

Efficiency analysis of telecommunications companies in Southeast Asia using Stochastic Frontier Analysis (SFA) method

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Abstract

This study aims to analyze the efficiency of telecommunications companies and find out the variables of efficiency of telecommunications companies in Southeast Asia in the period of 2008-2017 involving 14 telecommunications operators using the Stochastic Frontier Analysis method. The results of these studies show that the telecommunications companies in Southeast Asia still had room to improve their profit efficiency scores for $0,984 - 0,689 = 0.295$. Furthermore, the results show that input variables such as Personal, capex and opex have a positive effect on the value of efficiency which means that each increase in the variable Capex, Opex and Personal Expenses will have an impact in increasing the value of efficiency Whereas the total assets have negative effects on the efficiency value of telecommunications operators. Output variables consisting of revenue, subscribers and ARPU have a significant effect on the value of efficiency. These three output variables in the SFA measurement method have a positive influence on the efficiency of telecommunication operators. Inflation used as an environmental variable in measuring the efficiency of telecommunication operators shows that it does not have a significant impact on the efficiency value of telecommunications operators.

Keywords: Efficiency, Southeast Asia, Stochastic Frontier Analysis (SFA), telecommunication industry

JEL Classification Code: G10, G21

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Introduction

The telecommunications industry is believed to have brilliant digital prospects. In the digital age, everything can be done with the support of internet network where telecommunications operators have very large contribution in providing internet services to customers. On the other hand, the growth opportunities of the digital era leave challenges for cellular telecommunications operators. To meet customer needs, cellular telecommunications operators incur substantial investment costs in providing high speed services, a wide range of investment and operating costs.

Based on the financial data for 2008-2017, the revenue growth in Southeast Asia shows a positive growth from year to year, the revenue growth has been increasing with the range of 1% to 9%. The highest NPM growth reached 21% in 2010. After 2010, the value of NPM of telecommunications operators in Southeast Asia gradually decreased with the last NPM value in 2017 which reached 12%. On the other hand, the highest EBITA value was 52% in 2008 and gradually declined with the lowest value of 43% in 2015. In 2018 the average EBIDA value of telecommunications operators in Southeast Asia reached 44%. While EBIT (Earning Before Interest and Tax) showed a downward trend, which was gradually falling from 30% in 2008 and reached a value of 14% in 2017.

The phenomena above show that although the telecommunications business is still promising business in terms of revenue growth, it has very tight business competition, as indicated by the weakening of NPM, EBITDA and EBIT from year to year. In this case, the telecommunications operators must execute efficient strategies in carrying out its business processes to maintain the company's performance.

Because of the importance of efficiency in a company, many experts have conducted research related to the measurement of the efficiency of telecommunications companies. Previous

researcher, such as Kang (2007), stated that privatization does not have a positive influence on Chungwa Telecom performance. Moriwaki, Era, Osajima and Umino (2009) reported that the value of technical efficiency of telecommunications companies in Asia Pacific is still lower compared to telecommunications companies in developed countries, such as the United States.

According to Sharma, Momoya and Monahar (2010), Bharti Airtel, Vodafone Aircel and BSNL are the most efficient operators in India. Masson, Jain, Ganesh and George (2016) stated that telecommunication operators that have high value in operational efficiency and service delivery effectiveness will get superior profitability and Finally Hendrawan and Nugroho (2018) state that telecom companies should increase efficiency by increasing the value of their output variables. Based on these phenomena and previous research above, the authors of this study intended to conduct a research on the profit efficiency of telecommunications companies in Southeast Asia by using the Stochastic Frontier Analysis (SFA) method.

Literature Review

Berger (1997) explains that the Stochastic Frontier Approach (SFA) is used to measure the cost, profit or production relationship between input and output. The advantage of the SFA method compared to other parametric methods is that SFA allows errors random error and cost inefficiency. Random error is assumed to follow symmetrical standard distribution. Whereas cost inefficiency is assumed to follow asymmetrical distribution.

Several approaches have been developed in measuring and comparing the efficiency of a company. Saxena, Thakur and Singh (2009) categorize efficiency comparisons with two methods, namely the average method and the frontier method. The average method compares the target variable with the average performance, while the frontier method compares the variable by taking the best value of the compared variable.

Karlsson, Back, Vanharanta and Visa (2001) conducted a comparative study on the performance of telecommunication operators in 88 telecommunications companies in various countries using data from 1995 to 1999. The results showed that the six classification groups of companies were based on financial ratio efficiency. Classifications were grouped according to the best class which had very good efficiency profit with a very high financial ratio on Operating Margin, ROTA and ROE. Whereas the lowest group was the company that had the lowest efficiency profit among other financial ratios.

Meanwhile, Kang (2007) researched on telecommunications companies in Taiwan using the data from 1997 to 2004 which were related to production and cost efficiency in telecommunications companies. It was concluded that the efficiency of Chungwa Telecom Company before and after professionalization did not experience the significant changes. After the privatization of Chungwa Telecom, there was an increase in the efficiency of the company by 0.6% which was obtained from the technical efficiency (CRS and VRS), sale efficiency (VRS), allocation efficiency and cost efficiency.

In a broader scope, Moriwaki, Era, Osajima and Umino (2009) examined a telecommunication company performance within Asia Pacific. The method used in this study was Stochastic Frontier (SF). It aimed to calculate the technical efficiency of telecommunications companies in Asia Pacific region. The data used in this study were the panel data in the period from 1993 to 2004. The variables used in measuring technical efficiency were revenue, capital costs, number of workers and number of customers. The results showed that the technical efficiency value of telecommunications companies in Asia Pacific was still lower compared to in developed countries, such as the United States. Factors affecting the value of technical efficiency in telecommunications companies in various countries were number of populations, number of hand sets with total subscribers, privatization of the company and the level of tendency in internet usage.

Additionally, Sharma, Momoya and Monahar (2010) studied a performance on telecommunications companies in India focusing on efficiency. The method used in this study was Data Envelopment Analysis (DEA). The data used in this study included 10 telecommunications

companies in India from 2003 to 2010. The variables used were the number of subscribers as inputs and revenue as output variables. The study concluded that Bharti Airtel, Vodafone Aircel and BSNL were the most efficient operators while MTNL, Reliance and Tata Teleservices had the lowest efficiency among the other 10 operators.

The study of Masson, Jain, Ganesh and George (2016) on the efficiency services in telecommunications industry in India. This research was conducted by using the DEA method to measure the operational efficiency and service delivery effectiveness. The variables used were the number of BTS towers per million subscribers and network operation cost per total cost as the input variables. ARPU and active subscription percentage were used as the output variables. The study showed that operators who had high value in operational efficiency and service delivery effectiveness would get superior profitability.

A recent study by Suleiman, Hemed and Wei (2017) explored the efficiency of telecommunications companies in Tanzania. The methods used were Data Envelopment Analysis (DEA) and Slack Based on Measure (SMB). This study used company report data from 2010 to 2016 for as many as 27 reports. The results of the study showed that there were three operators categorized as efficient, which were Vodacom in the first rank and followed by Airtel and Tigo. However, the other 4 operators were less efficient.

Moreover, Sharma (2017) analysed a comparative study on the performance of telecommunications companies in India which involved 4 telecommunication companies namely Bharti Airtel, Tata Comm, Idea Cellular and Reliance Comm. The performance measurement method in this study was done by comparing the financial ratios from 2007 to 2016. The financial ratio parameters used were as follows: current ratio which is current assets divided by current debt, debt equity ratio that compares the amount of debt to equity, asset turnover ratio which divides net sales into total assets, and net profit margins which divides net profit by net sales. From this research, it can be concluded that Bharti Airtel's earning capacity category occupied the best position followed by Tata Communication, Idea Cellular and Reliance. Bharti Airtel moreover ranked the best in the asset turnover ratio. Idea Cellular occupied the highest position on the assessment of debt equity ratio. Tata Communication had the highest value in the current ratio assessment.

Likewise, a study by Vijayalakshmi, Sowndarya and Sowndharya (2017) examined the performance on the telecommunications company Bharti Airtel by analyzing short-term and long-term financial positions to determine the company's profit level. This research was conducted using secondary data in the period from 2011 to 2016. The ratios used were short-term ratio, long-term ratio and profitability ratio. From the study, it can be concluded that the performance of Bharti Airtel's company was in good condition and the company's performance could be further enhanced by concentrating on its operation, administration and reduction of spending costs.

Hendrawan, Nugroho and Permana (2019), investigated the impact of input and output variable to stock value using stochastic frontier analysis in asean telco industry. using data from 14 selected telco company in Asean Country from 2008 to 2017. Finding from this research show that all of the input and output variables are giving positive impact to the efficiency parameter except Total Asset, variable of Total Asset had negative impact to the efficiency score. By using further analysis of t-Ratio it showed that stock value is impacted by the efficiency parameters but not significant (t-Ratio 1.35).

Methods

Data

In this study, we used secondary data from financial statements from 2008 to 2017. The input variables (y) for this study were capital expenditure (Capex), operating expense (Opex), personnel expense and total assets. Whereas the output variables (w) were revenue, number of subscribers and ARPU (Average Revenue Per User). related to this, inflation (v) was used as an environmental

variable. We used 14 telecommunication operators represented 5 southeast asia countries, Indonesia represented by Telkomsel, XL Axiata, Indosat, Singapore represented by Starhub, Singtel and M1, Malaysia represented by Celcom, DiGi and Maxis, Philippines represented by Globe Telecom and Smart/PLDT and finally thailand represented by AIS, Dtac Telenor and TrueMove.

Methode of Analysis

The profit function used in this study was developed by Berger and Patti (2003), Berger and Mester (1997) proposed model to evaluate how close a company obtains profit as achieved by the best company within the same exogent condition and the equations as follows:

$$\ln (\pi) = f_{\pi} (y, w, v) + \ln u_{\pi} + \ln \epsilon_{\pi}$$

Where :

- π ; represented the profit variable, used by Al-Farisi and Hendrawan (2012)
- y ; represented the output variable, used by hendrawan, nugroho and permana (2019)
- w ; represented the input variable; used by hendrawan, nugroho and permana (2019)
- and v represented the environmental variable that could influence the company’s performance (Al Farisi and Hendrawan, 2012, Hendrawan, Nugroho and Permana (2019)). Additionally, u represented the controllable factors that may influence efficiency, while ϵ represented the uncontrollable factors or random error.

Results and Discussions

Table 1 below shows that in the year of 2008-2017 the maximum efficiency score was equal to 0,984, while the average for all telecommunications companies was 0,689. Hence, on the average, telecommunications companies in Indonesia still had room to improve their profit efficiency scores for $0,984 - 0,689 = 0.295$. Furthermore, Telkom Indonesia’s profit efficiency score is the best and the score is 0,984, whereas the lowest profit efficiency scores is 0,400 belongs to StarHub.

Table 1. Profit Efficiency Scores Year 2008–2017

No.	OPERATORS	Efficiency Score
1	Telkom Indonesia	0.984(*Max)
2	AIS	0.976
3	Maxis	0.864
4	Smart (PLDT)	0.787
5	Celcom (Axiata)	0.781
6	DiGi	0.727
7	dTac (Telenor)	0.708
8	Globe Telecom	0.657
9	XL (Axiata)	0.652
10	Indosat Ooredoo	0.604
11	True Move H	0.552
12	Singtel	0.502
13	M1	0.451
14	StarHub	0.400 (**Min)
	Mean	0.689
	Skewness	0.139

Overall, Telkom had the input and output variables higher than the average value of flat variables in Southeast Asia. Capex, revenue and subscriber variables in Telkom had superior value compared to various variable values in Southeast Asia but ARPU value has a fairly small coefficient value. The efficiency value of AIS (Thailand) occupied the second position. In the output variable,

the value of AIS revenue variable was at an average rate of 108% that had a large coefficient value and subscriber variable of AIS has 14% higher than the average subscriber operators.

Maxis efficiency value was in the third position with an efficiency value of 0.862 which was 25% higher than the average efficiency value in Southeast Asia. The total asset variable owned by Maxis was 6% higher than the average value of total assets in Southeast Asia. Moreover, the output revenue variable was 6% higher than the average value in Southeast Asia. The ARPU output variable showed an advantage of 10% compared to the average value of ARPU in Southeast Asia. Smart (PLDT) was ranked fourth with an efficiency value of 0.787 which was 14% higher than the average efficiency value in Southeast Asia. Smart had a value above the Southeast Asian average of 8% in capex, 77% in total assets, 2% in revenue and 77% in subscribers.

Cellcom (Axiata) was ranked fifth with an efficiency value of 0.781 where Cellcom's efficiency value was 13% higher than the average efficiency score in Southeast Asia. Cellcom had a value above the Southeast Asian average in the capex variable of 59%, total Assets of 34%, revenue of 1% and ARPU of 29%. The superiority of these variables put Cellcom in number five on the value of operator efficiency score in Southeast Asia. The regression result using the SFA DiGi method obtained an efficiency value of 0.727 that was 6% higher than the average efficiency value in Southeast Asia. DiGi had a total asset variable that was quite low compared to other operators. DiGi was ranked 6th out of 14 operators analyzed.

Dtac where it was 3% higher than the average efficiency value in Southeast Asia. Dtac was ranked 7th out of 14 operators analyzed. In general, Dtac's efficiency value was still above the average of operator efficiency value in Southeast Asia. This was supported by many variable values, such as opex, personal expenses and revenue that showed above-average values. Globe was ranked 8th out of 14 operators analyzed. Globe had the revenue of 27% lower than the Southeast Asian average. Several other variables, such as opex and ARPU, showed values that were below average.

XL Axiata had an efficiency value of 0.652 that was 5% lower than the average efficiency value in Southeast Asia. XL Axiata had a large number of subscribers, which was 39% above the average value of Southeast Asian operators. However, the superiority in the number of subscribers was not accompanied by high revenue and XL Axiata which placed XL Axiata in 9th out of 14 operators analyzed. Indosat Ooredoo obtained an efficiency value of 0.604 which was 12% lower than the average efficiency value in Southeast Asia. Indosat Ooredoo was ranked 10th in the efficiency scores. Indosat Ooredoo had a fairly low efficiency value due to the lack of efficiency in generating revenue from the existing inputs. Similar to XL Axiata, Indosat had a number of subscribers that were quite high, but not in line with revenue and ARPU obtained. In addition, Indosat Ooredoo had a value of total assets that was above average, which was in accordance with the analysis of efficiency variables. The high total value of these assets could have a negative impact on the value of efficiency.

TrueMove H obtained an efficiency value of 0.552 which was 20% lower than the average efficiency value in Southeast Asia. TrueMove H in the variable capex had a value of 43% and the variable opex had a value of 45%. Both were above the average Southeast Asian operators. However, the advantages of input variables were not in line with the high output variables, such as revenue, subscribers and ARPU. TrueMove H output variables were below the average value of Southeast Asian operators, placing TrueMove H in 11th out of 14 operators analyzed on the order of efficiency values. Singtel obtained an efficiency value of 0.502 which was 27% lower than the average efficiency value in Southeast Asia. Singtel had a higher ARPU value than the ARPU average value of Southeast Asia. On the other hand, Singtel's total asset variable was above the average value in Southeast Asia which contributed negatively to the efficiency value, thus placing Singtel in 12th of 14 operators analyzed on the order of efficiency value.

M1 had an efficiency value of 0.451 which was 34% lower than the average efficiency value in Southeast Asia. The majority of input and output variables owned by M1 occupied the lowest positions among other telecommunications operators in Southeast Asia. This condition put

M1 in 13th position in terms of efficiency. StarHub obtained an efficiency value of 0.400 that was 42% lower than the average efficiency value in Southeast Asia. StarHub had the lowest efficiency value among the 14 operators analyzed. This was due to the low variables that contributed positively to efficiency values, such as very high total asset variables but low in low revenue and subscribers that contributed negatively to the efficiency value.

Effect of input, output and environmental variables on Telecommunications Company’s Efficiency

Tabel 2. Factors Influencing the Efficiency Value

Variable Type	Variables	Coefficient	t-value	Sig. Level
Input	Capex	0.00756	2.47444	**
	Opex	0.51173	26.45143	***
	Total Asset	-0.07851	4.67096	***
	Personal Expenses	0.09903	8.06992	***
Output	Revenue	6.40793	17.85059	***
	Subscriber	0.21728	10.38675	***
	ARPU	0.01994	6.30495	***
Environment	Inflation	-0.15927	-0.96245	-

Remarks:

*** Significant $\alpha = 1\%$

** Significant $\alpha = 5\%$

* Significant $\alpha = 10\%$

The results of the study are portrayed in Table 2 above. The table indicates the factors that influence the efficiency of telecommunications operators. Furthermore, the results showed that the input variables consisting of capex, opex, total assets and personal expenses had a significant effect on the efficiency of telecommunication operators with varying degrees of Capex, opex and personal expenses had a positive effect on the value of efficiency. These conditions mean that each increase in the variable capex, OPEX and personal expenses would have an impact in increasing the value of efficiency. While the total assets had negative effects on the efficiency value of telecommunications operators.

The output variables which consisted of revenue, subscribers and ARPU had a significant effect on the value of efficiency. These three output variables in the SFA measurement method had a positive influence on the efficiency of telecommunication operators. Inflation used as an environmental variable in measuring the efficiency of telecommunication operators showed that it did not have a significant impact on the efficiency value of telecommunications operators. This was indicated by the value of table t from the SFA processing results at a value of 0.96245.

The input capex variable produced a coefficient of 0.00756. A positive coefficient number indicates the relationship between the input capex variable and the efficiency value that showed a positive relationship so that if the capex variable increases, it will have an impact in increasing the value of the company's efficiency. Table t was used to identify whether the variables used have a significant or insignificant influence on the value of efficiency.

The value of t in the capex variable was 2.47444 which can be interpreted that the capex variable had a significant effect on the value of efficiency with a range of α of 5% (1,984). The opex input variable shows that the opex input variable had a coefficient of 0.51173. The positive coefficient number shows the relationship between the opex input variable and the efficiency value had a positive relationship. So, if the opex variable increases, it will have an impact in increasing the efficiency value of the telecommunications operator. The opex variable had a t value of 26.45143 which can be interpreted that the opex variable had a significant effect on the value of efficiency with a range of α of 1% (2,626).

The regression results of total assets as input variables indicated that the total asset input variable had a coefficient of -0.07851. A negative coefficient value indicated that the growth of the total asset and efficiency value variables had a negative relationship, so that if the total asset variable increases then it will result in a decrease in the efficiency value of the telecommunications operator. The total asset variable had a t value of 4.670958. This value can be interpreted that the total asset variable had a significant effect on the value of efficiency with a range of α level of 1% (2,626).

For personal expenses variable, it had a coefficient value of 0.09903 and a t value of 8.06992. A positive coefficient value indicated that the growth of personal expenses will have a positive impact on the value of the company's efficiency, thus if the value of personal expenses increases it will have an impact in increasing the value of efficiency. Personal expenses variable had a t value of 8.06992. This value can be interpreted that personal expenses variables had a significant influence on the value of efficiency with a range of α level of 1% (2,626).

The output revenue variable had a coefficient of 6.40793. A positive coefficient value indicated that the growth of revenue variables and the value of efficiency had a positive relationship, thus if the revenue variable increases, it will result in an increase in the efficiency of telecommunication operators. The revenue variable had a t value of 17.85059 which can be interpreted that the revenue variable had a significant effect on the value of efficiency with a range of α of 1%.

Meanwhile, the subscriber output variable had a coefficient of 0.21728. A positive coefficient number shows the relationship between the subscriber output variables and the efficiency value had a positive relationship, then if the subscriber variable increases, it will have an impact in increasing the efficiency value of telecommunication operators. Subscriber variables had a t value of 10.38675. This value can be interpreted that the opex variable had a significant effect on the value of efficiency with a range of α level of 1%.

Moreover, ARPU output variable produced a coefficient of 0.01994. A positive coefficient number showed that the relationship between ARPU output variables and the efficiency value was a positive relationship, so that if the ARPU variable increases, it will have an impact in increasing the value of the company's efficiency. The value of t in the ARPU variable was 6.30495. This value can be interpreted that the ARPU variable had a significant effect on the efficiency value with an error rate range of 1%. The highest ARPU variable was owned by Singtel with a value of 42.46 USD and the lowest value was owned by Indosat with a value of 1.3 USD.

The results of inflation regression as environmental variables indicated that the inflation environment variable had a coefficient of -0.15927. Negative coefficient values indicated that the growth of inflation variables and the value of efficiency had a negative relationship, so that if the revenue variable increases then it will result in a decrease in the efficiency value of telecommunication operators. The revenue variable had a t value of 0.96245. This value was below the value of t 1.660 ($\alpha = 10\%$) so that the inflation variable can be interpreted as not having a significant influence on the efficiency value of telecommunication operators in Southeast Asia.

Conclusion

The results of this research can be concluded that during the period of 2008-2017, Telkom was a company with the highest efficiency value that was equal to 0.984 followed by AIS of 0.976 and Maxis with an efficiency value of 0.862. There were seven telecommunication operator companies that had efficiency values above average (above 0.689), they were Telkom, AIS, Maxis, Smart, Cellcom, DiGi and Dtac. On the other hand, there were seven operators with efficiency values below the average efficiency in Southeast Asia.

The results showed that the input variables which consisted of capex, opex, total assets and personal expenses had a significant effect on the efficiency of telecommunication operators with varying degrees of Capex, opex and personal expenses had a positive effect on the value of

efficiency. This would mean that each increase in the variable capex, OPEX and personal expenses would have an impact on increasing the value of efficiency, while the total assets had negative effects on the efficiency value of telecommunications operators. The output variables consisting of revenue, subscribers and ARPU had a significant effect on the value of efficiency. These three output variables in the SFA measurement method had a positive influence on the efficiency of telecommunication operators. Inflation used as an environmental variable in measuring the efficiency of telecommunication operators showed that it did not have any significant impact on the efficiency value of telecommunications operators.

Based on the efficiency studies that have been carried out on telecommunication operators in Southeast Asia, there are several suggestions for telecommunication operator organizations, they are: (1) Telecommunications operators can increase the value of efficiency by increasing input variables such as capex, opex, personal expenses that symbolize the productivity of the number of employees; (2) The total asset variables that have a negative influence on the value of efficiency should be maintained to grow; and; (3) Optimizing the current asset value in running its business can increase the efficiency value as well. Possible future research this model can be used in different industry.

References

- Al-Farisi, A.S., Hendrawan, R. (2012). "Effect of Capital Structure on Bank Performance: Profit Efficiency Approach Islamic and Conventional Banks Case in Indonesia". *International Research Journal of Finance and Economics*. Issue 86, pp 6-19.
- Berger, N.A. (1997). "Efficiency of Financial Institution". *International Survey and Directions for Future Research*.
- Berger, N.A. and Mester, L. J. (1997): "Inside the black box: What explains differences in the efficiencies of financial institutions", *Journal of Banking and Finance* 21, 895-947.
- Berger, N. A. and Patti, B.D.(2003). Capital structure and firm performance: a new approach to testing agency theory and an application to the banking industry. *Feds Paper*. (January 2003, paper No. 2002-54)
- Hendrawan, R. and Nugroho, K.W.A. (2018)," Telecommunication Sector Reform in Southeast Asia: A New Rationality", *Global J. Bus. Soc. Sci. Review*, 6(4), 147-154.
- Hendrawan, R., Nugroho, K.W.A. and Permana, G. T. (2019), How Impactful is Telecom Efficiency to Company Stock Value?, *J. Fin. Bank. Review* 4 (2): 58 – 63 [https://doi.org/10.35609/jfbr.2019.4.2\(2\)](https://doi.org/10.35609/jfbr.2019.4.2(2))
- Kang, C. C. (2007). "Measuring the Production and Cost Efficiency in Telecommunication Industry: The Taiwan Case". *Proceedings of the Eastern Asia Society for Transportation Studies*, Vol 6.
- Karlsson, J., Back, B., Vanharanta, H., and Visa, A., (2001). "Financial Benchmarking of Telecommunication Companies. Turku Center for Computer Science". *TUCS Technical Report* No 395. February 2001. pp. 1239-1891.
- Moriwaki, S., Era, A., Osajima, M., and Umino, A. (2009). "Efficiency Comparison of Telecommunication Industry among Asia-Pacific Region Countries". *Institute for Information and Communications Policy*. Pp 1-17.
- Masson, S., Jain, R., Ganesh, N.M., and George, S.A. (2016). "Operational Efficiency and Service Delivery Performance: A Comparative Analysis of Indian Telecom Service Providers". *Benchmarking: An International Journal*. 23 (4). 893-915.

- Saxena, V., Thakur, T and Singh, R.P, (2009). "Evaluating the Performance of Mobile Telecom Operators in India". *International Journal of Simulation System, Science & Technology IJSSST, Vol. 10, No.4.*
- Sharma, S., Momaya, K., Manohar, K, (2010). "Assessing the Performance of Telecommunication Industry in India: A Data Envelopment Analysis". *Journal of Business and Economy.*
- Sharma, V. (2017). "Financial Resources Management: A Comparative Study of Indian Telecommunication Sector". *International Journal of Emerging Research in Management & Technology.* ISSN: 2278-9359 (Volume-6, Issue-8).
- Suleiman, M.S., Hemed, N.S., and Wei, J. (2017). "Evaluation of Telecommunication Companies Using Data Envelopment Analysis: Toward Efficiency of Mobile Telephone Operator in Tanzania". *International Journal of e-Education, e-Business, e-Management and e-Learning.*
- Vijayalaksmi, S., Sowndarya and Sowndharya (2017). "A Study of Financial Performance Analysys of Bharti Airtel Limited". *International Journal of Business Marketing and Management (IJBMM).* ISSN: 2456-4559. Volume 2 Issue 3 March 2017, pp.23-32.