Efficiency and Total Factor Productivity Growth: Study on Malaysia 4IR Related Service Sector

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Abstract

The Fourth Industrial Revolution (4IR) has become a major research interest at nation and industry level as preparations to keep pace with it. 4IR basically is the development of disruptive technologies and trends such as the Internet of Things, robotics, virtual reality and artificial intelligence. The objective of this paper is to determine the readiness of Malaysia 4IR related service sector in facing the revolution by evaluating the efficiency of the industry. The first part of this paper aims to evaluate the technical efficiency of 4IR related service sector in Malaysia using Data Envelopment Analysis (DEA) for years from 2010 to 2014. Second part of this paper aims to employ DEA-Malmquist index to determine total factor productivity (TFP) growth in these 4IR related service sector using panel data from year 2000 to 2014. Results of DEA multi stages analysis shows that in overall, Malaysia's 4IR related service sectors' efficiency score is 89 percent, which is relatively high. Result of DEA-Malmquist index, TFP growth of the selected service industry is 1.9 percent, the improvement in technical change of 1.8 percent contribute the most to the positive TFP growth. On the other hand, TFP growth dampened by scale efficiency change.

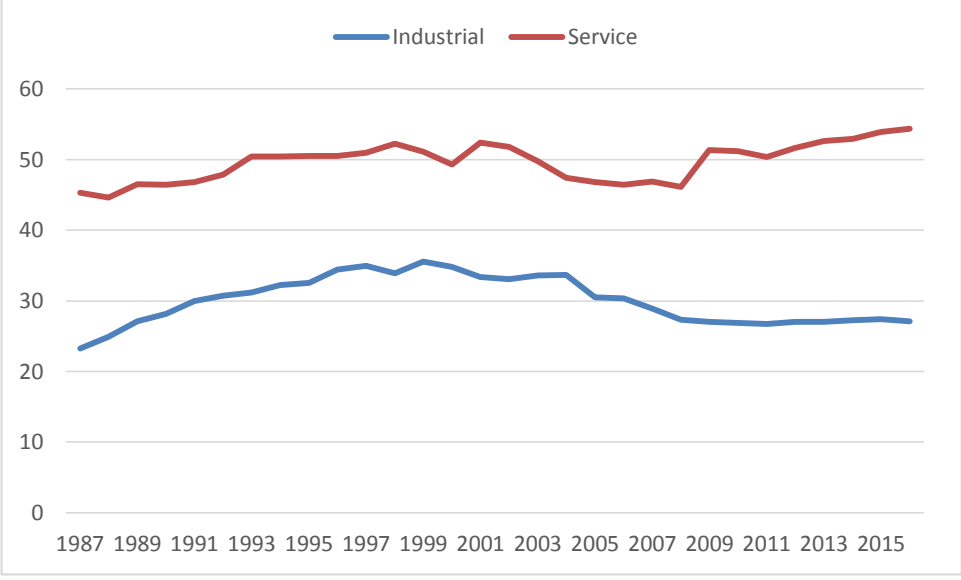
Keywords: technical efficiency, fourth industrial revolution, service sector, DEA

Introduction

Industrial has been the main focus for most of developing countries to achieve rapid economic growth as it is regarded as the engine of economic and social development. Industrial sector or secondary sector is one of the 3 sectors that make up a country's economy. The other two are the primary sector (includes agriculture, fishing, and mining) and service sector (includes hospitality, consultancy and nursing). Secondary sector is one that makes a complete product which can then be utilized. Examples of industrial sector are manufacturing industry and construction. Service sector serve as the support industry for industrial, for example transportation, logistics, ICT and accounting), thus service sector becomes the main income source of a nation's gross domestic product.

Malaysia is a good example of a developing countries which transforming into developed country through industrialization and the advancement of service sector in the post-industrialization era. During years 70's, the government focus on import-substituion industries and labour-oriented industries. In the 80's, heavy industry was developed in order to enhance nation's industrialization and increase people's skills in high technology. In 1986, Industrialization Blueprint had been announced with three aims: 1) to make manufacturing sector as catalyst for nation's industrialization growth; 2) to make full use of nation's natural resources and 3) to enhance domestic's level of research and development in technology. In conjunction of the industrial development, service sector grows and become the main contributor of Malaysia's GDP. Figure 1 shows the comparison of percentage of industrial sector (manufacturing and construction) and service sector (Utilities, Wholesale and Retail Trade, Accommodation, Food and Beverage, Transport, Storage, Information and Communication, Finance, Insurance, Real Estate and Business Services; Government Services). Service sector contributes around 45 percent to 54 percent while industrial sector contributes around 23 percent to 35 percent during year 1987 to 2016. The share of GDP contributed by service sector is increasing more rapidly compared to industrial sector.

Figure 1: Share of contribution on GDP



Source: Department of Statistics, 2017

Malaysia as an industrial economy is experiencing the Industrial Revolution, which is a worldwide phenomenon. Over the course of history, mankind has perfected its industry by not only relying on technical evolution but also by reinventing it as new resources have created new technical means. Therefore, industry has benefited from qualitative advancements which have sometimes been so ingrained in a certain time period and have had such an overwhelming impact that we have dubbed them "revolutions". The first evolution started at 1765 and spans to the beginning of the 19th century. During the period, mechanization replaced agriculture with industry as the foundations of the

economic structure of society. It is based on mechanical production equipment which powered by water and steam power. The second industrial revolution started around year 1870. New source of energy, i.e. electricity, gas and oil emerged and used by the development of combustion engine. Besides, the development of steel industry, chemical synthesis, invention of telegraph, telephone, automobile and the plane. All these inventions were made possible by centralizing research and capital structured around an economic and industrial model based on mass production and the organizational models of production. The third industrial revolution appeared at 1969 with the emergence of nuclear energy. This revolution witnessed the rise of electronics, telecommunications and computers. This gave rise to the era of high-level automation in production in industry. Now the industry have entered the fourth industrial revolution which builds upon the third revolution and the digital revolution that has been taking place since the middle of the last century. This fourth revolution with exponential expansion is characterized by merging technology that blurs the lines between the physical, digital and biological spheres to completely uproot industries all over the world. The extent and depth of these changes are a sign of transformations to entire production, management and governance systems. The industry of today and tomorrow aim to connect all production means to enable their interaction in real time. Factories 4.0 make communication among the different players and connected objects in a production line possible thanks to technology such as Cloud, Big Data Analytics and the Industrial Internet of Things.

In short, the first industrial revolution used water and steam to mechanize production, the second used electric energy to create mass production and the third used electronics and information technology to automate production. The fourth industrial revolution (4IR) is about cyber physical systems, internet of things and network. It not only having impact on industry, but also government and individual. Firstly, industry players need to re-examine the way they do business. They need to understand their changing environment, challenge the assumptions of their operating teams, and relentlessly and continuously innovate. Secondly, the ability of government systems and public authorities to adapt will determine their survival. If they prove capable of embracing a world of disruptive change, subjecting their structures to the levels of transparency and efficiency that will enable them to maintain their competitive edge, they will endure. If they cannot evolve, they will face increasing challenges. Thirdly, individual needs to keep upgraded in order to get along with the changes and equip themselves with necessary knowledge in skills to survive. Thus, the 4IR related service industry must be ready to provide competitive and efficient service to ensure the nation is able to catch up with the worldwide progression. Hence, the objective of this study is to examine the technical efficiency and productivity growth of 4IR related service sector, namely 1) telecommunications service; 2) computer service; 3) Programming and broadcasting services; 4) Information services activities and 5) Engineering services. The structure of this paper is organized as follow. Section 2 provides a short review of the literature and past studies that applied DEA method to measure efficiency and TFP growth. Section 3 presents the non-parametric method

applied in this paper. The empirical results are discussed in Section 4, and finally Section 5 summarizes and concludes.

Literature Review

Technical efficiency and productivity growth has been estimated at sectoral level for different types of industries using both parametric and non-parametric method. Stochastic Frontier Analysis (SFA) is performed in parametric method while Data Envelopment Analysis (DEA) is applied in non-parametric method. This paper applied non-parametric DEA method, which has been done for service sector in a number of countries. Fukao (2010) examines the productivity performance (TFP) of Japan's service and the importance of enhancing Japan's service sector. He concluded that TFP growth in the service sector is lower than manufacturing sector, which is found much higher than the other sectors. Besides, productivity growth in the service sector is the main key for Japan's economic growth. Cunha and Rocha (2012) measured the technical efficiency in higher education services sector in Portugal. They found that higher education institution in Portugal were less efficient in overall and there were waste in resources. Sanjeev (2007) applied the DEA method to evaluate the efficiency of 68 hotels and restaurant companies operating in India. Result of the study found that the average score for all the companies was quite high (0.73), indicating the hospitality industry was doing well. Maletic et al. (2013) employed two DEA models with different input-output indicators to measure the efficiency of banks in Serbia. They found that banks from public sector were the most efficient and superefficient. Navarro and Martin (2011) applied non-parametric techniques to evaluate technical efficiency of total sectors, total services and 16 categories in OECD countries in 2006. They found that the average efficiency level in the aggregated service sector is around 57 percent with Estonia, Luxemburg, United States and Mexico being the leading countries in the total services efficiency rankings.

Several studies on Malaysia services reports that the TFP growth is positive. Chandran and Veera (2008) examines 20 service industries for the period of year 1987 to 1992. Their DEA analysis shows that the selected industries experienced positive TFP growth of 1.8 percent. Technical efficiency was the contributing factor while technological change dampen the growth. Susila (2009) assesses the impact of ownership on water supply entities performance by applying DEA method. Result shows that there is variations of efficiency for different types of ownership and different service areas. On overall, private entities perform better than public entities in term of technical efficiency. Another study on water supply service conducted by Norbaizura et al. (2014). They evaluate efficiency and effectiveness of water supply service industry in Malaysia. Their main finding is that water supply service in most of the 14 states in Malaysia is efficient but only three states are efficient and effective in production and distribution of water to consumers.

Jajri (2011) focuses on five service industries: advertising agencies, accommodation services, real estate agents, real haulage and stock, share, commodity

brokers and foreign exchange services. Using data from 1986 to 2007, he found that TFP growth is positive and mainly due to the improvement in technical efficiency. On the other hand, technological change dampened the TFP growth. Besides, result from second estimation of output function shows that capital and labour growth as well technological change contribute positively to service sector output growth. However, TFP growth do not significantly affect the output growth of three service industry. Shazali and Alias (2000) measures the productivity of the insurance industry by employing the non-parametric Malmquist Index method. The technical efficiency index obtained from DEA analysis for period of 1987 to 1997 indicates that the industry is 72.6 percent efficient in overall. They also found that the productivity growth is relatively low compared to Malaysia real economic growth. The results also suggest that both technical efficiency and technical progress contribute to the overall productivity growth of the industry. Baharin and Isa (2013) measured the relationship between efficiency and organisational structure for Takaful and insurance operators in Malaysia's dual financial system. Their sample consisting of 19 firms, chosen between year 2002 and 2010, applying Stochastic cost Frontier Analysis approach. It was found that Takaful has a lower cost efficiency than conventional insurance. In addition, the level of efficiency scores for both life insurance and Takaful do not vary across time.

Lee et al. (2011) studied the impact of privatization in Malaysia's telecommunications sector and on the performance of the national telecommunication company (TM). They also examined the impact of regulatory changes on the business performance of TM. Employing the DEA analysis, the results supported that privatization had led to a better performance for TM. There were notable post-privatization efficiency and productivity gains. Saharawati et al. (2015) measured the level of technical efficiency in the private higher education services sector in Malaysia for the year of 2010. Besides, they also further analyse the level of technical efficiency using cross tabulation and chi-square test with the size of operational of sample and their capital intensity. Their DEA results shows that more medium-and-large-sized as well as capital intensive sample are operating at a higher level of technical efficiency than small-sized and less capital intensive samples. Fadzlan et al. (2016) analysed the efficiency of the Malaysian banking sector by utilizing DEA method to compute the efficiency of individual banks during the period 1999 to 2008. They also applied bootstrap regression to examine the impact of origins on bank efficiency. DEA results indicate that the Malaysian banking sector exhibited increase in efficiency over the sample period. Besides, banks from Asian countries are found to be relatively more efficient compared to foreign banks from other regions and their domestic bank peers.

In general, past study on Malaysia service sectors have widely done. DEA is the common analysing method applied by researcher. To the best of own's knowledge, specific study focus on 4IR related service sector can hardly find. Thus making this study an

important one as 4IR is not only affecting nation's current economic performance, but also the future of the nation economic development.

Methodology and Data

The analysis in this paper consists of two parts. The first part is the evaluation of technical efficiency among selected 4IR related service industry and second part is examine the productivity change among the industries. Data Envelopment Analysis (DEA) will be applied in both analysis. DEA is a non-parametric linear programing performance evaluation method which evaluates peer entities or decision making unit (DMU) which convert input/s into output/s (Cooper et al., 2011). DEA evaluates comparative efficiency by aggregating multiple performance indicators into single framework to identify best practise. The input-oriented constant return to scale (CRS) DEA following Charnes, Cooper and Rhodes (1978), which known as CCR model is specified as below:

$$\min \theta - \varepsilon \left(\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+ \right) \tag{1}$$

Subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j + S_i^- = \theta x_{i0} \qquad i = 1,2,\dots,m;$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j - S_r^- = y_{r0} \qquad r = 1,2,\dots,s;$$

$$\lambda_j \geq 0 \qquad j = 1,2,\dots,n.$$

Where n is the number of DMU; m is the number of different inputs to produce s different outputs. Specifically, DMU_j converts amount x_{ij} of input i to amount $y_{rj}$of output r. θ is the efficiency score, if the value is equal to one, this indicates that the DMU is on the frontier; S_i^- and S_r^- are slack variables; λ is a vector of weights that defines the linear combination of the peers of the jth DMU and ε is the non-Archimedean element of element which is smaller than any positive real number. The linear programming problem needs to be solved n times.

Next, Panel data can be utilized to examine changes in total factor productivity (TFP) and decompose it into two components: 1) technical efficiency change (TEFC) and technical change (TEC). TEFC measures the change in current efficiency between period t and period $t+1$ while TEC captures the shift in technology frontier. The value of the decomposition is that it provides important information on the source of overall productivity change in the industries. This study applies the DEA-Malmquist index to

measure TFP change. The index is a non-parametric approach introduced by to measure change in productivity of DMUs over two or more time points and can be of input or output oriented. The input-oriented is predicted on the minimum input/s requirement to produce a certain amount of output/s, i.e. input minimization. On the other hand, output-oriented is predicted on maximum production with certain amount of input/s, i.e. output maximization. This study applies output-based model to put much weight on the expansion of output level out of a given level of input. Thus, TFP index is a ratio of the weighted aggregate outputs to weighted aggregate inputs, using multiple outputs and inputs.

The Malmquist output-based productivity change index between period $t+1$ and t is specified by Fare et al. (1994) as:

$$M_0(y^t, y^{t+1}, x^t, x^{t+1}) = \left[\frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^t(x^t, y^t)} \times \frac{d_0^{t+1}(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^t, y^t)}\right]^{1/2} \quad (1)$$

Where d_0 is the output distance function; y^{t+1} and x^{t+1} is the output and input in period $t+1$ respectively; and $y^t$and x^t is the output and input at period t respectively. Equation (1) represents the productivity of the production point (x^{t+1}, y^{t+1}) relative to the production point (x^t, y^t). The index uses period t technology and the other period $t+1$ technology. TFP growth is the geometric mean of two output-oriented Malmquist-TFP indices from period t to period $t+1$. Positive TFP growth is indicated by a value of one while a value less than one indicates a negative TFP growth. The Malmquist TFP index (Equation 1) is further decomposed into EFC and TEC (Fare et al., 1994; Coelli, 1996) as follow:

$$M_0(y^t, y^{t+1}, x^t, x^{t+1}) = \left[\frac{d_0^{t+1}(x^{t+1}, y^{t+1})}{d_0^t(x^t, y^t)}\right]\left[\frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_0^t(x^t, y^t)}{d_0^{t+1}(x^t, y^t)}\right]^{1/2} \quad (2)$$

(TFP) (TEFC) (TEC)

Furthermore, Fare et al. (1994) suggested that TEFC can be decomposed into scale efficiency change (SEC) and pure efficiency change (PEC). Therefore, equation (2) can be represented as TFP = SEC × PEC ×TEC. The computation of Malmquist TFP change is done by utilizing software developed by Tim Coelli, namely Data Envelopment Analysis Program (DEAP). DEAP is the most popular DEA software package especially among academicians (Abdullahi et al., 2015). Statistics summary of inputs and output selected are reported in Table 2. Five 4IR related service sector under evaluation are 1)

telecommunications service; 2) computer service; 3) Programming and broadcasting services; 4) Information services activities and 5) Engineering services. All data were obtained from Malaysia Statistics Department's Time Series Data for period of year 2005 to 2014. The thumb rules for sample size adequate for conducting DEA is $n \geq max\{m \times s; 3(m+s)\}$ (Cooper et al., 2007). Where m and s is the number of input and output variables respectively. In this case, m = 2 and $s = 1$. This implies that the number of unit under evaluation should be equals to or greater than 9. The sample size in this study is 50, thus confirms the sample adequacy for conducting DEA.

Table 2: Statistic summary for input and output for DEA model

	Variable	Mean	Standard deviation
Input	Total number of employees	26257.6	18131.3
	Value of fixed capital assets (RM'000)	6273804	10386700
Output	Revenue (RM'000)	14752000	17583400

Results and discussion

The results of efficiency evaluation for each 4IR related service industry is reported in Table 3. As shown in the table, the average technical efficiency score for the selected service industry in quite high, which is 88.8 percent. Three of the selected service industry obtain unit technical efficiency score, i.e. computer service, programming and broadcasting, and information services activities. This indicates that the current input levels cannot be reduced and the industries is an efficient unit among the selected industries. Meanwhile, the technical efficiency score for telecommunications and engineering services are less than 1. This indicates that both the industries appears to be less efficient among the selected service industries, suggesting that the industries can reduce the current input levels. In other words, telecommunications service's current output could have been obtained by using 16.3 percent less inputs resources compared to current consumptions. Besides, there is 39.1 percent overuse of input resource to obtain the current level of output for engineering services.

Table 3: Technical efficiency scores (CRS)

Industry	Technical Efficiency
Telecommunications	0.837
Computer service	1.000
Programming and broadcasting	1.000
Information services activities	1.000
Engineering services	0.601
Mean	0.888

Next, the results of DEA analysis on productivity change is reported in Table 3. TFP growth of the selected service industry between 2005 and 2014 is 1.9 percent, which is shown by a TFPCH mean of more than value of one. According to DEA analysis, the improvement in technical change (TECHCH) of 1.8 percent contribute the most to the positive TFP growth. On the other hand, TFP growth dampened by scale efficiency change (SECH) (-0.2 percent). Three of the industries are having positive which indicates that the industries are operating at maximum potential output. Telecommunications service experienced negative TFP growth (-1 percent) while programming and broadcasting experienced negative TFP growth of 2.2 percent. Computer service industry experienced the highest TFP growth of 7.1 percent. It is mainly due to technological improvement. Individually, Telecommunications service facing negative technical efficiency growth, indicating it is not operating at optimum output level. Programming and broadcasting industry is experiencing negative technological growth. Similarly, engineering services is also facing negative technological growth. Indicating that these industries gains no benefit from better technology and capital equipment or simply put innovation. Furthermore, value of SECH for engineering services is less than unity which shows that the industry is not operating at optimum scale.

Table 3: Malmquist index of industry means (2005-2014)

Industry	EFFCH	TECHCH	PECH	SECH	TFPCH
Telecommunications	0.968	1.022	0.954	1.015	0.990
Computer service	1.000	1.071	1.000	1.000	1.071
Programming and broadcasting	1.000	0.978	1.000	1.000	0.978
Information services activities	1.000	1.040	1.000	1.000	1.040
Engineering services	1.040	0.982	1.065	0.976	1.021
Mean	1.001	1.018	1.003	0.998	1.019

Conclusion

This paper has evaluate technical efficiency and TFP growth of selected 4IR related service industries. To the best of our knowledge, this is the first analysis on 4IR related service industries. DEA methodology is employed using constant returns to scale assumption to measure the technical efficiencies while the output based Malmquist productivity change index is applied to examine TFP growth. Five service industries is selected and the period of study is from year 2005 to 2014. Result of DEA technical efficiency and Malmquist index results suggests that 1)telecommunications services could reduce the current input levels as there is evidence of overuse on inputs and enhance productivity-based catching-up capability; 2) computer service and information services activities is on the efficiency

frontier and experienced positive TFP growth; 3) programming and broadcasting and engineering services industries should made effort to enhance the technological adaptation to further improve their TFP growth. In general, 4IR related service industries in Malaysia is efficient and experiencing positive TFP growth. This is an indicator that Malaysia is on the right track in moving towards 4IR. However, efforts must be made in order to improve efficiency and TFP growth.

Acknowledgements

The first author would like to thank the Universiti Kebangsaan Malaysia (The National University of Malaysia) for the resources and support (Faculty Grant: EP-2018-001) needed to complete this study.

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