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Do FDI enterprises work more efficiently than domestic ones in Vietnam? Evidence from panel data analysis

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Abstract

This paper examines the performance of foreign vs. domestic enterprises in Vietnam. Specifically, it evaluates firm - level technical efficiency and identifies the determinants of technical efficiency of these enterprises. The paper uses an econometric approach based on a stochastic frontier production function with the transcendental form to analyse 25,411 panel observations of enterprises from five annual surveys conducted in 2005–2009.

The results from the estimations reveal that, in general, enterprises in Vietnam have relatively high average technical efficiency ranging from 0.01 percent to 74.9 percent. Large-size manufacturing enterprises vary from a negligible percent to 96.11 percent; small and medium-size manufacturing from 0.05 percent to 60.92 percent. Average efficiency tends to increase in large size enterprises, but decrease in small and medium-size ones in period 2005–2009.

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The paper further examines factors influencing technical efficiency. It gains significant evidence that foreign enterprises do not always work more efficiently than domestic ones, depending on the types of ownership cooperation between domestic and foreign enterprises and on sub - industries. To be more specific, state - owned with foreign partner in (1) food product and beverages, (2) textiles, wearing apparel and footwear, (3) energy and chemical sectors have higher efficiency than other ownership cooperation. However, the highest group is belonged to (2) domestic private with foreign partner in metallurgical, machinery and other non-metallic mineral products sector, (2) 100% foreign capital enterprise in furniture sector, and (3) 100% foreign capital enterprise in construction sector.

The paper also finds that firm age, capital to labour ratio, regional location, types of ownership, types of sub - industries and some possible interactions among them significantly relate to technical efficiency, albeit with varying degrees and directions.

Keywords: *FDI enterprises, technical efficiency, panel stochastic frontier production function, Vietnam*.

JEL code: F23, D24, C23.

1. Motivation and introduction

Continual interest in the comparative performance of domestic owned and foreign owned enterprises since policy makers have long believed that foreign direct investment (FDI) can be an important source of technology for developing economies (World Bank 1993). They argue that foreign investment may generate some benefits for the host country. For example, by financing the expansion of business or the creation of new firms, it increases employment. It also may lead to the transfer of knowledge or new technologies from foreign to domestic firms and it may provide critical know-how to enable domestic plants to enter export markets (Harrison, 1996). Policy makers expected the potential for FDI and multinational enterprises as important channels for productivity transfers to host countries.

Many empirical researches follow this line of interesting field of study and most of them confirm that foreign enterprises are more efficient than domestic ones in the context of developing countries. Xiaming Liu (2000), using a cross-section of 191 branches of Chinese industry to study comparative performance of foreign and local firms in Chinese industry, compared labour productivity of foreign invested, state-owned and other local-owned enterprises in Chinese industry. The study shows that foreign invested enterprises, which enjoy greater capital intensity, higher labour quality as well as other specific advantages, have significantly higher value-added per worker than state owned enterprises and other local-owned enterprises.

In the same vein, Nurhan Aydin (2007) looked at the issue whether foreign owned firms perform significantly better than domestically owned Turkish corporations. The empirical study consisted of 42 firms with foreign ownership and 259 domestic corporations listed on Istanbul Stock Exchange in Turkey. The results reveal that firms with foreign ownership in Turkey perform better than the domestic owned ones in respect to Return on Assets. The evidence thus supports the hypothesis that foreign ownership participation increases performance of firms.

Helena Hannula,Katrin Tamm (2002) used level data of the Estonian Statistical Office for the period 1995 – 1998 and found that foreign enterprises are more productive than domestic ones.

Based on a sample of 191 branches of Chinese industry, Xiaming Liu (2000) concludes that foreign invested enterprises have significantly higher value - added per worker than state - owned enterprises and other local enterprises. Scale economies are exploited in foreign invested enterprises but not in state owned enterprises and other local owned enterprises unless capital intensity and labour quality are both controlled for. The overall results suggest the importance of foreign presence, domestic investment in physical and human capital and further economic reforms for efficiency improvements in whole industry.

However, while most studies support the hypothesis that foreign ownership participation increases performance of firms in terms of productivity and efficiency, some works find no differences, leading to a controversy on this issue. Peter Rowland and Banco de la Repyusblica (2006) used a dataset containing 7,001 firms in Columbia and found that foreign firms tend to have a larger total asset turnover than domestic firms. Foreign firms are more leveraged than domestic firms and they tend to have a lower net – profit margin than domestic firms. Eyup Basti and Ahmet Akin (2008) combined 186 companies listed in the Istanbul Stock Exchange from the period 2003 - 2007 and Malmquist total factor productivity (TFP) index to compare relative productivity growths of domestically-owned and foreign-owned firms. Their results indicated that there is no difference between the productivities of foreign - owned and domestically - owned firms operating in Turkey.

Data available from Enterprise Censuses conducted by GSO of Vietnam give some lights on the comparative performance between domestic and foreign enterprises in Vietnam. Table 1 presents the performance of enterprises in terms of the profit to capital ratio, profit to equity ratio, and labour productivity. First, among enterprises of many

kinds, domestic state – owned enterprises prove to be more efficient in terms of profit to capital ratio, profit to equity ratio, and labour productivity than foreign ones.

Table 1: Performance of enterprises in Vietnam, 2005 - 2009

Year	*Types of enterprises*	*Profit to capital*	*Profit to equity*	*Labour productivity*	*Wage ('000 000 VND)*	*Revenue ('000000 VND)*
2005	State – owned enterprise	0.03	0.4	457.89	17.69	166,421.40
	Domestic private enterprise	0.01	0.01	387.45	11.78	6,486.21
	Foreign direct investment enterprise	-0.13	-0.24	439.89	35.25	103610.5
	100% foreign capital enterprise	-0.18	-0.36	324.93	35.33	67,968.66
	State - owned with foreign partner	0.06	0.22	1,147.27	38.96	355,626.30
	Domestic private with foreign partner	-0.02	0.05	385	29.4	41,211.48
2006	State – owned enterprise	0.05	na	581.3	19.8	191,958.70
	Domestic private enterprise	0.01	na	193.59	7.02	5,596.87
	Foreign direct investment enterprise	-0.06	na	499.22	31.12	107372.6
	100% foreign capital enterprise	-0.09	na	396.47	29.49	74,520.13
	State - owned with foreign partner	0.08	na	1,254.49	40.67	405,440.10
	Domestic private with foreign partner	-0.02	na	482.19	33.62	38,506.70
2007	State – owned enterprise	0.05	2.06	612.51	22.89	216,583.60
	Domestic private enterprise	0.01	0.05	445.35	14.99	7,665.31
	Foreign direct investment enterprise	-0.09	-1.22	494.35	31.69	103846.5
	100% foreign capital enterprise	-0.09	-2.02	402.47	30.19	73,853.05
	State - owned with foreign partner	0.09	0.15	1,304.97	42.23	430,704.20
	Domestic private with foreign partner	-0.26	3.97	500.04	34.39	48,396.71
2008	State – owned enterprise	0.05	0.5	958.72	23.67	229,134.50
	Domestic private enterprise	0.02	-0.16	667.4	14.86	9,013.38
	Foreign direct investment enterprise	-0.08	-0.23	500.20	34.05	96122.91
	100% foreign capital enterprise	-0.09	-0.31	416.72	32.62	71,316.85
	State - owned with foreign partner	-0.57	-0.58	1,399.20	47.94	439,473.20
	Domestic private with foreign partner	0.31	0.59	497.35	35.2	38,876.90
2009	State – owned enterprise	0.03	0.35	792.94	26.35	258,808.00
	Domestic private enterprise	0	0.01	768.95	6.09	7,149.97
	Foreign direct investment enterprise	0.022	-0.61	546.13	36.40	87271.19
	100% foreign capital enterprise	0.02	0.02	502.7	34.94	69,259.40
	State - owned with foreign partner	0.02	0.05	1,188.52	49.22	390,172.10
	Domestic private with foreign partner	0.02	-5.81	492.45	39.92	43,128.39

Source: Authors'calculation from The Enterprise Census

Second, by splitting foreign enterprises into three types, namely 100% foreign capital, state – owned with foreign and domestic private with foreign enterprises, state – owned enterprise turns to be the most efficient ones in terms of labour productivity. However, state – owned enterprises still prove to be dominant in terms of both profit to capital and profit to equity ratios.

Third, among foreign capital enterprises, 100% foreign capital enterprise is seemingly less efficient in terms of labour productivity, profit to capital and profit to equity ratios than domestic private with foreign partner.

Fourth, sometimes, enterprises are more efficient in terms of profit to capital ratio but less in terms of profit to equity ratio. This raises a question about the role of ownership between domestic and foreign enterprises and among foreign enterprises as well.

Comparisons coming from Table 1 give rather sophisticated messages against most of mentioned studies in this field around the world. Controversies raise two following main research questions:

Firstly, what is the pattern of enterprise efficiency among five mentioned types of ownership in Vietnam?

Secondly, what is the role of ownership in determining efficiency of various types of economic sectors (such as labour vs. capital intensive, industries by sub - sectors)?

This paper uses data from Enterprise Census of various years in Vietnam and by applying a method of estimating technical efficiency from a stochastic frontier production function as proposed by Battese and Coelli (1992).

The data for the empirical analysis come from a unique database of enterprises in Vietnam over the period 2005 – 2009. The database is constructed on the basis of the files of Taxation Office which collects the annual reports (including balance statements and profit/loss accounts) for all firms active in Vietnam. Consequently, this database includes not only a broad range of firm information like net assets, employment, profit/loss, but also other variables like years of operation, types of ownership, types of

industries (up to 4 – digit number). Since each enterprise is assigned an identification code, enterprises could easily be connected in years.

The rest of the paper is organised as follows. In section 2, model and procedure of estimation are reviewed. Section 3 describes the data. Section 4 presents empirical models and our estimation results and the corresponding discussions. Finally section 5 offers concluding remarks and policy implications.

2. Model and procedure of estimation

A stochastic frontier production function as proposed by Battese and Coelli (1992) can be defined by equation (1):

$$Y_{it} = \exp(x_{it}\beta + V_{it} - U_{it}) \qquad (1)$$

Where Y_{it} denotes the production for the t-th year (t=1,2,3,…, T) for the i-th firm (i=1,2,3,…,N);

X_{it} is a (1xk) vector of values of known functions of inputs of production associated with the i-th firm at the t-th period of observation;

β is a (kx1) vetor of unknown parameters to be estimated;

V_{it} is assumed to be iid $N(0, \sigma_v^2)$ random errors, independently distributed of the U_{it} which are non - negative random variables, associated with technical inefficiency of production;

U_{it} is assumed to be independently distributed, such that U_{it} is obtained by truncation (at zero) of the normal distribution with mean, $z_{it}\delta$, and variance, σ^2

Z_{it} is a (1xm) vector of firm-specific variables which may vary over time;

and δ is an (mx1) vector of unknown coefficients the firm - specific inefficiency variables.

Although it is assumed that there are T time periods for which observations are available for at least one of the N firms involved, it is not necessary that all the firms are observed for all T periods.

Equation (1) specifies the stochastic frontier production function (e.g. of Cobb-Douglas or transcendental-logarithmic form) in terms of the original production values.

However, the technical inefficiency effects, the U_{it} is assumed to be a function of a set of explanatory variables, the z_{it}'s, and an unknown vector of coefficients, δ. The explanatory variables in the inefficiency model would be expected to include any variables which explain the extent to which the production observations fall short of corresponding stochastic frontier production values, $\exp(x_{it}\beta + V_{it})$. The z_{it} vectors may have the first element equal to one, include some input variables involved in the production function and/or interaction between firm-specific variables and input variables. If the first z-variable has value one and the coefficients of all other z-variables are zero, then this case would represent the model specified by Stevenson (1980) and Battese and Coelli (1988, 1992). If all elements of the δ - vector were equal to zero, then the inefficiency effects are not related to the z-variables and so the half-normal distribution originally specified by Aigner, Lovell and Schmidt(1977) would be obtained. If interactions between firm – specific variables and input variables are included, then the non-neutral model proposed by Huang and Liu(1993) is obtained.

The inefficiency effects, U_{it} , in the stochastic frontier model (1) could be specified in equation (2).

$$U_{it} = z_{it}\delta + W_{it} \qquad (2)$$

Where the random variable, W_{it}, is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $-z_{it}\delta$, i.e. $W_{it} \geq -z_{it}\delta$. These assumptions are consistent with the U_{it} being non-negative truncations of the $N(z_{it}\delta, \sigma^2)$ distribution.

The assumption that the U_{it} is independently distributed for all t = 1,2,….,T and i = 1,2,..,N. is obviously a simplifying, but restrictive, condition. Alternative models are required to account for possible correlated structures of the inefficiency effects over time. It should be noted that the inefficiency frontier model (1) - (2) is not a generalization of the Battese and Colli (1992) model for time-varying inefficiencies, even if the inefficiency effects are time invariant. The Battese and Coelli (1992) model specifies that the inefficiency effects are the product of an exponential function of time and non-

negative firm specific random variables, i.e, $U_{it} = \{\exp[-\eta(t-T)]\}U_i$, where ŋ is an unknown parameter and the U_i is non-negative truncations of the $N(\mu, \sigma^2)$ distribution. This model does not define the inefficiency effects in terms of firm specific explanatory variables. Further, the Battese and Coelli (1992) model specifies well-defined correlated structures for the inefficiency effects over time for particular firms.

When the model in equation (1) is assumed, the technical efficiency of production for the i-th at the t-th observation is defined by equation (3).

$$TE_{it} = \exp(-U_{it}) = \exp(-z_{it}\delta - W_{it}) \qquad (3)$$

3. Data descriptions

Data on industry enterprises from Vietnam are considered for empirical application of inefficiency stochastic frontier production function discussed in the previous section. These data were collected by the GSO in the period 2005-2009. This Census covered about 112,950 enterprises in 2005; 131,318 enterprises in 2006; 155,771 enterprises in 2007; 205,689 enterprises in 2008 and 248,710 enterprises in 2009.

In this paper, we will use a panel data of 2599 (2005), 2593 (2006), 2605 (2007), 2586 (2008), 2546 (2009) enterprises (Table 2), or we have 12929 observations in total be analyzed.

Table 2: Enterprise size in Vietnam, 2005-2009

Year		Mean	Med.	Max	Min	Std. Dev	Obs
2005	L	182	33	17529	1	588	2599
	KL	373	109	117252	0	2481	2599
	RL	444	129	47739	0	1361	2599
2006	L	188	36	16215	1	601	2687
	KL	399	114	115225	0	2714	2687
	RL	475	134	40769	0	1443	2687
2007	L	190	38	16004	1	603	2605
	KL	499	121	294060	0	4777	2605
	RL	522	144	50298	0	1608	2605
2008	L	188	39	17390	1	605	2586
	KL	460	121	70730	0	2384	2586
	RL	560	121	50275	0	2199	2586
2009	L	181	36	16951	1	612	2546

Year		Mean	Med.	Max	Min	Std. Dev	Obs
	KL	519	134	67745	0	2611	2546
	RL	481	139	30824	0	1392	2546

Note: L is the number of labours, KL is Capital – labour ratio, RL is output-labour ratio. All numbers are rounded

Source: Authors complied from the dataset

For the time period 2005-2009, capital-labour is increasing, from 373 million VND in 2005 to 519 million VND in 2009. It means that almost enterprises tend to have higher capital intensity. On the other hand, we find that a trend that the mean revenue-labour ratio increased during study period. Labour productivity is typically measured as a ratio of output per labour, an input. So increased productivity represents greater output per unit of input.

The paper classifies firm by sub-industry in period 2005–2009 as below: mining and quarrying; food product & beverages; textiles, wearing apparel & footwear; paper, paper product and publishing, printing; energy and chemical; metallurgical, machinery and other non-metallic mineral products; furniture; electricity, gas and water supply and construction (Table 3).

Table 3: Distribution of enterprises by sub-industry in Vietnam, 2005-2009

Productive Sector		Mean	Median	Maximum	Minimum	Std.Dev	Obs
Mining and quarrying	L	1156	120	8542	2	1914	351
	KL	283	86	10014	0	921	351
	RL	153	111	1747	0	165	351
Food product & beverages	L	210	35	7325	1	483	1878
	KL	244	94	20480	4	711	1878
	RL	457	149	19090	5	1220	1878
Textiles, wearing apparel & footwear	L	606	174	17529	1	1364	2074
	KL	107	43	9561	1	285	2074
	RL	104	49	3277	0	174	2074
Paper, paper product	L	120	55	2060	3	189	1234

Productive Sector		Mean	Median	Maximum	Minimum	Std.Dev	Obs
and publishing, printing	KL	193	110	11464	1	420	1234
	RL	235	149	2946	0	289	1234
Energy and Chemical	L	233	78	3970	2	428	2065
	KL	401	163	40696	2	1801	2065
	RL	391	192	10292	0	691	2065
Metallurgical, machinery and other non-metallic mineral products	L	255	79	9961	1	666	1938
	KL	270	144	7579	2	476	1938
	RL	368	155	38815	0	1179	1938
Furniture	L	239	64	2308	2	408	541
	KL	266	92	20586	3	1170	541
	RL	151	99	2395	0	250	541
Electricity, gas and water supply	L	170	20	2775	2	361	178
	KL	1228	122	41913	4	5302	178
	RL	506	78	38536	0	3089	178
Construction	L	154	49	6870	1	367	2764
	KL	366	102	39748	2	1451	2764
	RL	195	80	16883	0	532	2764

Source: Authors complied from the dataset

Note: L is the number of labours, KL is capital – labour ratio, RL is output-labour ratio. All numbers are rounded.

As shown in Table 3, on average, total of labour in mining and quarrying is largest in the industries, 1156 labour per firm. Next is textiles, wearing apparel & footwear enterprises that have 606 labours per firm. It means that labour plays a role in the mining & quarrying and textiles, wearing apparel & foot wear enterprises industries. In by contrast, enterprises in paper, paper product and publishing, printing; electricity, gas and water supply and construction used quite small labour in producing.

In terms of capital - labour ratio, we find the electricity, gas and water supply sector is generally characterized as a capital-intensive activity while some other sector such as textiles, wearing apparel & footwear, paper, paper product and publishing, printing are quite labour-intensive.

The concept of productivity is generally defined as the relation between output and input. It is argued that productivity one of the basic variables governing economic production activities. Productivity is not everything, but in the long run it is almost everything. A firm's ability to improve its living standard over time depends almost entirely on its ability to raise output per worker. In Table 3, electricity, gas and water supply and food product & beverages sectors are sectors of highest productivity.

The four groups of sectors that have lowest productivity are: mining and quarrying; textiles, wearing apparel & footwear; furniture; construction. Productivity performance of the textile industry presents a disturbing picture of poor capacity utilization, outdated technology and machinery, poor maintenance and excess human power.

Table 4: Labour, capital, and revenue in terms of ownership

		Mean	Median	Max	Min	Std. Dev	Obs
State - owned enterprise	**L**	775	220	9961	4	1081	1619
	KL	417	194	53427	6	1937	1619
	RL	310	185	14127	0	1135	1619
Domestic private enterprise	**L**	152	26	9453	1	329	9337
	KL	249	106	294060	0	2409	9337
	RL	265	128	50298	0	1754	9337
100% foreign capital enterprise	**L**	583	135	17529	2	1202	1679
	KL	341	139	117252	2	7290	1679
	RL	228	133	13187	0	790	1679
State – owned with foreign partner	**L**	332	143	1584	4	274	213
	KL	637	565	23529	18	2575	213
	RL	991	421	8219	0	1140	213
Domestic with foreign partner	**L**	396	68	4777	3	541	175
	KL	243	209	23401	6	2976	175
	RL	340	190	21796	0	1870	175

Source: Authors complied from the dataset

For the purpose of efficiency analysis, as mentioned revenue is output, while labour and capital are inputs of model. One thing that we can do before our estimation is to convert all nominal variables into real value. Ideally, each input and output variable should be deflated with its own deflator.

These numbers in Table 4 show that state –owned enterprises have biggest size of employees, with average 775 employees. Followed by 100% foreign capital enterprise, with 583 labour per firm. The domestic private enterprise often has smallest size, with 152 workers per firm. Both state–owned with foreign partner and state-owned enterprises are larger on average capital-labour ratio or more capital-intensive than 100% foreign capital enterprises. 100% foreign capital enterprise has lowest labour productivity with 228 million VND/labour/year compared with 991 million VND/labour/year for state–owned with foreign partner and 310 million VND/labour/year for state-owned enterprises.

4. Estimation of econometric model and discussion

In this paper, we follow the methodology of G. E. Battese and T. J. Coelli (1992), which advance a model for technical inefficiency effects in a stochastic frontier production function with panel data. In contrast to the so-called deterministic frontier models (including the technique of Data Envelopment Analysis), the stochastic approach is able to discriminate between inefficiency and statistical noise (i.e. due to factors outside the control of firms). In order to prevent mistakes of specifying the wrong parametric production function, a translog function has been used for estimating the industry production frontiers (Christensen et al, 1973).

The stochastic frontier production function to be estimated is defined by equation (4):

$$\text{Ln}\,(Y_{it}) = \beta_0 + \beta_1 \text{LnL}_i + \beta_2 \text{LnK}_i + \beta_3\,(\text{LnL})_i^2 + \beta_4\,(\text{LnK})^2_i + \beta_5\,(\text{LnL})_i\,(\text{LnK})_i + V_i - U_i \qquad (4)$$

The technical inefficiency effects are assumed to be defined by equation (5):

$$U_{it} = \delta_0 + \delta_1 z_{1t} + \delta_2 z_{2t} + \delta_3 z_{3t} + \delta_4 z_{4t} + \delta_5 z_{5t} + \delta_6 z_{6t} + \delta_7 z_{7t} + \delta_8 z_{8t} + \delta_9 z_{9t} + w_{it} \qquad (5)$$

Where:

Y_i is the total value of output in the i^{th} firm, and it is measured in millions of Vietnamese

Dong (VND)

L_i is labour, which is measured in person, representing the total employment in the i^{th} firm per annum.

K_i is capital of the i^{th} firm per annum. It is measured in VND million.

z_1 is the firm age in years

z_2 is the capital to labour ratio

z_3 is a vector of ownership (domestic vs. foreign enterprises)

z_4 is a vector of FDI ownership (types of FDI enterprises) .

z_5 is a vector of regions (8 regions in Vietnam)

z_6 is a vector of sectors (4 industries)

z_7 is a vector of interactions between FDI ownership and industries

z_8 is a vector of interactions between FDI ownership and capital to labour ratio

z_9 indicates a vector of years of the observation involved.

W_t is error terms which are assumed to be independently and identically distributed followed by the truncation of the normal distribution with zero mean and unknown variance σ^2_w.

The inefficiency frontier model, defined by equations (4) and (5), account for both technical change and time-varying technical inefficiency effects. The year variable in the inefficiency model (5) specifies that the inefficiency effects may change linearly with respect to time. The distributional assumptions on the inefficiency effects permit the effects of technical change and time-varying technical inefficiencies to be identified, in addition to the intercept parameters in the stochastic frontier and the inefficiency model, given the specifications of the time effects involved.

Statistical description of the dataset is illustrated in Table 5. Data in the full sample are unbalanced and most of sources of variance come from between variance.

Table 5: Statistic description of dataset

Variable (in logarithm)		**Mean**	**Std. Dev.**	**Min**	**Max**	**Observations**
Output	Overall	8.772561	2.196002	-.3804891	16.66981	N = 25314

Variable (in logarithm)		Mean	Std. Dev.	Min	Max	Observations
	Between		2.137872	1.942138	16.45507	n = 5091
	Within		.543978	1.570803	14.1233	T-bar = 4.9
Capital	Overall	8.584311	2.078063	.3045559	18.11526	N = 25392
	Between		2.040988	2.367387	17.44657	n = 5093
	Within		.4106059	2.930813	14.36811	T-bar = 4.9
Labour	Overall	3.760031	1.591332	-.6931472	9.771584	N = 25411
	Between		1.550781	.5972532	9.729508	n = 5093
	Within		.3702339	.5232245	6.994095	T-bar = 4.9
Capital squared	Overall	78.00858	37.66506	.0927543	328.1627	N = 25392
	Between		37.0575	6.690383	304.6888	n = 5093
	Within		6.895536	-14.44185	201.2867	T-bar = 4.9
Labour squared	Overall	16.67007	13.60202	.1644019	95.48385	N = 25411
	Between		13.30735	.3751027	94.66467	n = 5093
	Within		2.834392	-17.0659	45.59232	T-bar = 4.9
Interaction between capital and labour	Overall	34.78975	21.66565	-4.134694	159.5537	N = 25392
	Between		21.33397	2.197218	143.4512	n = 5093
	Within		3.869715	-7.093635	66.24291	T-bar = 4.9

Sources: Authors' calculation

Maximum - likelihood estimates of the parameters of the model defined in (4) and (5) are obtained by using Stata version 11 with an ado file named xtfrontier (see Appendix). This ado file was written to estimate the time-varying inefficiency frontier model of Battese and Coelli (1992). The results are given in Table 6 for model from equation (4), and in Table for model from equation (5).

According to the results in Table 6, the signs are all as expected; with the coefficient for labour input are 0.497 for all enterprise (full sample), 0.982 for large-size enterprise and 0.759 for small and medium-size enterprise. The estimated coefficient for the capital input are 0.377 for all enterprise (full sample), 0.414 for large-size enterprise and 0.114 for small and medium-size enterprise. These imply that during the studied

period, labour and capital play an important role in total production. The results also indicate that labour follows a U–shaped relationship with output with respect to enterprises in full sample and to small and medium-size enterprises; and there is no evidence of diminishing returns with regard to capital.

Table 6: Estimation results of production function

Output (Logarithm)	**Enterprise (full sample)**	**Large size enterprise (industry and construction sample)**	**Small and medium-size enterprise (industry and construction sample)**
Labour (Logarithm)	0.497 (15.21)***	0.982 (4.18)***	0.759 (10.48)***
Capital (Logarithm)	0.377 (12.08)***	0.414 (2.45)**	0.114 (1.67)*
Labour square (Logarithm)	-0.031 (6.98)***	0.018 (1.35)	-0.039 (4.22)***
Capital square (Logarithm)	0.005 (2.15)**	0.039 (5.50)***	0.032 (6.46)***
Interaction between capital and labour (logarithm)	0.019 (3.66)***	-0.081 (4.89)***	-0.007 (0.74)
Constant	7.887 (5.95)***	1.603 (1.18)	6.902 (7.71)***
Obs	25,296	2,919	9,959
/mu	4.767 (3.61)***	-7.052 (0.78)	3.801 (4.50)***
/eta		.0021209 (0.46)	-.0051234 (-3.27)***
/lnsigma2	.3622007 (21.31)***	2.321126 (2.47)**	-0.087 (3.68)***
/Ilgtgamma	1.342 (55.76)***	4.227163 (4.52)***	0.689 (17.15)***
σ_u	1.138892	10.04061	.6105743
σ_v	.2975956	.14653	.3065555
gamma	.792831	.9856162	.6657447
σ^2	1.436487	10.18714	.9171298

Source: Authors' estimation

*Note: * p<0.1; ** p<0.05; *** p<0.01*

σ^2 is the total variance of productivity, including two components: variance of error terms $\sigma_u{}^2$ and variance of technical inefficiency $\sigma_v{}^2$. In order to measure the source of total variance, researchers use $\gamma = \sigma_u / \sqrt{\sigma}$: the more γ is, the more source of total variance come from non – technical noises (γ is positive and less than 1). Unobserved

technical noises may come from the interactions between technical factors such as capital to labour ratio, and capital to land ratio. Non-technical noises are such economic policies, environmental factors, and education. Table 6 shows that most of variance of productivity comes from non –technical noises. However, our concern in this paper is seeking factors belonged to the enterprises to explain efficiency differences among domestic and foreign enterprises.

The technical inefficiency (u_{it}) follows $N(\mu, \sigma^2_u)$, and it is the product of an exponential function of time as $u_{it} = \eta u_i = u_i \exp[-\eta(t-T)]$, $t \in \tau(i)$, in which the unknown parameter η shows inefficiencies are time-varying or time-invariant, the value of η, which is significantly different from zero, indicates time-varying inefficiencies.

Table 6 also provides estimates of the variance parameters of the time varying inefficiencies model (η) is insignificantly different from zero, implying that non-time-varying inefficiencies in Large size enterprise. However, it is significantly different from zero with negative coefficient (-0.0052), imply the technical inefficiency effects tend to decrease over time. Also, μ is significant positive with a value of 4.767 in full sample, insignificant in large-sized enterprises, and significant positive with a value of 3.801 in small and medium-sized enterprise.

The estimated coefficients of the inefficiency model are listed in Table 7. This shows that most of the coefficients are highly significant and have the expected signs. Firstly the estimate for the coefficient associated with age firm is positive, which indicates that are younger enterprise less technically efficient than the older enterprise. This result supports the common prediction of the models of Jovanovic (1982) and Pakes and Ericson (1987), namely that young firms are on average less productive than older firms. However, this finding is validated with large-size enterprises only. In comparison with small and medium-size enterprise, the coefficient of large size enterprise is highly significant, indicating that the age of firm is more important to large size enterprise than small and medium-size ones.

Secondly, capital intensity (capital to labour ratio) explaining efficiency differences between large-size and small and medium-size enterprises is also clearly demonstrated. It indicates that large-size firms are more capital intensive and thus facing the law of diminishing returns, whereas small and medium-size ones tend to be more labour intensive and thus having more space to increase efficiency by more capital investment. This finding is in line with a study by Nguyen Khac Minh (2007) found that for small and medium-sized firms in Vietnam, the higher capital-labour ratio, the higher level of technical inefficiency of firms.

The estimated interaction between and capital to labour ratio and dummy variable (domestic private with foreign partner enterprise) indicates that capital intensity (capital to labour ratio) can also explain the efficiency difference between foreign firms and domestic firms. Specifically, the difference is between domestic private with foreign partner enterprise with other kinds of domestic and FDI enterprises. This is in line with previous research showing that FDI firms employ more capital intensive methods of production than their indigenous competitors (Dunning, 1993).

Thirdly, the coefficients associated with types of ownership show that the sign of state - owned enterprise is negative in both full sample and small and medium-size enterprise. This indicates that state-owned enterprise tends to be less technically efficient than FDI enterprise and domestic private ones, ceteris paribus. In addition, the coefficient of FDI enterprise is positive in both large-size enterprise and small and medium-size enterprise, resulting that FDI enterprises are more technically efficient than both state-owned and domestic private enterprises. Moreover, in the full sample, domestic private with foreign partner enterprise tends to be more technically efficient than both state-owned enterprise and other kinds of FDI ones. This part of Table 7 answers for the research question: *what is the pattern of enterprise efficiency among five mentioned types of ownership in Vietnam?*

Table 7: Estimation results of technical efficiency, 2005 - 2009

Output (Logarithm)	**Enterprise (full sample)**	**Large size enterprise (industry and construction sample)**	**Small and medium-size enterprise (industry and construction sample)**
Age (in years)	0.000 (6.42)***	0.002 (4.72)***	
Capital to labour ratio	0.000 (7.47)***	-0.00001(5.73)***	0.0000(8.68)***
State - owned enterprise	-0.001 (1.72)*		-0.002 (1.75)*
FDI enterprise	-0.005 (4.97)***	0.164 (8.30)***	0.010 (3.46)***
Domestic private with foreign partner enterprise	0.012 (4.46)***		
Red river delta 1	-0.015 (15.03)***	-0.202 (7.28)***	-0.015 (10.72)***
North-western region 2	-0.013 (8.57)***	-0.185 (6.49)***	-0.018 (5.90)***
North-eastern region 3	-0.014 (8.04)***		-0.023 (4.16)***
North central coast 4	-0.016 (7.83)***	-0.162 (5.09)***	-0.012 (4.08)***
South central coast 5	-0.014 (11.63)***	-0.266 (6.30)***	-0.015 (8.06)***
South-eastern region 7	-0.011 (14.75)***	-0.138 (5.77)***	-0.009 (8.09)***
Mining and quarrying sector	-0.007 (4.52)***	0.269 (10.50)***	0.004 (2.04)**
Manufacturing sector	-0.008 (18.18)***	0.176 (13.94)***	0.013 (17.13)***
Electricity, gas and water supply sector	-0.013 (5.88)***	-0.148 (3.88)***	-0.008 (3.10)***
Year 2005			0.002 (2.06)**
Year 2006			0.002 (2.11)**
Interaction between 100% foreign capital enterprise and mining and quarrying sector		-0.250 (2.48)**	
Interaction between 100% foreign capital enterprise and manufacturing sector	0.007 (5.19)***	-0.219 (10.50)***	-0.018 (6.34)***
Interaction between state - owned with foreign partner and manufacturing sector	0.014 (6.01)***		

Output (Logarithm)	**Enterprise (full sample)**	**Large size enterprise (industry and construction sample)**	**Small and medium-size enterprise (industry and construction sample)**
Interaction between domestic private with foreign partner and manufacturing sector	-0.007 (1.99)**	-0.160 (4.60)***	-0.009 (2.29)**
Interaction between 100% foreign capital enterprise and other industry sector	0.024 (1.81)*		
Interaction between 100% foreign capital enterprise and construction sector	0.023 (4.13)***		
Interaction between domestic private with foreign partner and construction sector			
Interaction between domestic private with foreign partner and capital to labour ratio	0.000 (12.51)***	.0000 (2.73)***	
Constant	0.029 (37.32)***	0.420 (15.83)***	0.030 (25.09)***
Obs	24,623	2,867	9,959
R^2	(0.029)0.04	(0.216)0.16	(0.03)0.06

Source: Authors' estimation

*Note: * p<0.1; ** p<0.05; *** p<0.01*

Fourth, Table 7 show that estimated coefficients of regions are significantly and negative in full – sample model, large-size sample and small & medium-size sample as well. These results indicate that enterprises located in Red river delta, Northwest region, Northeast region, North central coast, South central coast and Southeast region tend to be less technically efficient than those belonged to Central Highland region and Mekong river delta. It must note that Nguyen Khac Minh et al. (2007) found that enterprises located in Red river delta, North-western region, Mekong river delta have higher technically efficient than those located in North-eastern region and Central Highland region. Since mentioned that one of our findings is that most of of variance of productivity comes from non –technical noises such as economic policies, environmental factors, and education and these factors may not be well captured in our models those aim

at seeking factors belonged to the enterprises to explain efficiency differences among domestic and foreign enterprises

Fifth, in sub - samples, enterprise in mining and quarrying industry and manufacturing industry tend to be more technically efficient than the two other industries (namely, electricity, gas and water supply sector and construction) in Vietnam. However, in full sample, enterprises in construction have highest technically efficient, ceteris paribus.

Sixth, the coefficients of year in 2005 and year in 2006 for small and medium-size sample is positive and significant. The *year* variable in the efficiency model (5) specifies that the efficiency effects may change linearly with respect to time. Thus, the result indicates that technical efficiency of the enterprises in the dataset increased in the period 2005 – 2006.

Seventh, to answer the second main research question: *what is the role of ownership in determining efficiency of various types of economic sectors (such as labour vs. capital intensive, industries by sub - sectors),* we look at some groups of estimated coefficients:

- In the full sample, interaction variables between types of ownership and industries indicate that both 100% foreign capital enterprise and state - owned with foreign partner enterprise in sub – industries are more efficient than those are domestic private with foreign partner.

However, in the sub - samples, interaction variables between types of ownership and industries indicate that both 100% foreign capital enterprise and domestic private with foreign partner in sub – industries are more efficient than those are state - owned with foreign partner enterprise.

- In the full sample and large-size sample, interaction variables between types of ownership and capital intensity indicate that domestic private with foreign partner are more efficient than the two other types.

A more specific discussion on technical inefficiency in Vietnam is started from Table 8.

Table 8: Average efficiency level by year, 2005-2009

Year	Large size enterprises		Small & medium size enterprises	
	Efficiency	Obs	Efficiency	Obs
2005	0.4426174	582	0.032324	2017
2006	0.4363804	590	0.0318329	2003
2007	0.438	614	0.0312336	1991
2008	0.439628	585	0.030887	2001
2009	0.4514754	562	0.0302574	1984

Source: Authors compiled from the estimation results

The mean technical efficiency for large size enterprise is at 44.26 percent, 43.64 percent, 43.8 percent, 43.96 percent and 45.15 percent in 2005, 2006, 2007, 2008 and 2009 respectively. These results indicate that large size enterprise in Vietnam can increase the current level of output by 55.74 percent in 2005, by about 56.36 percent in 2006, by about 56.2 percent in 2007, by about 56.04 percent in 2008, and by 54.85 percent in 2009 with the same level of inputs. Compared to the mean technical efficiency at 3.23 percent in 2005, 3.18 percent in 2006, 3.12 percent in 2007, 3.09 percent in 2008, and 3.02 percent in 2009 of the best practice frontier for small and medium- size enterprise (Table 8). It is concluding that efficiency of large size enterprises tend to increase in 2005 – 2009. In contrast, efficiency of small & medium size enterprises have downward trend in the same period.

Table 9: Average efficiency level by sub-industries for large size enterprises

Productive Sector	Large size enterprises		Small & medium size enterprises	
	Efficiency	Obs	Efficiency	Obs
Mining and quarrying	0.5483137	133	0.022796	218
Food product & beverages	0.6068488	362	0.045819	1422
Textiles, wearing apparel & footwear	0.3625954	818	0.024517	1256
Paper, paper product and publishing, printing	0.5255513	141	0.033696	1093
Energy and Chemical	0.508348	481	0.03845	1584
Metallurgical, machinery and other non-	0.4795869	420	0.032186	1518

metallic mineral products				
Furniture	0.460038	118	0.025695	423
Electricity, gas and water supply	0.1793213	39	0.017679	139
Construction	0.2927781	421	0.022189	2343

Source: Authors compiled from the estimation results

In Table 9, we report a few summary statistics on efficiency by sub-industries. Average efficiency in mining and quarrying is 54.83 percent; in manufacturing sector change from 36.25 percent to 60.68 percent. While average efficiency in electricity, gas & water supply and construction are only 17.93 percent and 29.27 percent. It provides evidence in support of estimation results from model 2.

Results summaries in Table 10 indicate that large size enterprise in food product & beverages sector had higher technical efficiency in period 2005 – 2009 compared to enterprises in other sub - industries, with 60.68 percent. Where, efficiency of state - owned with foreign partner enterprise is 73.66%, 100% foreign enterprise is 61.69%, domestic private with foreign partner is 56.91%. Efficiency of state – owned enterprise and private – owned enterprise is only 58.83 percent and 58.33 percent. These results imply that for food product & beverages sector foreign direct investment higher efficiency than domestic enterprise. On the other hand, some sub - industries with quite high tech efficiency including mining and quarrying sector, paper, paper product and publishing, printing and energy and chemical sectors with efficiency at 54.83 percent, by about 52.56 percent and by about 50.83 percent. By contrast, the lowest technical efficiency is belonged to enterprises in electricity, gas and water supply sector, with 17.93 percent, where efficiency of state – owned enterprise and private – owned enterprise sector are 12.78 percent and 33.18 percent, efficiency of 100% foreign capital enterprise sector is 50.81 percent. Therefore, we find that almost foreign direct investment with large firm size enterprises has higher technical efficiency than their counterparts in domestic enterprises. These results also helps explain estimation from model 2, state-owned enterprise tends to be less technically efficient than FDI enterprise.

Table 10: Average efficiency level by sub-industries for large size enterprises

Productive Sector	Ownership	Efficiency	Obs
Mining and quarrying	State – owned enterprise	0.594094	105
	Domestic private enterprise	0.329777	23
	100% foreign capital enterprise	0.425922	5
Food product & beverages	State – owned enterprise	0.588321	140
	Domestic private enterprise	0.583322	140
	100% foreign capital enterprise	0.6169	44
	State - owned with foreign partner	0.736604	33
	Domestic private with foreign partner	0.569115	18
Textiles, wearing apparel & footwear	State – owned enterprise	0.363078	95
	Domestic private enterprise	0.341547	351
	100% foreign capital enterprise	0.351716	309
	State - owned with foreign partner	0.45599	31
	Domestic private with foreign partner	0.430084	32
Paper, paper product and publishing, printing	State – owned enterprise	0.545537	81
	Domestic private enterprise	0.506008	32
	100% foreign capital enterprise	0.478781	26
	State - owned with foreign partner	0.396222	1
	Domestic private with foreign partner	0.254054	1
Energy and Chemical	State – owned enterprise	0.531666	173
	Domestic private enterprise	0.497242	213
	100% foreign capital enterprise	0.445052	76
	State - owned with foreign partner	0.511711	18
	Domestic private with foreign partner	0.35784	1
Metallurgical, machinery and other non-metallic mineral products	State – owned enterprise	0.420663	124
	Domestic private enterprise	0.553722	112
	100% foreign capital enterprise	0.407098	152
	State - owned with foreign partner	0.70985	27
	Domestic private with foreign partner	0.874465	5
Furniture	State – owned enterprise	0.481456	12
	Domestic private enterprise	0.370832	25
	100% foreign capital enterprise	0.488829	73
	State - owned with foreign partner	0.396222	4
	Domestic private with foreign partner	0.254054	4
Electricity, gas and water supply	State – owned enterprise	0.127858	30
	Domestic private enterprise	0.331818	4
	100% foreign capital enterprise	0.508081	5
	State – owned enterprise	0.247544	160
	Domestic private enterprise	0.304162	248

Productive Sector	Ownership	Efficiency	Obs
Construction	100% foreign capital enterprise	0.536078	8
	Domestic private with foreign partner	0.53425	5

Source: Authors compiled from the estimation results

The average efficiency estimates for sub - industries with small and medium size enterprise shown in Table 11. Similar to estimation result from model 2, food product & beverages enterprises and manufacturing enterprises tend to higher than average efficiency electricity, gas & water supply enterprises and construction enterprises. The highest technical efficiency is on food product & beverages enterprises, where, state – owned enterprise is 3.52 percent, private enterprise is 4.61 percent, 100% foreign capital enterprise is 4.35 percent, state - owned with foreign partner is 3.05 percent, and domestic private with foreign partner enterprise is 6.57 percent. It implies that foreign direct investment and private enterprise have technical efficiency higher than state-owned enterprise and state - owned with foreign partner enterprises. Enterprise in paper, paper product and publishing, printing sector, energy and chemical sector, metallurgical, machinery and other non-metallic mineral products sector have quite high technical efficiency. State - owned with foreign partner efficiency of three sub-industries above are always higher than those other types of enterprises. However, efficiency of 100% foreign capital enterprise is often quite low in comparison to other type of enterprises in the same industries. There are only two types of enterprises (state – owned enterprise and private– owned enterprise) in electricity, gas and water supply sector, therefore, technical efficiency of this industry is lowest in sub-industries.

Table 11: Average efficiency level by sub-industries for small and medium size enterprises

Productive Sector	Ownership	Efficiency	Obs
Mining and quarrying	State – owned enterprise	0.017684	27
	Domestic private enterprise	0.023606	191
Food product & beverages	State – owned enterprise	0.035171	75
	Domestic private enterprise	0.046079	1267
	100% foreign capital enterprise	0.043535	132
	State - owned with foreign partner	0.033054	11

Productive Sector	Ownership	Efficiency	Obs
	Domestic private with foreign partner	0.065674	18
Textiles, wearing apparel & footwear	State – owned enterprise	0.030788	8
	Domestic private enterprise	0.025345	984
	100% foreign capital enterprise	0.021561	244
	State - owned with foreign partner	0.030029	4
	Domestic private with foreign partner	0.021944	16
Paper, paper product and publishing, printing	State – owned enterprise	0.031991	240
	Domestic private enterprise	0.034147	761
	100% foreign capital enterprise	0.030918	67
	State - owned with foreign partner	0.06879	7
	Domestic private with foreign partner	0.047998	18
Energy and Chemical	State – owned enterprise	0.03333	61
	Domestic private enterprise	0.039803	1244
	100% foreign capital enterprise	0.034526	204
	State - owned with foreign partner	0.040596	41
	Domestic private with foreign partner	0.028412	34
Metallurgical, machinery and other non-metallic mineral products	State – owned enterprise	0.027207	117
	Domestic private enterprise	0.034017	1152
	100% foreign capital enterprise	0.022535	194
	State - owned with foreign partner	0.052817	35
	Domestic private with foreign partner	0.025325	20
Furniture	State – owned enterprise	0.026552	8
	Domestic private enterprise	0.028097	294
	100% foreign capital enterprise	0.01967	120
	State - owned with foreign partner	0.029578	1
Electricity, gas and water supply	State – owned enterprise	0.015156	32
	Domestic private enterprise	0.018606	107
Construction	State – owned enterprise	0.021086	131
	Domestic private enterprise	0.022184	2189
	100% foreign capital enterprise	0.042072	20
	Domestic private with foreign partner	0.047777	3

Source: Authors compiled from the estimation results

It is conclusion that electricity, gas and water enterprises and construction enterprises are lower efficiency because policy prevent from foreign investor invest into these fields. The Table 12 show that the highest efficiency belongs to State - owned with foreign partner enterprises in both large size enterprises and small & medium size

enterprises. However, the lowest efficiency is on 100% foreign capital enterprises, with value of 41.90% in large size enterprises and 3.0% in small & medium size enterprises. This can be explained that government is face to difficult for management annual report of enterprises. Almost 100% foreign capital enterprises have loss report to avoid of paying business income tax for government. They import input with very high prices from parent company and export with zero tax duty. Therefore, although sub-companies have loss annual report, parent companies have high return. On the other hand, in many sectors foreign companies are required to joint venture with Vietnam companies. For example, in the education and training field, foreign companies must joint Vietnam partner. Additionally, in foreign companies are currently limited to a 49 percent maximum share in a Joint Venture Enterprise. It is important to not that foreign invested companies are licensed for a limited term. Typically, the duration of a foreign invested enterprises or business cooperation contract will not exceed 50 years. The Government may permit longer term on a case by case basis but the maximum is 70 years. In regard to trade, certain restrictions are also in place. For example, the amount of foreign films that may be imported is limited to a fixed ratio of the amount Vietnam films shown or produced. In regard to trading and distribution, as well as retail sales operations, Vietnamese law contains many restrictions at present, and investors must carefully consider various options for structuring business operations.

Table 12: Average efficiency level by ownership for both large size enterprises and small & medium size enterprises

Ownership	Large size enterprises		Small & Medium size enterprises	
	Efficiency	Obs	Efficiency	Obs
State – owned enterprise	0.4563018	910	0.026279	675
Private– owned enterprise	0.4231795	1146	0.030091	8170
100% foreign capital enterprise	0.418985	697	0.030726	945
State - owned with foreign partner	0.6081139	114	0.042416	97
Domestic private with foreign partner	0.5023652	66	0.039265	109

Source: Authors compiled from the estimation results

5. Conclusions

This paper shed a light on the efficiency differences between FDI and domestic enterprises by looking in details into the types of ownership and industries in the context of developing countries. The paper focussed on examining the technical efficiency performance of manufacturing enterprises in Vietnam, using comprehensive panel data from large surveys of enterprises in 5 years, from 2005 till 2009. This study is the first to use this comprehensive dataset to analyse the technical efficiency performance of Vietnamese enterprises. This research also revealed the impact of different firm characteristics on the technical efficiency performance of Vietnam manufacturing firms. The research also aimed at providing empirically founded policy recommendations to enhance efficiency of manufacturing enterprises in Vietnam. The findings from this study are useful for policy - makers and entrepreneurs in Vietnam and for other transitional economies and developing countries as well in the promotion of manufacturing enterprises.

The results obtained in the empirical application of the proposed inefficiency stochastic frontier production function exhibit some interesting differences from previous studies. The present model specifies that the inefficiency effects are a linear function of some firm - specific variables and time, together with an additive stochastic error which is assumed to be independent over time and among firms.

The results also show that, in general, panel enterprises in Vietnam have relatively high average technical efficiency ranging from 0.01 percent to 74.9 percent. Large-size manufacturing enterprises vary from a negligible percent to 96.11 percent; small and medium-size manufacturing from 0.05 percent to 60.92 percent.

The analysis clarifies the pattern of enterprise efficiency among five mentioned types of ownership in Vietnam. That is: by industry, state-owned enterprise tends to be less technically efficient than FDI enterprise and domestic private ones and FDI enterprises are more technically inefficient than both state-owned and domestic private

enterprises. By the economy (not including agriculture), domestic private with foreign partner enterprise tends to be more technically efficient than both state-owned enterprise and other kinds of FDI ones.

Taking the sub – industries into account, the result proves that the impact of ownership on efficiency varies from industry to industry. By the economy (not including agriculture), both 100% foreign capital enterprise and state - owned with foreign partner enterprise in sub – industries are more efficient than those are domestic private with foreign partner. By the industry, both 100% foreign capital enterprise and domestic private with foreign partner in sub – industries are more efficient than those are state - owned with foreign partner enterprise.

With respect to capital intensity, the result indicates that domestic private with foreign partner is more efficient than the two other types.

A further discussion about the policy implaications is needed in the future, given the rich infomation from the analysis of this paper.

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Appendix

Box 1: Estimation of technical inefficency in panel stochastic frontier models by using Stata version 11

xtfrontier fits stochastic production or cost frontier models for panel data. More precisely, xtfrontier estimates the parameters of a linear model with a disturbance generated by specific mixture distributions.

The disturbance term in a stochastic frontier model is assumed to have two components. One component is assumed to have a strictly nonnegative distribution, and the other component is assumed to have a symmetric distribution. In the econometrics literature, the nonnegative component is often referred to as the inefficiency term, and the component with the symmetric distribution as the idiosyncratic error.

xtfrontier permits two different parameterizations of the inefficiency term: a time-invariant model and the Battese - Coelli parameterization of time-effects. In the time-invariant model, the inefficiency term assumed to have a truncated-normal distribution. In the Battese - Coelli parameterization of time effects, the inefficiency term is modeled as a truncated-normal random variable multiplied by a specific function of time. In both models, the idiosyncratic error term is assumed to have a normal distribution. The only panel-specific effect is the random inefficiency term.

Source: Stata Help