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Assessing The Technical Efficiency Of Pulp And Paper Production In Vietnam: The Data Envelopment Analysis Approach

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Abstract:
The research aims to examine factors affecting the technical efficiency (TE) of 1,121 pulp and paper enterprises in Vietnam with the support of STATA software. By applying the Data Envelope Analysis (DEA), this study conducted a TE assessment and applied the Tobit model to examine the factors that influence technical performance. Factors affecting TE are calculated with a set of explanatory variables, including size, capital per labour, the cost to revenue ratio, financial leverage, liquidity ratio. The data used for this study is the survey data for 6 years from 2012 to 2017 by the General Statistics Office of Vietnam (2018). Experimental results indicate that there is a significant difference in TE between enterprises of different sizes, ranking in order of decreasing efficiency from medium to large firms and after all, small and micro-businesses. The study results also show that there is a positive relationship between capital per labour, financial leverage and technical efficiency; and a significant negative relationship between cost to revenue ratio and technical efficiency. The liquidity ratio is the factor that does not affect technical efficiency. The research also provides evidence-based policy recommendations to improve the TE and competitiveness of pulp and paper enterprises in developing countries.

Keywords: Data envelope analysis; factors affecting; pulp and paper enterprise; technical efficiency; Vietnam.

Introduction

Pulp and paper is a key industry in the world and paper products are one of the main exports in many countries. In Vietnam, the paper industry has made a significant contribution to the development of the economy, promoting and supporting many manufacturing industries to develop, creating thousands of jobs. Although it is not one of the key industries, holding a key position in the economy, the representative products of the paper industry are essential products in the lives of every citizen. Thanks to the application of advanced production technology, strict compliance with the requirements for environmentally friendly products, the Paper Industry in Vietnam has experienced strong growth. The average growth rate of Vietnam's Paper Industry is about 10-12%/year, contributing about 1.5% of GDP, export turnover reaching over 1 billion USD (General Statistics Office, 2020).

Although the potential is great, the paper industry in Vietnam is facing many difficulties and challenges. Paper enterprises must meet the requirements of improving modern production technology, saving energy and water sources, reducing the use of chemicals, meeting environmental regulations, and aiming for sustainable development. In addition, the legal documents related to pulp and paper products are not clear and specific, the management policies for the paper industry are still many points that do not encourage industry development, the competition is fierce in the domestic and export markets, the price of input materials increased. Besides, investment status in Vietnam's paper industry is still fragmented, not concentrated, small scale, old technology and equipment; investors are small and medium enterprises (accounting for about 90% of quantity and 60% of production capacity), limited financial capacity; business linkages in the industry are weak, and large-scale production enterprises cannot be formed (General Statistics Office, 2020).

From the late 1980s and earlier, ratios based on financial data such as return on assets, return on equity, ... were used as a technique to evaluate the performance activities of businesses. Financial ratios were used to evaluate the performance of firms (e.g., return on assets and return on equity) because of the available data of the financial statements. Many empirical studies noted that financial ratios are always a valuable tool of financial management, preferred by managers when summarizing, analyzing and providing useful information for managers to decision making, forecasts about the state of enterprises (Beaver 1966; Singh and Schmidgall, 2002). However, financial ratios only provide simple information about the financial performance of enterprises compared to previous periods and each financial ratio only evaluates the proportional relationship between two specific variables, no single indicator can provide general conclusions about the operational state of an enterprise (Diaz-Balteiro et al., 2006). To make a comprehensive evaluation

of the state of an enterprise that needs to analyze a series of ratios, such assessments can lead to misleading conclusions since these ratios are single analyses.

To improve efficiency and performance, businesses need to have a certain understanding of the factors affecting the TE of the business. In terms of production orientation, TE reflects the ability of firms to produce the maximum viable output given a given set of inputs. In output orientation, TE reflects the ability of firms to use minimal inputs to produce output levels (Farrell, 1957). A firm is said to be technically efficient if this firm produces the maximum output from the minimum amount of inputs, such as labour capital, and technology. TE is a reflection of the actual output that can be achieved at the maximum level of a unit of production (Färe & Lovell, 1978). Understanding the potential causes of inefficiencies is essential to help managers take important countermeasures to significantly save resources. Saving resources directly benefit producers, generates higher income and thus, has a better chance of survival and business as well as helping manufacturers to improve productivity, improve their efficiency level, increase competitiveness. An understanding of the factors that determine productivity or efficiency in pulp and paper production is essential, especially in countries like Vietnam, where the Vietnamese pulp and paper industry is mainly are many small-scale enterprises with limited capacity. Enterprises with a capacity of fewer than 10,000 tons/ year account for 81.79% of the number of enterprises but the total capacity only accounts for 21.26% of the total capacity of the whole industry; mainly belonging to paper packaging and votive paper products. The number of enterprises that has a capacity of 50,000 tons/ year or more only accounts for 3.31%, but the total capacity accounts for 45.5% of the total capacity of the whole industry, with an average capacity of 94,435 tons/ year (General Statistics Office, 2018).

The effectiveness of Vietnam's pulp and paper enterprises is not high. Therefore, it is necessary to consider, evaluate and explore the factors that affect efficiency. To survive and thrive in a competitive environment, managers need to understand the effectiveness of their organization in the general business environment and find out the factors that affect it using different measurements (Neely, 1998). Measuring business performance is considered as a means of checking the health of the business and a means of controlling the performance of the organization over time compared to the set goals.

In this context, the main objective of this paper is to analyze the determinants of TE in pulp and paper enterprises in Vietnam in order to help informed producers and policymakers. to improve productivity and increase competitiveness. This study makes important contributions to the TE literature not only in that it formulates hypotheses from earlier literature's recommendations for TE estimation in pulp and paper businesses that. It also tests hypotheses in empirical research to understand the factors influencing TE as well as it compares previous work on TE determinants in pulp and paper businesses.

The article is organized into five sections. Section 2 presents the theoretical background and hypothesis development. Section 3 describes the research methodology applied to empirical research in Vietnamese pulp and paper manufacturing enterprises. Section 4 presents the main results (TE estimates, benchmarks, TE determinants and discussions). Section 5 presents the main conclusions and recommendations of the study.

Theoretical Background and Hypotheses Development

Technical Efficiency

Most early studies on TE ignore undesirable outputs and do not consider separating inputs into different categories (Wang et al., 2013). Derived from the study of Debreu (1951) on the coefficient of resource utilization, in his groundbreaking research, Farrell (1957) mentioned how to evaluate a unit's performance through TE and allocation efficiency. Allocative efficiency refers to the way of combining different resource inputs to create a mixture of different outputs, while TE relates to achieving maximum output at the lowest cost. Building on the ideas of Farrell (1957); Charnes et al. (1978) develop into DEA - an important initiative for many subsequent applications. DEA constructs an efficiency frontier that allows multiple inputs and outputs to be combined. The efficiency frontier is similar to a positioning map that could show the efficiency value of each decision-making unit - DMU (Chiang et al., 2011; Sun et al., 2013). This method is simple because it only needs to determine the value of the input and output without requiring additional specific information and can be done in a small sample size. DEA has the advantage of applying to many different fields (Wang et al., 2013; Wu et al., 2013; Lozano et al., 2013; Lema, 2017; Horvatova, 2018; Abdulai et al., 2018; Chen et al., 2019).

Wang et al. (2013) while studying energy efficiency and the environment in 29 administrative regions of China in the period 2000 - 2008 showed that China's energy efficiency and environment increased slightly from 2000 to 2008; in which, the East is more balanced than the Central and Western regions. Wu et al. (2013) when studying resource allocation has found that economic factors are often associated with environmental factors in production. Therefore, the goal set for resource allocation scenarios is to maximize the desired output and minimize the unwanted output. To evaluate airport performance, Lozano et al. (2013) divided the operations of 39 Spanish airports in 2008 into two successive phases corresponding to the movement of the aircraft and the payload of the aircraft. The plane's motion phase is the one that produces undesirable results (flight delays and flight delays). Based on research results, the authors make recommendations on the responsibility of the airport manager for operational efficiency.

For the factors that determine the technical performance of commercial banks in Ethiopia, Lema (2017) found that the level of capitalization, liquidity risk, rate of return on assets and market share tend to direction positively and significantly affects TE score. Meanwhile, at banks in Central and

Eastern European countries during the financial crisis (2006 - 2013), Horvatova (2018) found that there is an ambiguous relationship between the TE and size of a bank's assets, as well as the significant positive relationship between customer deposits and the banks' TE during the financial crisis.

For the adoption of rice farming technology and its effect on TE Abdulai et al. (2018) found that farm size, fertilizers, herbicides, household labour and technology have a positive and significant effect on the TE of farmers. Chen et al. (2019) when measuring the technical performance of the public accounting firms in Taiwan found a negative correlation between technical performance and management consulting services (MAS) rates.

TE can be used to assess the causes of development in macroeconomic regions or different geographical areas within the same country or over a long period. Pengfei and Bing (2004) measured TE in 30 Chinese provinces from 1978 to 2001 showed an effective convergence of the Chinese economy before 1992. After 1992, there was a productivity gap in different economic sectors, Shanghai and Guangdong achieved high technical efficiency, expanding the amplitude of production capacity. Neves et al. (2020) using annual data from 2010 to 2018 to measure the effectiveness of the battery-powered electric vehicle (BEV) market expansion in 20 European countries have shown that EU countries have not yet reached the border of technical efficiency, must better monitor and control the inputs in the process of expanding BEV market share.

Analyzing the relationship between leverage, TE and profitability in 238 foreign-invested toy manufacturing companies in China, Mok et al. (2007) have acknowledged that leverage has a positive effect on the TE of the company business and there is a positive relationship between TE and profitability.

To assess the contextual factors influencing the TE of freshwater pond culture systems in Peninsular Malaysia, Iliyasu, Mohamed (2016) observed fish farmers can achieve adequate TE by reducing input use at the current level of technology to produce the same level of production. Research results also show that farmers' age, experience, extension training and water management have a positive and statistically significant impact on technical efficiency.

Some other studies related to technical efficiencies such as the study of Barros and Athanassiou (2004) comparing the TE of an economic sector among many countries: comparing and ranking the efficiency of seaports of Greece and Portugal in the period from 1998 to 2000; Battese et al. (2004) analyzed differences in agricultural productivity between 97 countries in Asia, the Americas, Europe and Africa between 1986 and 1990; research by Moreira and Bravo-Ureta (2010) measuring the TE and technological scale of dairy farms in Chile, Uruguay, and Argentina. The results from empirical studies show that there are many factors from firm's managerial efforts affecting technical efficiencies such as technical level, managerial training level, education level,

and marketing opportunity, the number of years of operation, firm size (Lee and Pitt, 1981, Haddad and Harrison, 1993; Lundvall et al., 2000; Sonnenfeld, 2000; Amornkitvikai et al., 2014; Adusei, 2016); there are many factors from the financial characteristics such as capital per labour (Latruffe et al., 2005; Balcombe et al., 2008), financial leverage (Mok et al., 2007), liquidity (Goldar et al., 2004).

The biggest limitation when using the DEA method to analyze TE is that it ignores the effect of exogenous variables on activity; ignore statistical errors. Therefore, to alleviate this drawback, many studies have used a combination of data envelope analysis and regression analysis (Diaz-Balteiro et al., 2006; Neves et al., 2020). Accordingly, DEA is firstly used to calculate TE for several inputs and outputs related to economic and financial data. Next, a regression analysis of effective measures to explore the change in calculation efficiency.

In addition to the non-parametric DEA approach, to determine the factors affecting technical efficiency, the researchers also approached Stochastic Frontier Analysis (SFA). SFA is an economic modelling method, derived in random production frontier models (Aigner et al., 1977; Meeusen and Van den Broeck, 1977). The SFA also tested "cost" and "profit" efficiency (Kumbhakar and Lovell, 2000; Gralka, 2018), measuring the firm's performance relative to the minimization of total costs (i.e., cost-effectiveness). The SFA assumes that an underlying mathematical function (usually a production or cost function) represents the benchmark, the so-called frontier. SFA, as a parametric method based on an estimate, allows consideration of random errors. The resulting regression table allows further verification of the quality of the estimate and allows the comparison of different specifications. Can view one output for multiple inputs or vice versa. Andersson and Stone (2017) provided evidence that global sourcing (such as import of intermediate inputs) and the TE of firms in the IT manufacturing industry have improved firms' ability to combine and recombine inputs inefficient ways, thus increasing technical efficiency. They also find a close relationship between engineering efficiency and international outsourcing. As one of the most prominent methods for estimating efficiency, SFA is applied in many fields of study, such as agriculture (Xu et al., 2018; Abdulai et al., 2018; Dessale, 2019; Girma, 2019), banking (Thoraneenitiyan and Avkiran, 2009; Oteng-Abayie, 2017), education (Gralka, 2018), automobile industry (Sur and Nandy, 2018), ICT industry (Andersson and Stone, 2017) and the others (Lee and Pitt, 198; Gamtessa, 2014; Mutz et al., 2017).

The biggest difficulty that the researchers encountered when applying SFA is the estimation of the parameters in the equation. In practice, the mean of inefficiencies is nonzero, but a modified minimum squares algorithm or maximum probable algorithm is often used. Due to this difficulty, SFA has little use in research compared to DEA (Lawanson and Novignon, 2017; Mutz et al., 2017).

Compared with SFA, DEA as a non-parametric digital is preferred for the following reasons: (1) complex production functions with multiple inputs and outputs that can be analyzed and described with unique efficiency indicators; (2) no specific function connection as a production function should be identified; (3) best practices can be directly identified; and (4) digitally create powerful solutions for the desired production efficiency (Abramo et al., 2011; Abramo and D'Angelo, 2014; Chen et al., 2015; Mutz et al., 2017).

Firm Size

The Firm size is determined based on the number of employees, the total capital, and the revenue of enterprises. The conflicting results have been shown in empirical studies. Many studies have shown that large-sized enterprises are more effective than small-sized enterprises due to small-sized enterprises having fewer resources so hard to compete in a highly competitive environment; large-sized enterprises have a larger market share and therefore have more opportunities to earn profit. Especially, in sectors that require a high rate of capital, if enterprises have greater resources, they can operate with less competition (Abeyrathna and Priyadarshana, 2019; Subramaniam and Was iuzzaman, 2019; Le et al., 2020). According to Lundvall and Battese (2000), many studies have shown the positive effect of Firm Size on TE such as Lee and Pitt (1981), Haddad and Harrison (1993). Some studies did not find the link between firm size and TE(Hill and Kalirajan 1993, Crespi and Alvarez, 2003). Sonnenfeld (2000) confirms that small and medium-sized pulp and paper enterprises in Vietnam are using low technology, which is more polluting. But in this study, Sonnenfeld (2000) had not yet indicated whether size affects the efficiency of pulp and paper enterprises in these areas. Jensen (1993) explain that larger-sized enterprises are more difficult to reach directorate consensus and reduce business efficiency. The research results of Tingum and Ofeh (2017) also show that firm size is inversely related to TE in the food processing sub-sector.

Capital per Labour

The impact of capital per labour on TE was found in the study of Balcombe et al. (2008). Research shows that the capital per labour ratio has a negative impact on the TE of individual farm groups but has no impact on company farms. However, these are results in the agricultural sector which can take advantage of family labour. Whether those manufacturing enterprises have different, especially paper production?

Total Cost per Total Revenue

The total cost per total revenue ratio reflects the ability to adjust the relationship between the input-output ratio to achieve an efficiency level. Therefore, the smaller the ratio, the higher the efficiency index. This variable is included in the Tobit regression model to confirm the hypothesis that the smaller the ratio of the total cost to total revenue, the higher the firm's efficiency.

Liquidity

Most enterprises tend to make financing through short-term debt. Analysts need to consider Liquidity to assess the ability to pay due to debts of enterprises. Liquidity contains the degree of ease and quickness that an asset can be converted into cash without its significant price reduction. The liquidity of an enterprise is usually assessed by its current ratio. According to Gitman et al., (2013), the current ratio is calculated by dividing the company's short-term assets with short-term liabilities. Goldar et al. (2004) found that liquidity has a positive impact on TE in both periods 1997-1998 and 1999-2000. In this period, technical enterprises in India were facing capital problems, liquidity is an important factor for all activities to be implemented. An enterprise that has high liquidity will be flexible and proactive in its short-term debt obligations. The opposite results are found in Deitiana and Habibuw (2015) when they discovered that a company with a high level of liquidity means that the company is investing too much in short-term assets (cash, inventory, short-term receivables) that lead to an increase in operating expenses (such as the opportunity cost of keeping the money instead of investing money, storage costs, inventory, costs debt collection) or the business may not be able to take advantage of loans to finance short-term assets. That has led to a decrease in profits and a negative impact on business performance.

Financial Leverage

The financial leverage ratio is one of several financial measures that consider the amount of capital acquired in the form of debt or a firm's ability to meet its financial obligations. Financial leverage is like a double-edged sword because: (1) if used properly and effectively, financial leverage will increase the profitability of assets as it creates opportunities to increase the capital of the business; (2) If not using financial leverage effectively, the business will fall into financial crisis. Sena (2006) and Mok et al. (2007) show that financial leverage has a positive impact on technical efficiency. This study expects financial leverage has a positive impact on the TE of Vietnamese pulp and paper enterprises.

Based on the above review results, we propose the following research hypotheses:
H_1: Firm size is positively correlated with technical efficiency
H_2: Capital per labour has a positive impact on technical efficiency
H_3: Total cost per total revenue has a negative impact on technical efficiency
H_4: Liquidity is negatively correlated with technical efficiency
H_5: Financial leverage has a positive relationship with technical efficiency

Research Methods and Models

The Pulp and paper enterprise has a complex business process, combining many inputs to create many outputs. Therefore, to be able to evaluate the overall efficiency of Vietnamese pulp and paper

production enterprises in combining the inputs to create a set of outputs, the efficiency frontier analysis method is a modern method, applied in many research. From the existing data set, this method will measure the TE of DMUs by comparing the effective distance of each DMU with the most effective DMU on the production frontiers, then ranking the efficiency of DMUs.

There are two TE calculation methods: Stochastic frontier analysis (SFA) and data envelopment analysis (DEA). However, the SFA method is a parametric technique, so it is required to specify a type of specific production function and to specify the ineffective distribution or random errors. If the production function is wrong, the calculation result will have the opposite effect on efficiency indicators. Meanwhile, DEA is a non-parametric technique used to empirically set production limits and measure the production efficiency of DMUs. DMUs in this case have the common feature of using multiple inputs to produce multiple outputs. The DEA or CCR model allows each pulp and paper enterprise to apply its own set of weights, thus maximizing its own best possible performance compared to other pulp and paper enterprises. In these cases, efficiency for pulp and paper enterprises is defined as the maximum ratio of output to weighted input. The algebraic model for the CCR ratio form (based on input) is as follows:

$$(CCR)\ \max h_c = \frac{\sum_{r=1}^{s} u_r y_{rc}}{\sum_{i=1}^{m} v_i x_{ic}} \qquad (1)$$

$$s.t.\ \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1$$

$$u_r, v_i \ge 0$$

$$r = 1, 2, ..., s; i = 1, 2, ..., m \text{ and } j = 1, 2, ..., n$$

Where

c = a specific pulp and paper enterprise to be evaluated

y_{rj}= the amount of output r from pulp and paper enterprise j

x_{rj}= the amount of input r from pulp and paper enterprise j

u_r = weight chosen for output r

v_i = weight chosen for input i

n = number of pulp and paper enterprises

s = the number of outputs

m = the number of inputs

In this study, we use 2 inputs such as Wages, Capital and 2 outputs as EBIT, ROA.

The target function defined by h_c aims to maximize the rate calculated from the sum of the total weighted output equal to the sum of the weighted inputs of the paper and pulp enterprises being monitored. By using the same weight, all pulp and pulp in the sample cannot exceed unit performance. These weights are assumed to be unknown, but obtained through optimization. Such optimization is done separately for each unit to calculate weights and measures of efficiency.

The problem setting in (1) is a fractional program. To intuitively describe the reformulation from (1) to the linear programming (LP) equivalence, the LP version of the fractional setting is shown in model (2).

$$\begin{aligned} &\max h_c = \sum_{r=1}^{s} u_r y_{rc} \\ &s.t. \sum_{i=1}^{m} v_i x_{ik} = 1 \\ &\sum_{r=1}^{s} u_{rc} y_{rj} - \sum_{i=1}^{m} v_{ic} x_{ij} \le 0 \\ &u_r, v_i \ge 0 \\ &r = 1,2,...,s; i = 1,2,...,m \; and \; j = 1,2,...,n \end{aligned} \qquad (2)$$

Model (2) assumes constant returns for scale technologies. That is to say, pulp and paper businesses will minimize the use of inputs.

One possible solution for LP (primitive) in (2) is to formulate a dual companion. By denoting the input weights of enterprises c by θc and the input and output weights of other enterprises in the sample by λj the dual form of the maximising problem is formalised as follows:

$$\begin{aligned} &\max h_c = \theta_c \\ &s.t. \sum_{j=1}^{n} \lambda_j y_{rj} - s_i^+ = y_{rc} \\ &\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_c x_{ic} \\ &\lambda_j, s_i^-, s_i^+ \ge 0 \\ &j = 1,2,...,n \end{aligned} \qquad (3)$$

Pulp and paper enterprises are considered efficient if θc = 1 and pulp and paper enterprises are considered ineffective if θc <1. For these inefficient pulp and paper enterprises, the optimum values of λj construct a hypothetical enterprise, that is, formed by a subset of the efficient enterprises.

The pulp and paper enterprise c is regarded as efficient if the θc is equal to one and the slacks (s_i^- and s_i^+) are zero. That is, if and only if,

$h_c^*=1$ with $s_i^{-*}= s_i^{+*}=0$, for all c and j,

Where the asterisk denotes optimal values of the variables in the dual.

For these inefficient pulp and paper enterprises, the optimal values of λj for constructing a hypothetical enterprise, formed by a subset of the DEA efficiency score, are used as performance indicators to determine if pulp and paper businesses are operating in a technically efficient manner. Therefore, interpretation of the DEA efficiency score by investigating the TE determinants is also of great interest.

In previous studies, we found that using the Tobit model can process the characteristics of the delivery of efficiency measures and thus provide results that can guide policies for improvement. performance improvement. The Tobit model was first proposed in econometrics by Tobin (1958).

The standard Tobit model can be defined as follows for observation (pulp and paper enterprises) i:

$$y^*_i = \beta' x_i + \varepsilon_i$$
$$y_i = y^*_i \quad \text{if} \quad y^*_i > 0 \text{ and } y_i = 0, \text{ otherwise} \qquad (4)$$

In this study, to determine the factors affecting the TE of pulp and paper enterprises, we use the Tobit model (Tobin, 1958). The model has the following form:

TE = β1*SIZ + β2*CL + β3*TCR + β4*LIQ + β5*LEV + ε

In where:

- TE: is the dependent variable, reflecting the TE of pulp and paper businesses.
- SIZ, CL, TCR, LIQ, LEV: are independent variables.

+ SIZ (Firm size): represents the size of the company and is calculated by Total labour. SIZ gets a value of 1 for micro-sized, 2 for small-sized, 3 for medium-sized and 4 for large-sized.

+ CL (Capital per labour): is calculated by the Total capital/Average number of employees.

+ TCR (Total cost per total revenue): is calculated by Total cost/Total revenue.

+ LIQ (Liquidity): reflects short-term solvency and is calculated by Short-term assets/Short-term liabilities.

+ LEV (Financial leverage): reflecting the financial leverage and is calculated by Total liabilities/Total assets.

β1, β2, β3, β4, and β5: are coefficients

ε: is error.

Research Results

The Efficiency of Vietnam's Pulp and Paper Enterprises

The paper industry has a large workforce and has steadily increased over the years. In the year 2012, the total number of employees involved in the paper industry was 96,963 person and by 2017 that number reached 106,382 people (Table 1).

Table 1. Statistics on the number of labourers involved in the paper industry in the period of 6 years (2012-2017) (Unit: Person)

	Year						
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**Total**
Production of pulp, paper and paperboard	23,067	30,283	20,507	18,570	16,481	14,730	**123,638**
Production of packaging from paperboard	37,187	38,733	40,925	42,081	42,416	44,619	**245,961**
Production of label paper	10,336	12,090	13,490	14,254	14,912	15,936	**81,018**
Production of other paper	26,373	24,557	25,544	26,249	29,242	31,479	**163,462**
Total	**96,963**	**105,663**	**100,466**	**101,154**	**108,051**	**106,782**	**614,079**

The total average income per year of a worker improves over the years and it is slightly different between groups. In the year 2012, the total average income per year of a worker was 43,4 million. In the year 2017, the average annual income of workers in this sector was almost double that of the number in the year 2012, averaging 78.5 million VND/ person/year. The size of the enterprise varies with income. The general trend is that workers in microenterprises have lower incomes than workers working in large enterprises. For example, in 2017, the average annual income of workers who worked in super small enterprises was about 66.4 million VND/ person/year whereas the average annual income of workers who worked in large enterprises is 134.7 per person per year (Table 2).

Table 2. Statistics average annual income of employees who worked in the paper industry in the period of 6 years (2012-2017) (Unit: Million VND per person per year)

	Year						
Size	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**Total**
Super small	35,9365	47,8357	56,3002	48,7073	75,6721	66,3764	56,5585
Small	44,3625	53,2543	62,8771	73,5299	119,0956	84,3533	73,6794
Medium	67,8584	95,3974	83,5508	91,0704	95,7559	105,8014	90,3156
Large	81,4937	80,4827	82,2777	100,6096	104,5817	134,7114	97,7207
Total	**43,4139**	**53,1607**	**61,4936**	**64,2618**	**101,0187**	**78,5255**	**68,0637**

The increasing number of paper enterprises shows the attractiveness of investing in this area. According to the statistical survey data, in 2017, Vietnam had 2,485 pulp and paper enterprises of different firm sizes, mainly micro and small size (General Statistics Office, 2018).

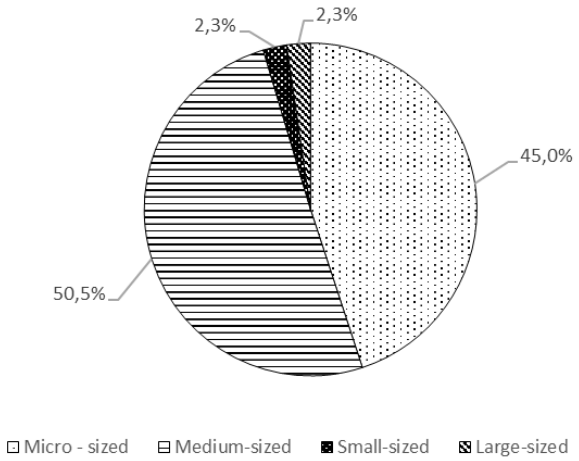

Figure 1. Vietnamese pulp and paper enterprises' size in 2017

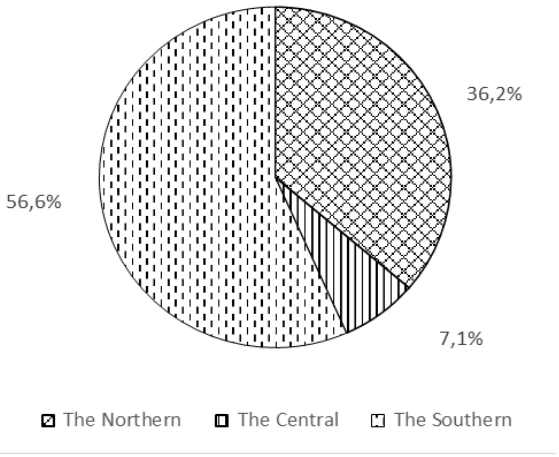

Figure 2. Vietnamese pulp and paper production enterprises by region

Pulp and paper enterprises have been distributed almost everywhere in regions that can develop, the ability to receive projects and respond to the demand for raw materials for production. The Northern Delta (Red River Delta) and the South (including the South East and the Mekong Delta) are the main areas for the development of investment projects in the construction of paper factories which have the large capacity and high concentration industry (Vinh Phuc, Bac Ninh, Ha Noi, Ho Chi Minh City, Binh Duong, Dong Nai, Can Tho ...). In fact, only some provinces have some concentrated paper industrial parks, for example, Bac Ninh Province. In other provinces, paper factories can be located in the industrial zone together with the enterprises of other industries.

Statistics of some major business results and some efficiency indicators of paper enterprises in the period of 2012-2017 show that in this period, the business results of enterprises have improved, increasing average revenue, added value and the average annual State budget contribution (Figure 3).

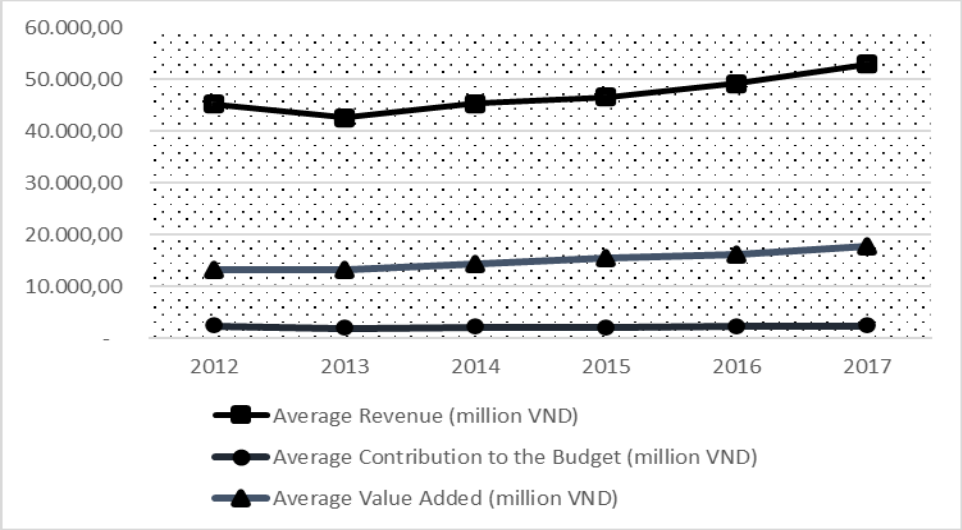

Figure 3. Business results of Vietnam pulp and paper enterprises in the period 2012-2017

Correlation Analysis

Table 3 illustrates the number of observations, mean, standard deviation, min, and a max of 2 inputs variables (Wages, Capital) as well as 2 outputs variables (EBIT, ROA) and 5 different dependent variables (SIZ, CL, TCR, LIQ and LEV) in 1,121 pulp and paper enterprises in Vietnam in 2017.

Table 3. Summary inputs and outputs of technical efficiency

Variable	Obs	Mean	Std. Dev	Min	Max
Wages (million VND per year)	1,121	6,490.7	19,569.4	10	350,715
Capital (million VND)	1,121	73,108.2	289,865.9	26	4,718,378
EBIT (%)	1,121	7,127.4	42,596.2	1	1,005,591
ROA (%)	1,121	0.0724	0.354401	0	8.25740
SIZ	1,121	1.842997	0.6907343	1	4
CL	1,121	949.3515	1354.771	13.98182	16,972.58
TCR	1,121	0.9505674	0.1099426	0.0009983	1,241,785
LIQ	1,121	8.459454	90.46524	0.52	2,786.625

After selecting the inputs and outputs representative variables for the sample of 1,121 Vietnamese pulp and paper production enterprises in 2017, according to the non-parametric DEA approach and the support of Stata 14, we calculated the TE Index of Vietnamese pulp and paper enterprises. Assuming the effect of constant size (CRS) and the statistics described in Table 4 are as follows:

Table 4. Summary of the TE of Vietnamese pulp and paper production enterprises in 2017

Variable	Obs	Mean	Std. Dev	Min	Max
CRS_TE	1,121	0.0329813	0.0916442	0.000106	1

The estimated results of the Tobit regression model on the influence of factors on the TE of Vietnam pulp and paper enterprises are shown in Table 5. Small and medium-sized enterprises are more effective than small enterprises. Although these results seem similar to those of Lee and Pitt (1981)), and Haddad and Harrison (1993), large-sized enterprises seem to be ineffective even though large-sized enterprises have a better advantage of raw materials and access to capital.

At the 1% significance level, the CL factor is statistically significant and positive. This is true of the initial hypothesis that the article expected, that the higher the capital/labour investment, the more technically efficient the business will operate. The TCR variable is statistically significant at the 1% significance level and has an opposite impact on the TE of Vietnamese Paper enterprises. This result is entirely consistent with the content that the more enterprises save costs, the greater the technical efficiency. LIQ has no impact on the TE of Vietnam pulp and paper enterprises. This result is not consistent with the research of Goldar et al. (2004) as well as Deitiana and Habibuw (2015). LEV has a positive impact on TE at the 5% significance level. This is consistent with the research of Sena (2006) and Mok et al. (2007).

Table 5. Variable Correlation

VARIABLES	(1) model	(2) sigma
Small-sized	-0.00976*	
	(0.00522)	
Medium-sized	0.0231**	
	(0.0112)	
Large-sized	-0.000188	
	(0.0121)	
CL	7.07e-06***	
	(1.72e-06)	
TCR	-0.437***	
	(0.0210)	
LIQ	-3.80e-07	
	(2.57e-05)	
LEV	0.0178**	
	(0.00864)	
Constant	0.437***	0.0769***
	(0.0206)	(0.00162)

Observations	1,121	1,121

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Conclusions and Recommendation

The TE of Vietnam pulp and paper enterprises were very low, the average was 0.033. In 1,121 enterprises in 2017, there were only 13 enterprises that achieved constant effect on a scale of 0.5 or more of which only 4 enterprises reached the maximum level (Te = 1). Even some enterprises have the minimum (Te = 0.0001). This analysis indicates that Vietnam pulp and paper enterprises had not yet achieved the goal of avoiding waste.

Obviously, firm size is too large or too small to have certain management problems, thus reducing technical efficiency. Through the analysis data, it can be concluded that in general for Vietnamese pulp and paper enterprises, large enterprises with certain advantages but operating are not effective as small, medium and micro-sized enterprises. The advantage of large-sized enterprises come from stable raw material sources, some large-sized enterprises have built their pulp factories to self-supply raw materials to reduce costs. In addition, large-sized enterprises invest in large-capacity equipment lines, modern wastewater treatment systems, creating conditions to increase product quality and increase competitiveness. However, a difficult problem for the Vietnamese pulp and paper industry is that the large-sized enterprises are not much, but it is mainly foreign direct investment (FDI) enterprises. Micro and small-sized domestic enterprises are facing difficulties in uncertain, seasonal and small input sources; low capacity, low-quality paper, increasingly fierce competition from FDI enterprises has a capacity of dozens of times.

The average capital per labour is 949 million VND/person. Estimated results show that the higher this equipment level, the greater the technical efficiency. The average capital in Vietnamese pulp and paper production enterprises is invested in production lines, inventory, and other working capital.

The smaller the total cost per total revenue earned, the more effective the pulp and paper enterprises are. This is also the goal that pulp and paper enterprises set out in the operation process. The costs incurred in production include the cost of raw materials, the cost of producing energy, the cost of wages, general expenses, and other indirect costs. In short-term strategies as long term, enterprises should be pointed that set goals to avoid wasting each stage of the business process, boosting consumption to reduce the ratio of cost to revenue thereby improving efficiency.

Pulp and paper enterprises are using business leverage effectively. The liquidity ratio does not affect the TE of pulp and paper enterprises. Pulp and paper enterprises have an average capital structure of 56% of liabilities. Therefore, if pulp and paper enterprises maintain a reasonable debt structure, they will be more active and flexible in business.

Based on research results, we find that: To improve technical efficiency, Vietnamese pulp and paper production enterprises need to focus on the following issues:

✓ Cost savings: Pulp and paper enterprises should take the initiative in supplying materials, signing long-term contracts to buy raw materials to stabilize input prices. Improve techniques, invest in modern technology lines in boiler systems, grinding systems, pressing systems to increase paper dryness before drying, using LED lighting systems or small-capacity light bulbs ... increase productivity, save electricity, save coal, reduce emissions.

Organize movements to save costs in production among departments based on cost norms. Setting up cost norms or making annual cost estimates allows enterprises to calculate norm norms or planned efficiency targets. These targets are calculated for each department from the purchasing department, production department, sales department, etc. as part of the targets to be achieved. Enterprises need to have a reward regime for the departments to achieve the efficiency norms or plans to encourage and set an example for the departments in the enterprise.

✓ Expanding the size of enterprises, investing in renovating and upgrading modern production equipment lines to improve labour productivity and increase profitability for enterprises. In our opinion, pulp and paper enterprises should solve three main issues: investment capital; skilled technical workers and sources of raw materials for production.

To solve the capital problem, we recommend that pulp and paper enterprises should consider merging or consolidating to increase their size and facilitate investment in more modern equipment.
Regarding the issue of skilled technical workers to operate well the modern equipment lines, enterprises need to have a roadmap to link with training institutions to train paper technicians and cooperate in using trained workers.
Raw materials for paper production are and will be a difficult problem. Paper enterprises are not concerned about the demand of the consumer market but are struggling to solve the input supply issue. They should be proactive in setting up a wide and ensure purchasing system to be proactive in production. In addition, pulp and paper enterprises need to participate in a series of activities to spread consumer awareness about the collection of waste paper. For example, print slogans to encourage the collection of waste paper directly on paper products, instructions on how to classify paper, point of collection locations ...
Attract foreign investment projects to produce paper using high technology, especially investment projects in paper products that cannot be produced domestically. At the same time, the State should have policies to encourage investment in the production of imported substitutes and in areas with suitable natural and environmental conditions.

✓ Maintain a reasonable loan structure to avoid falling into a financial crisis. While the costs of input materials, energy costs, water ... are fixed costs that are increasing due to price fluctuations, the more interest expenses incurred, the higher the return rate of businesses decreased. If the enterprises maintain a large loan structure, the debt burden makes them easy to ignore the costs of branding, staff training ... reducing the value of the business in the future.

✓ Determining suitable production products: Focusing on developing and manufacturing all kinds of common paper products with great demand such as pulp, packaging paper, tissue paper; prioritize investment in projects of large scale, advanced technology, high efficiency, saving raw materials, fuel, energy, and being environmentally friendly... Since then, created momentum for the paper manufacturing industry to improve competitiveness in the domestic and international markets.

✓ Develop national regulations and standards for paper products: The State should have policies on paper collection and recycling, contributing to environmental protection and saving natural resources. Making use of recycled paper for production helps businesses reduce energy consumption, costs, solid waste and wastewater compared to paper production from primary pulp, helping businesses reduce costs due to scrap prices low, reduce the cost of environmental treatment... Therefore, it is necessary to have policies to improve the rate of paper collection and recycling, to gradually reduce the import of recovered paper as well as to study and complete the development policy of the industry in accordance with the trend of developed countries towards manufacturing paper… creating favourable conditions for investment to expand product development.

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Conflicts of Interest
The authors declare no conflict of interest.

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