



The Influence of Road Infrastructure, Fuel Prices, and Logistics Fleet on PT Kereta Api Logistik (KALOG) Distribution Costs 2019-2024

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ABSTRACT

The purpose of this study is to examine how road infrastructure, fuel prices, and logistics fleets impact distribution costs at PT Kereta Api Logistik from 2019 to 2024. This study uses a quantitative descriptive and verification approach and utilizes secondary data from company reports and official data providers. Analysis is conducted to show how each variable develops and test its relationship with the model that has been built. The results show that although the three independent variables have a significant impact when tested partially, they do not have a significant impact when tested simultaneously. The results indicate that the trend of business distribution costs is more influenced by a combination of external and internal factors simultaneously rather than the influence of only one variable. The study suggests that an integrated approach to managing distribution costs should utilize the fleet, optimize the service network, and adapt to changes in the operational environment. In addition, this study provides a theoretical contribution on how the relationship between environmental factors and operational strategies is crucial to determining how efficient distribution costs are for multimodal logistics organizations

INTRODUCTION

Although the logistics sector is crucial for enhancing Indonesia's economic competitiveness, it still faces the problem of high logistics costs. Several studies indicate that transportation costs are the primary factor contributing to high national logistics costs (Santoso et al., 2021). Another study found that logistics costs can reach more than 14% of total investment costs, impacting the price competitiveness of products and services (Anggara et al., 2020). This situation demonstrates the importance of efficient distribution costs for the national supply chain. According to the Logistics Performance Index (LPI), there is a downward trend in Indonesia's logistics performance. High national logistics costs, which reach 14.1% of GDP, are associated with a decline in the LPI score from 3.15 to 3.00, according to Kurniawan, So, Ricardianto, and Soekirman (2025). Conversely, despite government spending on developing transportation infrastructure, the LPI ranking continues to decline. This indicates that infrastructure development has not fully reduced logistics costs (Setiawan et al., 2018). The integration of strategic planning and transportation connectivity is another important issue related to logistics costs. A study by Suparman, Abdal, Hidayat, Effendi, and Septiadi (2023) investigated how air connectivity and strategic planning are integrated into destination development. They explained that to improve the efficiency and performance of related industries, both must work together. Despite the fact that the research subject is the tourism industry, the basic principle applicable to the logistics industry is that the integration of planning and transportation connectivity impacts industry performance. This study shows that achieving an industry's strategic goals can be hampered by partial, unintegrated planning, or the neglect of important factors (Suparman et al., 2023, pp. 184–187). These results provide a theoretical basis for the idea that improvements in road infrastructure, energy costs, and distribution systems should be viewed as an integrated system that simultaneously impacts logistics cost efficiency.

Road-based transportation is the most important cost burden structure within the national logistics cost component. Syifa and Tohir (2023) found that land transportation contributes the largest proportion of domestic logistics costs, making the efficiency of this mode crucial for national logistics efficiency. However, many logistics corridors face issues such as limited capacity, damage, congestion, and legal and informal costs, which can increase distribution costs (Sudjana, 2016). This aligns with global research showing that improvements in transportation infrastructure directly reduce distribution costs and increase economic activity (Redding & Turner, 2015). Fuel price dynamics are another significant factor influencing distribution costs. From 2019 to 2024, Indonesia experienced several fuel price increases, including the Pertalite price increase in 2022. Studies in emerging markets show that fuel price increases directly impact logistics costs and business distribution strategies. Global studies also indicate that freight operating costs can increase by tens of percent, depending on the sensitivity of different transportation modes (Mustaffa et al., 2018). Logistics fleets, in addition to infrastructure and fuel costs, are a major factor influencing business distribution costs. Fleets, whether trucks, rail cars, or loading and

unloading equipment, are considered tangible resources that can provide a competitive advantage if managed properly from a Resource-Based View (RBV) perspective (Barney, 1991; Kurniawan et al., 2024). In Indonesia, research conducted by Budiman and William (2025) shows that the use of multimodal transportation and proper fleet management can significantly reduce distribution costs. Furthermore, research on distribution routes based on heuristic algorithms found that efficient fleet management has a direct impact on reducing business costs (Heuristic Route Optimization, 2024).

As a subsidiary of PT Kereta Api Indonesia (KAI), PT Kereta Api Logistik (KALOG) plays a crucial role in providing rail-based logistics services and operating a fleet of trucks for first- and last-mile services. A study by Priaswari and Tohir (2025) found that with good multimodal coordination, rail-based logistics integration can reduce export distribution costs. However, declining freight volumes, competition with trucks on the Trans-Java toll road, and limited rail network capacity are other challenges facing KALOG (Sembiring et al., 2024). Many studies have addressed logistics costs at the macro level, but very little empirical research has specifically examined the determinants of distribution costs at the rail-based logistics company level. National logistics performance, multimodal efficiency, or the macro effects of rising energy prices have been the sole focus of previous research (Li et al., 2023). Therefore, there are few micro-scale studies that simultaneously analyze the influence of road infrastructure, fuel prices, and logistics fleets on the distribution costs of specific logistics companies in Indonesia. To address this gap, this study utilizes two main theoretical foundations. First, the logistics cost function approach with explicit transportation costs is the first of its kind (Axbard et al., 2018). This approach provides a basis for simulating how overall distribution costs are affected by changes in transportation costs. Second, the resource-based perspective (Barney, 1991) is used to explain how logistics fleets can provide cost advantages. By integrating these two theories, KALOG's distribution costs can be comprehensively analyzed from both quantitative and strategic perspectives. This research is novel because three key variables—road infrastructure conditions, fuel prices, and fleet characteristics—are integrated into a single empirical model based on KALOG's operational data for the 2019–2024 period. This study not only addresses the shortcomings of previous research but also helps companies develop efficient distribution cost strategies.

LITERATURE REVIEW

Hypotheses Development

The Effect of Road Infrastructure on Distribution Costs

According to the logistics cost function, transportation costs are a major component of overall logistics costs. Therefore, changes in transportation costs will directly impact a company's overall logistics costs (Axbard et al., 2018; Santoso et al., 2021). Through its influence on travel speed, fuel consumption, and vehicle breakdown and maintenance rates, road infrastructure is a key factor influencing vehicle operating costs in land transportation. Studies on freight transportation in Indonesia indicate that truck operating costs increase due to

regulatory issues, poor road quality, and unofficial fees (Sudjana, 2016; Setiawan et al., 2018). Recent studies on logistics cost efficiency in Indonesia indicate that land transportation accounts for approximately half of domestic logistics costs; therefore, improving land transportation infrastructure is a key way to reduce logistics costs (Syifa & Tohir, 2025; Kurniawan et al., 2025). According to additional research on road quality and infrastructure development, improving road surface quality and network capacity can reduce travel costs and improve the smooth flow of goods (Road Maintenance and Local Economic Development, 2023). Within the framework of the logistics cost function, improving road infrastructure quality will reduce transportation costs per unit distance and per unit load, resulting in a decrease in the smooth flow of goods (Road Maintenance and Local Economic Development, 2023). This study positions road infrastructure as a factor influencing PT KALOG's distribution costs based on empirical findings and the theoretical framework of the logistics cost function. Assuming that better road infrastructure indices indicate smoother roads, sufficient capacity, and lower congestion, a negative relationship is expected between road infrastructure quality and distribution costs. Consequently, the first hypothesis is formulated as follows.

The Effect of Fuel Prices on Distribution Costs

Freight transport operating costs are largely influenced by fuel costs, particularly for road transport and modes still reliant on fossil fuels. Cargo vehicle operating cost models show that rising fuel prices significantly increase operating costs per kilometer. This is because fuel costs account for a significant portion of the total operating costs of trucks and other transport vehicles (Mustaffa et al., 2018). Other studies have reached similar findings, confirming that freight rate adjustments are driven by fuel price fluctuations and directly impact container transport costs (Sholagberu et al., 2018). Suraharta and Hendrasti (2025) found in the context of emerging markets that rising fuel prices increase logistics costs through two mechanisms: direct increases in freight costs and adjustments in distribution methods, such as fuel surcharges and changes in distribution network patterns. The prices of High-Speed Diesel (HSD) and Marine Fuel Oil (MFO) have increased, resulting in increased shipping operating costs and a decrease in the volume of goods transported. Overall, research shows that fuel price uncertainty is a major threat to logistics cost management, and businesses tend to increase logistics rates to cover these increased costs (Atlas International, 2024; Atlas Logistics Cost Review, 2023). Fuel prices directly determine the variable cost of transportation per kilometer in the context of a logistics cost function with clearly defined transportation costs (Axbard et al., 2018; Answer, 2018). In other words, first-mile and last-mile rail and truck transportation costs will increase due to rising fuel prices. The following is the second hypothesis developed by this study based on the empirical findings:

The Influence of Logistics Fleet on Distribution Costs

The number of units, carrying capacity, vehicle age, utilization rate, and maintenance patterns of a company's logistics fleet affect distribution costs. According to the resource-based logistics (RBV) perspective, a fleet is considered a tangible resource that can provide cost and competitive advantages if it meets the characteristics of being valuable, rare, difficult to imitate, and non-

substitutable (Barney, 1991; Desi, 2025; Karia, 2020). The concept of resource-based logistics asserts that logistics service providers that can effectively combine fleet resources and operational capabilities will achieve cost and competitive advantages. Operationally, recent research emphasizes the use of technology and dynamic fleet management to reduce costs. Kurniawan et al. (2024) developed a fleet management optimization model that combines preventative and predictive maintenance with operational workload sharing. Their research shows that this combination can significantly reduce total fleet costs. A more structured management of capacity, movement speed, and operating costs improves operational efficiency and productivity (Evaluating Successful Implementation of Fleet Management System, 2023). Furthermore, analytical research on fleet and cargo management shows that the use of tracking technology, matching fleet capacity to demand volume, and route optimization reduce logistics costs per unit of cargo (Selva Kumar, 2025).

Through more efficient management of distance, cargo weight, and delivery time, the right combination of modes and fleet design can reduce logistics costs in Indonesia (Budiman & William, 2025). Conversely, research on optimizing rail logistics for first-mile exports shows that using more wagons and integrating with land transportation networks reduces logistics costs (Priaswari & Tohir, 2025). Therefore, companies can reduce distribution costs by better managing their fleets from the perspectives of quantity, capacity, age, and utilization. This research positions the logistics fleet as a factor influencing PT KALOG's distribution costs. Based on the RBV perspective and empirical findings on fleet management, when the fleet is well-planned and managed (e.g., with high utilization, capacity aligned with demand, and timely maintenance), distribution costs per unit of cargo are expected to decrease. This leads to the formation of the hypothesis

Conceptual Framework and Research Hypothesis

This study develops a conceptual framework based on theoretical analysis and previous research findings. This conceptual framework positions the logistics fleet, road infrastructure, and fuel prices as independent variables that influence PT KALOG's distribution costs, which are the dependent variable. Previous studies have found that:

- a. Transportation costs and infrastructure efficiency significantly influence Indonesia's logistics costs (Santoso et al., 2021; Syifa & Tohir, 2025; Kurniawan et al., 2025).
- b. Fluctuations in fuel prices increase transportation operating costs (Mustaffa et al., 2018; Suraharta & Hendrasti, 2025; The Effect of Fluctuating Fuel Prices on MFO and HSD, 2022).
- c. Reducing logistics costs can be achieved through effective fleet management that relies on RBV and technology (Kurniawan et al., 2024; Karia, 2020; Selva Kumar, 2025).

Conceptually, the following is the research structure:

- a. Road infrastructure (X1) affects distribution costs through changes in travel time, fuel consumption, and the frequency of vehicle breakdowns.

- b. Fuel prices (X2): Tariff adjustments and increases in variable costs per kilometer affect distribution costs.
- c. Distribution costs are influenced by the logistics fleet (X3) through capacity, utilization, and fleet operational efficiency.
- d. PT KALOG's distribution costs (Y) are the sum of costs resulting from transporting goods by rail and supporting trucks.

For illustration, the conceptual framework of this study consists of three arrows connecting X1, X2, and X3 to Y. These arrows also indicate the partial and simultaneous effects of the three independent variables on distribution costs. Thus, in addition to the three partial hypotheses (H1-H3), this study also formulates a fourth hypothesis to identify the simultaneous effects:

METHODOLOGY

This study employed a quantitative descriptive and verification method. The descriptive method was used to explain how road infrastructure, fuel prices, logistics fleets, and distribution costs at PT Kereta Api Logistik (KALOG) changed from 2019 to 2024. Therefore, based on the conceptual framework and previously formulated hypotheses, the verification method was used to empirically test the effect of road infrastructure, fuel prices, and logistics fleets on PT KALOG's distribution costs. PT KALOG is a railway-based logistics company that operates a land distribution network and freight transportation services. This is the research unit of analysis. This study employed a quantitative approach because it focused on evaluating causal relationships between variables using a multiple linear regression model. The secondary data used in this study came from an annual time series from 2019 to 2020. The road infrastructure variable (X1) was calculated using the national-level indicator of decent roads. These indicators are derived from the official publication of the Indonesian Central Bureau of Statistics, "Land Transportation Statistics 2019–2024" (BPS, 2019–2024), national road stability data from the Directorate General of Highways, Ministry of Public Works and Public Housing (PUPR, 2019–2024), and the Satu Data Indonesia portal, which collects specific data on the percentage of national roads in stable condition per year.

The fuel price variable (X2) is represented by the average official price of diesel fuel across the country for 2019–2024. The "Performance Report of the Directorate General of Oil and Gas 2019–2024," published by the Ministry of Energy and Mineral Resources (ESDM, 2019–2024), and the official annual fuel price publication of PT Pertamina (Persero) (Pertamina, 2019–2024) are the sources of this data. Diesel prices are expressed in rupiah per liter and serve as a measure of energy costs, which directly impact the operating costs of KALOG's supporting trains and trucks. The logistics fleet variable (X3) is calculated based on fleet data managed by PT KALOG from 2019 to 2024. This data was obtained from the company's annual reports for each study year. Data includes the number of fleets and transport capacity used in logistics operations (PT Kereta Api Logistik, 2019; PT Kereta Api Logistik, 2020; PT Kereta Api Logistik, 2021; PT Kereta Api Logistik, 2022; PT Kereta Api Logistik, 2023; and PT Kereta Api

Logistik, 2024). The logistics fleet indicators used in this study were adjusted based on data availability and consistency.

Distribution costs (Y), the dependent variable, were obtained from PT KALOG's financial statements and annual reports from 2019 to 2024 (PT Kereta Api Logistik, 2019–2024). In this study, distribution costs are defined as the total distribution costs or distribution costs directly related to the transportation of goods and logistics services provided by KALOG. Distribution costs are expressed in rupiah per year. Distribution cost data can be transformed to improve normality and stability of variance if necessary for analysis purposes. This can be done without changing the substantive meaning of the variables. The data collection methods in this study consisted of documentation and literature review. A documentation study was conducted by downloading and compiling official publications from relevant government agencies, such as the Central Statistics Agency (BPS), the Ministry of Public Works and Public Housing (PUPR), the Ministry of Energy and Mineral Resources (ESDM), and Pertamina, as well as the annual reports and financial statements of PT KALOG from 2019 to 2020. All collected data was then checked for completeness, consistency, and suitability for the research requirements. The following are the formulas for measuring the variables in this study. Road infrastructure (X1) is calculated as the percentage of national roads in good condition to the total national road length per year. Fuel prices (X2) are calculated using the average annual national diesel fuel price in rupiah per liter. Logistics fleet (X3) is calculated by calculating the number of logistics fleets owned and/or operated by KALOG each year or the total available transport capacity in the units used in the annual report. Distribution costs (Y) are calculated by calculating KALOG's total annual distribution load. This value is expressed in rupiah. All variables are analyzed using annual data from 2019 to 2024. This results in six time series observations for each variable.

The analysis model used in this study is multiple linear regression. In general, the regression model used can be written as follows:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \varepsilon$$

with:

Y: Distribution costs

X1: Road infrastructure

X2: Fuel prices

X3: Logistics fleet

β_0 : Constant

β_1 – β_3 : Regression coefficients for each independent variable

ε : Error term

Descriptive analysis was used to describe the development of each variable during the study period, including the trend of stable road infrastructure, the dynamics of national diesel prices, changes in the KALOG logistics fleet, and the dynamics of the company's distribution costs. Regression model parameters were estimated using the Ordinary Least Squares (OLS) method using statistical software. Before hypothesis testing, the feasibility of the regression model was tested through a series of conventional assumption tests.

The distribution of residuals was tested using a normality test. A multicollinearity test was used to determine whether there was excessive correlation between independent variables, which could disrupt the stability of coefficient estimates. A heteroscedasticity test ensured that the residual variance remained constant throughout the observation period, and an autocorrelation test examined the presence of residual correlation between periods, which could reduce the accuracy of the model in the context of time series data (Gujarati & P). The regression model is considered suitable for use in hypothesis testing if the classical assumptions are met. A t-test to assess the partial effect of each independent variable on distribution costs and an F-test to assess the simultaneous effect of all independent variables on distribution costs test the hypothesis. The coefficient of determination (R²) is used to determine the proportion of distribution cost variation explained by variations in road infrastructure, fuel prices, and logistics fleets in the model. With a significance level of 5%, a p-value less than 0.05 is considered sufficient statistical evidence to reject the null hypothesis and support the alternative hypothesis. Therefore, the results of the regression analysis are expected to provide accurate and unbiased information regarding the influence of logistics fleets, fuel prices, and road infrastructure on PT KALOG's distribution costs during the 2019–2024 period.

RESULTS

Statistik Deskriptif

Tabel Statistik Deskriptif Variable Penelitian				
	X1	X2	X3	Y
Mean	103.5750	6929.167	1330.417	307.0833
Median	104.0000	5150.000	1320.000	297.5000
Maximum	107.9000	10150.00	1465.000	360.0000
Minimum	98.20000	5150.000	1230.000	260.0000
Std. Dev.	3.125804	2317.838	76.90927	31.82550
Skewness	-0.350476	0.608586	0.276821	0.208991
Kurtosis	1.890058	1.456267	1.747744	1.581277
Jarque-Bera	1.723306	3.864618	1.874663	2.187484
Probability	0.422463	0.144813	0.391672	0.334961
Sum	2485.800	166300.0	31930.00	7370.000
Sum Sq. Dev.	224.7250	1.24E+08	136045.8	23295.83
Observations	24	24	24	24

Figure 1. Results of Descriptive Statistical Data Processing

To provide an overview of the data characteristics during the study period, descriptive statistical analysis was performed. The road infrastructure variable (X1) had a median of 104,000, a maximum of 107,900, and a minimum of 98,200. The level of road stability during the observation period tended to be stable from year to year, as indicated by a standard deviation of 3.125, indicating relatively low data dispersion. A kurtosis of 1.890 indicates a distribution flatter than normal, and a skewness value of -0.350 indicates a slight left skew. Because the probability value is greater than 0.05, the Jarque-Bera test results, with a value of 1.723 and a probability of 0.422, indicate that the X1 data is normally distributed.

The mean value of the fuel price variable (X2) was 6,929.167 rupiah per liter, with a median of 5,150, a maximum of 10,150, and a minimum of 5,150. Although not extreme, the standard deviation of 231.888 indicates that fuel prices fluctuate between years. A skewness of 0.608 indicates a rightward skew, and a kurtosis of 1.456 indicates a distribution flatter than normal. At the 5% significance level, the data do not deviate from a normal distribution, as indicated by the Jarque value, which is 3.865 with a probability of 0.144.

The logistics fleet variable (X3) has a total of 1,330,417 units, with a median of 1,320, a maximum of 1,465, and a minimum of 1,230. With a standard deviation of 76.909, the data distribution shows moderate variation each year. This suggests that KALOG adjusts its fleet size to meet logistics demand. The distribution pattern shows a symmetrical trend, with a skewness of 0.276 and a kurtosis of 1.747. The Jarque value—with a value of 1.874 and a probability of 0.391—represents a normal distribution.

The distribution cost variable (Y) has an average value of 307.083 million, with a median of 297.500, a maximum value of 360,000, and a minimum value of 260,000. Distribution costs vary throughout the study period, with a standard deviation of 31.825. This variation can be caused by high transportation volumes, changing energy prices, and infrastructure conditions. The Jarque-Bera value of 2.187 with a probability of 0.334 indicates that the data is normally distributed at the 95% confidence level. The skewness value of 0.208 and kurtosis of 1.581 indicate that the data distribution is relatively symmetrical and not as skewed as a normal distribution. Overall, all four variables show a tendency towards a normal distribution, so further analysis should be conducted using a multiple linear regression model.

Classical Assumption Test

The following classical assumption test was used before conducting further analysis to determine the effect of Road Infrastructure, Fuel Prices, and Logistics Fleet on PT Kereta Api Logistik (KALOG) Distribution Costs for 2019–2024, both partially and simultaneously:

Normality Test

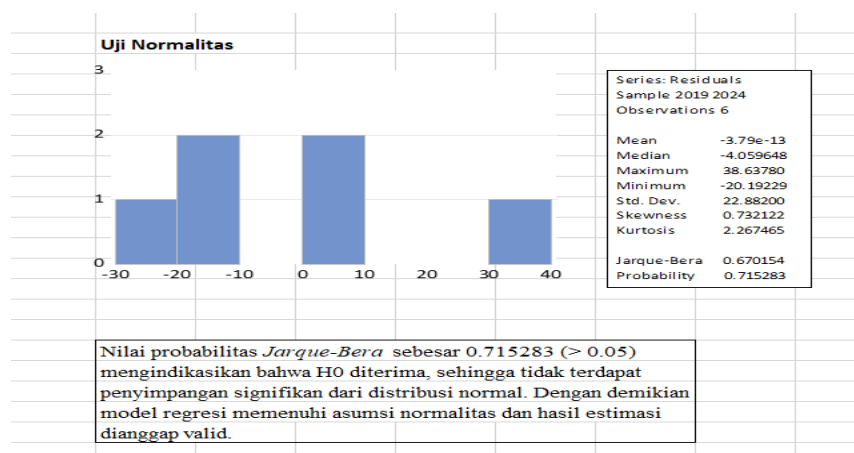


Figure 2. Normality Test Results

A normality test was performed to ensure the regression model residuals were normally distributed. This was done to ensure that the resulting parameter estimates were unbiased and efficient. The Jarque–Bera normality test revealed a Jarque–Bera value of 0.670154 and a probability value of 0.715283. This probability value is greater than the 0.05 significance level, indicating that the null hypothesis cannot be rejected for a normally distributed residual. In other words, the regression model residuals do not exhibit significant deviations from the normal distribution.

According to the descriptive statistics of the residuals, the mean residual value is nearly zero; the standard deviation is approximately 22.88 and the skewness value is 0.73, indicating that, although still within the acceptable range, there is a slight skew to the right. Furthermore, the residual distribution closely resembles a normal distribution, with a kurtosis value of approximately 2.27. The conclusion that the assumption of normality of the residuals is met is reinforced by the combination of a low Jarque–Bera value and a high probability.

If the regression model used in this study is deemed to meet the basic assumptions of normality, then the estimated regression coefficients and the hypothesis tests can be considered valid and can be used as a basis for drawing empirical conclusions.

Multicollinearity Test

Uji Multikoleniaritas			
Variance Inflation Factors			
Date: 11/20/25 Time: 16:20			
Sample: 2019 2024			
Included observations: 6			
Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	1206014.	5528.100	NA
X1	645.1226	31889.71	2.864441
X2	0.000580	145.8132	1.294964
X3	2.090871	17291.64	6.105193
Hasil uji VIF menunjukkan bahwa variabel X1 tidak mengalami multikolineritas, sedangkan variabel X2 dan X3 memiliki nilai VIF masing-masing sebesar 1.29 dan 6.10 adanya multikolineritas sedang namun masih berada dalam batas toleransi karena nilainya tidak >10. Dengan demikian model regresi tidak mengandung multikolineritas yang serius dan secara umum tetap layak digunakan, meskipun hubungan X2 dan X3 perlu diperhatikan.			

Figure 3. Multicollinearity Test Results

A multicollinearity test was conducted to determine whether there was a strong linear relationship between the independent variables in the regression model. According to the variance inflation factor (VIF) calculation, variable X1 had a central VIF of 2.864441, while variables X2 and X3 had central VIF values of 1.294964 and 6.105193, respectively. All VIF values were well below the threshold of 10, which is typically used to indicate serious multicollinearity.

The linear relationship between the independent variables is within acceptable tolerance limits if the VIF value is less than 10. While variable X1 did

not exhibit multicollinearity, variables X2 and X3 exhibited moderate correlations but remained within safe limits, thus not causing significant distortion to the regression coefficient estimates. Therefore, it can be concluded that the regression model used does not contain disruptive multicollinearity.

Furthermore, this condition substantially aligns with the characteristics of the research data. Road infrastructure (X1), fuel prices (X2), and logistics fleet (X3) are not expected to be significantly correlated with each other because they come from different sources and operational contexts. The low VIF value indicates that, without excessive overlap, each independent variable provides distinct information to explain variations in PT KALOG's distribution costs. The relationship between the independent variables does not affect the validity of the estimates or the interpretation of the model. This multicollinearity test indicates that the regression model is suitable for further hypothesis testing.

Heteroscedasticity Test

Uji Heteroskedastisitas				
Heteroskedasticity Test: Breusch-Pagan-Godfrey				
Null hypothesis: Homoskedasticity				
F-statistic	0.317067	Prob. F(3,2)	0.8170	
Obs*R-squared	1.933858	Prob. Chi-Square(3)	0.5862	
Scaled explained SS	0.136172	Prob. Chi-Square(3)	0.9872	
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 11/20/25 Time: 14:50				
Sample: 2019 2024				
Included observations: 6				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-13147.80	21260.00	-0.618429	0.5993
X1	84.25570	491.7089	0.171353	0.8797
X2	-0.292228	0.466405	-0.626554	0.5949
X3	5.148634	27.99307	0.183925	0.8710
R-squared	0.322310	Mean dependent var	436.3215	
Adjusted R-squared	-0.694226	S.D. dependent var	538.1027	
S.E. of regression	700.4076	Akaike info criterion	16.17592	
Sum squared resid	981141.7	Schwarz criterion	16.03710	
Log likelihood	-44.52777	Hannan-Quinn criter.	15.62019	
F-statistic	0.317067	Durbin-Watson stat	3.097465	
Prob(F-statistic)	0.817017			
Diketahui nilai <i>probability Obs R-Square</i> sebesar 0.5862				
(>0.05). Maka dapat disimpulkan bahwa asumsi uji				
heteroskedastisitas sudah terpenuhi atau sudah lolos uji				
heteroskedastisitas.				

Figure 4. Heteroscedasticity Test Results

The heteroscedasticity test was conducted to determine whether the residual variance in the regression model is constant (homoscedastic) or non-uniform (heteroscedastic). For reliable and unbiased estimation results, a good regression model requires consistent residual variance. The Breusch-Pagan-Godfrey test was used in this study to verify this.

According to the heteroscedasticity test results, the ObsR-Squared value was 1.933858 with a probability value of 0.5862. This probability value is greater than the 0.05 significance level, so the null hypothesis indicating that the model has constant residual variance (homoscedasticity) cannot be rejected. Therefore, there is no statistical evidence that the model exhibits heteroscedasticity.

Furthermore, the F-test probability value was 0.8170 and the Scaled Explained SS probability value was 0.9872, each indicating values greater than 0.05. The consistency of probabilities across the various test indicators indicates

that the residual variance of the regression model does not exhibit a non-uniform distribution pattern and is stable.

Substantially, the homoscedasticity assumption is met, indicating that the independent variables—such as logistics fleets, fuel prices, and road infrastructure—do not cause unreasonable changes in residual variance. Because the coefficient estimates are not affected by the variation in error variance between observations, this strengthens the validity of the regression model. Therefore, the heteroscedasticity assumption is met by the regression model used in this study, and the estimation results can be interpreted correctly.

Autocorrelation Test

Uji Autokorelasi				
Breusch-Godfrey Serial Correlation LM Test				
Null hypothesis: No serial correlation at up to 2 lags				
F-statistic	1.736604	Prob. F(2,18)	0.2044	
Obs*R-squared	3.881906	Prob. Chi-Square(2)	0.1436	
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Date: 11/20/25 Time: 16:24				
Sample: 2019Q1 2024Q4				
Included observations: 24				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-26.57976	164.8810	-0.161206	0.8737
X1	1.268718	4.051267	0.313166	0.7578
X2	0.001495	0.003687	0.405528	0.6899
X3	-0.086533	0.235866	-0.366875	0.7180
RESID(-1)	0.289204	0.244334	1.183638	0.2520
RESID(-2)	-0.402154	0.274744	-1.463743	0.1605
R-squared	0.161746	Mean dependent var	-6.10E-14	
Adjusted R-squared	-0.071102	S.D. dependent var	11.17249	
S.E. of regression	11.56286	Akaike info criterion	7.945792	
Sum squared resid	2406.597	Schwarz criterion	8.240306	
Log likelihood	-89.34951	Hannan-Quinn criter.	8.023927	
F-statistic	0.694641	Durbin-Watson stat	1.737947	
Prob(F-statistic)	0.634210			
Diketahui nilai <i>probability Obs R-Square</i> sebesar 0.1436				
(>0.05). Maka dapat disimpulkan bahwa asumsi				
uji autokorelasi sudah terpenuhi atau data sudah lolos				
uji autokorelasi.				

Figure 5. Autocorrelation Test Results

The autocorrelation test determines whether the residuals from the current period and the residuals from the previous period are correlated with each other. Autocorrelation often occurs in time series data, so it is crucial to test for it to ensure the regression model is functioning properly. This study determined the presence of autocorrelation up to two lags using the Breusch-Godfrey Serial Correlation LM test.

The autocorrelation test output shows that the ObsR-Squared* value is 3.881906 with a probability value of 0.1436. Therefore, the null hypothesis that there is no autocorrelation cannot be rejected. Therefore, the regression model is declared to be autocorrelated, and the residuals do not exhibit a systematic interperiod pattern.

Furthermore, the F-test probability value shows a consistent result of 0.2044 (>0.05), supporting the conclusion that the model lacks autocorrelation. The absence of autocorrelation indicates that the model's error pattern is not consistent with a specific trend from one period to the next and is random.

Autocorrelation can cause regression coefficients to be inefficient and compromise the accuracy of hypothesis testing, making it crucial for regression.

The Breusch–Godfrey test results are supported by the Durbin–Watson value of 1.737947. Although this value is not exactly 2, it is still within the acceptable range and does not indicate strong indications of positive or negative autocorrelation.

Therefore, it can be concluded that the autocorrelation assumption has been met by the regression model. Autocorrelation-free residuals allow for valid interpretation of the regression coefficients and statistical testing. Therefore, the analysis results can be used with confidence to answer the research hypothesis.

Multiple Regression Analysis

Hasil Analisis Regresi Linier Berganda					
Persamaan Ekonomi					
Dependent Variable: Y					
Method: Least Squares					
Date: 11/20/25 Time: 14:37					
Sample: 2019 2024					
Included observations: 6					
Variable	Coefficient	Std. Error	t-Statistic	Prob.	
C	317.8652	1098.187	0.289445	0.7995	
X1	-14.37962	25.39926	-0.566143	0.6284	
X2	0.007149	0.024092	0.296736	0.7946	
X3	1.754545	1.445984	1.213392	0.3488	
R-squared	0.966558	Mean dependent var	1228.333		
Adjusted R-squared	0.916396	S.D. dependent var	125.1266		
S.E. of regression	36.17962	Akaike info criterion	10.24959		
Sum squared resid	2617.929	Schwarz criterion	10.11076		
Log likelihood	-26.74877	Hannan-Quinn criter.	9.693854		
F-statistic	19.26851	Durbin-Watson stat	2.075240		
Prob(F-statistic)	0.049741				

Figure 6. Results of Multiple Regression Analysis

The influence of road infrastructure (X1), fuel prices (X2), and logistics fleet (X3) on PT KALOG's distribution costs (Y) was tested using multiple linear regression analysis. Based on the regression output, the following equation was found:

$$y=317,8652-14,37962X1+0,007149X2+1,75455X3$$

This equation shows how and how much influence each independent variable has on distribution costs.

Explanation of the Regression Coefficient

Distribution costs are estimated at 317.8652 units if all independent variables are held constant or zero, based on the constant value (C) = 317.8652. This value indicates the basic cost component not explained by variables X1, X2, and X3.

Road Infrastructure (X1) = -14.37962, a negative coefficient value indicates that improving road infrastructure conditions (stable roads) tends to reduce distribution costs. However, a probability value of 0.6284 (>0.05) indicates that this effect is not statistically significant. This indicates that PT KALOG's distribution costs are not significantly affected by changes in the percentage of nationally maintained roads during the study period.

Fuel Price (X2) = 0.007149, with a positive coefficient, indicates that distribution costs tend to increase when fuel prices increase. However, a probability value of 0.7946 (>0.05) indicates that this variable does not have a significant effect on distribution costs. These results suggest that KALOG may have internal mechanisms such as tariff adjustments, long-term contracts, and energy efficiency, resulting in an insignificant impact in the model despite fluctuating fuel prices.

Logistics Fleet (X3) = 1.754545, with a positive coefficient. A probability value of 0.3488 (>0.05) indicates that this effect is statistically insignificant. This could be due to differences in fleet utilization efficiency or because fleet expansion does not directly increase distribution costs.

Model Testing

Dependent Variable: Y				
Method: Least Squares				
Date: 11/20/25 Time: 14:37				
Sample: 2019 2024				
Included observations: 6				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	317.8652	1098.187	0.289445	0.7995
X1	-14.37962	25.39926	-0.566143	0.6284
X2	0.007149	0.024092	0.296736	0.7946
X3	1.754545	1.445984	1.213392	0.3488
R-squared	0.966558	Mean dependent var	1228.333	
Adjusted R-squared	0.916396	S.D. dependent var	125.1266	
S.E. of regression	36.17962	Akaike info criterion	10.24959	
Sum squared resid	2617.929	Schwarz criterion	10.11076	
Log likelihood	-26.74877	Hannan-Quinn criter.	9.693854	
F-statistic	19.26851	Durbin-Watson stat	2.075240	
Prob(F-statistic)	0.049741			

Figure 7. Model Test Results

T-Test (Partial)

To determine the partial effect of each independent variable on PT KALOG's distribution costs, a t-test was conducted with a 5% significance level ($\alpha = 0.05$). The probability value (p-value) of a variable is considered significant if its probability value is less than 0.05. This is a detailed explanation of the regression coefficient estimation results.

Impact of Road Infrastructure (X1) on Distribution Costs (Y)

The road infrastructure variable (X1) does not have a significant effect on distribution costs, according to the t-test results, with a t-statistic of -0.566143 and a probability value of 0.6284. This indicates that the probability value is greater than 0.05.

Although the regression coefficient is negative (-14.37962), indicating that theoretically, distribution costs could be reduced by increasing the proportion of improved roads, this effect is not statistically significant. This may be because changes in road infrastructure across the country are not directly reflected in the condition of KALOG's operational routes, or because the contribution of rail transportation is not highly dependent on general road conditions.

Effect of Fuel Prices (X2) on Distribution Costs (Y)

The fuel price variable (X2) does not significantly influence distribution costs, with a t-statistic of 0.296736 and a probability value of 0.7946. This probability value is significantly greater than 0.05.

The theory that fuel price increases tend to increase distribution costs indicates a positive relationship, with a regression coefficient of 0.007149. However, this insignificant statistical result indicates that during the study period, the effect of fuel prices on KALOG's distribution costs was not strong enough. Possible causes include the use of more energy-efficient rail transportation, long-term agreements for fuel use, or the company's operational efficiency that mitigates the impact of changes in fuel prices.

Effect of Logistics Fleet (X2) on Distribution Costs (Y)

The logistics fleet variable (X3) does not significantly influence distribution costs, according to the partial test results, which showed a t-statistic of 1.213392 and a probability value of 0.3488. The probability value is well above 0.05.

The regression coefficient of 1.754545 indicates a positive effect, meaning that distribution costs tend to increase if the capacity or number of fleets is increased. However, statistical insignificance indicates that KALOG's fleet changes have not had a direct impact on the distribution cost structure. This could be due to variations in fleet utilization, uneven utilization rates, or capacity availability that is not always directly proportional to distribution costs.

Conclusion: Hypothesis H3 is partially invalid. PT KALOG's distribution costs are not significantly affected by the logistics fleet.

General t-test results

The results show that, although in theory, distribution costs can be influenced by a third independent variable, the empirical results indicate that:

- a) X1 (road infrastructure) → unimportant
- b) X2 (fuel price) → unaffected
- c) X3 (logistics fleet) → unimportant

This indicates that no variables partially influence distribution costs; However, the results of the simultaneous test (F test) show that all three variables influence distribution costs together, so the model is still relevant to explain variations in distribution costs.

F Test (Simultaneous)

The F-test was used to determine whether the road infrastructure (X1), fuel prices (X2), and logistics fleet (X3) variables significantly influence PT Kereta Api Logistik's distribution costs (Y). In other words, this study examined the validity of the overall regression model. This study used a 5% significance level ($\alpha = 0.05$).

The null hypothesis, which states that the regression coefficients are simultaneously equal to zero, was rejected because the F-value was less than 0.05. The regression output showed an F-statistic of 19.26851 and a Prob(F-statistic) of 0.049741. In other words, there is strong statistical evidence that X1, X2, and X3 simultaneously significantly influence PT KALOG's distribution costs.

This result is also supported by an R-squared value of 0.966558 and an adjusted R-squared value of 0.916396, indicating that the combination of the three independent variables in the model can account for 96.66% of the variation in

distribution costs. Therefore, although each variable is partially insignificant, all three still contribute to explaining changes in distribution costs. This suggests that PT KALOG's distribution cost efficiency is better understood as a result of a combination of road infrastructure conditions, logistics fleet management, and fuel price changes, rather than a single variable.

Determination Test

For this study, the coefficient of determination is the R-squared and adjusted coefficient of determination; they are used to determine how well the independent variables explain the variation in the dependent variable.

The R-squared value of 0.966558 was found based on the regression results. According to this value, the three independent variables (X1), road infrastructure (X2), and fuel prices (X3) change approximately 96.66% of the variation in PT KALOG's distribution costs. In other words, the constructed regression model fully explains the behavior of distribution costs during 2019–2024. Factors outside the model, such as tariff policy, transportation demand volume, internal company efficiency, and other external conditions, account for approximately 3.34% of the total variation.

Furthermore, the Adjusted R-squared value of 0.916396, which takes into account the number of independent variables and observations, remains very high. The Adjusted R-squared value provides a more realistic picture of the model's capability. This value indicates that the combination of the three independent variables accounts for approximately 91.64% of the variation in fixed distribution costs after adjusting for degrees of freedom. This suggests that, rather than merely illusorily increasing the R-squared, the addition of variables X1, X2, and X3 to the model actually contributes.

Overall, the results of the determination test indicate that the regression model used in this study has strong predictive ability and is suitable for explaining the influence of road infrastructure, fuel prices, and logistics fleets on PT Kereta Api Logistik's distribution costs during the study period.

DISCUSSION

Understanding the Results and Partial Significance Issues

The regression estimation results show that all three variables—road infrastructure (X1), fuel prices (X2), and logistics fleet (X3)—jointly influence distribution costs (Y) (F test). However, none of the independent variables have a significant partial effect on distribution costs (t test). The probability values for X1 are 0.6284, X2 is 0.7946, and X3 is 0.3488, each above the 0.05 threshold.

This phenomenon opens the door to interesting interpretations. First, these findings suggest that KALOG's distribution costs are not highly sensitive to changes in a single independent variable; instead, a complex interaction between the three influences them. Therefore, distribution costs can only be significantly affected by changes in road infrastructure or fluctuations in fuel prices if they are not combined with fleet changes, or vice versa.

This condition may indicate an internal compensation effect in KALOG's operations. For example, when fuel prices are high, companies can improve operational efficiency or fleet utilization to prevent distribution costs from skyrocketing. Conversely, substantial road improvements may not have an

immediate and significant impact if the rail or truck modes used are suboptimal or have low utilization.

These results indicate that distribution cost control strategies cannot be implemented in isolation, such as improving road infrastructure or replacing fleets. Instead, a holistic approach, considering the synergy between fleet management, energy, and infrastructure, is necessary.

Comparison with Previous Literature

Contrary to numerous studies worldwide that emphasize that fuel price changes are the primary factor influencing transportation costs, these findings indicate that fuel price variables do not significantly impact distribution costs. For example, research by *The Effects of Rising Fuel Prices on Logistic Costs in Emerging Markets* shows that fuel price increases directly increase logistics costs in developing countries through increased freight charges and fuel surcharges. Furthermore, research by *Effects of the Fuel Price Increase on the Operating Cost of Freight Transport Vehicles* shows that fuel price increases significantly impact the operating costs of freight transport modes.

However, the findings of this study differ, possibly due to the unique nature of KALOG as a logistics company that utilizes both rail and truck distribution modes. Therefore, the impact of rising fuel prices on land transportation may be offset by the efficiency of rail or other distribution routes. This finding aligns with literature recommendations on the use of multimodal systems and modal integration to offset rising energy costs.

Regarding infrastructure, research in Indonesia suggests that one factor contributing to high logistics costs in Indonesia is poor transportation infrastructure.

However, increasing the proportion of established roads (X1) did not significantly impact distribution costs in KALOG's case. This may be because KALOG's operational routes rely primarily on the public road network, but also on rail lines, intermodal efficiency, and the company's internal logistics. Previous studies on infrastructure needs and freight transport performance indicate that rail transportation has significant potential to reduce logistics costs if optimally utilized in conjunction with other modes.

Although the coefficient is positive, the logistics fleet variable is insignificant. This suggests that fleet capacity or size alone is not sufficient to reduce distribution costs. Utilization management, routes, schedules, loading, and operational management may be more important. Research on the cost efficiency of multimodal transportation logistics suggests that multimodal factors and load management are more important determinants of logistics efficiency than fleet size.

Therefore, this study's findings extend previous research by demonstrating that the dynamics of distribution costs in large logistics companies like KALOG—which utilizes a combination of modes and internal fleet management—are far more complex than relying solely on roads, fuel, or fleet.

New Findings

This study adds several new findings to logistics research, particularly regarding the distribution costs of multimodal logistics companies in developing countries:

- a. **Company-specific approach:** Many previous studies have been macro- or sector-specific; however, this study focuses on a single large company (KALOG) and uses real-world internal operational data from 2019 to 2020. The results provide an empirical picture of how external (infrastructure, energy) and internal (fleet) factors contribute to the company's logistics distribution costs.
- b. **Results on simultaneous versus partial effects:** Although theory and literature indicate that each factor (road, fuel, and fleet) has a significant effect, empirical research shows that significant effects only emerge when the variables are tested simultaneously. This suggests that distribution cost control strategies should be comprehensive, rather than partial—an important insight for transportation policy and logistics management in Indonesia.
- c. **Implications for mode use and internal management:** Fuel prices and road conditions are not partially significant, suggesting that large logistics companies with internal fleets and multimodal structures can mitigate the impact of external factors through operational efficiency. This demonstrates the importance of internal management and company policies in mitigating risk.

Practical and Political Implications

Integrated Efficiency Strategy:

- a. **Focusing solely on one aspect** (such as purchasing a new fleet or improving roads) may not be sufficient for logistics companies like KALOG. Therefore, they should employ an integrated strategy that includes fleet optimization, modal integration (rail and truck), and long-term operational planning.
- b. **The Role of Rail and Multimodal Systems:** To reduce distribution costs in the long term, rail and multimodal systems must be further optimized, especially considering fuel price fluctuations and road infrastructure limitations. This aligns with global efforts for more environmentally friendly and efficient transportation.
- c. **Government Policy & Infrastructure:** These results indicate that, while road infrastructure is important, improving logistics services and business efficiency is also crucial. The government should provide incentives to logistics companies to optimize their operations and fleets.
- d. **Energy Risk Management:** Because fuel prices do not directly affect distribution costs for companies like KALOG, they can leverage long-term contracts, operational efficiencies, and modal diversification to mitigate energy cost risk. This is a relevant strategy in a country like Indonesia where fuel prices fluctuate.

Limitations and Requests for Further Research This study has several limitations that warrant consideration.

- a. The results may be affected by short-term fluctuations or unique circumstances each year due to the small data sample and short period (2019–2024; 6 annual observations).
- b. Other important control variables, such as cargo volume, shipping distance, operational routes, port conditions, and tariff policies, all of which can affect distribution costs, are missing.
- c. Delivery time, service quality, and cargo consolidation are not considered, although these elements are crucial for determining logistics modes and costs.

For further research, the data coverage should be expanded by: (1) including control factors such as cargo utilization, distance, routes, and shipping volume; (2) using quarterly or monthly data to collect more data; (3) considering sustainability, energy efficiency, and the transition to alternative modes or fuels; and (4) testing the model on other logistics companies to generalize the results.

Summary Conclusions from the Discussion

- a. According to the regression model, road infrastructure, fuel prices, and logistics fleet variables simultaneously influence KALOG's distribution costs.
- b. The partial insignificance of each variable indicates that the interaction between factors influences distribution costs more than any single factor.
- c. The results indicate that effective distribution cost management requires holistic consideration and synergy between operational components rather than partial strategies.
- d. This study enriches research on logistics in Indonesia and improves our understanding of distribution cost structures in a multimodal context.

CONCLUSIONS AND RECOMMENDATIONS

This study investigates how road infrastructure, fuel prices, and the logistics fleet impact PT Kereta Api Logistik (KALOG)'s distribution costs from 2019 to 2024. Data analysis results indicate that all three variables are correlated with the company's distribution cost dynamics; however, no single variable has a significant overall impact. Changes in KALOG's distribution costs are more influenced by a combination of infrastructure conditions, energy price movements, and the company's approach to fleet management than by a single factor. These results indicate that KALOG's distribution cost structure is complex and influenced by many different operational decisions within the company.

This study has limitations. First, the observation period is relatively short, so it cannot capture long-term dynamics, major policy changes, or broader business cycles. Second, all variables used are calculated on an annual aggregate basis, so differences between routes and seasonal variations are not fully reflected. Third, additional factors that can influence distribution costs include demand patterns, cargo volumes, fare-setting strategies, and internal efficiency at the operational level. These factors were not included in this study. Fourth, all data is secondary, so the researcher does not have complete control over the accuracy of the definitions and measurement methods of the original sources.

The results of this study indicate that KALOG management cannot rely on a single policy to reduce distribution costs from a management perspective. A package of mutually supportive policies would enable infrastructure improvements, fuel consumption controls, or fleet expansion. Businesses should strengthen multimodal rail-truck network planning, increase fleet utilization through more precise routes and schedules, and prepare for operational scenarios in the event of changes in energy prices or infrastructure quality. Truck and railcar utilization rates, load levels, and actual travel times in each service corridor are some of the operational indicators that should be linked to cost performance measurements.

In the context of multimodal logistics companies, a logistics cost model should be applied. This is a theoretical implication of this study. The results, which do not support the partial hypothesis, indicate that the relationship between distribution costs, fleet, infrastructure, and energy prices is not direct and linear. Instead, factors such as service patterns, operational strategies, and managerial adaptability influence this relationship. To gain a broader understanding of how logistics companies respond to changes in the external environment, future research could develop models that include moderating or mediating variables, extend the observation period, and use cross-company data. This will allow for a more comprehensive research gap in cost distribution behavior in railway-based logistics companies. This will also contribute to the development of logistics cost management theory in developing countries.

FURTHER STUDY

This research still has limitations, so it is necessary to conduct further research related to the topic of The Influence of Road Infrastructure, Fuel Prices, and Logistics Fleet on PT Kereta Api Logistik (KALOG) Distribution Costs 2019-2024 in order to perfect this research and increase insight for readers.

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