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From Efficiency Analyses to Policy Implications: a Multilevel Hierarchical Linear Model Approach

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ABSTRACT

This paper examines the key factors that influenced the cost efficiency of 7,633 Vietnamese manufacturing firms during 2010–2016 via a hierarchical linear modelling (HLM) approach. The main reason for using HLM in this case is that observations in the same group may not be independent from each other (e.g. firms operate within the same city), and some variables may not vary across those observations. Although most of the findings are consistent with previous studies, the statistical power of our HLM model is higher than that of the traditional single-level analysis, suggesting that HLM can provide better analytical insights. The results further indicate a case for cities or provinces pursuing different policies aimed at improving the performance of their local firms.

KEYWORDS

Efficiency; hierarchical linear modelling (HLM); Vietnam; manufacturing

JEL CLASSIFICATION

D24; L60

1. Introduction

Efficiency and performance analysis has attracted a lot of interest from researchers across different disciplines – see, for example, the literature reviews by Liu et al. (2013), Assaf and Josiassen (2016) and Kaffash et al. (2020).

On the one hand, efficiency and performance analysis, using tools such as Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA), can provide estimates of how well a certain firm (or decision-making unit, DMU) performs relative to the other DMUs being examined. This can help managers improve their DMU's efficiency by adjusting the (internal) inputs and outputs involved. On the other hand, it is also possible to extend this into a two-stage analysis and use regressions (e.g. Tobit or truncated) to determine the external factors that contribute to improvements in efficiency. In the latter situation, it has been noted that 'papers that estimate technical efficiency in the first-stage analysis and then regress these estimates on some environmental variables in a second-stage Tobit model continue to appear' (Daraio, Simar, and Wilson, 2010, p. 1).

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In the regression stage of a two-stage efficiency and performance analysis, the environmental variables are the characteristics that distinguish DMUs from each other (e.g. ownership, size or the firm's age) and/or the various macro-economic conditions that DMUs operate under (e.g. local government policies, local economic developments or time-variant factors such as inflation or exchange rates). The assumption and managerial implications of this second-stage analysis is that different characteristics and macro-economic conditions have different impacts on the efficiency and performance of the DMUs. Therefore, by adjusting these characteristics and conditions, one can also improve the efficiency of the sampled DMUs. Most previous studies used dummy variables to differentiate these characteristics and conditions (e.g. a dummy variable for ownership that takes value of 1 if the firm is state-owned and 0 otherwise) in the second-stage regression. Consequent popular implications include suggestions that a firm's characteristics can improve efficiency (Bamiatzi and Hall, 2009; Lee, 2009; Vu et al., 2016; Chen, Chen, and Wei, 2017; Ngo and Tripe, 2017; Ngo and Tsui, 2020; Sahoo et al., 2021) and that the location's characteristics (e.g. urban versus rural or local economic development) are important factors for firm performance (Vu et al., 2016; Nguyen et al., 2019; Fu et al. 2020; Ngo and Tsui, 2020).

The introduction of firm characteristics and macro-economic conditions implicitly assumes that some DMUs are more similar to each other than others, meaning that sub-group analyses may provide more insightful information for the second-stage regression analysis than the use of dummy variables.

Another approach used to deal with sub-grouping in efficiency and performance analysis is the use of meta-frontiers (Verschelde et al., 2016; Walheer, 2018; Kerstens et al., 2019). However, the meta-frontier approach does not account for cases where the DMUs and groups are sometimes nested within each other, e.g. state-owned DMUs from the same city operating in the same year. For those cases, firm ownership, location, local macro-economic conditions, inflations and exchange rates do not vary among those DMUs and thus, the usefulness of dummy variables is very limited. Given this, our key research question is 'How can we account for the hierarchical structure of such data?' Our research objective is to propose a new approach for second-stage regression in efficiency and performance analysis that can deal with this hierarchical or nested data structure.

To be specific, we apply hierarchical linear modelling (HLM) in the second-stage regression to account for the hierarchical structure of the data. The HLM approach was first introduced in educational research where hierarchies occur naturally: students are nested within classrooms, classrooms are nested within schools, and schools are nested within towns or cities (Bryk and Raudenbush, 1992; Sullivan et al., 1999). It was then applied in various fields such as transportation (Chen and Jou, 2019), medical and health care (Daniels and Gatsonis, 1999; Adewale et al., 2007; Bouwmeester et al. 2013), firm strategy (Mauri and Michaels, 1998; Hawawini, Subramanian, and Verdin, 2004; Dang and Lin, 2017) and psychology (Raudenbush and Chan, 1993; Woltman et al., 2012; Huta, 2014), among others.

Applications of HLM in efficiency and performance analysis, however, are still limited (Cook and Green, 2005; Makridou et al., 2019; López-López et al., 2020). Our study extends the use of HLM in efficiency analysis by using empirical data from 7,633

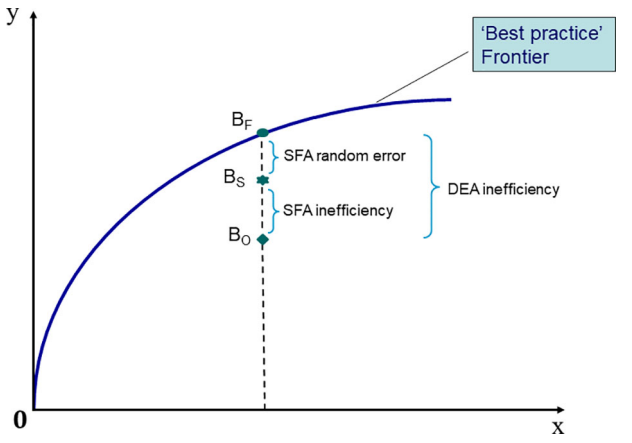

Figure 1. The basic principles of DEA and SFA.

Vietnamese manufacturing firms in the 2010–2016 period. Our findings should provide helpful policy implications. In the next section, we will briefly explain the HLM technique as well as the characteristics of our data. Section 3 will discuss the findings and relevant policy implications, and Section 4 concludes the paper.

2. Hierarchical linear modelling (HLM) for efficiency analysis

2.1. Efficiency and performance of the vietnamese firms

Although there is a rich body of literature on the efficiency and performance of firms across industries and across the globe (Kang et al., 2020; Kohl et al., 2019; Ngo and Le, 2019; Hammami et al., 2020; Ho and Huang, 2020; Jiang and Andrews, 2020; Le and Ngo, 2020), studies on Vietnamese firms' efficiency are still limited. According Ngo et al. (2019a) and Ho et al. (2021), efficiency studies on Vietnamese firms only began in 2003 (Vu, 2003), with the current number of studies being less than 10 (for manufacturing firms) or less than 30 (for Vietnamese banks). Nevertheless, the relative efficiency of Vietnamese firms ranges from moderate (i.e. around 50%) to high (i.e. around 96%), and the variance of efficiency scores among them can be explained by various factors such as firm age, firm size and ownership, as discussed previously (Ngo et al., 2019a; Ho et al., 2021).

The basic principle of frontier analysis, including both DEA and SFA, is to estimate a 'best practice' frontier from the sample (see Figure 1). Firms that are close to or at this frontier are deemed to be efficient, whereas the others are inefficient. In DEA, if a firm B_O is away from the frontier, the deviation is treated as inefficiency (e.g. the distance B_OB_F in Figure 1); however, in SFA, this deviation is decomposed into inefficiency and random error (e.g. the distances B_OB_S and B_SB_F, respectively), arguing that exogenous factors such as statistical error or even the weather could also contribute to this deviation and should therefore be distinguished from inefficiency. For more details on the two approaches, especially in terms of methodologies, the readers are encouraged to see the work of Coelli et al. (2005), Cooper, Seiford, and Zhu (2011) and Bogetoft and Otto (2011), among others.

Table 1. Factors at each hierarchical level that can affect firms' efficiency and performance.

Hierarchical structure	(Sub)Sample	Potential explanatory variables
Level 1 (Within-City)	Firms in the same city or province	Ownership (varying among firms) Firm age (varying among firms) Local economic developments (invariant) Local governmental policies (invariant)
Level 2 (Across-City)	Firms across cities/provinces	Ownership (varying among firms) Firm age (varying among firms) Local economic developments (varying among cities or provinces) Local governmental policies (varying among cities or provinces) Exchange rates (invariant among cities and provinces) Inflation rates (invariant among cities and provinces)

It is noted that although SFA studies tend to produce higher estimations of the efficiency scores than DEA studies (Bauer et al., 1998; Delis et al., 2009; Dong, Hamilton, and Tippett, 2014), this difference is not statistically significant for Vietnamese firms, possibly due to the small number of studies examined (Ho et al., 2021). Consequently, in this study, the choice of method e.g. SFA or DEA should not influence our results; we therefore used SFA in the first-stage analysis to estimate the efficiency scores of the sampled Vietnamese manufacturing firms, since it is deemed to be appropriate for the manufacturing sector (Ngo et al., 2019b). In essence, the cost efficiency scores calculated by Ngo et al. (2019a) represent how well Vietnamese manufacturing firms managed and minimised their costs during the 2010–2016 period. In particular, the cost efficiency was estimated based on a cost frontier constructed from three inputs (number of employees, value of total assets and amount of materials) and one output (total revenue) – see Ngo et al. (2019a) for more details. Note that Ngo et al. (2019a) tried to examine the effect of location characteristics (i.e. municipalities vs. others) on cost efficiency but it was not significant. This study further examines this effect using the HLM approach, which can provide better insights into the nested structure of the location characteristics of the sampled firms.

2.2. The HLM approach

As discussed previously, traditional two-stage efficiency analysis uses regression, popularly Tobit or truncated regression, in the second stage to determine if the firm's characteristics and macro-economic conditions have any influence on the estimated efficiency scores with the help of dummy variables (note that for SFA studies, one can either use the efficiency scores or their counterparts of inefficiency component as the dependent variable of those regression e.g. Verschelde et al., 2016; Ngo and Tripe, 2017; Lu et al., 2018; Nguyen et al., 2019). When the data are hierarchically structured, observations in the same group may not be independent from each other (e.g. firms operating within the same city), and thus traditional techniques such as ordinary least squares, Tobit or truncated regressions are biased. In contrast, the HLM approach enables us to investigate the relationship between the

dependent variable Y and the independent variables X_i, given that X_i may not vary at a certain level of the hierarchical structure of the data (Bryk and Raudenbush, 1992; Rabe-Hesketh and Skrondal, 2012; Huta, 2014). Note that while cluster OLS or panel data regressions can also deal with observations which are not independent within groups/clusters, those techniques cannot estimate the effects of level-two or higher-level variables and thus, HLM is often seen as a more general form of the two that can produce better and robust results (Cheah, 2009; Rabe-Hesketh and Skrondal, 2012; Schunck and Perales, 2017).

If we return to our discussion in the Introduction and assume that we are examining firms at a national level, we can formally describe the two-level HLM structure of this data (Table 1). One can easily see that, for example, the impact of local economic development is the same on firms that operate in the same city or province, but it has different impacts on firms operating in other cities or provinces. This issue is not accounted for in Tobit or truncated regression and, therefore, HLM is more appropriate. In addition, HLM can also incorporate the Tobit model to deal with censored data – we also applied a Tobit HLM to account for the fact that our dependent variable (i.e. the inefficiency scores) are bounded between 0 and 1.

Following Sullivan et al. (1999) and Woltman et al. (2012), our HLM analysis starts with an unconditional model assuming that, even when no explanatory variables are involved, there are still variances (or differences) between firms from the same city or province, and between firms across cities or provinces. This unconditional two-level HLM model is presented in Equations (1)–(3) below.

$$\text{Level 1 (Within} - \text{City)}: EF_{ij} = \alpha_{0j} + \varepsilon_{ij} \tag{1}$$

$$\text{Level 2 (Across} - \text{City)}: \alpha_{0j} = \beta_{00} + \epsilon_{0j} \tag{2}$$

$$\text{UnconditionalHLM}: EF_{ij} = \beta_{00} + \epsilon_{0j} + \varepsilon_{ij} \tag{3}$$

where EF_{ij} is the efficiency score of firm i operating in city/province j (derived from the first stage), α_{0j} is the within-city/province coefficients, β_{00} is the across-city/province coefficient, ϵ_{0j} is the random intercept and ε_{ij} is the random error.

Note that the unconditional HLM model in Equation (3) differs from a traditional single-level regression in terms of the random intercept ϵ_{0j} which allows the intercepts of firm efficiency to vary randomly across cities and provinces, whereas in traditional regression, there is only one intercept and it is assumed to be fixed. If the random intercepts ϵ_{0j} are significantly different from zero, we argue that firm efficiency varies across cities or provinces. Therefore, the HLM approach is more appropriate than traditional single-level regression. This can be checked by a simple likelihood ratio test comparing a 'restricted' model (single-level, with only β_{00}) and a 'full' model (multi-level, with both β_{00} and ϵ_{0j}). We now turn to the conditional (or 'mixed') two-level HLM model, which can examine these differences as follows (please see the Appendix, Supplementary material for the mathematical transformation).

$$\text{Level 1 (Within}-\text{City)}: EF_{ij} = \alpha_{0j} + \alpha_{1j}X_{ij} + \varepsilon_{ij} \tag{4}$$

$$\text{Level 2 (Across} - \text{City)}: \alpha_{pj} = \beta_{0p} + \beta_{1p}Z_j + \epsilon_{pj} \tag{5}$$

$$\text{'Mixed'HLM}: EF_{ij} = \beta_{00} + \beta_{01}X_{ij} + \beta_{10}Z_j + \beta_{11}Z_jX_{ij} + \epsilon_{1j}X_{ij} + \epsilon_{0j} + \varepsilon_{ij} \tag{6}$$

where p is 0 or 1 for Level 1's intercept and the slope coefficients of Equation (4), X_{ij} represents the within-city explanatory variables, Z_j represents the across-city explanatory variables, ϵ_{pj} is the random intercept (at city level) and ε_{ij} is the random errors (at firm level).

2.3. Data and variable selection

The main purpose of our analysis was to test for the impacts of location characteristics on firms' performance, given the hierarchical structure of our data – our sampled Vietnamese firms are distributed throughout all 63 cities and provinces of the country (see also Appendix 3, Supplementary material). Consequently, the across-city explanatory variables (i.e. Z_j) measured the factors that vary across the 63 cities or province that may influence the operation and performance of the firms. The data were extracted from the annual surveys of business enterprises conducted by the Vietnamese General Statistics Office (GSO, 2016, 2018). The literature on firm efficiency suggests that local governmental policies such as those regarding competition or the quality of public service play an important role in this context (Choi, Jiang, and Shenkar, 2015; Kalyuzhnova and Belitski, 2019); accordingly we selected the provincial competitiveness index (PCI) (VCCI and USAID, 2018) as a proxy for local governance. Other firm variables include the firms' age (AGE, number of years in operation), total assets (SIZE, the logarithmic value of total assets), ownership dummy variables (SOE = 1 if a firm is a central or local state-owned company, a collective enterprise or a joint stock company with more than 50% state capital, FOE = 1 if the firm is 100% foreign-owned or is a joint venture with foreign capital), the female participant rate (FERATIO, the ratio of female employees to total employees), export dummy status (EX = 1 if the firm is involved in exporting activities), industrial zone dummy status (IZONE = 1 if the firm is located inside an industrial zone) and large municipality status (MUNI = 1 if the firm's headquarters is located in one of the five municipalities: Hanoi, Hochiminh City, Haiphong, Danang and Can Tho) (Ngo et al., 2019a). The information on firm characteristics was extracted from annual surveys of Vietnamese firms (GSO, 2016, 2018), and 7,633 manufacturing firms operating during the 2010–2016 period were included in this study. The official exchange rate (EXCH, the logarithm of the yearly average exchange rate between VND and USD) as well as inflation (INF, the annual growth rate of the implicit deflator of GDP), which were extracted from the World Bank (2021), were also included to measure the macro-economic variables that did not change across the examined cities and provinces but varied across time (hence, a time variable t is also included). According to Table 1, these variables play different roles in the operation and performance of the firms; consequently, their influence on the firm's efficiency differs. Short definitions and the descriptive statistics of our data are presented in Table 2, where an average firm in our sample is about 68% efficient in terms of managing its costs (i.e. EF = 0.68). This average firm employs more male than female employees (i.e. FERATIO = 0.44), has been operating for nearly 12 years (i.e. AGE = 11.61), and has accumulated nearly 46 million VND in total assets (i.e. SIZE = 10.73). This average firm also tends to be (slightly) involved in exporting activities (i.e. EX = 0.52), operates in an industrial zone (i.e. IZONE = 0.64) outside a

Table 2. Description of the variables.

Variable	Definition	Mean	Min	Max
	Dependent variable			
EF	Cost efficiency	0.68	0.52	0.85
IEF	Cost inefficiency	0.38	0.16	0.66
	Explanatory variables			
SIZE	The logarithmic value of total assets	10.73	0.92	18.82
PCI	Provincial Competitiveness Index	59.59	45.12	73.53
AGE	Number of years in operation	11.61	1.00	71.00
FERATIO	Ratio of female employees over total employees	0.44	0	1
SOE	Dummy variable, =1 if the firm is a central or local state-owned company	0.06	0	1
FOE	Dummy variable, =1 if the firm is 100% foreign-owned or is a joint venture with foreign capital	0.39	0	1
EX	Dummy variable, =1 if the firm is involved in exporting activities	0.52	0	1
IZONE	Dummy variable, =1 if the firm is located inside an industrial zone	0.64	0	1
MUNI	Dummy variable, =1 if the firm's headquarters are located in one of the five municipalities (Hanoi, Hochiminh City, Haiphong, Danang and Can Tho)	0.27	0	1
EXCH	The logarithmic value of the yearly average exchange rate between VND and USD	9.94	9.83	10.00
INF	The annual growth rate of the implicit deflator of GDP	132.42	100.00	150.50
T	Time variable, =1 for the year 2010, =2 for 2011 and so on	4	1	7

municipality (i.e. MUNI = 0.27) and under moderate or good governance (i.e. PCI = 59.59; the maximum value of PCI is 73.53). Among the sampled firms, only 6% are state-owned (i.e. SOE = 0.06), 39% are foreign-owned (i.e. FOE = 0.39) and the rest are privately owned. One can also observe that during the study period of 2010–2016, the regional or global market was more or less stable (i.e. EXCH = 9.94 and ranged from 9.83 to 10.00) but the domestic market was more volatile (i.e. INF = 132.42 and ranged from 100.00 to 150.50). We expect that the inclusion of those variables in our HLM analysis would provide more insights into the efficiency and performance of Vietnamese manufacturing firms.

3. Results and discussion

In the first step, our unconditional HLM model (see Equations (1)–(3) above) resulted in an α_{0j}'s coefficient of 0.40245 (at the 1% level of significance), for which the estimated variances of ϵ_{0j} is 0.0006. The likelihood ratio test has a $\overline{\chi}^2_{(1)}$ of 9326.68 with a *p*-value of 0.0001, suggesting that the multilevel assumption of HLM is justified. In the next step, for comparison purposes, we re-report the results of Ngo et al. (2019a) in the second and third columns of Table 3 (as the non-HLM results)[1] as well as in Appendices 2 and 3, Supplementary material; our HLM results are represented in

Table 3. Determinants of the inefficiency (IEF) component.

	Non-HLM results (Ngo et al., 2019a)		HLM Results (Model 1)		HLM results (Model 2)	
	Coef.	*SE*	*Coef.*	*RSE*	*Coef.*	*RSE*
Panel A: Fixed effects						
Constant	0.6992***	0.0590	0.7138***	0.0044	1.0311***	0.0287
SIZE	−0.0254***	0.0008	−0.0261***	0.0000	−0.0259***	0.0000
PCI	−0.0004**	0.0002	−0.0006***	0.0000	−0.0005***	0.0000
AGE	−0.0004***	0.0001	−0.0004***	0.0000	−0.0004***	0.0000
FERATIO	0.0028	0.0030	0.0011***	0.0001	0.0015***	0.0001
SOE	−0.0016	0.0031	−0.0008***	0.0003	−0.0015***	0.0002
FOE	−0.0191***	0.0017	−0.0209***	0.0002	−0.0205***	0.0002
EX	−0.0147***	0.0018	−0.0099***	0.0005	−0.0117***	0.0003
IZONE	0.0008	0.0017	0.0012***	0.0001	0.0011***	0.0002
MUNI	0.0024	0.0017	0.0023***	0.0033	0.0020***	0.0003
EXCH					−0.0358***	0.0032
INF					0.0003***	0.0000
T					−0.0026***	0.0002
Panel B: Random intercepts						
Parameter			*Estimate*		*Estimate*	
City or province-level						
$\mathrm{Var}(\epsilon_{0j})$			6.07e − 07		3.61e − 07	
Firm-level						
$\mathrm{Var}(\varepsilon_{ij})$			1.88e − 05		1.54e − 05	

Notes: SIZE, natural logarithm of the firms' total assets; PCI, the Provincial Competitiveness Index; AGE, the firms' age (in years); FERATIO, the ratio of female employees to total employees; SOE, dummy variable for a central or local state-owned company, collective enterprise or joint stock company with state capital of more than 50%; FOE, dummy variable for a firm that is 100% foreign-owned or a joint venture with foreign capital; EX, dummy variable for firms with exporting activities; IZONE, dummy variable for firms located inside an industrial zone; MUNI, dummy variable for firms located in a municipality in Vietnam; EXCH, logarithm of the yearly average exchange rate between VND and USD; INF, the annual growth rate of the implicit deflator of GDP; Coef. stands for coefficient; SE and RSE stand for the standard error and robust standard error, respectively; *, ** and *** indicate the significance at the 1%, 5% and 10% levels, respectively.

Columns 3 to 6. To control for the sensitivity issue (i.e. the choice of variables may affect the results), we used two HML models: Model 1 uses the same set of variables as the non-HLM approach but Model 2 includes three extra variables: EXCH, INF and T. All results were estimated with Stata 16 (StataCorp, 2019) via the '*metobit*' command (Statistics > Multilevel mixed-effects models > Tobit regression).

Note that Table 3 presents a straightforward comparison between HLM and non-HLM (e.g. Tobit) regressions in the second-stage DEA analysis.[2] We do not examine the cross-level interactions between our variables (as in Equation (6)) because (i) the HLM model will be so complicated that comparisons between HLM and non-HLM will not make sense, and (ii) HLM estimations involving interactions among more than 20 groups/provinces tend to be biased (Stegmueller, 2013). This limitation, however, does not affect our results or the relevant findings and discussion regarding the superiority of HLM over non-HLM regression in the case of structured data.

According to Table 3, both Model 1 and Model 2 of the HLM approach show a consistent improvement in terms of statistical power, relative to the non-HLM approach, suggesting that this improvement is not subject to the choice of variables. We can therefore also examine (*i*) the variance of firm efficiency across cities and provinces and (*ii*) the roles of additional macro-economic variables (i.e. EXCH and INF) on firm performance. Firstly, it can be seen from Panel B of Table 3 that the cost efficiency of

firms differs not only because of their characteristics (i.e. at firm-level) but also because of where they are located (i.e. at city/province-level). It is therefore reasonable to suggest that different cities or provinces should have different policies regarding improving the performance of local firms. Secondly, the statistical power of our HLM results is higher than that of the non-HLM results, whereas most of our HLM results in Table 3 are consistent with Ngo et al. (2019a) and other literature regarding Vietnam and elsewhere (Vu, 2003; Lee, 2009; Huang and Yang, 2016; Vu et al., 2016; Bačić, Rašić Bakarić, and Slijepčević, 2018; Sahoo et al., 2021) and thus are not reported again; the variables FERATIO, IZONE and MUNI are now all significant. We argue that by accounting for the hierarchical structure of the data, we can now identify the impact of these factors on Vietnamese firms' efficiency.

Specifically, there is a positive and significant relationship between the female employment ratio (i.e. FERATIO) and inefficiency – in other words, firms with a higher female labour ratio tend to underperform compared with their counterparts in terms of cost efficiency and management. This result may partly reflect the low productivity of females in manufacturing industries such as the garment, textile and footwear industries, which has been found in Vietnam (Pham et al., 2010) and other developing countries (Abegaz and Nene, 2018; Heshmati and Rashidghalam, 2018). Therefore, greater employment of women may increase the size of the workforce and thus the firm's operational costs but not their outputs – the cost efficiency therefore decreases. In addition, firms operating inside an industrial zone (i.e. IZONE = 1) and/or inside a municipality (i.e. MUNI = 1) tend to be less efficient than the others. We argue that the industrial zone or municipality status does not provide enough information on the business environment that those firms were exposed to, such as if the industrial zone is old or newly established (Hu, Yeh, and Chang, 2009) or the business promotion policy that these zones or cities impose on firms (Farole,). It would be interesting for future studies to further examine these issues.

More importantly, it can be observed that the cost efficiency of Vietnamese firms increased over time (i.e. T is negatively associated with the inefficiency component and thus, it is positively associated with cost efficiency) and when there was a devaluation of the VND (i.e. when EXCH increased); however, when inflation increased, it hindered the performance of the firms and dragged their cost efficiency down. These new findings are in line with and contribute to previous studies on efficiency and productivity changes over time (Nguyen et al., 2012a; Nguyen et al., 2012b; Nguyen and Simioni, 2015; Vu, 2016; Vu et al., 2016), studies on the impacts of domestic currency devaluation on firms' exporting activities (Greenaway, Kneller, and Zhang, 2010; Cheung and Sengupta, 2013), and studies on the relationship between inflation and firm performance (Forbes, 2002; Mirza and Javed, 2013; Alcock and Steiner, 2017).

Consequently, more policy implications can be drawn from our HLM findings compared with the single-level analysis. For example, we can now argue that the domestic currency devaluation is the factor that contributes the most to firm efficiency (the coefficient of EXCH is −0.0358). With the ongoing trend of the exchange rates (1USD were valued at 18,612.92VND in 2010, 21,935.00VND in 2016 and 23,050.2VND in 2019, according to World Bank, 2021), it will continue to contribute to the performance of Vietnamese firms and therefore the devaluation policy could be kept up.

Additionally, a price stabilizing policy to keep inflation down could also be seen as a positive contributor to Vietnamese firms' performance. Other policy implications include the promotion of foreign ownership, asset accumulation, provincial governance, and export orientation.

4. Conclusions

This paper examined the key factors that influenced the cost efficiency of 7,633 Vietnamese manufacturing firms during the 2010–2016 period. Unlike previous two-stage efficiency analyses, where single-level models such as Tobit or truncated regression were used in the second stage to examine the relationship between the firms' characteristics (e.g. ownership or firm age) and other environmental factors (e.g. local governmental policy or local economic development), we used hierarchical linear modelling (HLM) in this second stage.

The main reasons supporting the use of HLM in this case are that observations in the same group may not be independent of each other (e.g. firms operating within the same city), and that some variables may not vary across these observations (e.g. the impact of local economic development is the same on firms operating in the same city but is different on firms operating in other cities).

Although our empirical results using HLM are generally consistent with previous studies, the statistical power of our HLM model is higher than the traditional single-level analysis. As a result, HLM may provide better analytical insights. Our results also indicate the potential benefits of different cities and provinces pursuing different policies aimed at improving the performance of their local firms and suggest that policy tools addressing exchange rates and inflation may be able to boost the operation and performance of Vietnamese firms.

Notes

1. Details of the SFA estimations regarding the cost efficiency of the sampled 7,633 Vietnamese manufacturing firms are discussed in Ngo et al. (2019a).
2. We are thankful for the anonymous reviewer for pointing this out. Since our research objective is to propose a better approach using HLM for the second-stage regression of efficiency and performance analysis that can deal with hierarchical/nested data, the straightforward comparison in Table 3 is justified. We leave further HLM analyses for future studies.

Disclosure statement

No potential conflict of interest was reported by the authors.

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