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CONTENTS

Page

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ALLOCATIVE EFFICIENCY OF VIETNAM'S MANUFACTURING ENTERPRISES BY TECHNOLOGY LEVEL

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Studying about allocative efficiency is very important in policy formulation and management of each enterprise. The data envelopement analysis method was used to calculate the allocative efficiency of Vietnam's manufacturing enterprises from 2000 to 2018. At the same time, the study divided enterprises into three group by technology level for more detailed analysis. The results show that allocative efficiency tends to decrease during the studied period and there is not much difference between the three groups of enterprises. However, the group of low-tech enterprises has the highest allocative efficiency, followed by the group of medium-tech enterprises and the group of high-tech enterprises with the lowest allocative efficiency. The results also show that the allocative efficiency of two-digit VSIC sectors in each group is significantly different.

Keywords: *Allocation efficiency, DEA method, technology level.*

JEL Classifications: *C14, D61, O14.*

1. Introduction

Studying about allocative efficiency at the industry and firm level is one of the classic topics. It has attracted the attention of the research community and policy makers, especially in the field of productivity and efficiency analysis at the micro level.

Many researchers and policymakers have focused their attention on applying new technologies to increase productivity and benefits. However, when the major achievements of technology have shrunk with world development, the interest in increasing productivity through more efficient use of existing technologies is justified (Bravo-Ureta and Pinheiro, 1993). Improving efficiency will help businesses save more costs than adopting new technology as a means to increase productivity (Omonona et al., 2010). Efficiency refers to the global relationship between all inputs and outputs in a production process (Speelman et al., 2007). The manager will be concerned with efficiency to achieve the goal of production. Efficiency measurement is important as it can lead to significant resource savings, which in turn can have important implications for policy formulation and corporate management (Bravo-Ureta and Rieger, 1991).

The measurement of production efficiency was proposed in a paper published by Farrell in 1957 taking all inputs into account. Farrell (1957) states that if economic planning is concerned with specific industries, it is important to know how far that particular industry can be expected to increase output if only by increasing output efficiently without attracting additional resources. Over the years, several extensions to Farrell's deterministic model have been made by Aigner and Chu (1968), Aigner et al. (1977), Meeusen and Van Den Broeck (1977), Charnes et al. (1978), Schmidt (1980), Greene (1980) and Banker et al (1984). Efficiency measures can be separated into three different measures, namely technical efficiency, allocative efficiency and economic efficiency (Speelman et al., 2007).

Besides many studies on technical efficiency, the research on allocative efficiency, especially research on manufacturing enterprises, is relatively few. According to Chukwuji et al. (2006), when the production process in enterprises becomes technically efficient, the problem of allocative efficiency arises. So it is very important to measure allocative efficiency. There are also many different measures of allocative efficiency. Allocative efficiency can be expressed as a measure of a firm's ability to use factors of production based on the best combination of prices of inputs, so allocative efficiency is also known as price efficiency of production (Farrell and PEARsoN, 1957).

With the development of computational techniques and the application of mathematics in economics, paper of Farrell (1957) led to the development of several approaches to efficiency and productivity analysis. Among these, Stochastic Frontier Analysis - SFA method (Aigner et al., 1977; Meeusen and Van Den Broeck, 1977) and Data Envelopment Analysis method - DEA (Charnes et al., 1978) are two revolutionary contributions. The main difference between the two methods is: SFA is a parametric method, which takes into account both inefficiencies and white noise, while DEA is a non-parametric method and attributes all deviations from the boundary to zero effective. Coelli (1995) provided a comprehensive view of the strengths and weaknesses of these two methods. The groundbreaking paper by Charnes et al. (1978) led to the development of the DEA method, a new methodology widely used to measure the performance of firms.

In this study, the author uses the DEA method to estimate the allocative efficiency of Vietnam's manufacturing enterprises in the period from 2000 to 2018. In which, enterprises are divided by process's technology for more detailed analysis. The rest of the paper consists of: Section 2 presents a summary of the theoretical basis and an overview of the research; Section 3 deals with research methods; Section 4 presents and discusses the research results and Section 5 concludes with the research problem.

2. Literature review and theoretical framework

With the development of computational techniques and the application of mathematics in economics, there have appeared more accurate methods of estimating types of production efficiency in general and allocative efficiency in particular. The most common are the parametric approach and the non-parametric approach. The main difference between these two approaches is that the parametric approach assigns a special form of function to the production or cost function while the non-parametric approach does not.

DEA is the most common non-parametric method used in efficiency analysis. This method has been developed by Charnes et al. (1978) from the concept of relative efficiency of Farrell (1957) by extending Farrell's model. This model is called the CCR model (Charnes, Cooper and Rhodes) and is a non-parametric model that provides measures of best practice efficiency (Omonoma et al., 2010). This method is widely used to measure the relative effectiveness of the decision-making unit (DMU) by providing an estimate for predicting inefficient DMUs up to the "efficient margin". These projections may involve shrinking inputs or expanding outputs, or both. From the input orientation, the efficiency of these DMUs is calculated as the input radial drop for the input levels of the best performing DMUs to produce the same output level. The DEA method can be applied using either an output-based or an input-based approach depending on whether these methods use an input distance function or an output distance function. These two measures give dissimilar results unless we assume constant returns to scale (CRS) (Färe et al., 1994). The first DEA model assumes CRS, which implies that if the input is increased by a certain amount, the output will increase by a corresponding amount (Frija et al., 2009). However, in practice, this is not always the case, so it is advisable to consider choosing a model with the assumption of VRS (return to scale) when measuring efficiency. The first DEA model assuming VRS was developed by Banker et al. (1984) and is called the BCC model (Banker, Charnes and Cooper).

Studies often use this method to measure different types of effects simultaneously. Uri (2001) used the DEA method to calculate the technical efficiency, allocative efficiency for domestic US carriers held by Bell from 1985 to 1998. The results related to allocative efficiency are: a marked upward trend in allocative efficiency was observed starting from 1985; it is likely that part of the subsequent allocation efficiency improvement up to 1993 was due to an incentive regulation in which a form of ceiling price was implemented for local carriers in 1991.

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To assess the efficiency of banks both technically and allocatively, Rouse and Tripe (2016) used the DEA method with 120 observations of six banks between the first quarter of 2010 and the fourth quarter of 2014. These are three of New Zealand's four main banks and three smaller banks, which account for 74% of the assets in New Zealand's banking system. The authors asserted that focusing only on technical efficiency can seriously mislead the performance of the banks in the sample. Adding in allocative efficiency reveals a larger variation in performance as well as highlights changes in the mix of inputs and outputs needed for banks to improve productivity.

However, studies show that the DEA approach is widely used in agricultural researches. As in Islam et al. (2011), the authors used data from 355 rice farms in 2009 of Bangladeshi; the farms are divided into two groups, with finance and without finance, with the aim of comparing the performance of these two groups and analyzing the farm and institutional financial factors affecting the performance. With the pooled sample, the authors found the mean of TE, AE and EE to be 72%, 66% and 47% respectively. With a given variable technology, financial borrowers and non-financial borrowers can increase physical output by 27% and 29% respectively. While they can reduce production costs by 52% and 54% respectively with the assumption of scale. With the VRS DEA model, when external environmental influences are calculated, microfinance participants increase their technical efficiency, allocative efficiency and economic efficiency by 7%, 2% and 7% respectively.

In Vietnam, there are few studies on allocative efficiency. Research by Quang Minh Nhut (2009) used the DEA method, specifically the CRS-DEA and VRS-DEA models to analyze the efficiency types of seafood processing and rice milling enterprises in Mekong Delta in 2007. The results show that for rice milling enterprises, the allocative efficiency has a high value and tends to be concentrated near the value 1 and less volatile than that of seafood processing enterprises (two values of allocative efficiency for two groups of firms are 0.927 and 0.625, respectively).

3. Research Methodology

3.1. Research Data

The data used in the study are mixed data based on the annual enterprise survey of the General Statistics Office (GSO) of the manufacturing industry in the period from 2000 to 2018 with a total of 569,372 enterprises. This data source is full of important variables such as industry code (taken by VSIC 2-digit standard), type of ownership, number of employees, amount of capital, revenue, profit, depreciation, and expenses. labor, short-term assets, long-term assets, etc. Value added data are not available and are measured based on the income approach. Inputs and outputs have been deflated at the base of 2010. In order to have a detailed and in-depth analysis of the allocating efficiency of manufacturing enterprises in this period, the study is divided into enterprises into small groups according to the technology level of the enterprise.

3.2. Methodology to calculate allocative efficiency by non-parametric approach

In this study, allocative efficiency is measured by the most popular non-parametric approach, which is the input-oriented DEA method. According to Farrell (1957), the set of production possibilities P of each DMU is obtained by wrapping the observations as tightly as possible by a segmented linear outer boundary:

$$P = \{(x, y): \textstyle\sum_{j=1}^{K} \lambda_j x_{nj} \le x_n (n = \overline{1,N}), \sum_{j=1}^{K} \lambda_j y_{mj} \le y_m (m = \overline{1,M}), \sum_{j=1}^{K} \lambda_j = 1\} \quad (3.1)$$

There are K enterprises and the weights λ_j are not negative, defining the reference point on the boundary. M is the numbers of output, N is the numbers of input. For the ith enterprise out of K enterprises, the input-oriented technical efficiency under the CRS assumption is achieved by solving the following linear programming problem:

$$TE_i = \min_{\theta_i, \lambda} \theta_i^{CRS}$$

With constraints:

$$\sum_{j=1}^{K} \lambda_j y_{mj} - y_{mi} \ge 0, m = \overline{1,M}$$

$$\theta_i x_{mi} - \sum_{j=1}^{K} \lambda_j x_{nj} \geq 0, n = \overline{1,N} \quad (3.2)$$
$$\lambda_j \geq 0, j = \overline{1,K}$$
$$\theta_i \in (0,1]$$

Here, θ_i^{CRS} is a measure of the technical efficiency of the ith DMU under the assumption of CRS and λ_j are the weights assigned to each effective DMU. The solution of the above linear programming problem gives the technical efficiency score of each DMU in the sample. If $\theta_i^{CRS}=1$, then that DMU is on the boundary and is therefore technically efficient under the CRS assumption. If $\theta_i^{CRS}<1$, then the DMU is below the boundary and is not technically efficient.

The CRS linear programming model can be easily converted to VRS by adding the convex constraint $\sum_j^K \lambda_j =1, \lambda_j \geq 0$, j = $(\overline{1,K})$ to (3.2) (Banker et al., 1984).

Economic efficiency and allocative efficiency are obtained through solving the following cost minimization linear programming problem:

$$\min_{\lambda, x_i^*} w_i' x_i^*$$

With constraints:

$$\theta_i x_{mi} - \sum_{j=1}^{K} \lambda_j x_{nj} \geq 0, n = \overline{1,N}$$
$$\lambda_j \geq 0, j = \overline{1,K} \quad (3.3)$$
$$\theta_i \in (0,1]$$

Where w_i is the input price vector of the i^{th} enterprise, and x^*_{ni} (calculated by a linear programming problem) is the minimum cost vector of the inputs of the ith enterprise, with given price w_i and output level y_i.

The economic efficiency of the ith enterprise is calculated by comparing the minimum cost with the actual cost:

$$EE_i = \frac{w_i' x_i^*}{w_i' x_i} \quad (3.4)$$

Finally, the allocative efficiency is calculated according to the definition of Farrell (1957) as follows:

$$AE_i = \frac{EE_i}{TE_i} = \frac{w_i' x_i^*}{w_i'(\theta_i^{CRS} x_i)} \quad (3.5)$$

3.3. Input price estimation method

In order to calculate the efficiency classes according to the DEA method, we need input prices. In the enterprise survey data, there is no input price. To estimate the factor price, the study relies on the Euler theorem on homogeneous function. The procedure is as follows:

We consider the production function according to the Cobb-Douglas form of constant efficiency:

$$Y_i = AK_i^{\alpha} L_i^{1-\alpha} \quad (3.6)$$

According to Euler's theorem

The cost of capital is calculated according to the following formula:

$$W_K = \frac{\partial Y_i}{\partial K_i} = A\alpha K_i^{\alpha-1} L_i^{1-\alpha} \quad (3.7)$$

Labor cost is calculated according to the following formula:

$$W_L = \frac{\partial Y_i}{\partial L_i} = A(1-\alpha) K_i^{\alpha} L_i^{-\alpha} \quad (3.8)$$

From there, we solve the linear programming problem (3.3) and calculate the word allocation efficiency (3.5).

4. Research findings and discussions

4.1. Descriptive statistics for some variables

The study divides enterprises by technology level based on GSO's classification criteria (specifically, VSIC level 2 industries in each group are listed in the Appendix), including: low-tech enterprises (LTE), medium-tech enterprises (MTE) and high-tech enterprises (HTE). We have a statistical table describing some key variables including the amount of capital - K, number of employees - L, value added - VA and allocative efficiency - AE estimated in the whole study period of each group of enterprises:

In the period 2000-2018, the number of LTE accounted for the highest proportion, equivalent to 61.38% of the total number of enterprises in the industry; MTE accounted for the second highest proportion of 32.39%. And the high-tech enterprises accounted for a very small proportion of 6.43%. However, this is a group of large-scale enterprises

Table 1: *Statistical table describing a number of variables according to the technological level of enterprises*

Variable	Mean for period 2000 - 2018		
	Observations	Mean	Std. error
LTE			
K	348,343	52,772.81	690,659.8
L	348,343	160.9782	841.8946
VA	348,343	14,563.85	400,826.9
AE	348,343	0.757051	0.169850
MTE			
K	184,428	52,455.29	669,295.0
L	184,428	71.56329	251.2656
VA	184,428	8,234.81	54,925.96
AE	184,428	0.756478	0.167200
HTE			
K	36,601	176,452.2	221,727.7
L	36,601	219.008	1,218.132
VA	36,601	44,555.02	750.904,9
AE	36,601	0.752320	0.166577

Source: Author's caculated results

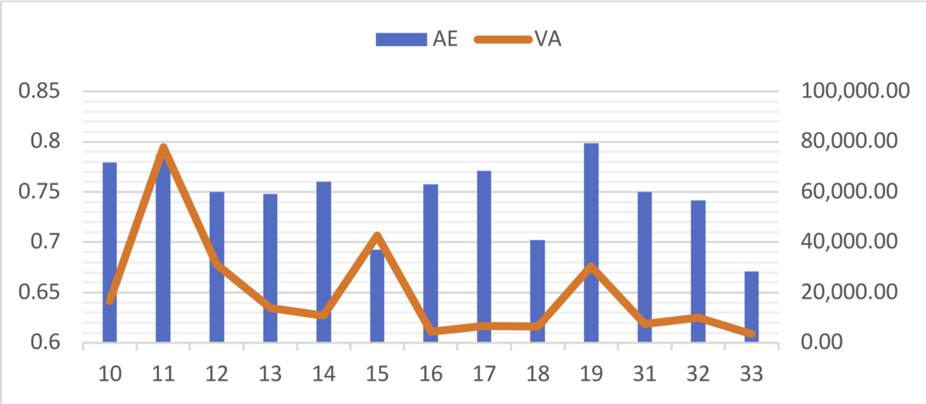
with higher capital, number of employees and added value than the other two groups. This is explained by the fact that the majority of high-tech enterprises are FDI enterprises. The group of medium-tech enterprises is the group with the lowest mean value of K, L and VA variables among the three groups, especially the value added is much lower than the other two groups. And the average allocative efficiency of the three groups of businesses is not much different, all greater than 0.75. But the HTE group has a slightly lower allocative efficiency than the other two groups. In addition, with this group, the allocation efficiency tends to decrease markedly. In 2009 and 2018, marked a sharp decrease in the allocative efficiency of all three groups of enterprises, especially in 2018, the allocative efficiency of all three groups of enterprises was only about 0.55. During the first year of the studied period, all three groups had an allocative efficiency of approximately 0.9. For a clearer analysis, the study analyzes each 2-digit sector in three groups divided by technology level.

4.2. Allocative efficiency of firm groups by technology level

Low-tech industries include thirteen 2-digit VSIC sectors with allocative efficiency and value added as shown in Figure 1.

The industry with the highest allocative efficiency in the group of LTE is the production of coke and refined petroleum with an allocative efficiency level of approximately 0.8; although this industry's added value is not high, ranked fourth. Beverage production enterprises have the second highest allocative efficiency in the group, but the added value of this industry group is the highest. Although in beverage manufacturing enterprises, there are big names of FDI enterprises such as Coca-Cola, Pepsi, etc, constantly reporting losses and low production efficiency, but domestic beverage enterprises account for a high proportion and operating effectively, so on average, the allocation efficiency of this industry group is still at a high level. Food processing enterprises are also in the group with high allocative efficiency but low added value. The sectors with low

Unit: million dongs



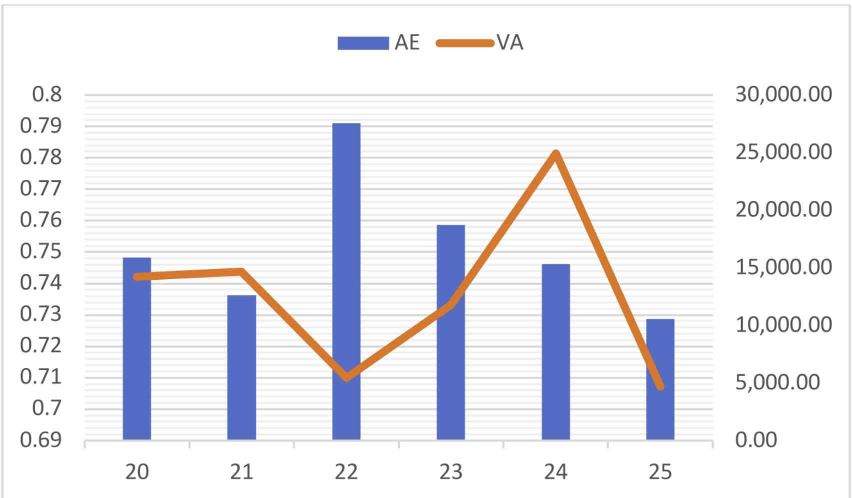
Source: Author's caculated results

Figure 1: *Allocative efficiency and added value of low-tech enterprises*

allocative efficiency are the leather and footwear industry, the printing industry and the industrial service sector. This comes from the fact that domestic enterprises in the leather and footwear industry can only produce simple items such as shoelaces, laces, labels, etc. While other plastic accessories such as eyelets, hooks, beads, and other products, are available. Other decorative accessories are also dependent on foreign enterprises. At the same time, labor in these industries is of low quality and the application of information technology and science technology progress is still limited.

The allocative efficiency and added value of the MTE group are shown in Figure 2. This is the industry group with the lowest average added value. In this group, the production of rubber and plastic products is the industry with the highest allocative efficiency, reaching more than 0.79. However, the added value of the industry is among the lowest. This is an industry with a lot of potential but the value brought is not commensurate. The metal manufacturing industry is the industry with the highest average added value in the group, but the allocation efficiency is not high. In recent years, this industry has grown at a high rate. The industry with the lowest alloacative efficiency as well as added value is the mechanical industry. This is explained by most of the enterprises in this industry being small-scale enterprises with limited qualifications, most of which have not yet mastered technology, and lack of specialized machinery for production specialization. Most domestic enterprises have not been able to research and design their own products, leading to very few Vietnamese mechanical brands in Vietnam, and the competitiveness of these products is still very poor. The level of

Unit: million dongs



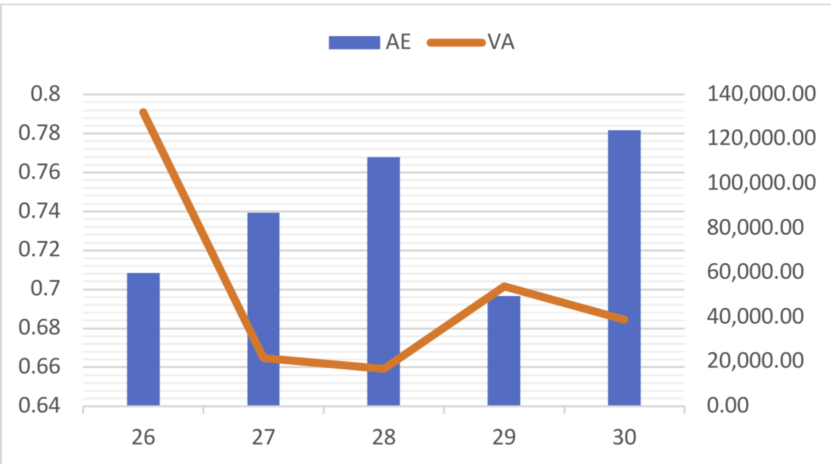
Source: Author's caculated results

Figure 2: *Allocative efficiency and added value of medium-tech enterprises*

mechanical engineering in our country is still backward compared to many countries from 2 to 3 centuries, the investment efficiency of the whole industry is not high and has not shown its role as a foundation for industrial development.

The high-tech enterprises of Vietnam in general and in the manufacturing industry in particular account for a low proportion. But the average added value is higher than other business groups. Of the five 2-digit sector in this group, the other transport industry has the highest allocative efficiency, greater than 0.78, but the value added ranks third, after electronics and cars and other engines manufacturing. These are the two industries with the lowest allocative efficiency in the group. The electronics manufacturing industry is the industry with the highest added value in the group, but the reallocation efficiency is the lowest in the group. This is an industry with strong growth during the research period, reflected in the rapidly increasing number of businesses and the number of employees in the industry and is the destination of many FDI enterprises such as Samsung, LG, Intel, etc, 95% of export turnover of electronic goods originates from foreign enterprises in Vietnam, the role of domestic enterprises is very faint. This is also the reason why the allocation efficiency of the industry is not high. In contrast, the electrical equipment manufacturing industry is the industry with the lowest added value, but the reallocation efficiency ranks third in the group. This is considered a fairly well-developed industry, especially in recent years. In 2015, accounting for about 3% of the industrial production value and 3.3% of the manufacturing industry. By 2018, these rates were 3.03% and 3.4%, respectively. Although achieving certain results in recent years, this is still a low value-added industry, not as expected because electrical equipment products manufactured in Vietnam are subject to fierce competition from products originating from neighboring countries such as China, Thailand, Korea, etc. Therefore, in the household electrical market, it is estimated that hundreds of billions of VND are used each year for purchasing needs buying electrical equipment, but mainly from imported brands, the sales from some big domestic brands such as Dien Quang, Rang Dong, Tran Phu... are not many. Facing that situation, the State has actively changed mechanisms and policies to promote the development of the industry, such as mechanisms to support investment projects in the production of equipment for hydroelectric and thermal power plants, products such as transformers from 220 KVA or more, and the entire part of substation equipment from 220 KV and above, so the production of these products is entitled to preferential policies on investment credit, investment in research and development, taxes and fees, etc. That is also the reason for increasing the allocation efficiency of the group.

Unit: million dongs



Source: Author's caculated results

Figure 3: *Allocative efficiency and added value of high-tech enterprises*

5. Implications and recommendations

For the purpose of studying allocative efficiency, this paper has measured the allocative efficiency of Vietnam's manufacturing enterprises in the period from 2000 to 2018 by data envelopment analysis method and have more specific analysis when dividing enterprises by technology level. From the results of the study, business managers in each specific industry can refer to them to make appropriate policies to improve the allocation efficiency of their businesses. The main results obtained are: Firstly, the allocative efficiency tended to decrease during the studied period and there was not much difference between the allocative efficiency of the three groups divided by technology level. Second, the group of high-tech and medium-tech enterprises have not yet operated as efficiently as possible. The third, the 2-digit VSIC sectors within each group have significant differences in allocation efficiency. However, the study has not evaluated the causes leading to the difference in the allocative efficiency of enterprises divided by technology level. Therefore, for the next research direction, the author will analyze specifically the technological factors affecting the allocative efficiency of enterprises.

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Appendix
Classification of manufacturing industries by technology level

Code	Industries
	Low-tech Industries
10	Food production and processing
11	Beverage production
12	Manufacture of tobacco products
13	Weaving
14	Production of costumes
15	Manufacture of leather and related products
16	Wood processing and production of products from wood, bamboo and cork (except for beds, cabinets, tables and chairs); produce products from straw and plaiting materials
17	Manufacture of paper and paper products
18	Print, copy records of all kinds
19	Producing coke, refined petroleum products
31	Manufacture of beds, cabinets, tables and chairs
32	Other processing and manufacturing industries
33	Repair, maintenance and installation of machinery and equipment
	Medium-tech Industries
20	Manufacture of chemicals and chemical products
21	Manufacture of drugs, pharmaceutical chemicals and medicinal herbs
22	Producing products from rubber and plastic
23	Manufacture of other non-metallic mineral products
24	Metal production
25	Manufacture of prefabricated metal products (except machinery and equipment)
	High-tech Industries
26	Manufacture of electronic products, computers and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment not classified elsewhere
29	Manufacture of motor vehicles
30	Manufacture of other means of transport

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Summary

Việc nghiên cứu về hiệu quả phân bổ là rất quan trọng trong việc xây dựng chính sách và quản lý của mỗi doanh nghiệp. Bài báo đã sử dụng phương pháp phân tích bao dữ liệu để đo lường hiệu quả phân bổ của các doanh nghiệp ngành chế biến chế tạo của Việt Nam từ năm 2000 đến năm 2018. Đồng thời nghiên cứu đã chia các doanh nghiệp thành ba nhóm theo trình độ công nghệ để có các phân tích rõ hơn. Kết quả cho thấy hiệu quả phân bổ có xu hướng giảm trong giai đoạn nghiên cứu và không có sự chênh lệch nhiều giữa ba nhóm doanh nghiệp. Tuy nhiên, nhóm doanh nghiệp công nghệ thấp có hiệu quả phân bổ cao nhất, rồi đến nhóm doanh nghiệp công nghệ trung bình và nhóm doanh nghiệp công nghệ cao lại có hiệu quả phân bổ thấp nhất. Kết quả còn cho thấy hiệu quả phân bổ của các ngành VSIC hai chữ số trong từng nhóm lại có sự khác nhau rõ rệt.

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- Workplace: Maths department, Thuongmai University
- Position: Lecturer

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- Efficiency, productivity, output of enterprises.
- Decomposition of productivity and contributions of enterprises.
- Application of time series models and econometric models in economics.

3. The magazines that published the author's papers

- Journal of Trade Science
- Journal of Economic Development
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