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Firm Efficiency in Selected Developed and Developing East Asia Countries: Using Data Envelopment Analysis

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ABSTRACT

Drawing on the significance of firm efficiency in attaining the primary firms' goal of profit maximization, the paper aims to examine the firm efficiency or technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) level in the selected East Asia countries during the period of 2009-2015, by employing the non-parametric Data Envelopment Analysis (DEA) based on the production approach. The efficiency level of firms in selected East Asia countries is found to be moderate, by experiencing the mean TE of 53.40per cent with input waste of 46.60per cent during the years 2009-2015. The paper find that the scale inefficiency (SIE) is the dominant source of inefficiency of firms. Furthermore, the paper reveals that the large firms are generally showed decreasing return to scale (DRS); while the small firms are commonly exhibited increasing return to scale (IRS). Finally, the paper concludes that the firms in selected developed countries are found to exhibit higher mean TE than those firms in selected developing countries.

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INTRODUCTION

Over the last few decades, East Asia appears to be the most rapid growing region in the world (White, 1988). East Asia also remains as one of the essential leaders of world economy (The World Bank, 2017). Therefore, a great of attention has been garnered by the economists and policymakers on this significant region. East Asia region includes Hong Kong, Indonesia, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand, etc. This region has a diversity in terms of ecosystem, population, religion, social structure, and political regime (Ohno, 2002). Remarkably, East Asia region encompasses both developed and developing countries with different institutional context. The firm efficiency level of the developed and developing countries hence could be vary (Jarboui et al., 2013).

For a firm, efficiency primarily focuses on technical efficiency (TE). Farrell (1957) defines TE as the firms' ability in producing maximum outputs from a given set of inputs or, the ability of firms in reducing the inputs to generate the same amount of outputs as on the efficient frontier. The production without the TE is costly, owning to the fact that the productive firms maximize the outputs without accounting the efficient inputs usage or the exploitation of scales economies (Coelli et al., 2005). In other words, the firms would be unable in maximizing profit in absence of TE. Therefore, TE is significant for firms in achieving the primary goal, which is profit maximization as drawn on microeconomic theory of firms (Primeaux and Stieber, 1994). The capability of firms to achieve goals of profit maximization depends on how technically efficient they are. Therefore, the investigation on TE level of firms in the selected developed and developing countries of East Asia region by the paper is signficant. Nevertheless, the prior literature in regards to the firm efficiency of multi-nation context is still underexplored, especially in the context of East Asia.

For the sake of brevity, the paper aims to examine the firm efficiency or TE, pure technical efficiency (PTE) and scale efficiency (SE) in the selected developed and developing countries of the East Asia region during the period of 2009 to 2015 by performing the non-parametric Data Envelopment Analysis (DEA) based on the production approach. The paper hence seek to contribute in the methodology part by using DEA methods, as the DEA is less popular within firm sector so far. The paper selects Hong Kong, Singapore, Malaysia and Thailand because these countries are among the representative countries of certain regional characteristics and also reflect the diversity in East Asia region. The paper therefore attempts to fill the literature gaps by examining the firm efficiency based on a cross-country sample of 400 firms in selected developed and developing East Asia countries with updated data of 2009 to 2015. The paper overall contributes knowledge to managers, investors, policy-makers, academicians and practitioners.

The paper finds that the efficiency level of firms in selected East Asia countries is moderate, by experiencing the mean TE of 53.40per cent with input waste of 46.60per cent during the years 2009-2015. Furthermore, scale inefficiency (SIE) is the dominant source of inefficiency of firms in selected East Asia countries. The paper also discovers that the large firms have experienced significantly higher mean TE as compared to small firms. Moreover, the paper shows that the large firms are generally exhibited decreasing return to scale (DRS); while the small firms are commonly showed increasing return to scale (IRS). Finally, the paper concludes that the average firm efficiency in selected developed East Asia countries is significantly higher than in selected developing East Asia countries.

The paper is developed as follows: Section 2 presents the review of literature. Section 3 presents the research methodology. The paper discusses the results in Section 4. Last section draws the conclusions.

REVIEW OF LITERATURE

Firm Efficiency or Technical Efficiency (TE)

Most studies on firm efficiency have based on single nation context. For instance, by employing Stochastic Frontier Analysis (SFA) method, Linz and Rakhovsky (2011) have discovered that the Russian manufacturing firms in low-priority sectors (e.g. wood, construction, materials and food processing) are relatively more technically efficient than those firms in high-priority sectors (e.g. fuel, chemical and machine building) for years 1992-1995. Charoenrat et al. (2013) have showed the TE of Thailand manufacturing small and medium size enterprises (SMEs) is low for year 2007 by using SFA method.

Moreover, by using DEA, De Jorge Moreno and Sanz-Triguero (2011) have found that the TE of the Spanish retail sector is high over the year 1997-2007. Al-Amri et al. (2012) have discovered that the overall technical efficiency (OTE) of the insurance sector in Arab Gulf is moderate under DEA method from 2005-2007. Under DEA method, Mandal and Ghosh Dastidar (2014) have documented that the TE of Indian insurance firms in public sector is relatively higher than in private sector during economic slowdown (2006-2010). In corporate finance literature, Yang et al. (2013) have pointed out that the detrimental impact of agency problems on separation between ownership and control on firm efficiency based on a sample of Taiwanese electronic firms from 2004 to 2010.

Few studies on firm efficiency has been conducted on a sample set of cross-countries. For example, Kinda et al. (2014) have indicated that the firms in India and China (i.e. Asiatic region) are less technically efficient than the best performing developing countries such as Brazil and South-Africa under SFA method from 2000 to 2006. Jarboui et al. (2014) have found that managerial optimism does reduce TE of sample firms in developed and developing countries from 2000 to 2011. See (2015) has revealed that the efficient of water utilities firms in Cambodia does note the highest scores among the Southeast Asia developing countries by using DEA method. Moreover, Jarboui et al. (2013) have discovered that the average public road transport TE in developed countries is relatively higher than in developing countries during 2000 to 2011 by employing SFA method, by explaining that the TE in developing countries could be due to the barriers in socio-economic, education, health and environment along with the low investment level. The scholars have also reported that the large size-operators are more technically efficient than small-size operators.

Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE)

The OTE could be decomposed into PTE and SE; and the dominant source of firm inefficiency therefore is determined by comparing the PTE and SE scores on average (Mitra Debnath and Sebastian, 2014). For instance, Sharma (2008) has found the high mean scores of both PTE and SE; which indicates the PTE and SE of Indian cement firms are comparably good. Similarly, Kabir Hassan et al. (2012) have indicated that the SE of the Middle East and North African micro financial institution is considered as a shortcoming; which indicated by the comparably high mean scores of PTE and SE by using DEA method.

Moreover, Kumar (2011) has identified that the dominant source of overall technical inefficiency (OTIE) for Indian state road transport undertakings for the years 2006-2007 is PTIE (or managerial inefficiency); which indicated by the lower PTE than SE mean score by employing DEA method. Similarly, Kundi and Sharma (2016) have discovered that the dominant source of OTIE for Indian glass firms is PTIE; which indicated by lower PTE than SE mean score by using DEA. The scholars also have found that small- and medium-scale firms are more efficient than large-scale firms. Sahoo (2016) have consistently revealed that the OTIE of Indian software companies is mainly due to the PTIE; which indicated by lower PTE than SE mean scores.

In short, by reviewing to past literature, the studies on firm efficiency are still limited in the context of multi-nation, especially on the developed and developing East Asia countries.

METHODOLOGY

Sample Selection and Data Sources

The selection of sample firms is primarily from the four East Asia countries, comprising Hong Kong, Singapore, Malaysia and Thailand, following The State of Asian and Pacific Cities (2015). These selected countries are among the representative countries of certain regional characteristics and also represent the diversity in East Asia region. Instead of all firms, 100 top listed firms from each country are being selected based on the respective country stock market indices as of most recent year 2015 (refer Appendix I). The final sample consists sum of 400 listed firms. The sample data covers seven-year period of 2009-2015, which is the post-crisis period. The data of inputs and outputs variables for DEA is mainly obtained from the Thomson Reuters DATASTREAM database in the home currencies of the countries. Therefore, to ensure data standardization, the data has been converted to same currency which is US dollar (USD).

Research Method

Data Envelopment Analysis (DEA)

The paper applies the non-parametric DEA frontier analysis to examine the TE of firm, drawing on the several advantages of DEA (Coelli et al., 1998; Sufian, 2007; Cummins and Xie, 2008; Charoenrat et al., 2013). First, the non-parametric DEA prevents misspecification of functional form and yields accurate efficiency estimates without holding any assumption on the estimation of an appropriate function (i.e. production function) for efficiency frontier and distributional assumptions. DEA is therefore, different from the parametric method such as Stochastic Frontier Analysis that assumes estimation of an appropriate production function (Charoenrat et al., 2013; Cummins and Weiss, 2013). Second, DEA allows ranking among the DMUs based on the single efficiency score of each decision-making unit (DMU). Third, DEA identifies the field that required for improvement on each DMU (e.g. excessive inputs usage or low output production) in enhancing firm efficiency based on the decomposition of TE into PTE and SE. Fourth, DEA figures out the global leader or DMU with most appearance in the set based on the measurement and comparison on the efficiency of each DMU with a set of most efficient firms. Fifth, DEA does not require standardization on the inputs and outputs selection (Ariff and Can, 2008), considering the conformation of rule of thumb by Cooper et al. (2002). Sixth, DEA is a maximum likelihood estimations and owns good statistical properties. Last, DEA is relevant to the small sizes of studied sample firms.

Farrell (1957) defines TE as the ability of a firm to generate maximum output from a given combination of inputs. Hence, the more efficient production is indicated by greater outputs from given inputs. Following Charnes et al. (1978), to maximize firm efficiency, each DMU is allowed to select own set of proper weights that is relatively favorable than other units under DEA. TE score is generally indicated by a ratio of weighted outputs to weighted inputs. According to Bader et al. (2008), the efficiency is measured as follows:

Maximize efficiency of unit m = $\sum_{r=1}^{s} uyrm$ =1 (1)
Subject to $\sum_{i=1}^{p} vixim$= 1
$\sum_{r=1}^{s} uyrm - \sum_{i=1}^{p} vixim \leq 1$, m = 1,2,…n
$ur \geq \mathcal{E}$, r = 1,2,…s
$vi \geq \mathcal{E}$, i = 1,2,…p

where,
vi = the weight assigned to input *i*
xim = the level of input *i* used by unit *m*
ur = the weight assigned to output *r*
yrm = the level of output *r* produced by unit *m*
$\mathcal{E}$ = a small number (i.e. with order of 10^{-6}) that ensures neither input nor output is given zero weight

The value of firm efficiency (TE) scores is from 0 to 1. As such, the DMU is considered as fully efficient in employing the inputs to maximize outputs if the efficiency value of unit m is equivalent to 1. While the DMU is considered as relatively inefficient if the efficiency value of unit m is less than 1. DEA model could identify the combination of input and output weights that would maximize the efficiency of DMUs.

Constant Return to Scale (CRS) and Variable Return to Scale (VRS)

The papers employs the DEA with VRS model by Banker et al. (1984) to compute the input-oriented TE of the firms. Basically, the model of Banker et al. (1984) namely BCC model (with the introduction of VRS) is an improved version of CCR model by of Charnes et al. (1978). The model namely CCR model does assume the CRS when all DMUs operate at optimal scale; and thus, CRS entirely delivers on OTE (Sufian, 2004). However, the VRS assumption under BCC model has noted that not all DMUs operate at optimal scale; and hence, the VRS delivers not merely the PTE (i.e. pure managerial efficiency of DMU), yet SE (i.e. scale or firm size efficiency). In this sense, the source of technical inefficiency (TIE) could be due to pure technical inefficiency (PTIE) or SIE under VRS assumption (Coelli et al., 1998; Sufian, 2004). Following Rao et al. (2010), SE of each period is computed as follows:

Scale Efficiency (SE) of each period = CRS/ VRS efficiency (2)

The DMU has SIE if the TE scores of a particular DMU are different under CRS and VRS methods. Hence, the differences between the TE score and PTE score indicates SIE (Coelli et al., 1998). Going further, the nature of SIE under VRS could be in the two form, namely IRS and DRS (Sufian, 2004). The IRS is considered if there is higher percentage increases in outputs in relative to increase in inputs; while the DRS is considered if there is the lower percentage increases in outputs in relative to increase in inputs (Kundi and Sharma, 2016).

The CRS and VRS frontiers in DEA are revealed by Figure 1. For point B, under CRS assumption, the distance of BBc is the TIE; while under VRS assumption, the distance of BBv is the TIE. Hence, the differences of BcBv denotes the SIE. The information whether a DMU is operating a field of IRS or DRS is provided by carrying out an additional DEA problem with non-increasing to scale (NRIS). The nature of SIE due to either IRS or DRS is identified by the differences between NIRS TE and VRS TE score. If VRS TE @ PTE is vary from NRIS TE, the DMU operates at IRS (point B); if VRS TE @ PTE is equal to NRIS TE, the DMU operates at DRS (point D).

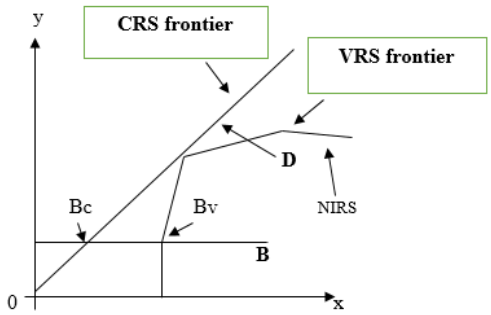

Figure 1 CRS and VRS frontier in DEA

Choice of Inputs and Outputs in DEA

The definition on inputs and outputs for efficiency within the firm sector however, remains arbitrary and arguable (Ariff and Can, 2008; Sufian, 2007). Remarkably, few common approaches to define outputs and inputs which depend on the nature of firms; including value added, intermediation and production approach (Sealey and Lindley, 1977). For firms, production approach is a well-known approach in selecting inputs and outputs as indicated the past studies; for example Bhandari and Ray (2012), Charoenrat et al. (2013), etc. Accordingly, the production approach is preferable for firms in choosing the inputs and outputs in the paper, by assuming that the sample firms are basically the producer of products and services for users.

The paper therefore chooses three inputs and a single output, by referring to past major studies such as Ariff and Can (2008), Jarboui et al. (2013), Castiglione and Infante (2014) and Demirbag et al. (2016). The single output consists of sales (y1), as represented by net sales. There are three inputs, namely, capital (x1), as defined by the total property, plant and equipment including physical assets and total intangible assets; labor (x2), as indicated by total number of employees; and operating expenses (x3), as measured by total operating expenses or the sum of expenses in relation to operation including cost of goods sold, selling and general maintenance and administration expenses. As noted by Cooper et al. (2002), the rule of thumb on number of inputs and outputs selection is as follows:

$$n \geq \max \{m \times s, 3(m + s)\} \quad (3)$$

Where n is the number of DMUs; m is the number of inputs; and s is the number of outputs. In the paper, as the total number of DMUs (firms) is 400 (n=400), n is more than the maximum number of inputs and outputs variables {3 inputs x 1 outputs, 3(3 inputs + 1 output)} = (3, 12), therefore has complied with rule of thumb and considered as valid. The variable inputs and output in DEA model are described as in Table 1.

Table 1 Summary Statistics of Variable Inputs and Output in DEA Model for Firms in Selected East Asia Countries, 2009-2015

Inputs and Output Variables	Firms in All Selected East Asia Countries			Firm in Selected Developed East Asia Countries			Firm in Selected Developing East Asia Countries		
	No. DMUs	Mean	Median	No. DMUs	Mean	Median	No. DMUs	Mean	Median
Capital (USD mil), x1	400	3022.91	263.55	200	5074.77	440.55	200	922.37	172.40
Labor, x2	400	14820.00	2429.00	200	23734.00	4143.00	200	5072.00	1869.00
Operating Expenses (USD mil), x3	400	5049.36	420.63	200	8752.57	640.42	200	1143.43	281.13
Sales (USD mil), y1	400	5271.94	449.16	200	9295.92	777.73	200	1201.10	293.06

RESULTS AND DISCUSSION

Efficiency of the Firms in All Selected East Asia Countries

Table 2 presents the mean efficiency scores for firms in all, developed and developing selected East Asia countries for years 2009 to 2015. From Panel H of Table 2, the firms in all selected East Asia countries are moderately efficient by experiencing the TE of 53.40per cent with input waste of 46.60per cent on average during 2009 to 2015. SIE (27.90per cent) is found to be the dominant source of inefficiency for firms rather than PTIE (26.60per cent). As implied by the results, the firms in all selected East Asia countries have not been operating at a relatively optimal scale of efficiency, although they have been managerially efficient to exploit their resources fully.

From Figure 2 as a summary of Table 2, the TE for firms in all selected East Asia countries indicates a fluctuation trend from 54.30per cent in year 2009, reducing to 43.10per cent in year 2011 and yet, eventually increasing to 57.40per cent in year 2015, on average. This perhaps could be explained, where the TE of firms seems to deteriorate during 2009 to 2011; which is the immediate recovering periods after global financial crisis year 2008. Yet, the TE of firms turns to rise starting the comparatively stable period of year 2012 until 2015.

Table 2 Descriptive Statistics of Efficiency Scores for Firms in Selected East Asia Countries, 2009–2015

Efficiency Measures	Firms in All Selected East Asia Countries		Firms in Selected Developed East Asia Countries		Firm in Selected Developing East Asia Countries	
	No. DMUs	Mean	No. DMUs	Mean	No. DMUs	Mean
Panel A: All Firms 2015						
Technical Efficiency	400	0.574	200	0.621	200	0.526
Pure Technical Efficiency	400	0.778	200	0.836	200	0.721
Scale Efficiency	400	0.724	200	0.751	200	0.698
Panel B: All Firms 2014						
Technical Efficiency	400	0.675	200	0.605	200	0.746
Pure Technical Efficiency	400	0.821	200	0.826	200	0.816
Scale Efficiency	400	0.826	200	0.736	200	0.916
Panel C: All Firms 2013						
Technical Efficiency	400	0.530	200	0.426	200	0.635
Pure Technical Efficiency	400	0.722	200	0.692	200	0.752
Scale Efficiency	400	0.741	200	0.644	200	0.838
Panel D: All Firms 2012						
Technical Efficiency	400	0.484	200	0.606	200	0.361
Pure Technical Efficiency	400	0.701	200	0.775	200	0.626
Scale Efficiency	400	0.691	200	0.779	200	0.602
Panel E: All Firms 2011						
Technical Efficiency	400	0.431	200	0.572	200	0.289
Pure Technical Efficiency	400	0.682	200	0.761	200	0.601
Scale Efficiency	400	0.625	200	0.740	200	0.509
Panel F: All Firms 2010						
Technical Efficiency	400	0.499	200	0.590	200	0.407
Pure Technical Efficiency	400	0.700	200	0.773	200	0.626
Scale Efficiency	400	0.708	200	0.753	200	0.662
Panel G: All Firms 2009						
Technical Efficiency	400	0.543	200	0.650	200	0.429
Pure Technical Efficiency	400	0.734	200	0.786	200	0.679
Scale Efficiency	400	0.729	200	0.822	200	0.631
Panel H: All Firms All Years						
Technical Efficiency	2800	0.534	1400	0.581	1400	0.486
Pure Technical Efficiency	2800	0.734	1400	0.778	1400	0.689
Scale Efficiency	2800	0.721	1400	0.746	1400	0.695

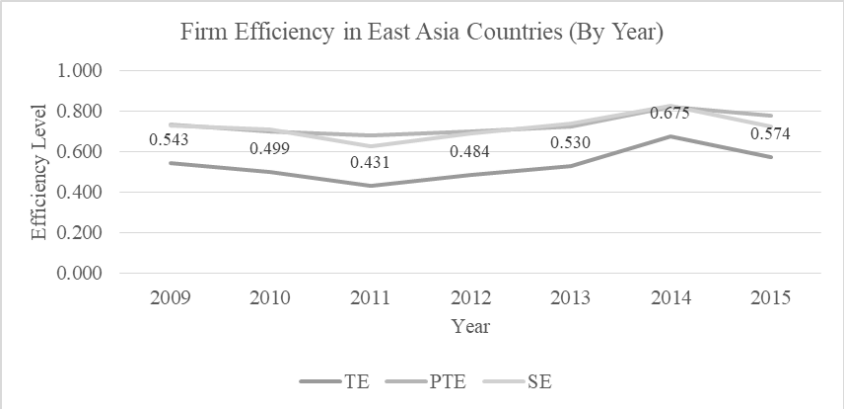

Figure 2 Firm Efficiency in All Selected East Asia Countries (By Year), 2009-2015

Efficiency of the Firms in Selected Developed versus Developing East Asia Countries

Following The State of Asian and Pacific Cities (2015), the paper classify Hong Kong and Singapore as developed countries; while Malaysia and Thailand as developing countries. As revealed in Table 2, the mean TE for firms in both selected developed and developing East Asia countries similarly indicates the fluctuation trend from 2009 to 2015. However, from Panel H of Table 2, different efficiency problem occurs for the firms in selected developed and developing East Asia countries. Even though the firms in the developed East Asia countries have been managerially efficient to exploit their resources fully, they have not been operating at a relatively optimal scale of efficiency (where, SIE=25.40per cent > PTIE=22.20per cent). In contrast vein, even though the firms in the developing East Asia countries have been operating at a relatively optimal scale of efficiency, they have not been managerially efficient to exploit their resources fully (where, PTIE = 31.10per cent > SIE=30.50per cent).

According to Figure 3 as a summary of Table 2, the firms in selected developed countries have exhibited higher mean TE (58.10per cent versus 48.60per cent), PTE (77.80per cent versus 68.90per cent) and SE (74.60per cent versus 69.50per cent) in comparison to the firms in selected developing countries of East Asia during the period 2009-2015. These results on the efficiencies are significantly different at 1per cent from parametric t-test, non-parametric Mann-Whitney and Kruskall-Wallis tests (refer Table 3). The reason of lower firm efficiency in selected developing East Asia countries probably due to the challenges in institutional features, especially weak market for corporate control, high information asymmetry environment and underdeveloped capital market that could affect the firm operation, and in turn firm efficiency (Jarboui et al., 2013; Gibson, 2003). In short, the paper concludes that the firms in selected developed countries are significantly more efficient than firms in selected developing countries of East Asia.

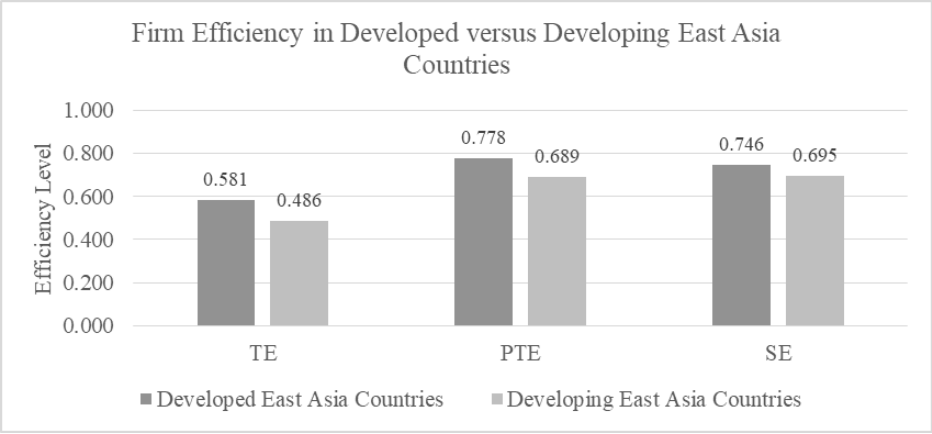

Figure 3 Firm Efficiency in Selected Developed versus Developing East Asia Countries, 2009-2015

Table 3 Robustness Tests of Efficiency Scores for Firms in Selected Developed and Developing East Asia Countries, 2009-2015

Test Groups						
Test Statistics	Parametric Test		Non-parametric Test			
	t-test		Mann-Whitney Test		Kruskall-Wallis Test	
	t (*Prb* > *t*)		*z* (*Prb* > *z*)		x^2 ($Prb > x^2$)	
	Mean	**t**	**Mean Rank**	**z**	**Mean Rank**	**x^2**
Technical Efficiency						
Developed Countries	0.581	9.363***	1537.460	-8.967***	1537.460	80.402***
Developing Countries	0.486		1263.540		1263.540	
Pure Technical Efficiency						
Developed Countries	0.778	9.873***	1511.270	-7.299***	1511.270	53.283***
Developing Countries	0.689		1289.730		1289.730	
Scale Efficiency						
Developed Countries	0.746	5.809***	1478.260	-5.091***	1478.260	25.919***
Developing Countries	0.695		1322.740		1322.740	

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Efficiency of the Large versus Small Firms in Selected East Asia Countries

The paper categorizes the sample firms into groups of large and small firms based on the firm size in term of total assets. Table 4 illustrates the efficiency scores of large and small firms in selected East Asia countries for years 2009 to 2015. As reported in Table 4, the average TE of both large and small firms consistently indicate the fluctuation trend from 2009 to 2015. Following Panel H of Table 4, the results shows that the large firms have experienced higher mean TE (59.50per cent versus 47.30per cent) and PTE (81.10per cent versus 65.70per cent) in relative to small firms. This perhaps because the large firms have greater competitive advantage and capability in investment on resources, according to Jarboui et al. (2013). These efficiency results are significantly different at 1per cent from parametric t-test and non-parametric Mann-Whitney and Kruskall-Wallis tests (refer Table 5). In a nutshell, the paper concludes that the large firms are significantly more efficient than small firms in the selected East Asia countries.

Table 4 Summary Statistics of Efficiency Scores for Large versus Small Firms in Selected East Asia Countries, 2009–2015

Efficiency Measures	**Large Firms in Selected East Asia Countries**		**Small Firms in Selected East Asia Countries**	
	No. DMUs	**Mean**	**No. DMUs**	**Mean**
Panel A: All Firms 2015				
Technical Efficiency	200	0.634	200	0.494
Pure Technical Efficiency	200	0.826	200	0.699
Scale Efficiency	200	0.761	200	0.688
Panel B: All Firms 2014				
Technical Efficiency	200	0.584	200	0.709
Pure Technical Efficiency	200	0.791	200	0.798
Scale Efficiency	200	0.725	200	0.891
Panel C: All Firms 2013				
Technical Efficiency	200	0.548	200	0.534
Pure Technical Efficiency	200	0.795	200	0.666
Scale Efficiency	200	0.676	200	0.802
Panel D: All Firms 2012				
Technical Efficiency	200	0.580	200	0.389
Pure Technical Efficiency	200	0.789	200	0.613
Scale Efficiency	200	0.725	200	0.657
Panel E: All Firms 2011				
Technical Efficiency	200	0.527	200	0.314
Pure Technical Efficiency	200	0.778	200	0.568
Scale Efficiency	200	0.680	200	0.575
Panel F: All Firms 2010				
Technical Efficiency	200	0.641	200	0.414
Pure Technical Efficiency	200	0.843	200	0.608
Scale Efficiency	200	0.761	200	0.691
Panel G: All Firms 2009				
Technical Efficiency	200	0.653	200	0.453
Pure Technical Efficiency	200	0.857	200	0.643
Scale Efficiency	200	0.761	200	0.698
Panel H: All Firms All Years				
Technical Efficiency	1400	0.595	1400	0.473
Pure Technical Efficiency	1400	0.811	1400	0.657
Scale Efficiency	1400	0.727	1400	0.715

Table 5 Robustness tests for Efficiency Scores of Large and Small Firms in Selected East Asia Countries, 2009-2015

Test Groups						
Test Statistics	Parametric Test		Non-parametric Test			
	t-test		Mann-Whitney Test		Kruskall-Wallis Test	
	t (Prb > t)		z (Prb > z)		x^2 ($Prb > x^2$)	
	Mean	t	Mean Rank	z	Mean Rank	x^2
Technical Efficiency						
Large Firms	0.595	11.266***	1568.48	-10.997***	1568.48	120.941***
Small Firms	0.473		1232.52		1232.52	
Pure Technical Efficiency						
Large Firms	0.811	15.882***	1602.32	-13.299***	1602.32	176.874***
Small Firms	0.657		1198.68		1198.68	
Scale Efficiency						
Large Firms	0.727	1.145	1420.41	-1.303	1420.41	1.699
Small Firms	0.715		1380.59		1380.59	

Notes: ***, ** and * indicate significance at the 1%, 5% and 10% level respectively.

Scale Inefficiency on Increasing Returns to Scale and Decreasing Returns to Scale

It would be worthwhile to determine further on the nature of SIE (the dominant source of inefficiency in East Asia) whether in the form IRS or DRS under VRS. Table 6 (and Table 7) present the SIE on CRS, IRS and DRS for the large (and small firms) in selected East Asia countries from years 2009 to 2015. From Table 6, the results reveal that the large firms are generally exhibited DRS (73per cent of DRS level). As implied by the results, the large firms in selected East Asia countries have been operating above their optimal scale size. Hence, to attain the efficiency benefits, the large firms might reduce their operation size. On the flip side, the results show that the small firms are generally showed IRS (58per cent of IRS level). The results indicate that the small firms in selected East Asia countries have been operating below their optimal scale size. Therefore, the small firms might expand their size of operation to achieve the efficiency gains. These findings are consistent with Aghimien et al. (2016), documenting that the small banks tend to operate at CRS and IRS while the large banks tend to operate at CRS or DRS.

Table 6 Scale Inefficiency of the Large Firms in Selected East Asia Countries, 2009–2015

County Name	**Total No. of Firms**	**Total Assets (US$ mil)**	**Return To Scale (RTS)**																
			2009			**2010**			**2011**			**2012**			**2013**				
			CRS	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**		
HK	84	10598023.58	14	21	48	13	12	59	8	13	63	8	19	57	5	3	76		
MAL	40	3134836.46	3	4	29	3	10	27	4	6	30	3	5	32	5	5	30		
SG	41	1238556.61	5	11	24	5	4	32	4	6	31	4	9	28	9	14	18		
THA	35	943792.43	4	1	28	3	5	26	3	4	27	2	6	26	4	1	30		
Total	**200**																		

Table 6 (Cont.)

County Name	**Total No. of Firms**	**Total Assets (US$ mil)**	**Return To Scale (RTS)**						**Count Firm in No.**			**Count Firm in %**		
			2014			**2015**			**All Years**			**All Years**		
			CRS	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**	**CRS**	**IRS**	**DRS**
HK	84	10598023.58	6	3	75	7	6	71	61	77	449	10	13	76
MAL	40	3134836.46	6	16	18	4	16	20	28	62	186	10	22	67
SG	41	1238556.61	5	8	28	7	6	28	39	58	189	14	20	66
THA	35	943792.43	5	4	26	2	1	32	23	22	195	10	9	81
Total	**200**	**MEAN**							**151**	**219**	**1019**	**11**	**16**	**73**

Notes: CRS is the constant return to scale; DRS is the decreasing return to scale; IRS is the increasing return to scale; Count Firm (CRS) is the number of times a firm has appeared on the efficiency frontier during the period of study; Count Year (CRS) is the number of firms that has appeared on the efficiency frontier during the year. HK is Hong Kong; SG is Singapore; MAL is Malaysia and THA is Thailand.

CONCLUSIONS

The paper investigates the firm efficiency or TE based on a sample of the selected developed and developing East Asia countries during the periods of 2009-2015 by adopting non-parametric DEA. The paper discovers that the firms in selected East Asia countries are moderately efficiency, on average. Moreover, the inefficiency of firms could be attributed mainly to SIE.

Furthermore, the paper concludes that the firms in selected developed countries is significantly more efficient than those firms in selected developing countries of East Asia. The reason of lower firm efficiency in selected developing East Asia countries perhaps could be due to the challenges in institutional features, such as weak market for corporate control, high information asymmetry environment and underdeveloped capital market that affects the firm operation; in turn firm efficiency. Moreover, different efficiency problem occurs for the firms in selected developed and developing East Asia countries.

Finally, the paper finds that the large firms have experienced significantly higher mean TE as compared to small firms, probably because the large firms have higher competitive advantage and capability in investment on resources. Additionally, the results reveals that the large are generally exhibited DRS; while the small firms are generally showed IRS. The results therefore suggests that the large firms should reduce or not to increase their operation size to achieve the efficiency gains. On the other hand, the small firms might attain the efficiency benefits by increasing their size of operation via internal expansion or merger and acquisition.

The findings of the paper could generally significant to the firm management, policymakers, academicians and practitioners as the insights on the efficiency performance of firms in the selected East Asia countries. First, the firm management might benefit from considering whether expand or reduce their operation size in achieving the efficiency gains. Second, the policy-makers might benefit from the findings as the inputs on rules and regulation in enhancing the firm efficiency in developed and developing countries with different institutional context. Third, the findings might benefits to the academicians and practitioners in improving the current knowledge on firm efficiency especially in East Asia context.

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