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

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Abstract

The paper primarily aims to examine the firm efficiency or technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) in the selected developed and developing Asia-Pacific countries. The sample of this paper consists a sum of 700 firms in selected developed and developing Asia-Pacific countries over the periods from 2009-2015. The non-parametric Data Envelopment Analysis (DEA) based on the production approach is used to assess firm efficiency. On average, the results indicate that the firms in selected Asia-Pacific countries reveal the TE of 53.2per cent with input waste of 46.8per cent during the years 2009-2015. Furthermore, scale inefficiency (SIE) is the dominant source of inefficiency of firms in selected Asia-Pacific countries. The results also show that the large firms (the 350 largest firms) have exhibited higher mean TE as compared to small firms (the 350 smallest firms). Moreover, the results also shows that the large firms tend to operate at either constant return to scale (CRS) or decreasing return to scale (DRS) level. Whilst the small firms tend to operate at either CRS or increasing return to scale (IRS) level. Finally, the results also conclude that the firm in selected developed countries (300 firms) have exhibited higher mean TE than those firms in selected developing countries (400 firms) of the Asia-Pacific region.

Keywords: Firm efficiency, data envelopment analysis, Asia-Pacific, technical efficiency, pure technical efficiency, scale efficiency

1. INTRODUCTION

The Asia-Pacific (AP) region as named, encompasses the countries in Asia as well as the Pacific in a very large geographical area. This region has a wide diversity in terms of societies, cultures, economies, politics, religions, corporate governance models and etc. (Kimber & Lipton, 2005). Nevertheless, the interdependence among the countries in terms of the various natural resources, trade or business and finance has expanded the economy of the AP. The AP region has outpaced many other regional economies, and experienced a remarkable economic growth over the last four decades (Cubbage & Brooks, 2012). In other words, AP region therefore has become the essential leader of the growth of world economy (Lee & Heshmati (Eds.), 2009). Therefore, throughout the years, a great of attention has been paid by the practitioners and researchers on the countries of AP region context. Moreover, the AP region encompasses the developed and developing countries in Asia and Pacific with a wide diversity of institutional context (Kimber & Lipton, 2005). As a result, the average firm efficiency between the developed countries and developing countries could be differ (Jarboui, Pascal & Younes, 2013).

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Additionally, firm efficiency or technical efficiency (TE) plays significant roles in attaining the primary goals of firms. As denied by Farrell (1957), TE is the ability of a firm in generating the maximum outputs from a given combination of inputs or, the firms' ability of reducing the inputs to produce the same amount of outputs as on the efficient frontier. As accordance to the microeconomic theory of firms, profit maximization is the primary goal of firms (Cummins and Weiss, 2013). The objective of profit maximization of firms is being attained, only when firms are efficient (Primeaux and Stieber, 1994). In other words, without firm efficiency, the firms could not achieve the main goal in maximizing profit. As noted by Coelli, Rao, O'Donnell & Battese (2005), the production without the TE is costly. The reason is that the productive firms maximize the outputs without considering the efficient inputs usage or the exploitation of scales economies. Furthermore, firm efficiency is an important prerequisite for the market competitiveness (Bhandari & Ray, 2012). Therefore, it is then worthwhile to investigate the firm efficiency in the selected developed and developing countries of AP region.

For the sake of brevity, this 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 AP region over the periods 2009 to 2015, by employing the non-parametric DEA based on the production approach. The selected AP countries in this paper are Australia, Hong Kong, Japan, Malaysia, Indonesia, Thailand and Philippines. This is because these countries are the representations of each AP region with great diversity. To the best of our knowledge, the studies on the firm efficiency of multi-nations context is still underexplored, especially in AP context when concerning on the prior literature. This paper attempts to fill the literature gaps by investigating the firm efficiency by using a sample of multi-countries (700 firms in selected developed and developing AP countries) with recent data (2009-2015).

This paper discovers that the firms in selected AP countries exhibit the technical efficiency (TE) of 53.2per cent with input waste of 46.8per cent during the years 2009-2015, on average. Furthermore, scale inefficiency (SIE) is the dominant source of inefficiency of firms in selected AP countries as indicated by the decomposition of TE into PTE and SE. This paper also finds that the large firms (the 350 largest firms) have exhibited higher mean TE as compared to small firms (the 350 smallest firms). Moreover, this paper shows that the large firms tend to operate at either constant return to scale (CRS) or decreasing return to scale (DRS) level. Whilst the small firms tend to operate at either CRS or increasing return to scale (IRS) level. Finally, this paper also concludes that the average firm efficiency in selected developed AP countries (300 firms) is higher than in selected developing AP countries (400 firms).

This paper is organized as follows: the next section presents the literature review. Section 3 discusses the methodology and data. This paper presents the empirical findings in Section 4. Last section provides the conclusion.

2. LITERATURE REVIEW

2.1 Firm Efficiency or Technical Efficiency (TE)

The literature on efficiency has documented the efficiency of firms by performing either parametric by either parametric [e.g. SFA Stochastic Frontier Analysis (SFA), Distribution Free Approach (DFA) and Thick Frontier Approach (TFA)] or non-parametric [e.g. Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) analysis] frontier analysis (De Jorge Moreno & Sanz-Triguero, 2011; Al-Amri, Gattoufi & Al-Muharrami, 2012; Cummins & Weiss, 2013).

Throughout the years, prior literature that has been done on firm efficiency or TE based on single nation context, as correspondence to the importance of firm efficiency. By employing Stochastics Frontier Analysis (SFA) method, Charoenrat, Harvie & Amornkitvikai (2013) have examined the TE of Thailand manufacturing small and medium size enterprises (SMEs), due to the fact that the firm efficiency is essential to enhance the readiness of firms in facing the intense international competition. The scholars have found that the TE of the Thailand SMEs for the year 2007 (i.e. cross-sectional data) is low. Moreover, the TE for of the Russian manufacturing firms in low-priority sectors (e.g. wood, construction, materials and food processing) is relatively higher as compared to high-priority sectors (e.g. fuel, chemical and machine building) for the year 1992-1995 by using SFA method (Linz & Rakhovsky, 2011).

On the other hands, by using DEA method, Bhandari & Ray (2012) have examined the TE of firms in the Indian textile industry, along with the notion that the efficiency is an important prerequisite for the market competitiveness. The scholars have discovered that the technological differences across states do affect the TE of the firms. In addition, De Jorge Moreno & Sanz-Triguero (2011) have similarly investigated the TE of the Spanish retail sector by using DEA method. The scholars have shown that the TE of the retail sector is high over the year

1997-2007. Furthermore, by adopting a sample of insurance firms in Arab Gulf countries from 2005-2007, 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. The findings have suggested that the insurance firms should improve the firm efficiency. Mandal & Ghosh Dastidar (2014) have examined on the TE of insurance firms in India as well, yet went further during the recession period by employing DEA methodology. The scholars have pinpointed that the TE of public sector firms is comparatively higher than private sector firms during economic slowdown (2006-2010). In corporate finance literature, Yang, Chen, Long Kweh & Chi Chen (2013) study is one of the very few studies relates to firm efficiency by using DEA methodology. The scholars have pointed out that the agency problems on separation between ownership and control does detrimental to firm efficiency, by employing a sample of Taiwanese electronic firms during 2004-2010.

Instead of the single nation context, few studies has examined the firm efficiency by using a sample set of cross-countries particularly on developing countries. For example, Kinda, Plane & Veganzones-Varoudakis (2014) have noted that the firm-level TE in India and China (i.e. Asiatic region) are much lower as compared to the best performing developing countries such as Brazil and South-Africa, by examining the TE on a sample set of developing countries during the period of 2000-2006 by applying SFA method. Also, by examining the TE on a sample of Southeast Asia developing countries, See (2015) has discovered that the efficient of water utilities firms in Cambodia does note the highest scores, with the application of DEA method. Moreover, the prior firm efficiency studies that based on the multi-countries context have also done by considering both of the developed and developing countries as sample countries. Jarboui, Forget & Boujelbene (2014) have addressed the impact of managerial optimism on firm TE by adopting SFA method in multi-countries context. The scholars have evidenced that managerial optimism does reduce TE of sample firms in developed and developing countries from 2000 to 2011. Also, Jarboui, et al. (2013) have examined the TE of public road transport in a sample set of multi-countries during the period 2000 to 2011, by conducting the SFA method for the panel data. Interestingly, the scholars have indicated that in comparison to the developing countries, the average public road transport TE in developed countries is relatively higher during these twelve years. The scholars have further explained that the lower TE in developing countries could be resulted from the barriers in socio-economic, education, health and environment along with the low investment level in developing countries. The scholars have also found that TE of large size-operators is greater than small-size operators.

Taken collectively, the studies on firm efficiency or TE has been underexplored based on the context of multi-countries, particularly in the comparison between developed and developing countries. Furthermore, there is a gap from prior literature where the firm efficiency literature have not yet emphasized on the context of AP region, which is a significant economy that is leading the growth of world economy. In light of this literature gap, this paper attempts to look into the firm efficiency in the selected developed and developing countries of AP region. Past literature on firm efficiency in developed and developing countries provide an earlier indication for different efficiency level of firm in both developed and developing countries.

2.2 Overall Technical Efficiency, Pure Technical Efficiency and Scale Efficiency

Additionally, the past scholars have extended and decomposed the TE into components, specifically into pure technical efficiency (PTE) and scale efficiency (SE) in their empirical studies (Kabir Hassan, Sanchez & Ngene, 2012; Sharma, 2008; Kumar, 2011; Kundi & Sharma, 2016, Sahoo, 2016). As revealed by Mitra Debnath & Sebastian (2014), the efficiency could be divided into three: PTE, overall technical efficiency (OTE) and SE. Indeed, the source that leads to the domination of firm inefficiency could be identified by comparing the mean PTE and SE scores. Kabir Hassan, et al. (2012) have empirically revealed that the SE of the Middle East and North African micro financial institution has not considered as a problem, as both the PTE and SE mean scores are relatively high under the DEA methodology. Following Sharma (2008), the pure and SE of Indian cement firms are good as indicated by the high mean scores of both PTE and SE. Besides that, Kumar (2011) has acknowledged that the overall technical inefficiency of Indian state road transport undertakings in the year 2006-2007 has dominated by PTIE (or managerial inefficiency) instead of SIE, since the PTE mean score lower than SE mean score (and higher standard deviation of PTE than SE score) under the DEA methodology. Kundi & Sharma (2016) in their study has pointed out that the PTIE has dominated the overall technical inefficiency since the PTE less than SE mean score (and higher standard deviation of PTE than SE score) under the DEA methodology based on a sample of Indian glass firms. The scholars also have discovered that efficiency of small- and medium-scale firms is higher than large-scale firms. Consistently, the overall technical inefficiency of Indian software companies is mainly due to the PTIE as the PTE mean scores less than SE mean scores (Sahoo, 2016).

3. METHODOLOGY AND DATA

3.1 Data Selection and Data Sources

This paper collects the data from the firms in the three selected developed (i.e. Australia, Hong Kong and Singapore) and four developing countries (i.e. Malaysia, Indonesia, Thailand and Philippines) of the AP region over the periods 2009-2015. The sample firms is made up of total 700 firms from the seven selected AP countries, where 100 top firms are chosen from each country by referring to the most recent country stock market indices respectively. The primary data source for inputs and outputs variables for DEA is the Thomson Reuters DATASTREAM database. Thomson Reuters DATASTREAM indicates the data in the home currencies of the countries. Therefore, the data could be convert to same currency, which is US dollar (USD) for ensuring data standardization.

3.2 Research Method

3.2.1 Data Envelopment Analysis (DEA)

As in efficiency literature, the two prominent approaches to measure firm efficiency include the parametric (econometric) and non-parametric (mathematical programming) methods. The parametric method such as Stochastic Frontier Analysis (SFA) does assume estimation of an appropriate function (i.e. production function) using econometric method. On the other hands, the non-parametric method such as Data Envelopment Analysis (DEA) does not hold any assumption on the form of appropriate function, particularly production function; therefore prevents misspecification of functional form and yields accurate efficiency estimates with the presence of specification error (Charoenrat, et al., 2013; Cummins & Weiss, 2013).

This paper employs the non-parametric or mathematical programming DEA frontier analysis to examine the firm efficiency or TE. This is due to several strengths of DEA (Coelli, et al., 1998; Sufian, 2007; Charoenrat, et al., 2013; Kim, 2010; Cummins & Xie, 2008). Firstly, a single efficiency score is provided on each DMU that could enable the comparison and ranking among the DMUs by DEA method. Secondly, DEA could figure out the field that needed for improvement on each DMU (e.g. excessive inputs usage or low output production) in order to enhance firm efficiency, as DEA decomposes TE into PTE and SE. Thirdly, the efficiency of each DMU is being measured and compared with a set of most efficient firms under DEA approach. Therefore, the global leader might be identified among the DMUs by investigating the DMU with most appearance in the set. Fourthly, DEA does not required particular production function for efficiency frontier, inputs and outputs selection as well as distributional assumptions. Notable that such assumptions could create specification errors. Fifthly, DEA owns good statistical properties, given that DEA is a maximum likelihood estimations, Also, DEA estimators are consistent and converge faster than estimators from other frontier approaches.

As accordance to Farrell (1957), TE defines the ability of a firm to obtain maximum output from a given set of inputs. Basically, the firm efficiency or TE score is acquired by a maximum of a ratio of weighted outputs to weighted inputs. The more outputs that are generated from given inputs indicate the production is more efficient. Under DEA, each DMU is permitted to choose own set of proper weights that is comparatively favourable than other units in order to maximize firm efficiency (Charnes, Cooper & Rhodes, 1978). Following Bader, Mohamad & Hassan (2008), the efficiency measure can be defined as:

$$\text{Maximize efficiency of unit m} = \sum_{r=1}^{s} uyrm = 1$$

$$\text{Subject to } \sum_{i=1}^{p} vixim = 1$$

$$\sum_{r=1}^{s} uyrm - \sum_{i=1}^{p} vixim \leq 1 \text{ , m} = 1,2,\ldots\text{n}$$

$$ur \geq \varepsilon,\ r = 1,2,\ldots s$$
$$vi \geq \varepsilon,\ i = 1,2,\ldots p$$

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

Thus, the efficiency scores (TE) of the firms are ranged from 0 to 1. If the efficiency value of unit m is equal to 1, the DMU is fully efficient in employing the inputs to maximize outputs. Yet, if the efficiency value of unit m is less than 1, the DMU is relatively inefficient in employing the inputs to maximize outputs. Hence, this model could discover the combination of input and output weights that maximize the efficiency of DMU.

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

In this paper, the DEA with variable return to scale (VRS) model by Banker, Charnes & Cooper (1984) is adopted to measure the input-oriented TE of the firms. The model of Banker, et al. (1984) namely BCC model have improved CCR model by introducing the VRS. In fact, the model of Charnes, et al. (1978) namely CCR model does assume the constant return to scale (CRS) when all DMUs operate at optimal scale. CRS merely delivers on OTE following Sufian (2004). Yet, the VRS assumption under BCC model has pointed out that not all DMUs operate at optimal scale. Thus, the VRS delivers not only the pure technical efficiency (PTE) that emphasized on pure managerial efficiency of DMU, yet scale efficiency (SE) that focussed on scale or firm size efficiency. In other words, technical inefficiency (TIE) could be dominated either by pure technical inefficiency (PTIE) or scale inefficiency (SIE) (Coelli, Rao, & Battese, 1998; Sufian, 2004). Basically, SE of each period is measured as in the following (Rao, Kashani & Marie, 2010),

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

By employing both CRS and VRS methods, in case that there is differences in TE scores of a particular DMU, it indicates that the DMU has SIE. In simple words, SIE is computed by the differences between the PTE score and TE score (Coelli, et al., 1998). Indeed, the nature of SIE under VRS could be in the form of increasing return to scale (IRS) and decreasing return to scale (DRS) (Sufian, 2004). The IRS is referred to the higher percentage increases in outputs in relative to increase in inputs; while the DRS is referred to the lower percentage increases in outputs in relative to increase in inputs (Kundi & Sharma, 2016).

Figure 1 indicates the CRS and VRS frontiers in DEA. Under CRS assumption, the technical inefficiency of point B is the distance of BBc; while under VRS assumption, the technical inefficiency is only the distance of BBv. Thus, the SIE is the differences of BcBv. By conducting an additional DEA problem with non-increasing to scale (NRIS), the information whether a DMU is operating a field of increasing returns to scale (IRS) or decreasing returns to scale (DRS) is provided. The differences between NIRS TE and VRS TE score determines the nature of SIE due to either IRS or DRS. If VRS TE @ PTE is different from NRIS TE, the DMU therefore is operating at IRS (point B); if the VRS TE @ PTE is equal from NRIS TE, the DMU therefore is operating at DRS (point D).

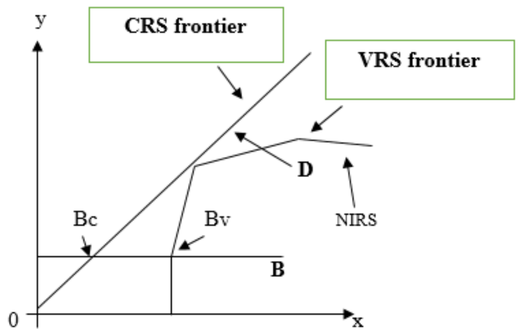

Figure 1. CRS and VRS frontier in DEA

3.3 Choice of Inputs and Outputs in DEA

The main variables for DEA approach that incorporate under DEA are the inputs and outputs for firm efficiency or TE. Nevertheless, the definition on inputs and outputs is still arguable and arbitrary as in prior economic literature (Ariff & Can, 2008; Sufian, 2007). Indeed, there are several significant approaches to define outputs and inputs such as value added, intermediation and production approach (Sealey & Lindley, 1977). The studies on manufacturing and service firms are mostly depending on production approach in selecting inputs and outputs such as Bhandari & Ray (2012), Castiglione & Infante (2014), Jarboui, et al., (2013), Charoenrat, et al. (2013), Demirbag, McGuinness, Akin, Bayyurt & Basti (2016), etc. In this paper, the production approach is preferable in choosing the inputs and outputs, since the sample firms are commonly the producer of products and services for users.

Therefore, this paper selects three inputs and a single output (Table 1). The selection of the inputs and outputs variable is according to Ariff & Can (2008) and the major studies on the firm efficiency (Jarboui, et al., 2013; Castiglione & Infante, 2014; Demirbag, et al., 2016). The three input vector variables consist of x1: capital (measured by the total property, plant and equipment; namely physical assets and total intangible assets); x2: labor (measured by total number of employees) and x3: operating expenses (measured by total operating expenses, which represent the sum of expenses in relation to operation including cost of goods sold, selling and general maintenance and administration expenses) and a single output of y1: sales (measured by net sales). The rule of thumb on number of inputs and outputs selection, $n \geq \max \{m \times s, 3(m + s)\}$, where n is the number of DMUs; m is the number of inputs; and s is the number of outputs, as noted by Cooper, Seiford & Tonr (2002). Given the total number of DMUs (firms) in the paper is 700 (n=700), n is more than the number of inputs and outputs variables {3 inputs x 1 outputs, 3(3 inputs + 1 output)} = (3, 12), which is complied with rule of thumb and considered as valid.

Table 1 summarizes the inputs and outputs for firms in selected AP countries. From Table 2, the results reveal that the mean of input capital, labor and operating expenses for firms in developed countries are higher than the firms in developing countries (capital: US$4670.76 mil vs US$766.81mil; labor: 19501 vs 5313; operating expenses US$7185.82mil vs US$920.43mil) during period 2009 to 2015. Likewise, the mean of output sales for the firms in developed countries is higher than the firms in developing countries (sales: US$7776.50mil vs US$997.66mil) from 2009 during the period 2009 to 2015.

Table 1. Variables of Outputs and Inputs

Variable	Symbol	Name of Variable
Output	y1	Sales
Inputs	x1	Capital
	x2	Labor
	x3	Operating Expenses

Table 2. Summary Statistics of Variable Inputs and Outputs in DEA Model

	Mean	Minimum	Maximum	Standard Deviation
Inputs				
Firms in Developed Countries 2009-2015				
Capital (x1) (USD mil)	4670.76	0.000	238484.60	16879.05
Labor (x2)	19501	1	552810	53700
Operating Expenses (x3) (USD mil)	7185.82	0.40	602161.68	34832.19
Firms in Developing Countries 2009-2015				
Capital (x1) (US$ mil)	766.81	0.000	18094.42	1734.74
Labor (x2)	5313	0	156097	11487
Operating Expenses (x3) (USD mil)	920.43	-3.15	17917.30	2006.40
Firms in All Countries 2009-2015				
Capital (x1) (US$ mil)	2479.69	0.000	238484.60	11419.78
Labor (x2)	11621	0	552810	37480
Operating Expenses (x3) (USD mil)	3672.39	-3.15	602161.69	23338.71
Outputs				
Firms in Developed Countries 2009-2015				
Sales (y1) (USD mil)	7776.50	-2.30	606743.27	35901.01
Firms in Developing Countries 2009-2015				
Sales (y1) (USD mil)	997.66	0.000	20034.14	2149.25
Firms in All Countries 2009-2015				
Sales (y1) (USD mil)	3925.49	-2.30	606743.27	23883.63

Notes: x1: Capital (the total property, plant and equipment; namely physical assets and total intangible assets), x2: Labor (total number of employees), x3: Operating expenses (total operating expenses, which represent the sum of expenses in relation to operation including cost of goods sold, selling and general maintenance and administration expenses), y1: Sales (net sales).

4. RESULTS AND FINDINGS

4.1 Efficiency of the Firms in Selected Asia-Pacific (AP) Countries

Table 3 demonstrates the mean efficiency scores for firms in selected AP countries (700 firms) for the years 2009 to 2015. According to the Figure 2, the mean technical efficiency (TE) scores for firms in selected AP countries indicate a fluctuation trend from 52.9per cent in year 2009 yet eventually rising to 59.3per cent in year 2015. Following the results for all firms in all years (Panel H) of Table 3, the firms in selected AP countries reveal the mean TE of 53.2per cent with input waste of 46.8per cent during the years 2009-2015. Moreover, SIE (27.6per cent) is the dominant source of inefficiency of firms in selected AP countries rather than PTIE (26.1per cent). As implied by the results, the firms in selected AP countries could produce the same amount of outputs by using only 53.2per cent of the amount of inputs. In other words, the firms in selected AP countries could reduce the amount of inputs with 46.8per cent by producing the same amount of outputs. In short, throughout the years 2009-2015, the firms in selected AP countries have not been operating at a relatively optimal scale of efficiency, even though they have been managerially efficient to exploit their resources fully.

Table 3. Summary Statistics of Efficiency Scores for Firms in Selected Asia-Pacific (AP) Countries (2009–2015)

Efficiency Measures	No. DMUs	Mean	Minimum	Maximum	Standard Deviation
Panel A: All Firms 2015					
Technical Efficiency	700	0.593	0.002	1.000	0.2586
Pure Technical Efficiency	700	0.774	0.096	1.000	0.2232
Scale Efficiency	700	0.763	0.002	1.000	0.2490
Panel B: All Firms 2014					
Technical Efficiency	700	0.631	0.006	1.000	0.2300
Pure Technical Efficiency	700	0.796	0.049	1.000	0.1892
Scale Efficiency	700	0.803	0.006	1.000	0.2335
Panel C: All Firms 2013					
Technical Efficiency	700	0.538	0.008	1.000	0.2520
Pure Technical Efficiency	700	0.728	0.077	1.000	0.2436
Scale Efficiency	700	0.750	0.017	1.000	0.2435
Panel D: All Firms 2012					
Technical Efficiency	700	0.504	0.003	1.000	0.2930
Pure Technical Efficiency	700	0.728	0.031	1.000	0.2635
Scale Efficiency	700	0.701	0.004	1.000	0.2936
Panel E: All Firms 2011					
Technical Efficiency	700	0.434	0.001	1.000	0.2986
Pure Technical Efficiency	700	0.692	0.056	1.000	0.2853
Scale Efficiency	700	0.637	0.001	1.000	0.3044
Panel F: All Firms 2010					
Technical Efficiency	700	0.496	0.000	1.000	0.2990
Pure Technical Efficiency	700	0.704	0.062	1.000	0.2783
Scale Efficiency	700	0.710	0.000	1.000	0.2932
Panel G: All Firms 2009					
Technical Efficiency	700	0.529	0.000	1.000	0.2931
Pure Technical Efficiency	700	0.755	0.065	1.000	0.2510
Scale Efficiency	700	0.703	0.000	1.000	0.2922
Panel H: All Firms All Years					
Technical Efficiency	4900	0.532	0.000	1.000	0.2822
Pure Technical Efficiency	4900	0.739	0.031	1.000	0.2518
Scale Efficiency	4900	0.724	0.000	1.000	0.2783

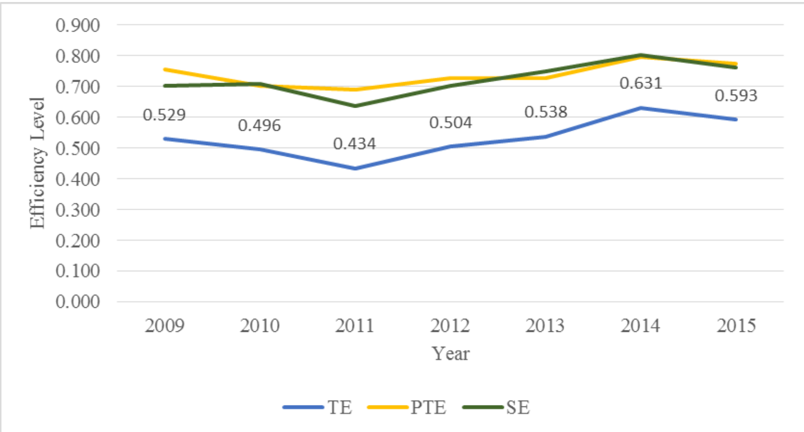

Figure 2. Firm Efficiency in Selected Asia-Pacific (AP) Countries 2009-2015

4.2 Efficiency of the Large VS Small Firms in Selected Asia-Pacific (AP) Countries

Table 4 summarizes the efficiency scores of large (350 largest firms) and small (350 smallest firms) firms in selected AP countries for years 2009 to 2015. Based on Table 4, the mean TE scores for large firms indicates a fluctuation trend from 63.4per cent in year 2009 yet eventually rising to 64.8per cent in year 2015. While the mean TE scores for small firms also indicates a fluctuation trend from 42.2per cent in year 2009 but finally increasing to 53.7per cent in year 2015. From the mean TE scores for all firms in all years (Panel H of Table 4), the results reveals that the large firms have exhibited higher mean TE (59.5per cent vs 46.9per cent), PTE (79.5per cent vs 68.3per cent) and SE (74.6per cent vs 70.2per cent) as compared to small firms. The reason could be the large firms are more competitive advantage and capable in investment on resources, as suggested by Jarboui, et al., (2013). Table 5 shows the robustness tests. The results from parametric t-test and non-parametric Mann-

Whitney test suggest that the large firms have exhibited higher mean TE than small firms (0.595 > 0.469) and significantly different at 1per cent. Likewise, the large firms have also exhibited a higher mean PTE (0.795 > 0.683) and SE (0.746 > 0.702) as compared to the small firms and significantly different at 1per cent. The results from the parametric t-test are further confirmed by the non-parametric Mann-Whitney and Kruskall-Wallis tests. In short, the study concludes that the large firms are more efficient than small firms in the selected AP countries since the results on the efficiencies are significant at 1per cent.

Table 4. Summary Statistics of Efficiency Scores for Large VS Small Firms in Selected Asia-Pacific (AP) Countries (2009–2015)

Efficiency Measures	Large Firms		Small Firms	
	No. DMUs	Mean	No. DMUs	Mean
Panel A: All Firms 2015				
Technical Efficiency	350	0.648	350	0.537
Pure Technical Efficiency	350	0.832	350	0.715
Scale Efficiency	350	0.779	350	0.748
Panel B: All Firms 2014				
Technical Efficiency	350	0.636	350	0.625
Pure Technical Efficiency	350	0.812	350	0.780
Scale Efficiency	350	0.788	350	0.818
Panel C: All Firms 2013				
Technical Efficiency	350	0.553	350	0.524
Pure Technical Efficiency	350	0.778	350	0.679
Scale Efficiency	350	0.713	350	0.787
Panel D: All Firms 2012				
Technical Efficiency	350	0.582	350	0.426
Pure Technical Efficiency	350	0.783	350	0.672
Scale Efficiency	350	0.741	350	0.662
Panel E: All Firms 2011				
Technical Efficiency	350	0.529	350	0.338
Pure Technical Efficiency	350	0.765	350	0.617
Scale Efficiency	350	0.681	350	0.592
Panel F: All Firms 2010				
Technical Efficiency	350	0.586	350	0.405
Pure Technical Efficiency	350	0.781	350	0.625
Scale Efficiency	350	0.744	350	0.676
Panel G: All Firms 2009				
Technical Efficiency	350	0.634	350	0.422
Pure Technical Efficiency	350	0.815	350	0.694
Scale Efficiency	350	0.776	350	0.629
Panel H: All Firms All Years				
Technical Efficiency	2450	0.595	2450	0.469
Pure Technical Efficiency	2450	0.795	2450	0.683
Scale Efficiency	2450	0.746	2450	0.702

Table 5. Robustness tests for Efficiency Scores of Large and Small Firms in Selected Asia-Pacific (AP) 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						
Largest Firms	0.595	16.286***	2766.77	-15.654***	2766.77	245.039***
Smallest Firms	0.469		2134.23		2134.23	
Pure Technical Efficiency						
Largest Firms	0.795	16.000***	2717.55	-13.303***	2717.55	176.964***
Smallest Firms	0.683		2183.45		2183.45	
Scale Efficiency						
Largest Firms	0.746	5.958***	2517.11	-3.297***	2517.11	10.873***
Smallest Firms	0.702		2383.89		2383.89	

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

4.3 Scale Inefficiency on Increase Returns to Scale and Decrease Returns to Scale

Table 6 and 7 illustrates the scale inefficiency on constant return to scale (CRS), increase returns to scale (IRS) and decrease returns to scale (DRS) for the large (350 largest firms) and small (350 smallest firms) firms in selected AP countries from years 2009 to 2015, respectively. Based on Table 6, the results show the large firms (the 350 largest firms) tend to operate at 11per cent of CRS or 73per cent of DRS level. The results imply that the large firms in selected AP countries have been operating above their optimal scale size. Therefore, the large firms might reduce their operation size to achieve the efficiency gains. On the other hand, following Table 7, the results show the small firms (the 350 smallest firms) tend to operate at 11per cent of CRS or 59per cent of IRS level. The results imply that the small firms in selected AP countries have been operating below their optimal scale size. Hence, the small firms could attain the efficiency benefits by expanding their size of operation. The findings are consistent with the study of Aghimien, Kamarudin, Hamid & Noordin (2016). To review, Aghimien, et al. (2016) have revealed 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 Asia-Pacific (AP) 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	86	10608158.68	14	23	48	13	13	60	8	15	63	8	21	57	5	5	76
AUS	68	4325469.35	7	5	56	12	11	45	9	3	56	8	6	54	8	2	58
SG	47	3165218.16	5	13	28	6	5	36	4	9	34	4	11	32	9	20	18
MAL	45	1263301.65	3	4	34	3	13	29	4	6	35	3	5	37	5	5	35
THA	36	949162.29	4	1	29	3	5	27	3	4	28	2	6	27	4	1	31
INDO	45	881690.75	5	26	14	4	6	35	4	4	37	5	1	39	4	4	37
PHI	23	635110.09	4	3	14	3	5	15	2	10	11	3	4	16	4	2	17
TOTAL	350																

Table 6. Scale Inefficiency of the Large Firms in Selected Asia-Pacific (AP) Countries (2009–2015) (*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	86	10608158.68	6	4	76	7	8	71	61	89	451	10	15	75
AUS	68	4325469.35	12	9	47	10	7	51	66	43	367	14	9	77
SG	47	3165218.16	5	9	33	8	7	32	41	74	213	13	23	65
MAL	45	1263301.65	3	5	37	4	21	20	25	59	227	8	19	73
THA	36	949162.29	5	4	27	2	1	33	23	22	202	9	9	82
INDO	45	881690.75	4	3	38	3	5	37	29	49	237	9	16	75
PHI	23	635110.09	3	9	11	5	1	17	24	34	101	15	21	64
TOTAL	350	MEAN										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; AUS is Australia; SG is Singapore; MAL is Malaysia; THA is Thailand; INDO is Indonesia and PHI is Philippines.

Table 7. Scale Inefficiency for the Small Firms in Selected Asia-Pacific (AP) Countries (2009–2015)

Country 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
SG	53	104717.09	2	33	18	2	23	28	3	24	26	1	27	25	2	51	0
AUS	32	87456.25	7	17	8	6	18	8	5	12	15	4	14	14	3	15	14
MAL	55	86770.19	6	13	34	4	31	19	3	24	27	3	17	34	11	24	20
INDO	55	86418.91	2	48	2	21	14	19	9	28	17	3	17	34	5	25	25
THA	64	82544.68	5	36	19	4	46	12	2	48	13	4	48	12	4	44	16
PHI	77	78772.23	5	57	8	6	61	7	4	69	2	4	65	7	6	48	23
HK	14	28462.30	3	8	3	5	4	5	3	8	3	4	7	3	3	5	6
TOTAL	350																

Table 7. Scale Inefficiency for the Small Firms in Selected Asia-Pacific (AP) Countries (2009–2015) (*cont.*)

Country 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
SG	53	104717.09	2	24	27	1	31	21	32	126	66	14	56	29
AUS	32	87456.25	4	24	4	3	26	3	21	46	31	21	47	32
MAL	55	86770.19	5	50	0	3	51	1	50	189	140	13	50	37
INDO	55	86418.91	5	23	27	5	34	16	35	210	135	9	55	36
THA	64	82544.68	5	43	16	3	28	33	40	414	72	8	79	14
PHI	77	78772.23	9	67	1	6	47	24	13	213	145	4	57	39
HK	14	28462.30	1	7	6	2	7	5	27	293	121	6	66	27
TOTAL	350	MEAN										11	59	31

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; AUS is Australia; SG is Singapore; MAL is Malaysia; THA is Thailand; INDO is Indonesia and PHI is Philippines.

4.4 Efficiency of the Firms in Selected Developed VS Developing Asia-Pacific (AP) Countries

Table 8 displays the efficiency scores of firms in selected developed (300 firms) VS developing (400 firms) AP countries for years 2009 to 2015, respectively. Based on Table 8, the mean TE scores for firms in selected developed AP countries indicates a fluctuation trend from 64.8per cent in year 2009 yet eventually reducing to 62.6per cent in year 2015. While the mean TE scores for firms in selected developing AP countries indicates a fluctuation trend from 43.5per cent in year 2009 but finally rising to 56.8per cent in year 2015. From the mean TE scores for all firms in all years (Panel H of Table 8), different efficiency problem arises for the firms in selected developed and developing AP countries. In particular, although the firms in the developed AP countries have been operating at a relatively optimal scale of efficiency, they have not been managerial efficient to exploit their resources fully (where, PTIE=24.0per cent > SIE=22.1per cent). Yet, although the firms in the developing AP countries have not been operating at a relatively optimal scale of efficiency, they have been managerially efficient to exploit their resources fully (where, SIE = 31.8per cent > PTIE=27.6per cent). Moreover, the results reveals that the firms in selected developed AP countries have exhibited higher mean TE (59.0per cent vs 48.8per cent), PTE (76.0per cent vs 72.4per cent) and SE (77.9per cent vs 68.2per cent) in relative to the firms in selected developing AP countries. The reason of lower firm efficiency in selected developing AP countries could be due to the challenges in institutional features, i.e. weak market for corporate control, high information asymmetry environment, underdeveloped capital market, etc. that could influence the firm operation, which in turn affect firm efficiency (Jarboui, et al., 2013; Gibson, 2003). Table 9 shows the robustness tests. The results from parametric t-test and non-parametric Mann-Whitney test suggest that the firms in selected developed AP countries have exhibited higher TE than firms in selected developing AP countries (0.590 > 0.488) and significantly different at 1per cent. Similarly, the firms in selected developed AP countries have also exhibited a higher mean PTE (0.760 > 0.724) and SE (0.779 > 0.682) as compared to the firms in selected developing AP countries and significantly different at 1per cent. The results from the parametric t-test are further confirmed by the non-parametric Mann-Whitney and Kruskall-Wallis tests. In short, the study concludes that the firms in selected developed AP countries are more efficient than firms in selected developing AP countries since the results on the efficiencies are significant at 1per cent.

Table 8. Summary Statistics of Efficiency Scores for Firms in Selected Developed VS Developing Asia-Pacific Countries (2009–2015)

Efficiency Measures	Firms in Developed Countries		Firm in Developing Countries	
	No. DMUs	Mean	No. DMUs	Mean
Panel A: Firms in Selected Developed Countries 2015				
Technical Efficiency	300	0.626	400	0.568
Pure Technical Efficiency	300	0.802	400	0.752
Scale Efficiency	300	0.789	400	0.744
Panel B: Firms in Selected Developed Countries 2014				
Technical Efficiency	300	0.598	400	0.656
Pure Technical Efficiency	300	0.777	400	0.810
Scale Efficiency	300	0.781	400	0.820
Panel C: Firms in Selected Developed Countries 2013				
Technical Efficiency	300	0.478	400	0.584
Pure Technical Efficiency	300	0.697	400	0.752
Scale Efficiency	300	0.707	400	0.783
Panel D: Firms in Selected Developed Countries 2012				

Technical Efficiency	300	0.605	400	0.428
Pure Technical Efficiency	300	0.756	400	0.706
Scale Efficiency	300	0.802	400	0.625
Panel E: Firms in Selected Developed Countries 2011				
Technical Efficiency	300	0.557	400	0.341
Pure Technical Efficiency	300	0.739	400	0.655
Scale Efficiency	300	0.745	400	0.554
Panel F: Firms in Selected Developed Countries 2010				
Technical Efficiency	300	0.621	400	0.401
Pure Technical Efficiency	300	0.772	400	0.651
Scale Efficiency	300	0.795	400	0.645
Panel G: Firms in Selected Developed Countries 2009				
Technical Efficiency	300	0.648	400	0.435
Pure Technical Efficiency	300	0.774	400	0.740
Scale Efficiency	300	0.836	400	0.598
Panel H: Firms in Selected Developed Countries All Years				
Technical Efficiency	2100	0.590	2800	0.488
Pure Technical Efficiency	2100	0.760	2800	0.724
Scale Efficiency	2100	0.779	2800	0.682

Table 9. Robustness Tests for Efficiency Scores of Firms in Selected Developed and Developing Asia-Pacific (AP) 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	0.590	16.286***	2766.77	-15.654***	2766.77	245.039***
Developing Countries	0.488		2134.23		2134.23	
Pure Technical Efficiency						
Developed Countries	0.760	16.000***	2717.55	-13.303***	2717.55	176.964***
Developing Countries	0.724		2183.45		2183.45	
Scale Efficiency						
Developed Countries	0.779	5.958***	2517.11	-3.297***	2517.11	10.873***
Developing Countries	0.682		2383.89		2383.89	

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

5. CONCLUSION

This paper examines the firm efficiency or technical efficiency (TE), pure technical efficiency (PTE) and scale efficiency (SE) in the selected developed and developing Asia-Pacific (AP) countries over the periods from 2009-2015, by employing the non-parametric Data Envelopment Analysis (DEA) based on the production approach. This paper discovers that the efficiency of firms in selected AP countries have exhibited only 53.2per cent, on average. The firms could therefore reduce the amount of inputs with 46.8per cent by producing the same amount of outputs. Furthermore, the firms in selected AP countries have been managerially efficient to exploit their resources fully. Nevertheless, they have not been operating at a relatively optimal scale of efficiency.

As implied by the results, the large firms (the 350 largest firms) have exhibited higher mean TE as compared to small firms (the 350 smallest firms). The reason could be the large firms are more competitive advantage and capable in investment on resources. Moreover, the results also shows that the large firms tend to operate at either constant return to scale (CRS) or decreasing return to scale (DRS) level. Whilst the small firms tend to operate at either CRS or increasing return to scale (IRS) level. Therefore, the large firms are advised to reduce or not to increase their operation size (for example, involves in merger and acquisition) to achieve the efficiency gains. On the other hand, the small firms are advised to attain the efficiency benefits by expanding their size of operation (for instances, internal expansion).

Finally, the results also conclude that the average firm efficiency in selected developed AP countries (300 firms) is higher than in selected developing AP countries (400 firms). The reason of lower firm efficiency in selected developing AP countries could be due to the challenges in institutional features, such as weak market for corporate control, high information asymmetry environment, underdeveloped capital market, etc. that affects the firm operation, which in turn influence the firm efficiency. Moreover, different efficiency problem arises for the firms in selected developed and developing AP countries. The firms in the developed AP countries have not been managerial efficient to exploit their resources fully, while the firms in the developing AP countries have not been operating at a relatively optimal scale of efficiency.

Overall, the findings of this paper is significant to the firm management, policy-makers, academicians and practitioners as the insights on the efficiency performance of firms in the selected AP countries. First, the firm management might benefit from considering whether expand or reduce their operation size in attaining the efficiency benefits. Second, the policy-makers might benefits from the findings as the inputs to enhance rules and regulation in improving the firm efficiency in developed and developing countries that display different institutional context. Third, the findings might benefits to the academicians and practitioners in enhancing the current knowledge on firm efficiency in the selected AP countries.

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