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Analysis of Factors Affecting Material Supply Chain Performance in High-Rise Building Construction Projects

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ABSTRACT
The construction industry plays a vital role in the economic development and infrastructure of a country. One of its main challenges lies in the complexity of high-rise building projects, which require tight coordination in the procurement of materials, equipment, and resource management, involving multiple parties that form a complex supply chain. This study aims to analyze the factors that influence the performance of the material supply chain, in order to improve the performance of the material supply chain in the future, with a focus on the flow in the supply chain. The research involved respondents from several high-rise construction projects using purposive sampling techniques. The analysis was conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) to identify relationships among variables. The results show that information flow and financial flow have a positive and significant impact on material supply chain performance, whereas material flow does not show a significant effect. However, proper monitoring and management of material flow remain essential to improving supply chain performance.

INTRODUCTION

The construction industry plays a significant role in driving economic development and advancing a nation's infrastructure. Adequate infrastructure not only enhances the quality of life but also serves as a key driver for sustainable economic growth (Fei et al., 2021). According to a report from the Ministry of Public Works and Public Housing (PUPR) (2015), the construction sector contributed approximately 10% to Indonesia's Gross Domestic Product (GDP) over the past decade, making it a vital sector in the national economy.

A significant hurdle faced by the construction industry is the intricate nature of projects, especially high-rise building developments. These projects demand meticulous coordination in sourcing materials, arranging equipment, and overseeing human resource management. As a result of complexity, the involvement of various parties and individuals becomes a necessity, ultimately leading to the formation of a complex supply chain (Maddeppungeng et al., 2014). The effectiveness of supply chain management, particularly in terms of material procurement and control, directly impacts project time and cost performance. Hence, an analysis of the material supply chain is necessary to identify obstacles, maintain quality, and improve the efficiency of material distribution from suppliers to project sites. The supply chain occurs continuously, from purchasing raw materials to producing finished products (Makkarennu et al., 2019).

The supply chain in construction projects includes three main flows: flow of material, flow of information, and flow of financial (Sandangan et al., 2022). The complex interaction between these flows often becomes a source of risk, potentially affecting supply chain performance. On-site challenges such as limited access to materials, labor, technology, and equipment further increase the risk of disruptions in the material supply chain process. Based on these conditions, this study was conducted to analyze the factors that influence the performance of the material supply chain in high-rise building construction projects. This study carries a different approach from previous studies, by focusing on three main flows in the supply chain, namely flow of material, flow of information, and flow of financial. This approach is different from the research conducted by Hatmoko and Kistiani (2017), which focused more on identifying the risk of material delays in the building construction supply chain by mapping risk factors based on aspects of supply, control, demand, and process. Thus, this study offers a different contribution because there are not many previous studies that simultaneously examine the three flows to the performance of the material supply chain in high-rise building construction projects. The purpose of this study is to determine the factors that influence the performance of the material supply chain and identify the factors that have the most influence on the performance of the material supply chain in high-rise building construction projects by considering the three main flows in the supply chain.

METHODS

This research method uses a quantitative method, namely, collecting questionnaire data with a direct survey. The quantitative method is based on the principles of positivism, which aims to examine a specific issue by collecting data using research instruments. The collected data is then processed and statistically analyzed to verify the hypothesis or assumption that has been previously established (Silvia et al., 2020). Predictor variables (X) are presented in Table 1, and response variables (Y) are presented in Table 2. The predictors used are obtained based on the predecessor journal.

Table 1. Variables X

Variable	Code	Factor	Reference
Flow of Materials (X_1)	$X_{1.1}$	Conformity of material specifications with planning	(Amalia et al., 2023; Aritonang et al., 2016; Dei et al., 2017; Hatmoko & Kistiani, 2017; Ismael & Junaidi, 2014; Kurniawan et al., 2020; Labombang & Musdalifah, 2023; Sandangan et al., 2022)
	$X_{1.2}$	Availability of material stock from suppliers	(Amalia et al., 2023; Hatmoko & Kistiani, 2017; Labombang & Musdalifah, 2023; Maditsaraga & Pontan, 2021)
	$X_{1.3}$	Suitability of the amount of material to the job required	(Aritonang et al., 2016; Ismael & Junaidi, 2014; Kumarayasa Mudita et al., 2016; Kurniawan et al., 2020)
	$X_{1.4}$	Timeliness of material arrival by supplier	(Dei et al., 2017; Sandangan et al., 2022)
	$X_{1.5}$	Location access conditions to the project	(Dei et al., 2017; Kumarayasa Mudita et al., 2016; Maditsaraga & Pontan, 2021)
	$X_{1.6}$	Conformity of the volume of material received from the supplier	(Hatmoko & Kistiani, 2017; Kurniawan et al., 2020; Labombang & Musdalifah, 2023; Sandangan et al., n.d.)
Flow of Financial (X_2)	$X_{2.1}$	Fluctuations in fuel prices and material taxes	(Ismael & Junaidi, 2014; Kumarayasa Mudita et al., 2016; Nurcahyo et al., 2016)
	$X_{2.2}$	Timeliness of payment by the owner	(Dei et al., 2017; Hayati et al., 2022)
	$X_{2.3}$	Material price fluctuations	(Amalia et al., 2023; Aritonang et al., 2016; Hatmoko & Kistiani, 2017; Kurniawan et al., 2020; Labombang & Musdalifah, 2023)
	$X_{2.4}$	Financial management conditions	(Amalia et al., 2023; Ismael & Junaidi, 2014; Maditsaraga & Pontan, 2021; Nurcahyo et al., 2016; Sandangan et al., 2022)
	$X_{2.5}$	Cost budget allocation	(Labombang & Musdalifah, 2023; Maditsaraga & Pontan, 2021)
Flow of Information (X_3)	$X_{3.1}$	Intensity of coordination meetings	(Kurniawan et al., 2020; Nurcahyo et al., 2016)
	$X_{3.2}$	Detailed information of shop drawings	(Dei et al., 2017; Labombang & Musdalifah, 2023)
	$X_{3.3}$	Re-schedule information	(Dei et al., 2017)
	$X_{3.4}$	Accuracy of pricing information	(Hayati et al., 2022; Nurcahyo et al., 2016)
	$X_{3.5}$	Rational scheduling	(Amalia et al., 2023; Aritonang et al., 2016; Labombang & Musdalifah, 2023)

Table 2. Variables Y

Performance of Supply Chain Materials (Y)		
Code	**Factor**	**Reference**
Y_1	Conformity of material specifications with planning	(Munawir, 2021)
Y_2	Availability of material stock from suppliers	(Munawir, 2021)
Y_3	Suitability of the amount of material to the job required	(Munawir, 2021)
Y_4	Timeliness of material arrival by supplier	(Munawir, 2021)

The research instrument used is a questionnaire with a numerical Likert scale. The Likert scale is a psychometric measurement tool commonly used in questionnaires to assess levels of agreement or influence. It is among the most popular in survey research (Sanaky et al., 2021)The Likert Scale is arranged on a five-point scale: very not influential (1), not influential (2), quite influential (3), influential (4), and very influential (5).

The respondents for the questionnaire were selected using a purposive sampling technique, which involves choosing samples based on specific criteria. The samples were chosen based on criteria related to contractor companies that carry out multi-story building construction projects. These respondents comprised *Project Managers, Project Production Managers, Project Construction Managers, Project Finance Managers, Supervisors, Finance personnel, Quantity Surveyors, Quality Control staff, Procurement officers, Logistics personnel, Engineers,* and *Schedulers.*

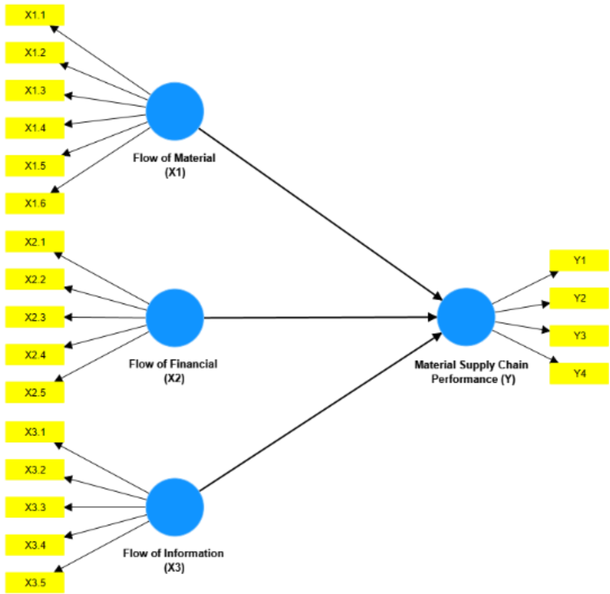

Figure 1. Path diagram model

Source: SmartPLS4 Processed Test Results(2025)

After the data is collected, it will be processed and analyzed using Smart-PLS software version 4.0.9.9. The research employs Partial Least Squares-Structural Equation Modelling (PLS-SEM) to explore relationships among variables, utilising a non-parametric method that does not require data assumptions (Rian Marliana, 2020). The PLS-SEM modelling involves creating a path diagram, as shown in Figure 1. It illustrates the relationships between variables X and variables Y and the relationships between variables and their respective indicators.

The first data analysis was the classical assumption test, including the normality test, multicollinearity test, and heteroscedasticity test. The next analysis stage is instrument testing, which is carried out during the measurement model testing stage (*outer model*). Instrument testing includes validity and reliability tests. Subsequently, structural model testing (*inner model*) is conducted, consisting of the Coefficient of Determination (R^2) test, Effect Size (f^2) test, and Prediction Relevance (Q^2) test. The next stage involves multiple linear regression analysis and hypothesis testing. Based on the results of the literature review that was conducted previously, the following hypothesis was obtained:

H_0^1 = Flow of material (X_1) has a significant effect on the performance of the material supply chain (Y).
H_0^2 = Flow of financial (X_2) has a significant effect on the performance of the material supply chain (Y).
H_0^3 = Flow of information (X_3) has a significant effect on the performance of the material supply chain (Y).

RESULT AND DISCUSSION

Normality Data Test

The data normality test measures whether the data obtained has a normal or abnormal distribution (Sidabutar et al., 2020). Normality tests can be performed using various methods, such as the Kolmogorov-Smirnov test, Anderson-Darling test, Cramer-von Mises test, Pearson Chi-Square test, Lilliefors test, Shapiro-Wilk test, Fisher's cumulative test, Chi-Square test, and the Skewness-Kurtosis test (Sintia et al., 2022). In this test, the skewness-kurtosis method is used. The test can be seen through the criteria of the critical ratio (c.r.) skewness and kurtosis value ± 2.58, which has a significance of 0.01. Data is considered normally distributed if the critical ratio (c.r.) skewness and kurtosis value is at or below the absolute value of 2.58 (Pratiwi & Dwiyanto, 2021). Table 3 below indicates that the indicators have kurtosis and skewness critical ratio results of ± 2.58, indicating that the data is normally distributed.

Table 3. Normality Data Test Results

Indicator	Mean	Median	Standard Deviation	Excess Kurtosis	C.R. Kurtosis	Skewness	C.R. Skewness
$X_{1.1}$	4.644	5.000	0.602	1.366	-0.939	-1.536	-1.536
$X_{1.2}$	4.578	5.000	0.577	0.146	-1.639	-1.035	-1.035
$X_{1.3}$	4.533	5.000	0.618	0.036	-1.703	-1.007	-1.007
$X_{1.4}$	4.600	5.000	0.573	0.391	-1.499	-1.141	-1.141
$X_{1.5}$	4.111	4.000	0.674	-0.765	-2.163	-0.141	-0.141
$X_{1.6}$	4.511	5.000	0.619	-0.126	-1.796	-0.916	-0.916
$X_{2.1}$	4.267	4.000	0.800	-0.141	0.218	-0.804	-1.206
$X_{2.2}$	4.156	4.000	0.815	3.436	0.264	-1.321	-1.651

Indicator	Mean	Median	Standard Deviation	Excess Kurtosis	C.R. Kurtosis	Skewness	C.R. Skewness
$X_{2.3}$	4.578	5.000	0.683	3.527	-1.560	-1.809	-0.779
$X_{2.4}$	4.289	4.000	0.806	-0.120	-0.485	-0.853	-1.118
$X_{2.5}$	4.422	5.000	0.683	2.030	-1.764	-1.225	-0.534
$X_{3.1}$	4.422	4.000	0.614	-0.528	-1.456	-0.585	-0.550
$X_{3.2}$	3.867	4.000	0.980	0.088	-1.218	-0.602	-0.943
$X_{3.3}$	4.356	5.000	0.765	0.564	-1.523	-1.033	-0.541
$X_{3.4}$	4.156	4.000	0.759	-0.045	-0.128	-0.593	-1.289
$X_{3.5}$	4.200	4.000	0.884	2.745	-1.795	-1.412	-0.264
Y_1	4.333	4.000	0.596	-0.589	2.234	-0.289	-1.920
Y_2	4.467	5.000	0.748	8.850	1.796	-2.352	-1.882
Y_3	4.489	5.000	0.778	7.702	-1.019	-2.305	-0.988
Y_4	4.556	5.000	0.652	0.332	0.636	-1.210	-1.403

Source: SmartPLS4 Processed Data Results (2025)

Multicollinearity Test

The multicollinearity test is carried out to assess whether a perfect or clear linear relationship exists among some or all of the explanatory variables in the regression model (Indartini & Mutmainah, 2024). For this test, the assessment can be made through the Variance Inflation Factor (VIF) value. The variable exhibits multicollinearity if the VIF value is ≥ 10 or the tolerance is ≤ 0.1 (Effiyaldi et al., 2022).

Table 4. Multicollinearity Test Results

Indicator	VIF
Flow of Material (X_1)-> Material Supply Chain Performance (Y)	1.671
Flow of Financial (X_2) -> Material Supply Chain Performance (Y)	1.945
Flow of Information (X_3) -> Material Supply Chain Performance (Y)	2.090

Source: SmartPLS4 Processed Data Results (2025)

Based on Table 4, the VIF value is < 10, indicating no multicollinearity between the predictor and response variables (unrelated). Therefore, these variables can be considered independent variables.

Heteroscedasticity Test

This test is conducted to identify whether there is a correlation between the residual variable and the independent variables. The model is considered good if the variance of the residuals is constant or does not exhibit signs of heteroscedasticity (Indartini & Mutmainah, 2024). The Breusch-Pagan test is used for this test. If the P-value is > 0.05, it indicates that heteroscedasticity is not present (ILORI & TANIMOWO, 2022). Based on Table 5, the P-value is > 0.05; thus, the variables are constant and do not exhibit heteroscedasticity.

Table 5. Heteroscedasticity Test Results

	P-value
Breusch-Pagan Test	0.592

Source: SmartPLS4 Processed Data Results (2025)

Validity Test

This validity test uses convergent validity, and the validity value is obtained through the loading factor value of each variable indicator. Convergent validity is considered very strong when the outer loading value > 0.7. Outer loading values ranging from 0.4 - 0.7 are still acceptable or deemed sufficiently adequate. Meanwhile, indicators with outer loading values < 0.4 are considered very weak and should be removed from the construct (Hair et al., 2017). The minimum acceptable AVE value is 0.50, which means the construct can explain at least 50% of the variance of its indicators (Hair Jr et al., 2021).

Table 6. Validity Test Results

Indicator	Outer Loading	AVE
$X_{1.1}$	0.739	0,511
$X_{1.2}$	**0.829**	
$X_{1.3}$	0.731	
$X_{1.4}$	0.563	

Indicator	Outer Loading	AVE
$X_{1.5}$	0.612	
$X_{1.6}$	0.778	
$X_{2.1}$	**0.795**	
$X_{2.2}$	0.744	
$X_{2.3}$	0.742	0,525
$X_{2.4}$	0.703	
$X_{2.5}$	0.628	
$X_{3.1}$	0.822	
$X_{3.2}$	**0.853**	
$X_{3.3}$	0.612	0,600
$X_{3.4}$	0.812	
$X_{3.5}$	0.749	
Y_1	0.867	
Y_2	0.881	0,673
Y_3	0.617	
Y_4	**0.886**	

Source: SmartPLS4 Processed Data Results (2025)

Based on Table 6 shows the result of the loading factor analysis on outer loading, where each variable has a value requirement > 0.4, and the AVE value is > 0,5. The highest loading factor value for variable X_1 is found at $X_{1.2}$ with a value of 0.829, while for variable X_2, the highest loading factor is at $X_{2.1}$ with a value of 0.795. For variable X_3, the highest value is found at indicator $X_{3.2}$, which is 0.853, whereas the largest loading factor value for variable Y is at indicator Y4, which is 0.886. Therefore, the data can be said to meet the requirements and to be valid.

Reliability Test

Reliability testing aims to assess the level of accuracy or consistency of the instrument in collecting data (Pradila et al., 2024). Cronbach's Alpha value is used for reliability testing. If the Cronbach's Alpha value is close to 1, then the variable has high reliability. The reliability is sufficient if the Cronbach Alpha value is > 0.70. For reliability to be said to be strong, the Cronbach Alpha value must be > 0.80. Meanwhile, for the Cronbach Alpha value > 0.90, the reliability is said to be perfect (Sanaky et al., 2021).

Table 7. Reliability Test Results

Variable	*Cronbach's Alpha*
X_1	0.774
X_2	0.829
X_3	0.805
Y	0.835

Source: SmartPLS4 Processed Data Results (2025)

Based on Table 7, the research data is reliable. The variables X_1, X_2 , and Y show strong reliability with a Cronbach alpha value > 0.80. Meanwhile, the variable X_1 shows lower reliability than the other variables with a value > 0.70, and is considered sufficiently reliable.

Coefficient of Determination (R^2)

The R^2 value shows how much the influence of independent variables affects existing dependent variables (Arifianti et al., 2023). The R^2 value is divided into three: 0.67 (substantial), 0.33 (moderate), and 0.19 (weak) (Hair et al., 2011).

Table 8. R^2 Test Results

	R^2	R^2 adjusted
Performance of Supply Chain (Y)	0.733	0.714

Source: SmartPLS4 Processed Data Results (2025)

The results based on Table 8 show that the R^2 value for the material supply chain performance success variable is 0.714. This value shows that the model built by the dependent variables used is 71.4% able to explain the variable's flow of materials, financial, and information flow. In comparison, other variables explain the remaining 28.6%.

Effect Size f²

The f² assesses the extent to which independent variables influence dependent variables. An f² value of 0.2 suggests a small effect, 0.15 indicates a medium impact, and 0.35 denotes a significant effect (Hair et al., 2017).

Table 9. f² Test Results

	f^2
Flow of Material (X_1)-> Material Supply Chain Performance (Y)	0.002
Flow of Financial (X_2) -> Material Supply Chain Performance (Y)	0.382
Flow of Information (X_3)-> Material Supply Chain Performance (Y)	0.401

Source: SmartPLS4 Processed Data Results (2025)

Based on the result of Table 9, the influence of X_2 on Y has a significant influence effect with a value of 0.382. The influence of X_3 on Y of 0.401 has a considerable influence effect. Meanwhile, in X_1 on Y, the f² is 0.002, which means the influence effect is negligible.

Prediction Relevance Q²

The Q² test shows how good the observation value results from the blindfold procedure (Suntara et al., 2023). The range of Q² values is divided into three ranges if the Q² value is 0.02 ≤ 0.15 (small), 0.15 ≤ 0.35 (medium), and ≥ 0.35 (large) (Hair et al., 2011). A model is said to have relevant predictive value if the Q² value is greater than 0 (zero) (Sardi et al., 2025).

Table 10. Q² Test Results

	SSO	SSE	Q² (=1-SSE/SSO)
Flow of Material (X_1)	270.000	270.000	0.000
Flow of Financial (X_2)	225.000	225.000	0.000
Flow of Information (X_3)	225.000	225.000	0.000
Material Supply Chain Performance (Y)	180.000	106.911	0.406

Source: SmartPLS4 Processed Data Results (2025)

Based on the results of Table 10, with a Q² value of 0.406, the model has good predictive ability and can explain about 40,6% of the variation in the observational data.

Multiple Linear Regression Analysis

Multiple linear regression analysis evaluates how strongly multiple independent variables affect a single dependent variable (Indartini & Mutmainah, 2024).

Table 11. Multiple Linear Regression Analysis Results

	Unstandardized coefficients	P-value
X_1	0.044	0.775
X_2	0.483	0.001
X_3	0.487	0.000
Intercept	0.112	0.845

Source: SmartPLS4 Processed Data Results (2025)

The multiple linear regression model using SmartPLS in Table 11 is as follows: $Y = 0.112 + 0.044 X_1 + 0.483 X_2 + 0.487 X_3$. This means that the coefficient value for the variable flow of material (X_1) concerning Y is relatively small, and the P-value of 0.775 indicates that this effect is insignificant. The variable flow of financial (X_2) shows a positive coefficient value of 0.483. This indicates that each increase of 1 unit in X_2 will affect Y by 0.483. Meanwhile, the variable flow of information (X_3) has a positive value of 0.487. This indicates that each increase of 1 unit in X_3 will affect Y by 0.487.

Hypothesis Test

This research occurred during the hypothesis testing phase while analysing the T-statistics and P-values. The hypothesis is acceptable if the T-statistic value > 1.96 and the P-value < 0.05. If the P-value < 0.05, it can be said that the variable is significant (Hair et al., 2019). Table 12 is the result of hypothesis testing in this study through the inner model.

Table 12. Hypothesis Test Results

Effect	T statistics (|O/STDEV|)	P-values
Flow of Material (X_1) -> Material Supply Chain Performance (Y)	0.191	0.848
Flow of Financial (X_2) -> Material Supply Chain Performance (Y)	3.477	0.001
Flow of Information (X_3) -> Material Supply Chain Performance (Y)	3.443	0.001

Source: SmartPLS4 Processed Data Results (2025)

Based on Table 12, it is found that for X_2 and X_3 the T-statistic values are 3.477 > 1.96 and 3.443 > 1.96, with a P-value of 0.001 < 0.05. Therefore, it can be concluded that X_2 and X_3 have a significant effect on the performance of the material supply chain (Y), so that the hypotheses H_0^2 and H_0^3 are accepted. For the variable X_1, the T-statistic value is 0.191 < 1.96, and the P-value is 0.848 > 0.05. Thus, it can be concluded that X_1 doesn't have a significant effect on the performance of the material supply chain (Y).

CONCLUSION

The results of the study show that variables X_2 and X_3 have a significant influence on variable Y. This is evident from the T-Statistic test results for those variables, each of which has a value greater than 1.96—namely 3.477 and 3.443—and P-values less than 0.05, which are both 0.001. For variable X_2, the indicator with the greatest influence is the fluctuation in fuel prices and material taxes ($X_{2.1}$), while for variable X_3, it is the detailed information on construction drawings ($X_{3.2}$). This is supported by their respective factor loading values of 0.795 and 0.853. Thus, it can be concluded that the indicator with the greatest influence is $X_{3.2}$.

Conversely, variable X1 was found to have no significant effect on the performance of the material supply chain, as the T-statistic is < 1.96 (0.191) and the P-value is > 0.05 (0.848). However, it can still be stated that X_1 has some influence on variable Y, as evidenced by its small coefficient of determination in the multiple linear regression test, which is 0.044. This means that although variable X_1 does not significantly affect variable Y, it still exerts some influence. The lower T-statistic value indicates higher data variability. As a result, greater data variability leads to lower statistical significance, making it more difficult to detect the effect of the variable.

Although the testing results show that material flow is not significant, proper monitoring and management of material flow remain essential. Efficient and effective material flow will undoubtedly enhance the performance of the material supply chain. This research is expected to provide insights into best practices in supply chain management within the construction industry, particularly for high-rise building projects.

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