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<b>AUTHOR(S)</b>	Indah Mulyawati, Erwin Saraswati, Yeney Widya Prihatiningtias
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# RELATIVE ROLES OF DEBT TO EQUITY RATIO AND TECHNOLOGY IN TOLL ROADS OPERATION MANAGEMENT

*Indah Mulyawati*

*Brawijaya University, Malang, Indonesia*

*Erwin Saraswati*

*Brawijaya University, Malang, Indonesia*

*Yeney Widya Prihatiningtias*

*Brawijaya University, Malang, Indonesia*

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Efficiency, Operating Cost, Maintenance Cost, Toll Road, Toll Companies.

## ABSTRACT

The purpose of this research is to analyze toll road's efficiency performance in Indonesia within 2018-2022 period. Using the Data Envelopment Analysis (DEA) method, the efficiency of operating costs and maintenance costs is assessed for 20 toll road sections in Indonesia. Additionally, the study employs the Tobit regression technique to examine the impact of Capital Structure (proxied by Debt-to-Equity Ratio) and technological sophistication (proxied by Gross Domestic Product - GDP) on the efficiency of Toll Road Companies. The analysis reveals that the efficiency level of Toll Companies remains relatively constant during 2018-2020 but experiences a significant decline in 2021-2022. DER is found to have a significant positive effect on Toll Road Companies' efficiency, suggesting that BUJT management should carefully consider debt and equity costs when determining the capital structure composition. Conversely, the sophistication of corporate technology exhibits a significant negative effect on Toll Road Companies' efficiency. This outcome arises from the high costs associated with the procurement and maintenance of advanced technology. Moreover, the implementation of new technology may temporarily reduce efficiency due to the time and resources required for employee training and adapting to new work processes and systems. This research aims to provide the management authorities for toll road's performance assesment indicators by investigating toll road efficiency.

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## Introduction.

Cost efficiency plays a crucial role in the decision-making process of companies. Sari & Saraswati (2017) defines efficiency as maximizing output through the utilization of existing inputs or achieving certain outputs with minimum inputs. Companies that can effectively manage their

resources are expected to achieve three main objectives: profitability, continuity/survival, and growth (Goyal et al., 2018; Narawish et al., 2022; Oktaviani et al., 2019). Measuring efficiency levels is essential across various industrial sectors, including agriculture, fisheries, forestry (Fenyves et al., 2022), banking (Sari & Saraswati, 2017), manufacturing (Goyal et al., 2018), infrastructure (López et al., 2018; Wei et al., 2019; Xu et al., 2021), and others.

Recognizing infrastructure as a fundamental factor impacting a country's competitiveness, the Indonesian government has prioritized infrastructure development in recent years (Yanwardhana, 2023).

More specifically, toll road development has been designated as one of the National Strategic Projects in Indonesia. Toll road infrastructure offers numerous positive impacts on both a regional (micro) and national (macro) scale. It enhances accessibility and connectivity, making it easier for people to access better healthcare, education, and other facilities (Kanwal et al., 2020). Additionally, toll roads contribute to the development of the tourism sector (Kanwal et al., 2020b; Kim et al., 2015; Nazneen et al., 2019) and stimulate investment growth in the areas they traverse (Natalia et al., 2021). Ultimately, toll road infrastructure acts as a catalyst for the development of various sectors, significantly impacting the economic growth of communities (Ahmad, 2022; Natalia et al., 2021; Thanh Truong et al., 2020).

The growth of toll road infrastructure in the last five years has experienced significant expansion (Rohman et al., 2017). As of December 2022, there were 70 toll roads operating in Indonesia, spanning a total length of 2,604 km. However, during the toll road construction process, the government often faces budget constraints. In light of these circumstances, the government invites the participation of private parties or businesses, also known as Toll Road Business Entity (TRBE), to collaborate in the provision of toll road infrastructure (Toll and Regulatory Agency, 2022).

To meet the demands of providing toll road infrastructure, Toll Road Business Entity (TRBE) are required to continually enhance services and ensure the satisfaction of toll road users (Suwanto et al., 2021). This necessitates a substantial allocation of budget by Toll Road Business Entity (TRBE). Analyzing the financial statements published by Toll Companies, the author has observed an upward trend in toll road operating costs and maintenance costs over the past five years. This phenomenon raises questions regarding the efficiency of toll road operations and maintenance costs, as cost efficiency is a vital aspect of operating toll roads.

The toll road industry is characterized by its high capital requirements. Constructing and operating toll roads are projects that involve substantial investments and long payback periods. Consequently, securing financing through loans, such as bank loans, becomes a critical source of capital. While debt can contribute to improving corporate governance, excessive debt can result in significant expenses for principal and interest payments (Wei et al., 2019). Research conducted by Zanufa and Saraswati (2017) found a positive correlation between capital adequacy and efficiency. However, the findings of Wei et al.'s research (2019) revealed a negative impact of a company's capital structure on its efficiency. Given the importance of decisions related to capital structure composition and the inconsistent research results on the effect of capital structure on firm efficiency, this topic warrants further investigation.

Additionally, this study aims to analyze the impact of economic growth on toll road operating efficiency. According to research by Wei et al. (2019) and H. Xu et al. (2020), regional economic growth can serve as an indicator to assess the level of technological sophistication, personnel qualifications, and managerial capabilities possessed by toll road companies. Toll companies operating in provinces with higher economic growth rates are assumed to have adopted more advanced technology and possess superior personnel and resource management capabilities compared to those operating in provinces with lower regional economic growth. H. Xu et al. (2020) found that regional economic growth plays a significant role in improving efficiency on toll road sections in Western China but does not affect the efficiency of toll road operations in Central and Eastern China.

Due to the inconsistent research findings on the influence of capital structure and economic growth on toll road operational efficiency, this topic becomes intriguing for further investigation. Moreover, to the best knowledge of the researcher, there has been no previous research conducted on the analysis of operational and maintenance cost efficiency of Toll Road Business Entity (TRBE) in Indonesia. Even the study by Lopez and Cacheda (2018) on estimating technical efficiency in toll roads in Spain using the DEA approach was merely presented as an academic exercise. This is primarily due to the difficulty in obtaining data related to toll road operational costs (Lopez and Cacheda, 2018; Xu et

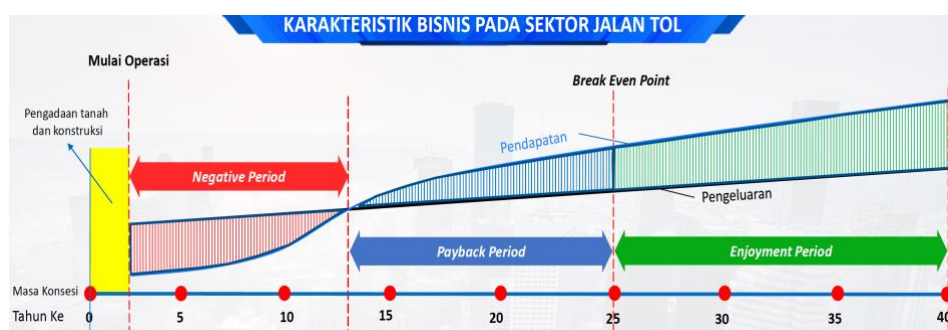
al., 2022). Furthermore, the performance assessment of Toll Companies (BUJT) is currently limited to compliance with the Minimum Service Standards for Toll Roads and does not take into account the level of operational and maintenance cost efficiency (referred to as efficiency in this study). Therefore, it is hoped that this research can provide valuable insights for the performance evaluation indicators of Toll Companies.

**Methodology.**

This study analyzes the operational and maintenance cost efficiency of 20 toll road sections in Indonesia using the Data Envelopment Analysis (DEA) method. The sampling technique employed in this research is purposive sampling. The selection criteria for the sample are as follows:

- 1) All toll road sections that have been in full operation.
- 2) Toll road sections that have been operating in Indonesia for a minimum of 12 years.

These criteria are based on the Public-Private Partnership (PPP) cycle released by the Toll and Regulatory Agency (BPJT) ([www.bpjt.pu.go.id](http://www.bpjt.pu.go.id)), as follows:



*Figure 2. Business characteristics of the toll road sector.*

The period of 12-25 years represents the Payback Period, as during this period, it is estimated that the expenses of Toll Road Business Entity (TRBE) become smaller compared to the revenue generated. Therefore, the researcher concludes that the financial condition of Toll Road Business Entity (TRBE) has improved compared to the previous period.

Furthermore, the researcher justifies the efficiency values of the toll road sections as the efficiency values of Toll Companies. The next stage of the research involves analyzing the impact of the Debt to Equity Ratio (DER) and the technological sophistication of Toll Companies, approximated by the Gross Domestic Product (GDP), on the efficiency of Toll Companies. This analysis will be conducted using the Tobit regression technique and will be supplemented with the interpretation of hypothesis testing results.

**Data Envelopment Analysis (DEA).**

DEA is a non-parametric method used to measure the relative efficiency of Decision-Making Units (DMUs) with multiple inputs and/or outputs. This research employs the DEA approach using the Banker Charnes Cooper (BCC) model with the Variable Return Scale (VRS) assumption focused on inputs. The BCC model, with the VRS assumption and input orientation, is used as a decision-making reference as it formulates the proportional reduction of operational and maintenance cost allocations (inputs) without compromising the output, which is the length of the operated toll road sections.

Table 1. List of Outputs and Inputs.

Variable	Indicator	Source of Data
Output	Toll Road Length Operated by Toll Companies (BUJT)	LAKIP ( <i>Laporan Kinerja Instansi Pemerintah</i> ) of The National Toll Road Authority, Ministry of Public Works and Housing (PUPR)
Input	Operational Costs	Toll Companies Annual Report
	Maintenance Cost	Toll Companies Annual Report

**Tobit Regression.**

Tobit regression, also known as Tobin regression, was first introduced by James Tobin in 1958. Tobit regression is a statistical analysis technique used to examine the relationship between a dependent variable and independent variables when the dependent variable is limited or bounded. Therefore, Tobit regression analysis is suitable for implementation in this study because the efficiency level, as the dependent variable, is censored data ranging from 0 to 1. The Tobit regression analysis used in the second stage of this study aims to measure the influence of capital structure variables and Gross Domestic Product on the level of technical efficiency obtained from the previous DEA analysis. The variables that are expected to affect the efficiency level of Toll Companies (BUJT) and will be examined through Tobit regression are listed in Table 2.

Table 2. List of Regression Variables and Data Sources.

Variable	Indicator	Symbol	Source of Data
Capital Structure	Debt to Equity Ratio	DER	Financial Statements of Toll Companies (BUJT)
Technology	Gross Domestic Product	GDP	Central Statistics Agency (BPS)
Technical Efficiency of Toll Company	Efficiency level of DEA data processed results	EFT	Processed Data

Debt can improve corporate governance (Wei et al., 2019). Meanwhile, the study by Zanufa and Saraswati (2017) found that the level of capital adequacy has a positive impact on efficiency. Furthermore, the research by Njagi Kirmi (2017) stated that debt has a positive influence on firm performance. Based on these explanations, the researcher proposes the first hypothesis:

*Hypothesis 1: Capital structure has a positive effect on the level of efficiency of Toll Companies.*

The researcher also analyzes the impact of the technology variables adopted by the companies on their efficiency level. Contingency theory assumes that there are three interrelated factors in improving performance: technology, organizational structure, and environment. The researcher uses Gross Domestic Product (GDP) as a measure of the technological sophistication adopted by Toll Companies in their operations, assuming that higher GDP indicates more advanced technology adopted by the companies (Xu et al., 2020). In light of this, the researcher proposes the second hypothesis:

*Hypothesis 2: Gross Domestic Product (GDP) has a positive effect on the efficiency level of Toll Companies.*

Based on the explanation above, the mathematical model used in this study for tobit regression analysis is:

$$EFT = \alpha + \beta_1 DER + \beta_2 GDP + e$$

Where:  $1 > EFT > 0$

Description:

EFT : Technical Efficiency obtained in DEA measurement

$\alpha$  : Constant

DER : Capital Structure (proxied by Debt to Equity Ratio)

GDP : Technology (Proxied by Gross Domestic Product)

$e$  : Error (unaccounted factor in the model)

$\beta_1 - \beta_2$  : Coefficients

**Results and Discussion.**

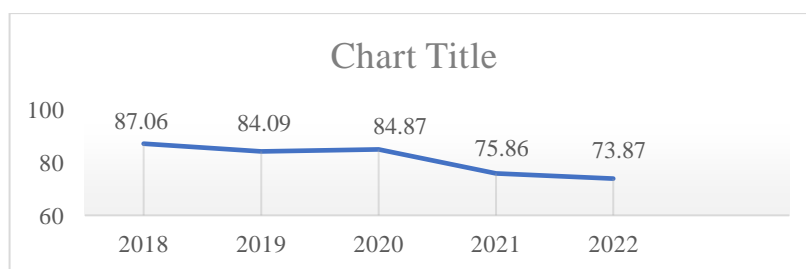
**Result of Efficiency Calculation.**

Based on the provided data of input and output variables, we analyzed the level of operational efficiency of 20 toll road sections using MaxDEA Lite v12.0 software. The researcher employed the assumption of CRS (Constant Returns to Scale), which implies that an increase in input will not affect the increase in output. This assumption aligns with this study, where an increase in operational costs and maintenance costs of toll roads as input variables will not increase the length of toll roads operated as output variables. The following table shows the levels of efficiency in toll road operations obtained from the DEA analysis.

Table 3. Efficiency Levels of Toll Road Sections.

Toll Road Section Name	2018	2019	2020	2021	2022
Jakarta - Bogor - Ciawi	100%	100%	100%	100%	100%
Prof.Dr.Ir.Soedijatmo	100%	100%	100%	83,2%	83,2%
Cawang - Tomang - Pluit (CTC)	100%	100%	100%	83%	83%
Cawang - Tj. Priok - Ancol Timur - Jembatan Tiga/Pluit	40,93%	38,61%	44,03%	63%	17,90%
Jorr S	46,07%	55,30%	100%	21,2%	22%
Jorr Non S	100%	100%	100%	94,8%	94,8%
JORR W1 (Kebon Jeruk - Penjaringan)	66,90%	49,75%	41,51%	29,7%	29,2%
Pondok Aren - Bintaro Viaduct - Ulujami	100%	100%	100%	49,10%	49,10%
Jakarta - Tangerang	100%	100%	100%	100%	100%
Jakarta - Cikampek	100%	100%	100%	100%	100%
Palimanan - Kanci	100%	100%	100%	90,20%	90,20%
Semarang Seksi A,B,C	100%	100%	100%	77,2%	77,2%
Surabaya - Gempol	100%	100%	100%	85,7%	85,7%
Padalarang - Cileunyi	100%	100%	100%	94,4%	94,4%
Surabaya-Gresik	64,65%	48,90%	30,18%	52,60%	58,5%
Cikampek - Padalarang	100%	100%	100%	92,5%	92,5%
Simpang Susun Waru - Juanda Airport	88,47%	100%	100%	100%	100%
Belawan - Medan - Tanjung Morawa	100%	100%	100%	86,40%	86,40%
Tanjung Priok ACESS	100%	60,38%	47,62%	93,20%	95,80%
JORR W2 Utara (Kebon Jeruk - Ulujami)	34,13%	28,92%	34,05%	17,5%	17,5%
Average	87,06%	84,09%	84,87%	75,68%	73,87%

Based on Table 3, it can be observed that the efficiency levels of operational costs and maintenance costs for toll roads tend to fluctuate during the years 2018-2020 and experienced a sharp decline in 2021-2022. The average efficiency level of toll roads, which was 84.87% in 2019, significantly dropped to 75.68% in 2020, as shown in the following graph:



*Figure 2. Trend of Average Efficiency in Operational Costs and Maintenance Costs of Toll Roads.*

*Source: DEA Data Processing Results.*

Based on the above graph, the efficiency level of Toll Road Business Entity (TRBE) or Toll companies experienced a slight increase in 2019-2020, which could be attributed to the phenomenon of the Covid-19 pandemic. One of the government's policies to prevent the spread of the Covid-19 virus was the implementation of Community Activity Restrictions (PPKM), which led to a decrease in the volume of vehicles passing through toll roads. Consequently, this had an impact on the operational costs and maintenance costs of toll roads, preventing them from escalating. The efficiency analysis using the DEA method also provides recommendations for toll road sections that can serve as benchmarks for other sections that have not yet achieved optimal efficiency. The following table shows the toll road sections that serve as benchmarks for sections with the lowest efficiency in operational costs and maintenance costs:

Table 4. Toll Road Sections with the Lowest Efficiency in Operational Costs and Maintenance Costs.

Rank	2018	2019	2020	2021	2022
1	JORR W2 Utara (Kebon Jeruk - Ulujami)	Jorr S	Jorr S	JORR W2 Utara (Kebon Jeruk - Ulujami)	JORR W2 Utara (Kebon Jeruk - Ulujami)
2	Cawang - Tj. Priok - Ancol Timur - Jembatan Tiga/Pluit	JORR W2 Utara (Kebon Jeruk-Ulujami)	Surabaya – Gresik	Cawang - Tj. Priok - Ancol Timur - Jembatan Tiga/Pluit	Cawang - Tj. Priok - Ancol Timur - Jembatan Tiga/Pluit
3	Jorr S	Cawang - Tj. Priok - Ancol Timur - Jembatan	JORR W2 Utara (Kebon Jeruk - Ulujami)	JORR W1 (Kebon Jeruk - Penjaringan)	Jorr S

**Result of Tobit Regression.**

The Researchers used the Eviews 12 software to analyze the effect of the Debt to Equity Ratio (DER) and technological sophistication used by Toll Companies to operate toll roads on the efficiency level of Toll Companies' with detailed results as follows:

Table 5. Regression Result.

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.736572	0.096574	7.627001	0.0000
Capital Structure	0.050179	0.028172	1.781173	0.0749
Technology and Competency	-0,00000143	-0,000000347	-4.128053	0.0000

Results of the regression estimation in Table 5 can be interpreted as follows:

- a. The regression coefficient for the Debt to Equity Ratio variable is 0.050179, indicating a positive one-way relationship between the Debt to Equity Ratio and the efficiency of Toll Companies. Furthermore, the Z-statistic value of 1.781173 and the p-value of 0.0749 suggest that, with a significance level of 0.1 (10%), it can be concluded that the Debt to Equity Ratio has a positive and significant impact on the efficiency of Toll Companies.
- b. The regression coefficient for the Gross Domestic Product (GDP) variable is -0.00000143, indicating an inverse relationship between the GDP level and the efficiency of Toll Companies. Furthermore, the Z-statistic value of -4.128053 and the p-value of 0.0000 suggest that, with a significance level of 0.1 (10%), it can be concluded that the GDP level has a negative and significant impact on the efficiency of Toll Companies. In other words, the Tobit regression estimation results indicate that as the GDP level of the region traversed by the toll road increases, the efficiency of Toll Companies decreases.

### **Discussion.**

#### **Capital Structure has a positive effect on the Efficiency of Toll Companies.**

The results of testing the variable Capital Structure of Toll Companies, represented by the Debt to Equity Ratio (DER), on the efficiency level of Toll Companies indicate that the capital structure variable has a positive impact on the efficiency level of Toll Companies. The Debt to Equity Ratio compares the total debt to the total equity of the company, reflecting the composition of debt and equity used by the company in its business operations.

This research supports the theory of X-efficiency, which assumes that decision-making within companies is often not based on available information and prevailing conditions but prioritizes individual interests over company interests, thereby reducing company efficiency. For example, a company may use a higher proportion of equity to conduct its business operations in the hope of delivering expected returns to investors. This condition can decrease the level of company efficiency. In line with this condition, the results of this research show that the higher the proportion of debt owned and used by Toll Companies to operate toll roads, the higher the level of company efficiency.

A high DER ratio is not always detrimental. Debt can enhance company efficiency by promoting managerial discipline. The presence of debt that needs to be repaid is expected to increase management awareness in running the company efficiently. Additionally, Toll Companies may choose to utilize more debt because the cost of debt may be lower compared to the cost of equity, especially in a low-interest rate environment. High debt levels also provide privileges to the company, as interest expenses on debt are deducted from income before taxes, resulting in lower corporate income taxes.

The findings of this study do not align with the research conducted by Zanufa and Saraswati, who found that the adequacy of capital ratio does not affect company performance. However, this research supports the findings of Sari et al. (2021), who found that the Debt to Equity Ratio (DER) partially affects Company Performance.

#### **The Adoption of Advanced Technology has a Negative Impact on the Efficiency of Toll Companies.**

The testing of the variable Gross Domestic Product (GDP), which serves as a proxy for the adoption of advanced technology and technical capabilities of the company, shows that the GDP variable has a significant negative impact on the efficiency level of Toll Companies. This research supports contingency theory, which assumes that three interrelated factors—technology, organizational structure, and the environment—are crucial in achieving organizational goals. In line with this theory, Toll Companies in Indonesia have adopted advanced technology to operate toll roads. However, the use of sophisticated technology in toll road operations incurs substantial costs, starting from acquisition, installation, and maintenance. As a result, the efficiency level of Toll Companies decreases.

An example of advanced technology implemented by Toll Companies in Indonesia is the use of video wall technology for real-time traffic monitoring on toll road lanes, which can further provide information to road users through digital information screens or Variable Message Signs (VMS). In addition to Variable Message Signs (VMS), several Toll Companies in Indonesia have also implemented Weight in Motion (WIM) technology. WIM is a highly accurate technology for measuring vehicle loads and justifying overloaded cargo vehicles. The use of WIM aims to sort out vehicles that violate the



permitted weight (JBI) or the permitted combination (JBKI). As a filtering system, the WIM device needs to be equipped with supporting tools such as loop detectors, license plate recognition cameras, surveillance cameras (CCTV), and dimension sensors (OD detection). The operation of WIM technology is expected to minimize the negative impacts caused by oversized and overloaded vehicles, such as severe traffic accidents and toll road infrastructure damage.

When a company introduces new technology for the first time, it may experience temporary efficiency decline. This is because time and resources are needed to train employees, adapt to new work processes, and adjust to the new system.

In addition to the high implementation costs of technology, the salary expenses for highly competent human resources also contribute to the allocation of Toll Companies' operational burdens. The Toll Companies analyzed in the Tobit Regression analysis in this study operate in Java Island, where the Regional Minimum Wage is higher compared to other islands. Therefore, it can be estimated that high salary expenses can reduce the efficiency level of Toll Companies.

These research findings align with the study conducted by Wei et al. (2019) and Xu et al. (2020), which found a significant impact of Gross Domestic Product on the efficiency level of toll road operations in the eastern region of China. Furthermore, Xu et al (2020) and Rico (2023) found that technological sophistication has a significant negative effect on the level of company efficiency.

### **Conclusions.**

The testing of the variable Debt to Equity Ratio (DER) as a proxy for the capital structure of Toll Companies shows that the level of capital structure has a positive impact on the efficiency level of Toll Companies. This means that the higher the proportion of debt in the company's capital structure, the higher the efficiency level of the company. A high DER ratio is not always negative. Debt can enhance company efficiency by promoting managerial discipline. The presence of debt obligations is expected to increase management awareness in running the company efficiently. Additionally, Toll Companies may choose to use more debt because the cost of debt is often lower compared to equity, especially in a low-interest rate environment. High debt levels also provide privileges to the company as interest expenses on debt are deducted from pre-tax income, resulting in lower corporate income tax payments.

The testing of the variable Gross Domestic Product (GDP) as a proxy for technological advancement and technical capabilities possessed by companies shows that the GDP variable has a significant negative impact on the efficiency level of Toll Companies. This is because the implementation of sophisticated technology incurs high costs, from acquisition to maintenance. Additionally, when companies first introduce new technology, they may experience temporary efficiency declines. This is due to the time and resources required for employee training, adaptation of work processes, and adjustment to the new system.

### **Implications.**

The findings of this study on the efficiency analysis of Toll Companies have several implications such as Policy Implications. The results of this research are expected to provide insights to policymakers regarding the efficiency level of Toll Companies in operating toll roads. This can help policymakers develop guidelines on how to effectively manage operational and maintenance costs, along with best practices. Furthermore, measuring the efficiency level of toll road operations can be an innovative approach to assessing the performance of Toll Companies. It expands the evaluation criteria beyond meeting the Minimum Service Standards (SPM) and includes evaluating the capability of Toll Companies in cost management.

Then, as practical implications, this research can serve as a scientific reference for leaders and management of Toll Companies regarding the input variables that cause inefficiencies within the companies. It also provides clear benchmarks as a basis for decision-making in allocating operational and maintenance costs for toll roads. Furthermore, this study can be considered by Toll Company management when making decisions regarding capital structure. The empirical evidence presented in this research indicates that higher debt ratios lead to higher efficiency levels. This finding suggests that the cost of equity is higher compared to the cost of debt in the toll road industry. Therefore, management should analyze the magnitude of the capital cost that the company has to incur before deciding to increase debt.

### **Study Limitations and Future Research.**

The researcher acknowledges several limitations in conducting this study. The limitations of this research are as follows:

Firstly, the researcher was unable to obtain financial data from some Toll Companies that should have been included as research samples. These Toll Companies did not provide the data, citing that their companies are not yet publicly listed, and therefore, some data are considered confidential. As a result, future research is recommended to use variables that have publicly available data, such as revenue, daily traffic levels, and others. These data are already presented in the Annual Reports of the Toll Regulatory Agency.

Secondly, one Toll Company was not included as a dependent variable in the Tobit Regression analysis. This was due to the fact that the Toll Company operates more than one toll road sections, making the Gross Domestic Product (GDP) variable less relevant as a factor influencing the efficiency of the Toll Company, as it cannot reflect the technological advancements and technical capabilities of the company. Additionally, the sample criteria set by the researcher only included toll road sections operating on the island of Java, limiting the analysis of efficiency comparisons among toll road sections across different islands in Indonesia. Therefore, future research is suggested to pay more attention to the sample criteria used so that the research findings can better represent the efficiency levels of all toll road sections operating in Indonesia.

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