY, a dummy variable that takes a value of 1 if the firm is located in a municipality in Vietnam; *, ** and *** indicate significant differences at $P < 0.01$, $P < 0.05$ and $P < 0.001$ respectively.

of cost efficiency. We therefore suggest that provincial policies regarding competition, as well as improving competitiveness, are important drivers to boost the development of the (manufacturing) firms of the provinces.

In addition, similar to Golikova, Gonchar, and Kuznetsov (2012), Huang and Yang (2016) and Vu (2003), we also found that foreign-owned firms and firms that are involved in exporting activities had higher cost efficiency than their counterparts. However, we do not have enough evidence to draw conclusions about the role of female employees, industrial park location or municipality location[6] on the cost efficiency of the sampled firms. These findings therefore support the argument that, in transition economies, it is important for the government to improve the competitive environment simply by increasing openness to trade and liberalisation (Jasinski & Ross, 1999).

4.4. Productivity changes over time

Following Equations (4)–(7), we further examine the changes in cost efficiency, technology, scale efficiency and the overall TFP of Vietnamese manufacturing firms over the period 2010–2016. The results are presented in Figure 2.

One can observe from Figure 2(a) that during the 2010–2016 period, the TFP of Vietnamese manufacturing firms was still greater than unity, meaning that those firms were still growing; this was mainly contributed to by CECH as shown in Figure 2(b). However, Figure 2(c,d) indicate that there is a decreasing trend in the efficiency and productivity growth of the sampled firms during the study period, resulting from decreases in technological (TECH) and scale efficiency (SCALE). Although the size of the firm can still improve its cost efficiency (see the previous section), this additional finding suggests that this trend is likely to bottom out – the scale efficiency effect actually started to drop below zero in 2016. It also suggests that these firms will need to pay more attention to research and development as well as technological

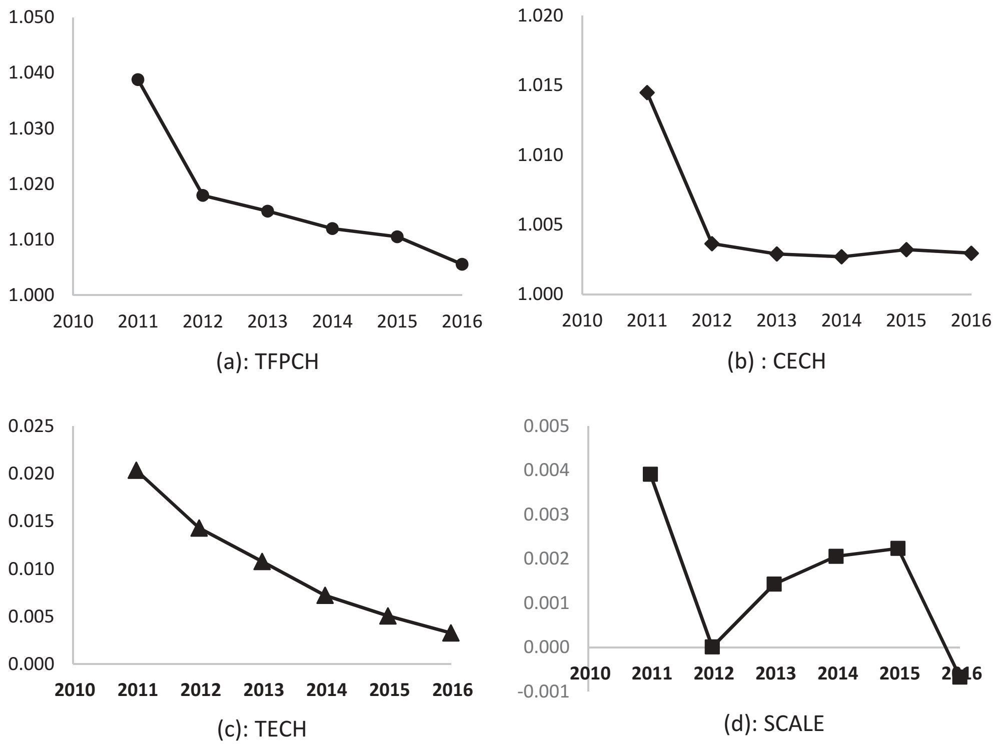

Figure 2. Components of total factor productivity in Vietnamese manufacturing firms.
TFPCH, total factor productivity change; *CECH*, the change in cost efficiency; *TECH*, technical change; *SCALE*, scale effect component.

implementation to improve the TECH component, to move towards a capital-intensive state and to improve their productivity. This finding is consistent with previous studies on other developing countries, such as China, where capital-intensive firms were found to perform better and have higher (stock) value than labour-intensive ones (Li & Zhao, 2018).

5. Conclusion

This study investigated the cost efficiency and productivity of the manufacturing sector in Vietnam from 2010 to 2016 to determine the sources of their performance. The findings show that the cost efficiency level of the Vietnamese manufacturing sector is relatively low (averaging 0.688 for the period 2010–2016), suggesting that there is room to improve its efficiency. The positive impact of provincial competition on the cost efficiency results supports the view that competition generates an efficient allocation of resources. It also suggests that it is important for the country and regions to create a competitive environment for the development of their local manufacturing firms. Additionally, cost-efficient firms appear to be associated with increased foreign ownership, suggesting that the authorities should further reduce the barriers for foreign investment into local enterprises (i.e. more open and liberal policies). The same is true for larger firms, for those that have been operating longer and those that are more export-oriented. We argue that these results are in line with previous findings on emerging and transition economies and that the government can ensure a more competitive environment simply by increasing openness to trade and liberalisation (Jasinski & Ross, 1999).

If we observe the changes in cost efficiency and the overall TFP of Vietnamese manufacturing firms, there appears to be a decreasing trend in efficiency and productivity caused by technological and scale efficiency slowdown. Nonetheless, the findings suggest that the firms should focus more on research and development as well as technological implementation to enhance their productivity. This conclusion can be applied to other transition and developing economies as well, since the transformation from a labour-intensive state towards being capital-intensive can add value to the firms' performance (Li & Zhao, 2018).

Notes

1. According to the GSO (2016), more than 98% of active enterprises in Vietnam are small and medium-sized with fewer than 300 employees. It is therefore more appropriate for them to increase their competitiveness by minimising inputs rather than maximising outputs.
2. The translog function has been popularly used in SFA since it is more reliable and flexible than other forms (Guilkey, Knox Lovell, & Sickles, 1983). Additionally, since the Cobb–Douglas form is subsumed by the translog (Griffin, Montgomery, & Edward Rister, 1987), it would be justifiable to apply the translog functional form instead of the original Cobb–Douglas form.
3. $TECH < 0$ indicates a cost reduction caused by technological progress; if $TECH = 0$, then the costs are unchanged regardless of technology; $TECH > 0$ indicates an increasing in total cost caused by a technological development.
4. These are official surveys consecutively conducted (and adjusted) yearly under the auspices of the Ministry of Planning and Investment of Vietnam, where the information can also be used for accounting and tax purposes. We believe that the GSO data are therefore reliable and consistent, and that any bias would be minimal.
5. PCI represents the Provincial Competitiveness Index, a weighted average index consisting of nine components measuring the business environment in each province in Vietnam (VCCI & USAID, 2018). PCI has been used to analyse tax incentives (Vu & Ly, 2018) or business performance in general (Nguyen, Mickiewicz, & Jun, 2018), but not in SFA cost efficiency.
6. Figure 1 indicates that manufacturing firms operating in the five municipalities had higher cost efficiency; however, there is no significant evidence to conclude that, as a group, they outperformed the other firms, since there are many highly efficient firms in other provinces as well.

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