Analysis of the Influence of Material Procurement Supply Chain Management on Project Time Performance

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ABSTRACT

Construction process often faces material-related issues. Materials really need special attention because the use of materials takes up 50% - 70% of the total cost of the whole project. Therefore, very good management is needed. Supply chain management is used to manage material procurement because it has a concept that is able to increase project success by producing products on time, reducing costs, and managing the industry effectively and efficiently. This study aims to find out the dominant factors that influence the implementation of material procurement supply chain management and the effect of material procurement supply chain management on construction project time performance. In this study three factors influenced the implementation of supply chain management of material procurement including financial flow, information flow, and material flow. This study uses a questionnaire as a data collection method, then analyzed with validity test, reliability test, classical assumption test, and verification test with the help of SPSS software. The results of this study indicate that the material flow (0.873) has a significant effect on the time performance of construction projects, and the biggest indicator is in the suitability of the material with technical specifications with a value of 4.14.

Keywords: *Implementation Influence Factors, Project Time Performance, Supply Chain Management, Material Procurement, Design-Bid-Build.*

1. INTRODUCTION

In the execution of construction projects, various operational problems are frequently encountered, one of which stems from material aspects [1]. Material is one of the resources that plays a crucial role in the construction execution process because material usage consumes 50% to 70% of the total budget established in contract documents [2]. To reduce problems arising from material aspects, a method or tool capable of managing material procurement effectively is required. Supply Chain Management (SCM) is used to manage material procurement because it offers a concept capable of improving project execution success [3]. To achieve project execution goals, several performance boundaries must be fulfilled, namely cost, quality, and time [4]. Research regarding construction supply chain management has been widely conducted at the macro-organizational level. However, this research specifically focuses on a high-rise office building project operating under a traditional contract scheme (Design-Bid-Build). In traditional contract systems, the structural separation of functions between designers and contractors frequently creates coordination bottlenecks and material procurement uncertainties in the field. Therefore, this study is required to fill the gap in specific material procurement supply chain studies on high-risk projects with traditional contract schemes in order to identify dominant factors and their measurable impact on project time performance.

Based on the description above, the research problem formulations in this study are what are the dominant factors influencing the implementation of material procurement supply chain management and how does the implementation of material procurement supply chain management influence construction project time performance. Based on the research problems above, the objectives of this study are to identify the dominant factors influencing the implementation of material procurement supply chain management and to determine the influence of implementing material procurement supply chain management on construction project time performance. Some benefits can be derived from this study. First, this research was conducted to expand knowledge regarding the implementation of supply chain management from the material procurement aspect and to understand its effect on project time performance; Second, this research is expected to serve as learning information and reference to broaden insight and knowledge related to SCM implementation in material procurement. Finally, this research is expected to provide valuable information for the construction industry regarding the importance of implementing material procurement supply chain management to maintain project time performance.

2. LITERATURE REVIEW

2.1 Supply Chain Management

A supply chain is an activity that contributes to managing raw materials into finished goods and distributing products. This activity begins with sourcing raw materials from nature, processing those raw materials into a product, and subsequently distributing them to consumers [5]. Three primary flows must be managed including the material flow and financial flow that

flowing downstream from upstream to downstream, as well as information flow that flowing bidirectionally from upstream to downstream or vice versa. Furthermore, supply chain management aims to reduce the risk of losses and uncertainties in terms of time or cost. The benefit of implementing SCM is to realize effective and efficient inter-organizational cooperation [6].

2.2 Supply Chain in Construction Sector

Supply chain management in construction is a method or tool used to regulate cooperation between contractors, owners, suppliers, and architects. The coordinator in this collaboration is the main contractor, whose task is to produce, deliver, arrange, and utilize information flows, material flows, equipment, and available resources to execute the construction process [7]. Construction SCM is an activity managing raw materials into a finished product with the final outcome being a building or infrastructure [8]. The key actors involved in supply chain management is presented in Figure 1, and described as follow [9]:

1. Owner (Downstream Actor): The supply chain originates from the owner's demand to construct a building and concludes with handover to the owner upon project completion.
2. Main Contractor (Primary Integrator): The main contractor acts as the primary service provider during project execution in accordance with plans and specifications agreed upon in the contract.
3. Subcontractors and Suppliers (Upstream Actors): Subcontractors and suppliers collaborate with the main contractor to execute specific work packages within the project.

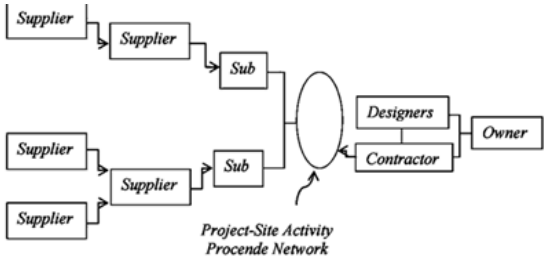

Figure 1. Conceptual framework of construction supply chain management [10]

2.3 Influential Factors in Supply Chain Management Implementation

Factors influencing SCM implementation in building construction include financial flow, material flow, and information flow [11]. The indicators for each factor are described as follows:

1. Financial Flow (X1): Indicators consist of payments made by owner/contractor to suppliers, price determination and payment agreements, and material changes inconsistent with contract documents.
2. Information Flow (X2): Indicators consist of coordination with suppliers during material procurement, communication with suppliers regarding material price adjustments, and optimal supply performance.
3. Material Flow (X3): Indicators consist of delivery smoothness, material sufficiency during procurement, material scheduling, and lead-time buffer between delivery time and site request [12].

2.3 Project Performance

Performance is the result or achievement obtained after executing work according to desired provisions [4]. To achieve these goals, project performance is assessed and evaluated based on cost, quality, and time boundaries [13].

1) Cost Performance: The outcome obtained after completing work utilizing resources valued in monetary units to carry out construction [14]. Indicators include: (a) adherence to contract documents, (b) project owner agreement to make progress payments until completion, and (c) satisfaction of involved parties.
2) Quality Performance: Project performance prioritizing customer satisfaction [13]. Indicators include: (a) compliance with technical specifications and contract terms, (b) absence of penalties, complaints, or quality claims, (c) satisfaction of all involved parties, and (d) enhancement of corporate reputation.
3) Time Performance: The alignment between the completion duration agreed upon by owner and contractor and actual field completion [13]. Indicators include: (a) project completion according to the contractual work schedule, and (b) owner acceptance and approval of partial or total work completion.

3. RESEARCH METHODOLOGY

This research focuses on Project Y, a high-rise office building project located in Central Jakarta. The study observes the supply chain of key structural materials (such as ready-mix concrete and steel rebar) involving several main suppliers with recurring delivery transactions during the construction period. This research utilizes a descriptive quantitative approach [15], where the research flow is presented in Figure 2. Descriptive research is conducted by describing and illustrating phenomena occurring at the research site [15]. The population in this study comprises all contractor staff members working on Project Y. Sample selection was carried out using non-probability sampling with a purposive sampling method. Purposive sampling determines sample

members based on specific predetermined criteria [15]. Based on the established criteria, the sample size in this study was set at 22 respondents.

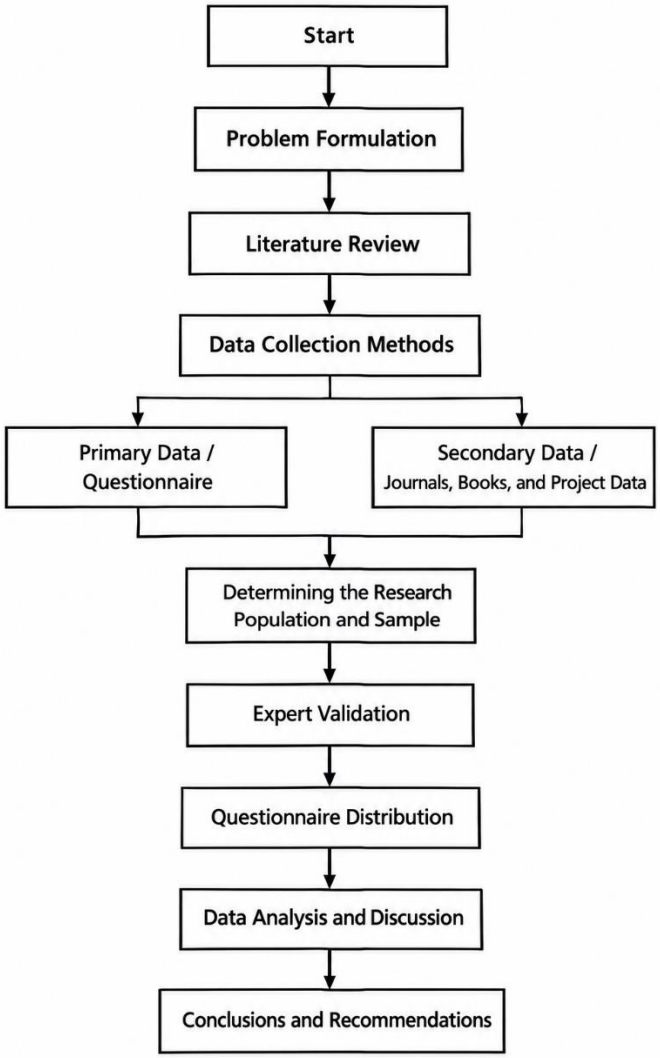

Figure 2. Research flowchart

4. RESULT AND DISCUSSION

4.1 Validity Test

Validity tes was performed to measure the accuracy and validity of data obtained from questionnaire distribution [16]. For N = 22 respondents at significance level α = 0.05 ($df = N - 2 = 20$), the critical threshold value is R_{table} = 0.423. An indicator is declared valid if $R_{calculated}$ > 0.423. Based on the validity results in Table 1, all indicators across all three independent variables (X1, X2, X3) and the dependent variable (Y) are valid because $R_{calculated} > R_{table}$ (0.423). In Financial Flow (X1), three main indicators show strong correlation values ranging from 0.683 to 0.792. In Information Flow (X2), seven valid indicators range from 0.438 to 0.693. In Material Flow (X3), seven valid indicators range from 0.490 to 0.686. For Project Time Performance (Y), all indicators exhibit exceptionally strong correlation above 0.800 (Y{1.3} = 0.872).

4.2 Reliability Test

Reliability testing assesses the consistency and dependability of the measuring instrument [16]. Depicted by Table 2, the reliability test results show that Material Flow (0.685) and Time Performance (0.769) possess high reliability levels, whereas Financial Flow (0.541) and Information Flow (0.596) demonstrate moderate reliability. The moderate alpha values reflect perceptual variance among respondents regarding administrative payment protocols and information coordination efficiency in the field, warranting careful interpretation

Table 1. Validity test results

Variable	Indicator	R Calculated	R Table	Status
Financial Flow (X1)	X{1.1}	0.792	0.423	Valid
	X{1.2}	0.698	0.423	Valid
	X{1.4}	0.683	0.423	Valid
Information Flow (X2)	X{2.2}	0.643	0.423	Valid
	X{2.3}	0.582	0.423	Valid
	X{2.4}	0.693	0.423	Valid
	X{2.5}	0.451	0.423	Valid
	X{2.6}	0.438	0.423	Valid
	X{2.9}	0.503	0.423	Valid
	X{2.10}	0.446	0.423	Valid
Material Flow (X3)	X{3.1}	0.490	0.423	Valid
	X{3.2}	0.642	0.423	Valid
	X{3.3}	0.566	0.423	Valid
	X{3.4}	0.686	0.423	Valid
	X{3.7}	0.537	0.423	Valid
	X{3.8}	0.648	0.423	Valid
	X{3.10}	0.558	0.423	Valid
Time Performance (Y)	Y{1.1}	0.826	0.423	Valid
	Y{1.2}	0.812	0.423	Valid
	Y{1.3}	0.872	0.423	Valid

Table 2. Reliability test results

Variable	Cronbach's Alpha	Reliability Level
Financial Flow (X1)	0.541	Moderate
Information Flow (X2)	0.596	Moderate
Material Flow (X3)	0.685	High
Project Time Performance (Y)	0.769	High

4.3 Normality Test

Normality testing determines whether regression model residuals are normally distributed as a core assumption of parametric testing. This was evaluated visually via Normal Probability Plot (P-Plot) of standardized regression residuals. Data points closely follow the 45-degree diagonal line from bottom-left to top-right without major deviation, confirming that regression residuals are normally distributed and free from residual bias, and this presented in Figure 3.

4.4 Multicollinearity Test

Multicollinearity testing is performed to ensure that in the multiple linear regression model, there is no perfect or near-perfect linear correlation among the independent variables. The presence of high multicollinearity can cause regression coefficients to become unstable and difficult to interpret. This test is conducted by evaluating the Tolerance and Variance Inflation Factor (VIF) values for each independent variable. The statistical threshold criteria require that the Tolerance value must be greater than 0.100 and the VIF value must be less than 10.00. Based on the test results in Table 3, the Financial Flow variable (X1) exhibits a Tolerance value of 0.496 and a VIF of 2.018. The Information Flow variable (X2) has a Tolerance value of 0.368 and a VIF of 2.714, whereas the Material Flow variable (X3) yields a Tolerance value of 0.382 and a VIF of 2.616. Because all independent variables have Tolerance values > 0.100 and $VIF < 10.00$, it can be concluded that the regression model is free from multicollinearity issues. This indicates that the three supply chain flow variables are independent of one another, thereby minimizing estimation errors in the regression coefficients.

4.5 Heteroscedasticity Test

Heteroscedasticity testing aims to determine whether there is an inequality of variance in the residuals from one observation to another within the regression model. A regression model that meets statistical estimation accuracy standards is homoscedastic,

where the variance of the residuals remains constant or equal across all levels of the independent variables. This test was conducted visually by analyzing a Scatterplot, which plots the Regression Standardized Predicted Value against the Regression Studentized Residual. Based on the Scatterplot in Figure 4, the data points are randomly and evenly dispersed above and below the number 0 on the Y-axis. Furthermore, the distribution of data points does not form any regular or recurring geometric pattern (such as widening, narrowing, clustering, or funneling). The absence of any specific pattern in the residual plot proves that the regression model is free from heteroscedasticity issues. Fulfilling the homoscedasticity assumption ensures that the obtained regression coefficients qualify as a Best Linear Unbiased Estimator (BLUE), thereby preventing the variance of the regression coefficients from being underestimated or overestimated.

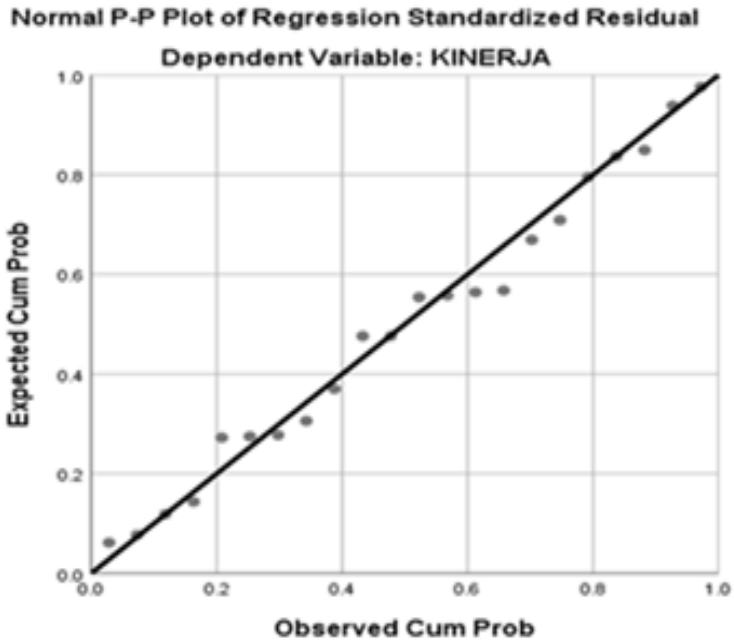

Figure 3. Normality test P-Plot result

Table 3. Multicollinearity test results

Variable	Tolerance	*VIF*	Status
Financial Flow (X1)	0.496	2.018	No Multicollinearity
Information Flow (X2)	0.368	2.714	No Multicollinearity
Material Flow (X3)	0.382	2.616	No Multicollinearity

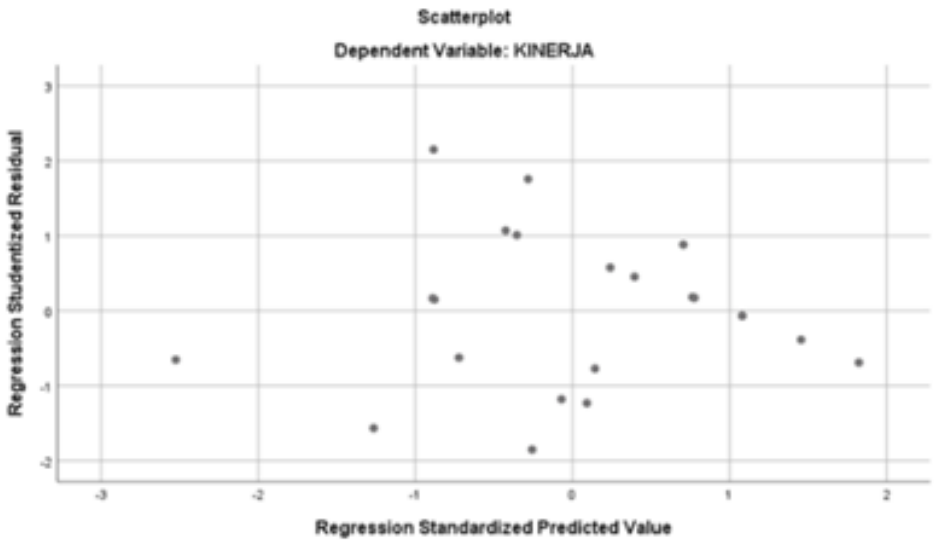

Figure 4. Results of heteroscedasticity test

4.6 Multiple Linear Regression Analysis

Multiple linear regression analysis determines the direction and magnitude of independent variables' influence on Project Time Performance (Y). The resulting empirical equation presented in Eq. (1). Constant $a = 12.025$ represents baseline time performance when all supply chain predictor variables equal zero. Material Flow Coefficient ($b3 = +0.444$) means that each unit increase in material flow efficiency increases project time performance by 0.444. Financial Flow ($b1 = -0.712$) and Information Flow ($b2 = -0.084$) coefficients exhibit negative signs. In traditional Design-Bid-Build contracts, additional layers of financial verification and multi-tiered information bureaucracy create processing delays in vendor disbursements and information overload, thereby inadvertently slowing site-level physical procurement and reducing time performance. However, it should be noted that this research is constrained by a sample size of N = 22 respondents from a single high-rise project. Statistical findings should be interpreted specifically within the context of commercial building projects of similar management scale.

$$Y = 12.025 - 0.712(X1) - 0.084(X2) + 0.444(X3) \quad (1)$$

4.7 Hypothesis Testing (F-Test)

The F-test (simultaneous test) is conducted to evaluate whether all independent variables in the model—namely Financial Flow (X1), Information Flow (X2), and Material Flow (X3)—collectively (simultaneously) exert a significant effect on the dependent variable, Project Time Performance (Y). This test serves as the foundation for assessing whether the developed multiple linear regression model is fit to explain the variance in construction project time performance. Based on the data processing results in Table 4 (ANOVA), an $F_{calculated}$ value of 3.695 was obtained with a significance level of 0.031.

Table 4. Hypothesis testing results (F-Test)

Model	*F*	Sig.
Regression	3.695	0.031
Residual		
Total		

4.8 Hypothesis Testing (T-Test)

The T-test measures the partial significance of each predictor variable. As detailed in Table 5, Material Flow (X3) exerts a significant partial positive effect on project time performance (t = 2.912, p = 0.009 < 0.05). Financial Flow (X1) also shows a statistically significant partial effect (t = -2.289, p = 0.034), underscoring the disruptive potential of financial verification bottlenecks under traditional contracting structures.

Table 5. Hypothesis testing results (T-Test)

Model / Predictor	t	Sig.
(Constant)	3.629	0.002
Financial Flow (X1)	-2.289	0.034
Information Flow (X2)	-0.444	0.662
Material Flow (X3)	2.912	0.009

4.9 Coefficient of Determination (R^2)

The coefficient of determination (R^2) test is conducted to measure how far the regression model can explain the variance in the dependent variable (Project Time Performance, Y). The coefficient of determination value ranges between 0 and 1; the closer it is to 1, the greater the proportion of variability in the dependent variable that can be collectively explained by the independent variables in the model. Based on the regression data processing results, a coefficient of determination (R^2) value of 0.381 or 38.1% was obtained. This value indicates that the combination of the three supply chain management flows including financial flow (X1), information flow (X2), and material flow (X3) collectively contributes 38.1% to the variance in construction project time performance achievement. From a critical analytical standpoint, this 38.1% finding is academically significant within the context of high-rise building construction management. The substantial contribution of the material supply chain reinforces that controlling physical material movement, maintaining clear information, and ensuring smooth payments are primary pillars of project scheduling. Meanwhile, the remaining 61.9% is influenced by exogenous factors outside the research model. These external factors include extreme site weather and climate conditions, site labour productivity, heavy equipment coordination, design fluctuations (design changes/variation orders), and project management leadership dynamics. The practical implication of this finding underscores that supply chain management effectiveness must be synergistically integrated with other site

operational controls to achieve optimal project completion timeliness. The result obtained in the determination test is 0.381 or 38.1%. Thus, it can be concluded that the independent variables influence the dependent variable by 38.1%.

4.10 Descriptive Analysis Test

Figure 5 describes the material flow variable indicators. The descriptive analysis result that can be interpreted from this graph is that the highest score is obtained by indicator X3.7, namely material conformity with technical specifications.

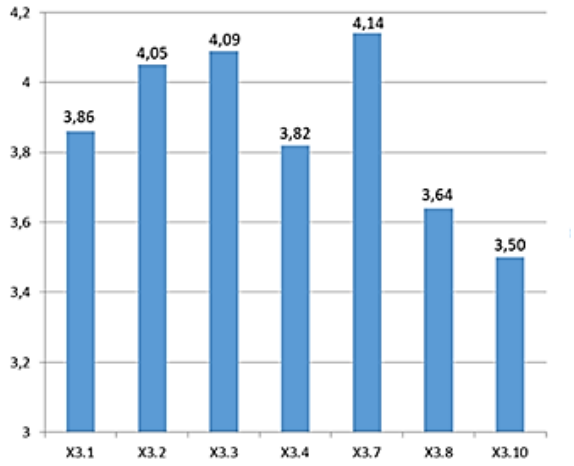

Figure 5. Graph of material flow variable indicators

5. CONCLUSION

Based on the analysis and discussion, this study concludes that the dominant factor in material procurement supply chain management is Material Flow, with its primary indicator being material suitability with technical specifications (mean score = 4.14). Integrated material procurement supply chain management significantly influences project time performance, contributing 38.1% (R^2 = 0.381, F = 3.695, p = 0.031) to schedule performance variance, while the remaining 61.9% is governed by external environmental and operational factors. Furthermore, negative regression coefficients for financial (-0.712) and information (-0.084) flows highlight how administrative payment verification friction and unintegrated information channels induce operational schedule delays in traditional Design-Bid-Build projects; therefore, future academic research should evaluate alternative procurement models (e.g., Design-Build or Integrated Project Delivery), while practitioners should prioritize factory pre-dispatch Quality Control (QC) inspections and streamline administrative payment approval workflows...

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