



The Impact of ICT on Technical Efficiency of Vietnam's Enterprises

Nguyen Anh Phong (Corresponding Author)

Ph.D. Associate Professor, Faculty of Finance and Banking, University of Economics and Law, VietNam National University, Ho Chi Minh City, Vietnam

Email: phongna@uel.edu.vn

Bui Thi Quynh Dao

Faculty of Finance and Banking, University of Economics and Law, VietNam National University, Ho Chi Minh City, Vietnam

Le Thi Thuy Hue

University of Economics and Law, VietNam National University, Ho Chi Minh City, Vietnam

Nguyen Ngoc Van Khanh

University of Economics and Law, VietNam National University, Ho Chi Minh City, Vietnam

Nguyen Lam Thanh Ngan

University of Economics and Law, VietNam National University, Ho Chi Minh City, Vietnam

Vu Thuy Hong Phuoc

University of Economics and Law, VietNam National University, Ho Chi Minh City, Vietnam

Article History

Received: 16 March, 2021

Revised: 19 April, 2021

Accepted: 30 May, 2021

Published: 2 June, 2021

Copyright © 2021 ARPG & Author

This work is licensed under the Creative Commons Attribution International



CC

BY: [Creative Commons Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/)

Abstract

This research evaluates the impact of ICT on the technical efficiency of firms in 63 provinces and cities in Vietnam. We apply to use the DEA method in which we use the variable return to scale to evaluate because firm sizes in 63 provinces are different. At the same time, this method aims to minimize input factors without reducing output factors to measure technical efficiency. This result that is used a binary variable in the logit regression model to identify factors that have an impact on technical efficiency, especially the ICT factor. The research results show that only nearly 10% of the provinces could be technically efficient in business activities. Provinces with sustainable performance and efficiency all depend on influencing factors such as equity ratio, labor productivity, market size, investment, and especially the ICT factor keep increasing over the years and fluctuate around a pretty high level. On the other hand, for the group of unsustainable and ineffective provinces, these variables tend to decrease and fluctuate around at a low level. The research shows that factors in labor productivity, equity ratio, market size, investment, and ICT all have a positive impact on a firm's performance in 63 provinces and cities of Vietnam. Therefore, firms that want to enhance their efficiency need to have strategies to improve the factors mentioned above. Moreover, the local government needs to improve the ICT index to help to increase their local Enterprises' efficiency.

Keywords: Enterprises in vietnam; Technical efficiency; ICT index.

1. Introduction

Information and Communication Technology (ICT) has led to changes in production processes and business management. The fourth industrial revolution was developed on the basis of the third revolution, combining technological elements together, thereby blurring the boundaries between physics, digital and biology. In particular, the development of ICT has become an important factor and the foundation of the fourth industrial revolution for the economy. Various economic and social activities have been applied to the use of ICT in the internet environment such as e-commerce (e-commerce), sharing economy (Uber, Grab, ...). The core elements of digital in the industrial revolution 4.0 will be: Artificial Intelligence and Artificial Interlligence and Machine Learning - Internet of Things - Big Data and Cloud computing. From there, it can be said that the strong development of social networking has changed the method and way of doing business in many different fields and industries of the enterprise and has shown the influence of ICT on the economic activity. Information and communication technology (ICT) is being at the core of all business activities of enterprises, from practical activities of social life to the most complex activities.

The rapid development of technology has resulted in traditional products and services being gradually replaced by more and more modern products and services. Therefore, technology innovation and ICT application are indispensable part of the business strategy of enterprises. Changes in the business environment have made enterprises increasingly dependent on ICT for competitive advantage and improving their performance (Apulu and Moreton, 2011; Yunis, 2018). According to Assoc. Prof. Dr. Vu Minh Khuong (Ly Quang Dieu School of Public Policy, National University of Singapore) (2019), ICT is and will make a great contribution to economic growth. However, the application of ICT in production and technological innovation to increase productivity is not a simple matter due to the limited human, resource and material resources of our country. Another reason is that our country is being in a development process as well as most of the current enterprises are small and medium-sized enterprises.

Previous studies have shown that ICT adoption in SMEs is slower than in other firms (Ntwoku *et al.*, 2017). The application and use of information technology are the fundamental foundation for the existence of small and medium-sized enterprises (Parker and Castelman, 2007). Previous studies have shown that ICT investment enterprises will have a large impact on their operational productivity (Barua-Kriebel-Mukhopadhyay, 1995). In general, studies on the impact of ICT on business technological efficiency are still very rare. The application of ICT in small and medium-sized enterprises may be different from larger ones (Haug, 2011; Lucchetti and Sterlacchini, 2004). Research by Dang Thi Viet Duc (2019), assessing the impact of information and communication technology on Vietnam's economy through analysis, synthesis and comparative methods are used to analyze more clearly about the impact of ICT on the economy. Research by also assesses the impact of information and communication technology on Vietnam's economy, quantifies the impact of ICT on the Vietnamese economy through the IO model. However, the research papers are still at the macro level of the economy, the industry group is the main. Therefore, the results of the study still show clearly not yet how ICT will affect SMEs as well as they are in different regions. Assoc. Prof. Dr. Tram Thi Xuan Huong - MSc. Dang Thanh Ngo (2012) with the topic "The impact of technology on banking income diversification - suggesting the development trend of fintech - banking in Vietnam" by linear regression method through table data with data from 24 Vietnamese Commercial Banks. The limitation of this study is only to mention the banking sector.

Vietnam is in the process of economic development and digital transformation, but the level of investment as well as interest in each province is different, so the impact results are also different. Studying the impact of ICT on technical efficiency of businesses operating in 63 provinces nationwide plays an important role in policy review, as well as in assessing sustainable effectiveness.

2. Literature Review

Roberto Alvarez and Gustavo Crespi (2001), in a research paper on "Determinants of Technical Efficiency in Small Firms" aimed at analyzing and evaluating the technical efficiency of small businesses using DEA method to estimate measure efficiency. The input variable used is labor, fixed capital and the output variable is total sales. The results of the study have shown that the effects are positively reflected in the human factor, increased investment in production and product innovation. Roghieh Gholami *et al.* (2004), in his research on "ICT and Productivity of the manufacturing industries in Iran" used data from 22 Iranian manufacturing industries from 1993 to 1999 to evaluate the impact between ICT and productivity. The study uses panel data to determine the positive impact of investing in ICT on productivity, the results of the study show that the positive side of investing in ICT contributes to productivity increases is the intangible form of capital such as labor skills and tangible capital form is investment in ICT. Same point of view on Phillip Koellinger is that it is stated that ICT innovation is positively related to revenue growth and productivity in enterprises. According to him, the positive effects of ICT are more likely to occur for firms conducting innovation and for firms with high labor skills. Research also shows that ICT has been changing dramatically in many important structures of the economy. This promotes the competitiveness in relation to the prices of products and services.

On the other hand, Rafi and Muhammed (2008) of Sultan Qaboos University assessed the impact of ICT on the performance of small and medium enterprises (SMEs) in Oman. Research data obtained from more than 50 SMEs surveyed. The results of the study have shown that only a small number of SMEs demonstrate the benefits of applying ICT in their business operations. However, there are some limitations such as the majority of ICT management is outsourced, human resources and some policies are limited. Since then, the research paper offers reasonable solutions to improve the use of ICT in businesses.

Recently, there are many studies applying to evaluate technical efficiency in which the DEA method is mainly used. The case studies such as: Jose Fernandez-Meneandez *et al.* (2009) have selected data from more 2000 companies in Spain to point out the relationship between ICT and performance, of which the greatest focus on ICT investments. The study used data envelopment analysis (DEA) method in calculating and estimating technical efficiency of firms. The results of the study have shown positive signals and the use of ICT and technical efficiency. At the same time, the author pointed out that the limitation of the study is the data limitation. The study also concludes that the Spanish economy needs to take measures to maintain competitiveness in the economy, and suggest improving the efficiency of companies using ICT. Besides, Ku Naraini Che Ku Yusof *et al.* (2010) also used DEA to analyze and evaluate the effectiveness of companies in Malaysia in the period from 2004 to 2008. DEA results under the CRS assumption (efficiency does not vary with size), then only a few firms are considered technically efficient. When the synergistic efficiency is split into pure technical efficiency and scale efficiency using the VRS production function, the source of inefficiency is scale inefficiency rather than scale efficiency purely technically ineffective. Alberto *et al.* (2011) have shown a positive relationship between ICT application. The paper collects data from more than 250 small and medium manufacturing enterprises in Spain and uses the OLS regression method to study the direct and indirect effects of ICT. The results of the study show that there is an impact of ICT on enterprise performance, but the impact is not immediate because it is affected by time delay. Dolores (2011) introduced the role of information and communication technology (ICT) on the performance of small and medium enterprises (SMEs). This study uses data of annual income from small and medium enterprises (ASBC) in 2004. In the study, the author uses the input variable is ICT, the output variable is process innovation and production product. The results of the study show that there are two effects of information technology and communication on the company and the external factor. Research has used the probit model to reflect the effects for contributing different innovation activities. In addition, the model examines the impact of technology innovation on business operations. According to research by Dang Thanh Ngo (2012): "Measuring the Performance of the Banking System Case of

Vietnam (1990-2010)" applied the DEA method, developed the CRS DEA model to analyze the efficiency change operations over time of the Vietnamese banking system in the period 1990-2010. Research shows that performance decreases over time as the size of the banking sector increases; financial markets are more liberal and when the world and regional economies have problems. In addition, the author also stated that when the banking system is operating with 2/3 of its capacity, the bank makes a limited contribution to the economy. Yu (2014) used the method of analysis of financial ratios combined with DEA and data from 24 listed companies in Taiwan to evaluate the performance of these companies. The results of the study show that most companies achieve efficiency levels between 0.94 and 1.00. The study's financial ratio analysis showed that only 4 firms out of 24 responded to their management efficiency. The limitation of the study mentioned by the author is the need to add inputs and outputs for more accurate results in the use of DEA method. Amir Gholam Abri and Mahmoud Mahmoudzadeh (2014) also studied the impact of information technology (IT) on the performance of manufacturing firms in Iran. The authors collected data from 23 Iranian manufacturing industries during from 2002 to 2006, used the DEA method accompanied by panel data to measure impact. This study concluded that IT has a positive impact on business productivity. However, the limitation that the author pointed out in the study is that there is no significant difference in the growth rate of labor productivity and the use of information technology. Research by Berrio *et al.* (2018) shown that in the context of increasingly global integration, companies must be willing to change their production, business and service processes to adapt to the development conditions of society, and it is appropriate to apply ICT in the operations of companies. Research using qualitative methods and results shows that the impact of ICT is highly valued in terms of profitability as well as customer satisfaction, but this positive effect also depends on external factors. Samwel Macharia Chege, Daoping and Shaldon (2019), using the five stage growth model (Churchill and Lewis, 1983) and the product-innovation model (product-process model of innovation) Utterback and Afuah (1995), using a variety of linear regression analysis, covariance and qualitative methods by creating questionnaires. Finally, from the research, the author has shown that technological innovation has a positive effect on the company's operations. However, the disadvantage of the study is that it limits the scope of sampling and is not general. From there, it is proposed that the government should have many related policies to promote the building of better information technology development infrastructure.

In Vietnam, there are a number of related studies such as: Vu and Vo (2015), which used parametric and non-parametric methods in combination with the random variable method (SFA) and data envelopment analysis (DEA) data for measuring and analyzing a set of 70 enterprises in the period from 2008 to 2012. The results show that Vietnamese enterprises in the integration period have not managed well their resources, so the cost burden affects their competitiveness and profitability.

Research by Dang Thi Viet Duc (2019) has shown issues about the impact of ICT on the Vietnamese economy. The research uses document search, analysis, synthesis and comparison methods, from which there are indicators of the impact of ICT on three aspects: macro, industry and business. The conclusion of the study has raised positive signals of ICT to the Vietnamese economy, but there are still some limitations as ICT has not yet made a comprehensive change in the way Vietnamese enterprises operate. From there, the solution is to increase investment in ICT.

In summary, most of the research have solved a number of contents: assessing the technical efficiency of enterprises through the impact of ICT is recorded with positive signs. These papers are mostly qualitative and only a handful of research papers with the use of SFA, DEA and Cobb-Douglas, Translog production functions for measurement are common. Some of the indicators selected in running the model are only suitable for developed countries. Most of the above studies are only research or research on technical efficiency via DEA method but do not mention the factors affecting efficiency or studying the impact of ICT on operational efficiency but not use marginal efficiency analysis approach much. Especially in Vietnam, there is very little impact of ICT on technical efficiency of enterprises, but mainly research on the impact of ICT on the Vietnamese economy, how it affects industries in the economy. The effective approach to the marginal efficiency analysis approach used is not yet popular. Most of the above studies are only single or research on technical efficiency through DEA method but do not mention the factors affecting efficiency or studying the impact of ICT on operational efficiency but do not use marginal efficiency analysis approach much. Especially in Vietnam, there is very little impact of ICT on technical efficiency of enterprises, but mainly research on the impact of ICT on the Vietnamese economy, how it affects industries in the economy. The effective approach to the marginal efficiency analysis approach used is not yet popular

3. Data and Research Methods

The research data is used by the team from the "White Book on Vietnamese Businesses 2019 & 2020" released by the General Statistics Office (GSO) and "Report on assessing and ranking the readiness level for IT development and application in Vietnam - Vietnam ICT Index" over the years from 2011 to 2018 was made by the Ministry of Information and Communications and the Vietnam Informatics Association. The content of "White Book on Vietnamese Businesses 2019 & 2020" includes basic information assessing the level of enterprise development nationwide and in localities in the 2016-2019 period.

In this study, we use the method of Technical Efficiency analysis (TE), which is commonly measured by two methods: Data Envelopment Analysis (DEA) and Stochastic frontier analysis (SFA). In this study, the team decided to choose the DEA method, which assumes Variable return to scale (VRS) in the direction of minimizing input factors without reducing output factors by Banker (1984) proposed because for businesses in general the assumption of constant efficiency by scale is difficult to meet, and only appropriate when all operations are at

optimal scale. The results from the non-parametric analysis are independent of the type of function selected and the normal distribution assumptions of the error.

Table-1. Variables used in measuring technical efficiency

Output				
	Variable name	Notation	Calculation	Unit
1	Sales	Sales	Net sales	Billions VND
Input				
	Variable name	Notation	Calculation	Unit
1	Capital	Capital	Equity + Debt	Billions VND
2	Labour	Labour	Number of employees in the enterprise	Billions VND
3	Tang	Tang	Fixed assets and long-term investments	Billions VND

Source: Author's synthesis

After measuring TE, using logit regression to assess the impact of factors and especially ICT on the performance of Vietnamese enterprises. All the independent variables selected by the authors to include in the model are based on the research review and collected data sources. Measuring technical efficiency with DEA, whereby the most efficient firms establish a production frontier and firms are compared to the frontier this to determine if they are working effectively. For firms that perform well, since they are on the limit line, their technical efficiency score (TE) is equal to 1. In contrast, firms perform poorly (on the line). limit), their effective point will be less than 1. TE has limit values from 0 to 1, they are encoded as variable I in the logit model as follows:

$$I = \log\left(\frac{p}{p-1}\right) = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_nx_n$$

With,

I is the dependent variable and takes only two values of 0 and 1, resulting from analysis of technical efficiency
 X_i is the independent variables (the variable acts on the dependent variable).

p is the probability that variable I can appear.

β_n is the coefficients, used to determine the mean value of I increases or decreases as x increases.

Specific variables, variable measurement is presented in [Table 2](#)

Table-2. Variables affecting technical efficiency in logit regression

Dependent variables				
	Variable name	Notation	Calculation	Unit
1	Technical efficiency	I	Resulting from analysis of technical efficiency	Binary 0 and 1
Independent variables				
	Variable name	Notation	Calculation	Unit
1	Asset Size	lnTA	ln(Total Asset)	-
2	Market Size	lnSales	ln(Sales)	-
3	Investment	lnTang	ln(Tang)	-
4	Debt ratio	DebtRaito	$\frac{\text{Averagetotaldebt}}{\text{Averagetotalequity}}$	Lần
5	Debt-squared index	De_Square	Debt ratio * Debt ratio	-
6	Equity ratio	ETA	$\frac{\text{Equity}}{\text{Capital}}$	%
7	Labor productivity	Lproductivity	$\frac{\text{Sales}}{\text{Labour}}$	%
8	ICT	lnICTindex	ICT index ranking	-

Source: Author's synthesis

Asset size: Measure the size of the group's assets to get ln(total assets). This measure is also used by [Huynh The Nguyen \(2019\)](#), [Concetta \(2012\)](#) and [Prabowo and Cabanda \(2011\)](#). The size of enterprise assets reflects many aspects: capacity for existence and development, description of market access, access to technology, access to human resources, and finance; in order to improve production efficiency. As a result, we can see that the majority of larger firms can have a greater technical efficiency than small firms.

Market Size: The company's market size is measured in ln (sales). This variable is a new variable based on the collected data, because in my literature review, no one has used it yet. Any business needs a market to ensure that it is operating effectively and meets its business goals, they need to choose the right market. Therefore, determining whether the business is operating in the right market and analyzing the size of the market is paramount to business performance. Market size analysis helps answer a few questions: Is the business market operating efficiently, and is it worth the business expansion? Are the products and services of the business appropriate?

Investment: measured by taking ln(Tang). The use and investment of capital plays a very important role in changing technical efficiency of enterprises. In particular, investing in fixed assets and new assets, replacing old technology with new technology to change production capacity, thereby improving technical efficiency. Especially

in today's competitive market economy, businesses that need transformation, have to make a high rate of investment in new technologies in order to survive.

Debt ratio: Reflecting the reality of debt and the ability to access external financial sources to meet the investment and development needs of the business. In business, the capital to operate is very important and especially the financial leverage that the company uses will affect the operational efficiency. Vania Sena (2004), Bedoya and Paganetto (2003) also used this variable in the firm's performance impact assessment model.

Debt-squared index: As far as we know debt and efficiency are not linearly correlated. Therefore, the group includes the variable of the debt-squared index to consider whether there is a nonlinear phenomenon or not..

Equity ratio: reflects the equity capital of the business, helping investors have an overview of the financial strength and financial structure of the business. This ratio is larger, which proves that the business has a very strong financial potential and if they want to use the leverage to expand capital, it will also be easier. Since then, investment opportunities, business innovation development will be higher and more feasible, helping to increase the efficiency of the business.

Labor productivity: Reflects the effectiveness of the business's use of labor to create products (revenue). Enterprises with competitive advantages in the market are derived directly or indirectly from human resources. In particular, high-productivity employees will improve their ability to efficiently use natural resources to increase operational efficiency. The author (Huynh The Nguyen, 2019) used the variable labor productivity to evaluate this problem.

ICT: This variable is grouped to scale based on the provincial ICT Index and ICT ranking. First, take ICTIndex multiply 63, then divided ICT raking. Final take ln. Our country has 63 provinces and ICT raking is ranked from 1 to 63. Any province with an ICT rating of 1 means that province has been and is being ready for the best IT development and application in the country. Conversely, if it equals 63, the province has the lowest readiness for IT development and application. When scaling variables like the above formula, it means that the province with the larger ICT, the better by rank. Nearly all businesses today use computers, connect to the Internet and use ICT applications in management, production and sales processes that have a strong impact on the company's performance. Concetta (2012) & Bedoya and Paganetto (2003) also included this variable in the model to assess the impact of TE.

4. Research Results

Table-3. Descriptive statistics of variables in TE estimation model

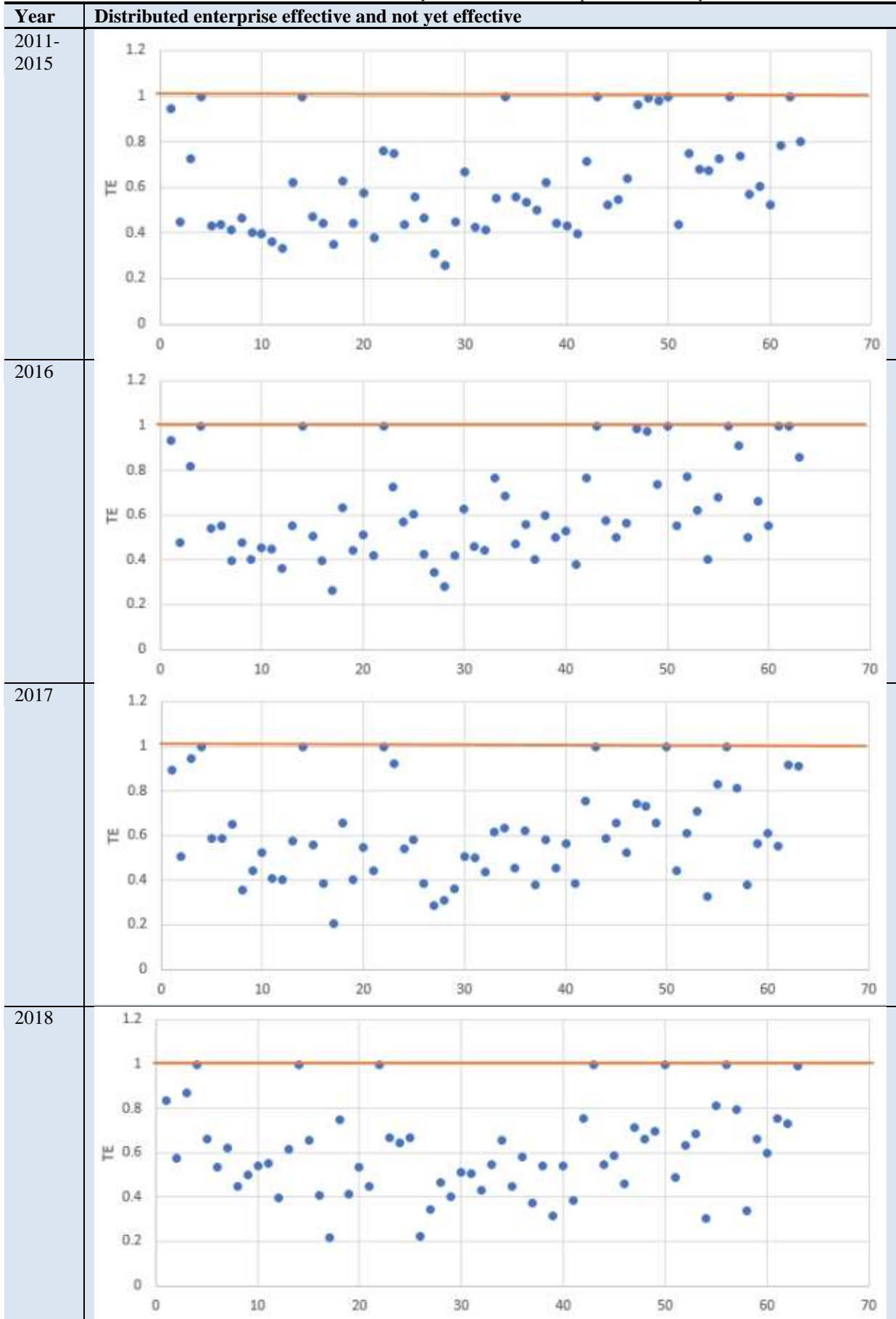
	Obs	Mean	Std. Dev	Min	Max
Sales	252	277962.9	694871.6	4021	5399432
Capital	252	364888.3	1179056	7584	8988171
Labour	252	212794.1	463243.1	7156	2958127
Tang	252	151990.4	461681.3	2328	3820547

Source: Author's calculations

The output variable *Sales* has an average value of 277962.9 with a standard deviation of 694871.6; The maximum value is 5399432 and the smallest value is 4021. The large difference in the maximum and the lowest value, together with a large standard deviation, shows that the provinces have *sales* spread and volatility across years. The variables *Labor*, *Capital* and *Tang* have a high mean and standard deviation; The highest and the lowest value are very different. The average *number of employees*, *capital* and *fixed assets & long-term investments* by provinces is very high, however there is a relatively large difference in maximum and minimum values, together with the standard deviation of Many deviations show that the number of employees in the whole province is relatively high, but there are differences and change over the years.

TE measurement results show that, although the provinces all use the same input variables to measure, due to the difference in the combination and effective use, maximizing the inputs, there is differentiation between the group of provinces with technical efficiency - provinces with 1 *TE* (100%) and provinces with less technical efficiency.

Table-4. Distribution technical efficiency of businesses across 63 provinces over the years



Source: Calculation results from DEA 2.1 software

Out of 63 provinces, only 10% of provinces use the inputs effectively. The *TE* between these groups of provinces is quite different (varying between 0.2 and 1). Most of the provinces only in the effective use of 0.4 - 0.8.

Over the years, the *TE* has been volatile, some provinces have improved in the use of inputs, increased efficiency and also some provinces have reduced efficiency levels.

Table-5. Descriptive statistics of the variables in the Logit model

	Obs	Mean	Std. Dev	Min	Max
I	252	0.1071429	0.3099103	0	1
ETA	252	37.85754	7.614103	10.3	57.9
lnICTscale	252	2.841283	7.413909	0.0913	59.2641
Lproductivity	252	1.145506	0.6326271	0.2574089	3.853752
lnSales	252	11.42224	1.35993	8.299286	15.5018
lnTang	252	10.7158	1.317679	7.752765	15.1559

Source: Author's calculations

The dependent variable *I* in the model has a mean value of 0.1071429 with a standard deviation of 0.3099103; The maximum value is 1 and the lowest value is 0. It shows that most of the provinces are not yet effective and there is a great difference between provinces, as well as fluctuations over the years. The variables *Lproductivity*, *lnSales* and *lnTang* have the mean value at a relatively high level with a low standard deviation; The difference between the lowest value and the highest value is not too large. This shows that the provinces do not have great disparities between provinces over the years in terms of labor productivity, revenue, fixed assets & long-term investment. The variables *lnICTscale*, *ETA* have low mean and high standard deviation; The distance between the lowest and highest value is a huge difference. The large difference between the maximum value and the lowest value, together with such a high standard deviation, shows that there is a variation of variables over the years and large variation across provinces.

Through the multi-collinearity test, some variables are violated multi-collinearity, we remove those variables from the model, the results of the remaining variables in the model are shown in [Table 6](#) below.

Table-6. Logit regression results

	ETA	Lproductivity	lnSales	lnTang	lnICTscale
Odds Ratio	1.061543	9.103344	3.032925	0.164046	1.899756
P> z 	0.088 (**)	0.000 (*)	0.099(**)	0.002 (*)	0.052 (**)

Source: Authors' calculation results from Stata 14.1 software, (*) and (**) correspond to the 1% and 10% statistical significance levels.

The results show that all included variables are statistically significant at 1%, or 10%, and have a positive impact on the technical efficiency of firms in the provinces.

Based on the regression results, we see that the variable of equity ratio (*ETA*) is statistically significant in the model and has an impact on technical efficiency. The equity ratio increased by 1%, the probability of improving the efficiency more than other businesses is 1.0615 times. In this case, the impact is because the firm has a high *equity ratio*, demonstrating the strong potential and financial stability. In addition, high *equity* also makes it easier for businesses to use financial leverage and mobilize capital. Therefore, more investment will be made in technology, production lines, scale expansion, and more product research and development, leading to an increasingly improved efficiency of the business. The estimated coefficient of labor productivity variable (*Lproductivity*) has the same impact as technical efficiency and has a significance level of 1%. The highest marginal impact coefficient shows that the probability of improving the efficiency of firms with improved labor productivity will be 9.103 times higher than those in low labor productivity provinces. Therefore, labor productivity is a factor that has a very strong impact on the efficiency of the provinces. Higher *Labor productivity* generates more business more profitable and leads to higher efficiency. Besides, when businesses gain more profits, they will invest more in production and business activities and increase efficiency. Similarly, the variable *lnSales* is also statistically significant and the coefficient of estimation is positive (firms expanding market, increasing *revenue* increases the probability of efficiency 3.032 times higher than firms in provinces that cannot increase market) This means that the technical efficiency of the provinces increases as *the market size* increases. Because the larger the market size, the higher *the revenue*, *the revenue* is one of the prerequisites to help determine the results of the business activities of the business, so when *the revenue* increases, the business will have higher efficiency. The investment variable (*lnTang*), is also statistically significant and has a positive impact on the enterprise's technical efficiency. This is obvious because the more enterprises invest in modern and advanced machinery, equipment, technology, software and labor training, the higher the labor productivity, the more enterprises efficient.

Finally, information technology (*lnICTscale*) has a positive and statistically significant impact on technical efficiency (which provinces have a 1-rank increase in the ranking coefficient, which promotes the efficiency of the province to 1.899 times). Because, using information and communications technology to help businesses expand, improve efficiency and save a lot of expenses. Business processes, control and data storage are also automated by technology software, resulting in new products and services to support customers more, contributing to helping businesses achieve competitive advantage is higher.

Recommendations

This research evaluates firms's technical efficiency in 63 provinces and cities in Vietnam by DEA method and identify factors that affect businesses's technical efficiency by using the Logit regression. The research results shows that only nearly 10% of the provinces could be technically efficient in business activities. With the purpose of the research to find out the impact of factors, especially ICT, on the technical efficiency of the business. The influencing factors include: *Equity ratio, Labor productivity, Market size, Investment, and especially ICT*. From we can see from the result tables, provinces that are sustainably efficient and provinces with increasing efficiency all have variables such as *Equity ratio, Labor productivity, Market size, Investment, ICT* grow over the years and fluctuate around a pretty high rate. On the other hand, for the group of unsustainable and ineffective provinces, these variables tend to decrease and fluctuate around at a low level.

The research result shows that there are 3 groups of businesses: The group decreases by size, for firms in the provinces of this group, the research team recommends that it should be considered when deciding to increase the scale, instead should reduce to expand investment so that businesses return to the state of optimal scale. *The group increasing in size* is in contrast with the previous group. *Optimal size groups* need to maintain and ensure the scale is always at the optimal level. There is no need to focus on scale investment anymore, instead businesses can invest in labor, engineering, technology or research and product development to increase efficiency for the business. *For volatility group*, the research team recommends to review the use of inputs and be able to learn and learn from businesses in the provinces effectively to improve their businesses.

To maintain and increase technical efficiency to optimal scale, businesses need to pay attention to improving labor productivity, increasing the equity ratio in the capital structure, paying attention to market expansion, including domestically and internationally. On the side of the local authorities, they need to pay attention to invest, improve and increase the ICT index because the research results show that ICT is a quite important factor to help improve business efficiency in their provinces. *ICT Index* is a measure of the level of development in Information and Communication Technology, a measure of the readiness to develop and apply ICT in all fields in each country. Including 3 main component indexes are *Technical Infrastructure, Human Infrastructure and IT Application*. Therefore, in order to improve and increase efficiency, the research team suggest that firms need to invest and apply ICT - increasing ICT indexes, namely, investing in the three component indexes of the *ICT Index*. For the *Technical Infrastructure Index*, priority should be given to allocating resources to invest in IT infrastructure such as adding landmarks, IT equipment, and software. If ICT is applied in business operations more smoothly, costs can be reduced, leading to increased efficiency in business operations. And then the business has additional capital for other things such as product research and development, scaling or human resource training. *In terms of human infrastructure*, to improve labor productivity, enterprises need to pay attention to invest in training and training their employees on IT skills and knowledge and how to operate it. If the labor productivity increases, the efficiency is achieved higher. In addition, businesses themselves also need to thoroughly *apply ICT* to improve productivity and quality of operations.

References

- Alberto, B.-M., Margarita, B. and Fernando, L.-L. (2011). Perceived performance effects of ICT in manufacturing SMEs. *Industrial Management and Data Systems*, 113(1): Available: <https://www.researchgate.net/publication/262860460> *Perceived performance effects of ICT in manufacturing SMEs*
- Amir Gholam Abri and Mahmoud Mahmoudzadeh (2014). Impact of information technology on productivity and efficiency in Iranian manufacturing industries. *Journal of Industrial Engineering International*, 11: 143-57. Available: <https://www.semanticscholar.org/paper/Impact-of-information-technology-on-productivity-in-Abri-Mahmoudzadeh/2669df50a5ea7a9b0a0f79c2beaa6935a120a709>
- Apulu, L. and Moreton (2011). Factors affecting the effective utilisation and adoption of sophisticated ICT solutions: Case studies of SMEs in Lagos, Nigeria. *Journal of Systems and Information Technology*, 13(2): 125-43.
- Banker (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9): 1078-92.
- Barua-Kriebel-Mukhopadhyay (1995). Information technologies and business value: An analytic and empirical investigation. *Information system research*, 6(1): Available: <https://pubsonline.informs.org/doi/abs/10.1287/isre.6.1.3>
- Bedoya and Paganetto (2003). ICT Investment, Productivity and Efficiency: Evidence at Firm Level Using a Stochastic Frontier Approach Working paper, No.29, CEIS Tor Vergata - Research Paper Series, Vol. 10, No. 29 August 200.
- Berrio, S. E. C., Redondo, R. P. and Hernandez, H. G. (2018). Impact of ICT on the generation of new services companies. *Contemporary Engineering Sciences*, 11(52): 2591-99.
- Churchill and Lewis (1983). The five stages of small business growth. *Entrepreneurial Management*: Available: <https://hbr.org/1983/05/the-five-stages-of-small-business-growth>
- Concetta, C. (2012). Technical efficiency and ICT investment in Italian manufacturing firms. *Applied Economics*, 44(14): 1749.
- Dang Thanh Ngo (2012). Measuring the performance of the banking system: case of Vietnam (1990-2010). *Journal of applied finance and banking*, 2(2): 289-312.

- Dang Thi Viet Duc (2019). The impact of information and communication technology on Vietnam's economy. *Hue Scientific Journal: Economy and Development*: Available: <https://www.adb.org/sites/default/files/publication/350191/adbi-wp770.pdf>
- Daoping, W. and Shaldon, L. S. (2019). Impact of information technology innovation on firm performance in Kenya. *Information Technology for Development*, 26(11): 1-30.
- Dolores, A. H. (2011). The impact of ICT on innovation activities: Evidence for UK SMEs. *International Small Business Journal*, 30(6): 684-99.
- Haug (2011). Learning through games? Evaluating the learning effect of a policy exercise on european climate policy. *Technological Forecasting and Social Change*, 78(6): 968-81.
- Huynh The Nguyen (2019). Factors affecting technical efficiency in small and medium enterprises in Vietnam. *Asian Journal of Economic and Business Studies*: Available: <http://growingscience.com/beta/msl/4014-technical-efficiency-of-small-scaled-manufacturing-enterprises-in-six-different-sectors-in-northern-vietnam.html>
- Jose Ferná'ndez-Mene'ndez, Jose Ignacio, Lo'pez-Sa'nchez, AntonioRodrı'guez-Duarte, Francesco, D. and Sandulli (2009). Technical efficiency and use of information and communication technology in Spanish firms. 33, 7(348-359):
- Ku Naraini Che Ku Yusof, Ahmad Rizal Razali and Izah Mohd Tahir (2010). *An evaluation of company operation performance analysis using data envelopment analysis (DEA) approach*. A Study on Malaysian Public Listed Companies.
- Lucchetti and Sterlacchini (2004). The Adoption of ICT among SMEs: Evidence from an Italian Survey. *Small Business Economics*, 23(2): 151-68.
- Ntwoku, Negash and Meso (2017). ICT adoption in Cameroon SME: application of Bass diffusion model. *Information Technology for Development*, 23(2): 296-317.
- Parker and Castelman, 2007. "Why should small firms adopt eBusiness?" In *A framework for understanding the SME eBusiness context, 18th Australasian Conference on Information Systems*.
- Prabowo and Cabanda (2011). Stochastic frontier analysis of indonesian firm efficiency. *International Journal of Banking and Finance*: Available: <http://e-journal.uum.edu.my/index.php/ijbf/article/view/8426>
- Rafi, A. and Muhammed, M. (2008). Use and Impact of ICT on SMEs in Oman. *The Electronic Journal Information Systems Evaluation*, 11(3): 125-38.
- Roberto Alvarez and Gustavo Crespi (2001). Determinants of technical efficiency in small firms. *Small Business Economics*, 20(3): 233-44.
- Roghieh Gholami, Saeed Moshiri and Sang-Yong Tom Lee (2004). ICT and productivity of the manufacturing industries in Iran. Available: <https://doi.org/10.1002/j.1681-4835.2004.tb00125.x>
- Utterback and Afuah (1995). The dynamic 'diamond': A technological innovation perspective. *Economics of Innovation and New Technology*, 6(2-3): 183-200.
- Vania Sena (2004). The return of the prince of denmark: A survey on recent developments in the economics of innovation Working paper, No.29 , CEIS Tor Vergata - Research Paper Series, Vol. 10, No. 29 August 2003. *Economic Journal*, 114: Available: <https://ideas.repec.org/a/ecj/econjl/v114y2004i496pf312-f332.html>
- Vu, T. T. and Vo, H. D. (2015). Measuring the technical efficiency of listed companies in Vietnam: Parametric and non-parametric methods. *Journal of Development Economics*: Available: https://www.researchgate.net/publication/321709637_Measuring_technical_efficiency_of_the_listed_firms_in_Vietnam_Parametric_and_non-parametric_approaches
- Yu (2014). Energy efficiency evaluation based on data envelopment analysis. *A Literature Review, Energies*: Available: <http://doi:10.3390/en13143548>
- Yunis (2018). The role of ICT and innovation in enhancing organizational performance: The catalysing effect of corporate entrepreneurship. *Journal of Business Research*, 88: 344-35. Available: <https://www.sciencedirect.com/science/article/abs/pii/S0148296317305246>