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Analysis of The Relationship of Rework and Inventory to Waste in The Ciputra Hospital Surabaya Project

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Abstract
The problem of material waste in construction projects will be difficult to avoid as it goes along with construction waste. One of the unavoidable problems in a construction project is repeating work or reworking. Rework will also affect the emergence of waste. In a series of construction project activities, inventory is always required to anticipate needs in the ongoing construction project process. Without an inventory, a construction project will encounter the risk that one day it will not be able to meet its needs. This research aimed to determine the correlation between rework and inventory to waste at the Ciputra Hospital Surabaya construction project. It employed a quantitative method by collecting data through a questionnaire distributed to 30 respondents in the project environment. Data analysis involved multiple linear regression analyzes and the SPSS 25 software program. The results of the t-test showed that rework partially had a positive effect on waste with a t-count value of 8.528, while inventory also had a positive effect on waste with a t-count value of 8.661. Simultaneous test results indicated that rework and inventory had a significant effect on waste, with an F-count value of 37.442.

Keywords: Waste; Rework; Inventory

INTRODUCTION

In every construction project there will always be material waste. The problem of material waste in construction projects will be difficult to avoid due to the emergence of construction waste. Waste is defined as all activities that require direct or indirect costs and the use of physical and non-physical resources, but do not add value to a product (Abdulrahman & Nuciferani, 2019). Waste or also called nonvalue -adding activity is all activities that do not provide added value in the eyes of the customer to a product being processed (Formoso et al., 2002). A series of construction activities consisting of planning, implementation and operations. At the planning stage there is a design process which most likely contributes to the emergence of waste during implementation. One of the wastes that arises from the implementation process is rework (Bolviken et al., 2014).With rework work on a construction project, waste will arise.

In a series of construction project activities, inventory is always needed which is aimed at anticipating needs in the ongoing construction project process. Without inventory, construction projects will be faced with the risk that one day they will not be able to meet the needs of a construction project. Inventory is stored materials or goods that will be used to fulfill certain purposes, for example used in the assembly production process, resale, or for spare parts for equipment or machines. Inventory can be in the form of raw materials, auxiliary materials, goods in process, finished goods or spare parts (Herjanto, 2014). In its implementation, problems often occur because material supplies are often empty (stockout) and often excess (overstock).

Waste in construction projects also occurs in the Ciputra Hospital Surabaya building construction project, such as formwork wood scraps, pieces of reinforcing steel, ceramics, bricks, coral and also sand. Therefore, special treatment is needed to clean up this waste. Waste will impact project performance as well as impact costs, time and labor. Among the losses incurred during the implementation of a construction project are due to rework and poor inventory on construction projects.

By reviewing the background that has been presented, there are 3 problem formulations in this research which are as follows:

(1) What are the factors that cause rework and inventory?
(2) What is the relationship between rework work on the emergence of waste and inventory on the emergence of waste?
(3) Rework work and inventory on the emergence of waste?

Framework of Thinking

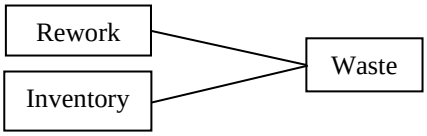

Figure 1. Research Framework

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METHOD

In this research, researchers use a type of quantitative research, where quantitative research will find an output obtained by using statistical procedures or by using several other methods of quantification (measurement) (Mardikaningsih et al., 2020). The data that will be obtained from the relationship between rework and inventory on waste in construction projects is in the form of quantitative data. The research object taken in this research is a building construction project Ciputra Hospital on Jalan Made, Lakarsantri District, Surabaya City, with the research period being carried out from December 2022 to January 2023.

Identify and define research variables to determine the factors that cause rework work and factors that influence inventory work from the independent variable (X) and the dependent variable (Y). In this case, the independent variable is a variable that has been measured, manipulated and a variable chosen by the researcher to be able to determine the relationship to an observed symptom. The independent variables in this research are rework (X1) and inventory (X2). The dependent variable is a variable item that is caused or influenced by the independent variable (Nanang Martono, 2015). The dependent variable in this research is waste (Y).

Validity Test

Test the validity in this research using construct validity with the Pearson formula (product moment) which is shown in the formula equation 1:

$$r_{xy} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}} \quad (1)$$

Information:

r_{xy} = Correlation coefficient between the independent variable and the dependent variable
X = Value of each item
Y = Total value
ΣXY = The product of the independent and dependent variables
ΣX^2 = Square value of the independent variable
ΣY^2 = Square value of the dependent variable
N = Number of subjects

To test correlation, the calculated r value will be compared with the value from the r table. The statement will be said to be valid if the calculated r is > 0.361(Sugiyono, 2013).

Reliability Test

The reliability test in this research used the Cronbach's Alpha technique which was carried out using interval data or essay data. Testing the reliability of the instrument uses the Alpha Cronbach formula because this research instrument is in the form of a questionnaire and Likert scale. Cronbach's Alpha formula is shown in equation 2 formula:

$$r_{11} = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum {\sigma_t}^2}{{\sigma_t}^2}\right) \quad (2)$$

Information:

r_{11} = Reliability to be sought
k = Number of question items tested
$\sum {\sigma_t}^2$ = Total variance in scores for each item
${\sigma_t}^2$ = Total variance

Normality Test

In this study, normality testing was carried out using the Kolmogrov Smirnov test method which is shown in the formula equation 3:

$$KD = 1{,}36\frac{\sqrt{n_1+n_2}}{n_1+n_2} \quad (3)$$

Information:

KD = Number of Kolmogorv Smirnov searched
n_1 = Number of samples obtained h
n_1 = Expected number of samples

Data will be said to be normal if the significant value is > 0.05. And the opposite applies, if the significant value is < 0.05 then the data is said to be abnormal.

Multicollinearity Test

The multicollinearity test aims to determine whether there is a significant correlation between independent variables in a multiple linear regression model. The statistical assumptions used to test multicollinearity disturbances are as follows:

1. The VIF value is > 10 and the Tolerance value is < 0.10, so multicollinearity occurs in the test.
2. The VIF value is < 10 and the Tolerance value is > 0.10, so there is no multicollinearity in the test.

Heteroscedasticity Test

Glejser test was used in this study to detect the presence of heteroscedasticity, by regressing the absolute value of the residual on the independent variable. The conditions for making a decision are as follows:

1. If the p-value is ≥ 0.05 then H_0 is accepted, there is no heteroscedasticity problem.
2. If the p-value is ≤ 0.05 then H_0 is rejected, there is a heteroscedasticity problem.

Autocorrelation Test

The autocorrelation test is used to detect whether in a linear regression model there is a correlation between the residual error in period t and the error in period t-1 or before (Ghozali, 2018). To find out whether there is autocorrelation or not, you can look at the *Durbin Watson value table* (DW test).

If the test significance level is > 0.05 then the null hypothesis (H_0) is accepted because it states that the residuals are random or there is no autocorrelation between the residuals (Ghozali, 2018).

Multiple Linear Regression Test

Multiple linear regression analysis in this research was used to describe the extent of the influence of rework and inventory on waste in construction projects. The multiple linear regression equation model shown in equation formula 4:

$$Y = a + b_1X_1 + b_2X_2 + e \quad (4)$$

Information:

Y = Waste Coefficient

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a = Constant
b_1 = Rework Coefficient
b_2 = Inventory Coefficient
X_1 = Rework Variable
X_2 = Inventory Variable
e = Standard Error

Coefficient of Determination Test

R Square coefficient of determination test is basically used to determine the percentage of changes that occur in the dependent variable caused by the independent variable (Sujarweni, 2014).

A low R Square value indicates that the ability of the independent variable to explain the dependent variable is limited. If the R Square value is smaller, then the percentage of change in the independent variable caused by the dependent variable will also be smaller. The coefficient of determination value can be calculated using the formula shown in equation 5:

$$Kd = r^2 x100\% \quad (5)$$

Information:
Kd = Coefficient of determination
r^2 = Correlation coefficient

The criteria for analysis of the coefficient of determination are:

a. If the Kd value detects zero, then the influence of the independent variable on the dependent variable is low.
b. Kd value detects one, then the influence of the independent variable on the dependent variable is strong.

T Test

To draw conclusions, it is stated by looking at the significance value and comparing it to the error level value used. If the probability value is smaller than the alpha value (α), then the independent variable has a significant effect on the dependent variable. By using the SPSS program, namely by looking at the results of the T count and t table with the following conditions:

1. H_0 is accepted if T count < T table value, meaning there is no significant influence between the independent and dependent variables.
2. H_0 is rejected if T count > T table value, meaning there is a significant influence between the independent and dependent variables.

F Test

The F test is a test of the significance of the equation which is used to determine the influence of independent variables together or simultaneously on the independent variable. The decision making criteria for the F test are as follows:

1. If the calculated F value is > the F table value and the probability value is < α (0.05) then H_0 is rejected or in other words that simultaneously there is a significant influence between the independent variable on the dependent variable.
2. If the calculated F value is ≤ the table F value and the probability value is ≥ 0.05 then H_0 is accepted or in other words it shows that simultaneously there is no influence between the independent variable on the dependent variable.

RESULT AND DISCUSSION

Validity Test

From the results of validity testing, the questionnaire has 3 variables with a total of 48 question items which were filled in by 30 respondents. From the results of validity calculations using the SPSS version 25 program, it can be seen that there are 47 question items whose calculated r value is greater than the r table value, which means that 47 question items in the questionnaire are valid. And there is 1 question item, namely late material with a calculated r of 0.315 which is smaller than the value in the r table of 0.361 and is declared negative or invalid.

Reliability Test

Table 1. Reliability Test Result

Variable	*Cronbach's Alpha*
Rework (X1)	0.826
Inventory (X2)	0.614
Waste (Y)	0.774

Source: Research Result of Data Processing (202X)

Based on the reliability test on each rework, inventory and waste variable as in table 1, it states that the Cronbach's Alpha value of these three variables is greater than 0.6. So, the variables in this research can be said to be reliable.

Normality Test

Table 2. Normality Test Results

One-Sample Kolmogorov-Smirnov Test	
Variable	*Asymp. Sig. (2-tailed)*
Rework	,200[c,d]
Inventory	,200[c,d]

Source: Research Result of Data Processing (202X)

Obtained each Asymp significance value. Sig. (2-tailed) in the rework normality test for waste is 0.200 and for the inventory variable for waste it is 0.200. This value states that 0.200 is greater than the value α = 0.05, which means that the decision taken to distribute the rework variable (X1), inventory variable (X2) to the waste variable (Y) has a normal distribution.

Multicollinearity Test

Table 3. Multicollinearity Test Results

Coefficients[α]		
Variable	*Collinearity Statisctics*	
	Tolerance	*VIF*
Rework	,753	1,329
Inventory	,753	1,329

Source: Research Result of Data Processing (202X)

It can be seen that the rework tolerance value (X1) is 0.753 > 0.10 and the VIF value of the rework variable is

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1.329 < 10.00. So, it can be concluded that for the rework variable there are no symptoms of multicollinearity.

In the inventory variable (X2) it is known that the tolerance value is 0.753 > 0.10 and the VIF value of the inventory variable is 1.329 > 10.00. So, it can be concluded that the two variables rework (X1) and inventory (X2) do not have symptoms of multicollinearity.

Heteroscedasticity Test

Table 4. Heteroscedasticity Test Results

Coefficients[a]

Variable	Sig.
Rework	,697
Inventory	,555

Source: Research Result of Data Processing (202X)

It is known that the significance value of the rework variable is 0.697 > 0.05 and the inventory variable has a value of 0.555 > 0.05. Based on these results, it can be concluded that the two independent variables rework and inventory have a significance value greater than 0.05, which states that the rework and inventory variables do not have symptoms of heteroscedasticity.

Autocorrelation Test

Table 5. Autocorrelation Test Results

Model Summary[b]

Variable *Independent*	Variable *Independent*	*Durbin-Watson*
Rework *Inventory*	Waste	1,701

Source: Research Result of Data Processing (202X)

The DW value obtained is 1.701, the DW value will then be compared with the 5% significance table value, with a sample size of 30 and the number of independent variables is 2 (k = 2). So, the dU value is 1.5666 and the dL value is 1.2837. The condition for decision making is the value dU (1.5666) < DW (1.701) < 4 – dU (2.4334), so it can be concluded that the data in this study do not have symptoms of autocorrelation.

Multiple Linear Regression Test

Table 6. Multiple Linear Regression Test Results

Coefficients[a]

Variable *Independent*	*Unstandardized Coefficients*	
	B	*Std. Error*
(Constant)	27,689	3,509
Rework	,219	,263
Inventory	,577	,502

Source: Research Result of Data Processing (202X)

Coefficients table, it is described in the following regression equation:

$Y = a + b_1.X_1 + b_2.X_2$
Y = 27.689 + 0.219 (X1) + 0.577 (X2)
Or
Waste = 27,689 + 0.219 (rework) + 0.577 (inventory)

The interpretation of the coefficients of the regression equation above can be explained as follows:

1. The constant value is 27.689 which is indicated if the independent variable is considered constant, the average waste is 27.689%. This means that if a construction project does not consider rework and inventory factors, then the generation of waste will continue to increase.
2. Rework regression coefficient value is 0.219 (positive sign) indicating that every time the rework factor increases by 1, assuming the other independent variables are constant, then waste will also increase by 0.219%.
3. Inventory regression coefficient value of 0.577 (positive sign) states that if the inventory level increases by 1 time assuming the other independent variables are constant, then waste will increase by 0.577%.

T Test

Table 7. T Test Results

Coefficients[a]

Independent Variable	*Dependent* Variable	*t*	*Sig.*
Rework	Waste	8,528	,000
Inventory		8,661	,000

Source: Research Result of Data Processing (202X)

According to research, the T test shows that the significance value is 0.000 < 0.05 and the calculated t value is 8.528 > the t table value is 2.052. In this case, it shows that H_0 is rejected, H_1 is accepted, which shows that the rework variable has a significant effect on the waste variable.

Referring to the results of the T test research for the inventory variable on the waste variable, it shows that the significance value is 0.000 <0.05 and the calculated T value is 8.661 > the T table value is 2.052. In this case, it shows that H_0 is rejected, which shows that the inventory variable has a significant effect on the waste variable.

Rework and Inventory Question Item T Test

Based on the results of the T test research on question items on the rework variable on the waste variable, it shows that there are 4 factors that fulfill the requirements for hypothesis testing as follows:

1. Question item X1.1, design and documentation as indicators and design errors as factors influencing the occurrence of rework work. With a calculated t value of 2.596 > t table of 2.052.
2. Question item X1.3, design and documentation as indicators and unclear details as factors influencing the occurrence of rework work. With a calculated t value of 2.752 > t table of 2.052.
3. Question item X1.11, managerial as an indicator and lack of teamwork as a factor influencing rework. With a calculated t value of 2.388 > t table of 2.052.
4. Question item X1.14, managerial as an indicator and lack of anticipation of natural conditions as factors influencing the occurrence of rework work. With a calculated t value of 2.447 > t table of 2.052.

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The inventory variable for the waste variable in table 4.12 shows that there are 4 question items that fulfill the following hypothesis testing requirements:

1. Question item X2.3, a question item with internal indicators and inventory costs as factors that influence inventory work. With a calculated t value of 2.517 > t table of 2.052.
2. Question item X2.4, question item with internal indicators and spending policies as factors that influence inventory work. With a calculated t value of 2.736 > t table of 2.052.
3. Question item X2.7, question item with internal indicators and purchasing raw materials as factors that influence inventory work. With a calculated t value of 3.398 > t table of 2.052.
4. Question item X2.8, a question item with external indicators and available sources of raw materials as factors that influence inventory work. With a calculated t value of 2.634 > t table of 2.052.

F Test

Table 8. F Test Results

ANOVA[α]

Independent Variable	*Dependent* Variable	F	*Sig.*
Rework Inventory	Waste	37,442	,000 [b]

Source: Research Result of Data Processing (202X)

Shows that the significance value is 0.000 < 0.05 and the calculated F value is 37.442 > the F table value of 3.35. So, H_0 is rejected, so that simultaneously the rework and inventory variables in this study have a significant effect on the waste variable.

Discussion:

Factors Affecting *Rework* and *Inventory*

There are 4 factors each that cause rework and inventory that fulfill the hypothesis test with the condition that the calculated t value is greater than the t table value, namely factors (X1.1) design errors, (X1.3) unclear details, (X1 .11) lack of teamwork, and (X1.14) lack of anticipation of natural conditions. 4 factors that influence work inventory, namely, (X2.3) inventory costs, (X2.4) spending policy, (X2.7) raw material purchases and (X2.8) available sources of raw materials.

The Relationship between *Rework* and *Waste*

By obtaining the test results in this research, it can be seen that the first hypothesis H_1 is accepted, namely that the rework variable has a positive and significant influence on the waste variable. This is in accordance with the regression coefficient value of 0.219 which states that each factor increases rework increases by 1 time, then waste will also increase by 0.219%. From the results of the t test, the t count was 8.528 and the t table was 2.052. So, the calculated t value > t table and for the significance value of the rework variable has a value of 0.000 below the significance value of 5%, namely 0.05. So, the conclusion obtained is that the rework variable has a positive and significant effect on the waste variable.

So, in the construction of the Ciputra Hospital Surabaya hospital building construction project, if the rework work increases, there will be a risk of increasing waste. This is supported by research conducted by (Wongso et al., 2019) which found that in residential finishing work there were jobs that experienced rework most often, namely painting work items, which had an effect on the generation of waste in the form of a buildup of waste material that was difficult to decompose. This is also supported by research.

Relationship between *Inventory* and Waste

From the test results in this research, it can be seen that the first hypothesis H_2 is accepted, namely that the inventory variable has a positive and significant influence on the waste variable. Therefore, in accordance with the regression coefficient value of 0.577, which states that each factor increases inventory increases by 1 time, then waste will also increase by 0.577%. And reviewing the results of the t test, the calculated t was 8.661 and the t table was 2.052. So, the calculated t value > t table and for the significance value of the rework variable has a value of 0.000 below the significance value of 5%, namely 0.05. So the conclusion is that the inventory variable has a positive and significant effect on the waste variable.

With this hypothesis proven, in the construction of the Ciputra Hospital Surabaya hospital building construction project, the worse the control over the implementation of inventory work, the greater the risk of waste generation. This is supported by research conducted by (Arnando, 2015) which analyzed the causes of waste generation for the inventory category showing the results that based on observations the causes of work-in-progress product waste being postponed were production machines being under maintenance or breakdown , production machines still doing other work, distribution operator work is uneven, and operators do not understand work rules so that this influences the emergence of waste in the form of a buildup of work in progress products on inventory and increased lead time.

The Influence of Rework and Inventory Together on Waste

The results obtained in this research resulted in an F test calculation with a calculated F value of 37.442 and a significance value of 0.000. The test results obtained were then compared with the F table value of 3.35. Thus, the F value is greater than the F table and the significance value is smaller than 0.05, which indicates that the author's three hypotheses, namely rework, inventory and waste, are acceptable.

Based on the research results above, it was found that the influence of the rework variable (X1) and the inventory variable (X2) on the waste variable (Y) together has a positive and significant influence.

CONCLUSIONS

There are 4 factors each that cause rework work and inventory work to occur on the Ciputra Hospital Surabaya construction project. The rework variable for the waste variable shows that there are 4 factors that fulfill it, namely design errors, unclear details, lack of teamwork and lack of

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anticipation of natural conditions. In the inventory variable y against the waste variable, it shows that there are 4 factors that meet the requirements, namely inventory cost factors, spending policies, purchasing raw materials and sources of raw materials.

Based on the T test carried out on the rework variable on the waste variable, it shows that the calculated t value on the rework variable is 8.528 and the calculated t value on the inventory variable on waste is 8.661 with a t table value of 2.052. This shows that the calculated t is greater than the t table value, so H_0 is rejected, which means that individually there is a significant relationship between rework and inventory on waste.

Based on the F test carried out jointly on the rework and inventory variables on the waste variable, the calculated F value is 37.442 with an F table value of 3.35. This shows that the calculated F value is greater than the table F value with a significance value of 0.000, which means that the rework and inventory variables have a significant influence on waste. And by looking at the value in the coefficient of determination test (R Square) of 0.735, it shows that the independent variables in the research (rework and inventory) explain variations in the waste variable of 73.5% and the other 26.5% will be explained by other factors outside this research.

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