# Integration of Supply Chain Network Design Models and Payment Options of Batik Wastewater Treatment Equipment

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## Abstract
The number of batik SMEs continues to grow in line with the amount of liquid waste produced by batik SMEs. But unfortunately, the shortcomings of batik SMEs in Indonesia is the treatment of waste that is still bad. This has an impact on the decrease in water and soil quality in the environment around batik SMEs. To reduce waste pollution, it has been supported by government regulations on hazardous and toxic waste. In line with this, academics and researchers in Indonesia have made innovations in the technology of effective batik wastewater treatment equipment. However, the technology still has commercialization problems to enter the market test related to tool prices and equipment availability. So it takes industry or business that can support it. A good business requires supply chain network design for manufacturing cost efficiency. Therefore, this study aims to evaluate the feasibility of commercialization and develop mathematical models on the supply chain system of batik wastewater treatment equipment. The research was conducted in three districts namely Pekalongan, Pemalang, and Tegal to propose the location of facilities that have the minimum investment cost and maximization profit. The method used is mix integer linear programming using ILOG CPLEX software. The results obtained from this study are commercialization feasibility decisions in the form of recommendations to establish supplier facilities with techno-economic methods such as, BEP, ROI, PBP, NPV and IRR. Another result is the recommendation of payment options that commercially allow for batik SMEs and the development of mathematical models of designing a supply chain network of batik wastewater treatment equipment that maximize profits.

## Keywords
Batik Wastewater Treatment Equipment, Investment Feasibility, Mix Integer Linear Programming, Payment Options, Supply Chain Network Design

## 1. Introduction

Batik has become an identity that is so attached to the People of Indonesia, coupled with the determination of UNSECO that Indonesian batik as an intangible or intangible cultural heritage on October 2, 2009. That makes the batik industry in Indonesia more and more. Until 2017, batik SMEs spread in 101 centers in Indonesia. According to (Ministry of Industry 2017), the number of Batik Micro, Small, and Medium Enterprises (SMEs) in Indonesia reached 49 thousand business units. With this growth, batik production certainly increased as well. However, the shortcomings of the batik industry are poor waste treatment (Amalia et al 2020). In the production process, batik produces batik liquid waste derived from chemicals and textile dyes, malam or wax. The liquid waste includes acidity (pH), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and high Total Suspended Solid (TSS) (Baladi et al 2018). If waste is dumped directly into the river, it will disrupt the balance of the water ecosystem and cause environmental issues. Environmental issues can be solved in several ways, one of which is by technology to reduce the chemical content in batik waste.

The technology has been created in Indonesia. However, it is still having problems with the economy to get into the market test (Amalia et al 2020). The commercialization problem becomes an obstacle in increasing the Technology Readiness Level (TRL). One of the most commercialized aspects is a technology called technology commercialization. Technological innovations that are not developed economically will only stop as laboratory products or even libraries. With the process of commercializing the technology, technological innovations can be applied or consumed appropriately and will generate economic benefits for the inventor (Sutopo 2019). There are batik SMEs that apply the technology but fails because the demand is low and the price is high. Procurement of technology burdens batik SMEs if making payments at the beginning. To provide alternative solutions to increase the level of readiness of a complete and qualified system through testing and demonstration in the environment (TRL 8) (Justyna et al 2015) to TRL 9, then the business idea of batik wastewater treatment technology needs to be implemented. In Indonesia at the moment, there is no batik wastewater treatment equipment business. In this research, the business will be designed with a supply chain network design that is expected to reduce the cost of manufacturers. Based on study of (Sutopo et al 2014) divided into three major topics, namely parametric cost estimation model, numerical example and the feasibility assessment. In other paper, it will cause the business prospects of the battery cell production electric vehicle will be very beneficial in the future (Sutopo et al 2013).

In this paper, feasibility assesment used to know the feasibility of estabilishing a supplier. The design of the business is coupled with payment solutions that relieve batik SMEs in the provision of wastewater treatment technology facilities. Thus, the integration of the supply chain network design model and payment options of wastewater treatment equipment became the main focus of this research.The purpose of this research is to know the feasibility of investment in the establishment of facilities, recommend payment options, and develop a mathematical model of the supply chain of batik wastewater treatment equipment.

## 2. Literature Review

According to SNI 0239:2014 batik is a handicraft as a result of coloring in a barrier using the malam (batik wax) heat as a color barrier with the main tool batik wax adhesive in the form of canting tulis and or canting cap to form a certain motif that has meaning. Batik is processed by various methods, namely batik tulis, cap, textile and printing. The process of batik improvement is done by washing which is done with a large amount of water media. This process creates liquid waste, where the waste contains the remains of color, high levels of BOD and COD, high oil content and toxic (containing high B3 waste) as in (Sirait 2018). The batik industry produced waste in the form of liquid waste with the characteristics of batik liquid waste contained in the river Pekalongan as in Table 1.

Table 1 Characteristics of Liquid Waste in Pekalongan River

| No. | Parameters | Unit | Value | Quality Standards **) |
|---|---|---|---|---|
| 1. | pH | - | 5,0 | 6,0 - 9,0 |
| 2. | BOD | mg/L | 960,0 | 60,0 |
| 3. | COD | mg/L | 3039.7 | 150,0 |
| 4. | TSS | mg/L | 855,0 | 50,0 |
| 5. | Total Chrome (Cr) | mg/L | 16,7 | 1,0 |
| 6. | Total phenol | mg/L | 0,1 | 0,5 |
| 7. | Oils and fats | mg/L | 2,0 | 3,0 |
| 8. | Sulfide | mg/L | 10,5 | 0,3 |

**) Regulation of the Minister of Environment of the Republic of Indonesia year 2014
Source : Baladi et al (2018)

There are several technological innovations related to batik wastewater treatment equipment. The methods used by the equipment to process batik wastewater are various, namely electrochemical methods (UGM), electrodegradation methods (ITS), methods of chemical and biological physics (BBKB), and methods of coagulation and ozonization (UNDIP). (Sutopo et al 2019) proposed study about accelerating a technology commercialization; with a discussion on the relation between technology transfer efficiency and open innovation.

According to (Simchi-Levi 2002), supply chain management is a collection of approaches used to integrate efficiently between suppliers, manufacturing companies, warehousing, and stores, so that goods are produced and distributed at the correct quantity, location, and time, to minimize costs in conditions that satisfy the needs of the service level.

The supply chain network has emerged as the most important factor in the supply chain in the modern world as it is today. The important thing is efficient and timely delivery of products. According to (Jayakumar et al 2017) supply chain network design is an efficient configuration of supply, manufacturing and demand operations network in terms of operational costs to meet customer needs. SCND involves supply chain network, formulation, analysis and solutions. SCND is done to meet customer needs and reduce costs associated with supply chains within the organization.

In Undang-Undang No.23 of 1999 concerning Bank Indonesia, it is explained that the payment system is a system that includes a set of rules, institutions and mechanisms used to carry out the transfer of funds to fulfill an obligation arising from economic activity. Generally, the payment system is divided into three systems, namely cash, credit and rent. In this study, the rental system payment option will be used to analyze the feasibility of investment and be included in the model. This study will conduct an investment feasibility analysis taking into account Break Even Point (BEP), Return of Investment (ROI), Payback Period (PBP), Net Present Value (NPV) and Internal Rate Return (IRR). Furthermore, the results of the analysis will be used as parameters for the development of Mix Integer Linear Programming (MILP) model in ILOG CPLEX software.

## 3. Methods

The methods or stages performed in this study are divided into three stages, namely the initial stage, the model development stage and the analysis stage. The early stages of research include references studies and object studies. References studies are conducted to collect secondary data and the theoretical basis to be used in research. While the study object of the study conducted is the determination of batik wastewater treatment equipment as the object of study and three districts such as Pekalongan, Pemalang and Tegal as a research place in the framework of primary data collection. The data collected can be seen in Table 2 below:

Table 2. Research Data Requirements

| Data Type | Source | Kind |
|---|---|---|
| Number of IKM batik in each district | Departement of Industry | Primary |
| Purchase price of tools from Factory | UNDIP | Primary |
| Amount of batik waste in batik SMEs | Batik SMEs | Primary |
| Number of tools needed by batik SMEs | Batik SMEs | Primary |
| Distance between entities | Google maps | Secondary |
| Transport costs between entities | Processed researchers | Secondary |
| Operating costs and investment costs | Processed researchers | Secondary |
| Delivery capacity | Processed researchers | Secondary |

The second stage is the development of models. In this stage, model development is done with Mix Integer Linear Programming (MILP). While the software used is ILOG CPLEX. At this stage, the model component is identified with the influence diagram first before coding the system. The last stage is analysis and discussion. At this stage, the output results of the model running in the system have been generated. Then in the analysis with the variable decisions that have been obtained, whether the external has answered the problem and fulfilled the purpose of the research. Sensitivity analysis will also be considered to determine the effect of parameter changes. The results will be concluded in detail and will provide advice for further research.

## 4. Data Collection

In this study, the data that has been collected and will be presented is the data of the number of demand for batik wastewater treatment equipment, the number of demand for filtration package, shipping capacity, investment costs of supplier establishment, fixed costs, variable costs, transportation costs and other costs involved in formulation. Data on the demand for waste processing equipment and filtration package will be presented in table 3 below. Filtration package is filtration material needed tools for the waste treatment process, where the material is replaced every day because it is only able to process five times in one day such as activated carbon, zeolite, gauze and bioform. Table 3 shows the needs of tools and the needs of filtration materials.

Table 3. Demand Data

| Regency | Demand BWTE (unit/year) | Demand Filtration (package/year) | Demand Filtration (package/5 years) |
|---|---|---|---|
| Pekalongan | 67 | 17688 | 88440 |
| Pemalang | 6 | 1584 | 7920 |
| Tegal | 37 | 9768 | 48840 |
| Total | 110 | 29040 | 145200 |

Source: Processed Primary Data, 2020

Table 4. Total Investment Costs

| Items | Investment Costs |
|---|---|
| Petarukan Supplier | IDR 740,000,000 |
| Kramat Supplier | IDR 600,000,000 |
| Total | IDR 1.340.000.000 |

Source: Processed primary data, 2020

Based on table 4. it can be known that the total cost of investment to open two suppliers is IDR. 1.340.000.000. Where each supplier requires different costs, the difference in costs lies in the cost of investment for buildings. This is seen from the cost burden of Petarukan suppliers is greater because they have to make investments in land and

buildings. As for Kramat suppliers are only charged to building investment only. Investment for land is not made because the system used in Kramat is land lease but buildings are set up privately.

Table 5. Total Fixed Cost

| Items | Fixed Cost |
|---|---|
| Petarukan Supplier | IDR 249.920.000 |
| Kramat Supplier | IDR 218,245,000 |
| Total | IDR 468,165,000 |

Source: Processed primary data, 2020

The total variable cost for both suppliers is shown in table 5 below with a total cost of IDR. 351.500.000 per 5 years.

Table 6. Total Variable Cost Supplier Petarukan and Kramat

| Items | Unit | Sum | Price | Variable Costs (per unit) | Variable Costs (per 5 years) |
|---|---|---|---|---|---|
| Activated carbon | Bag | 0,10 | IDR 50.000 | IDR 5.000 | IDR 250.000.000 |
| Zeolite | Kg | 1 | IDR 4.000 | IDR 4.000 | IDR 16.000.000 |
| Gauze | Box | 1 | IDR 5.000 | IDR 5.000 | IDR 25.000.000 |
| Biofarm | Kg | 0,5 | IDR 11.000 | IDR 5.500 | IDR 60.500.000 |
| Total | | | | IDR 19.500 | IDR 351.500.000 |

Source: Processed primary data, 2020

The selling price of filtration materials is IDR 29,250 which is a calculation of the 50% mark up of the cost of filtration which is IDR 19,500. The specified equipment rental demand is 6,600 hours per 5 years, with the number of equipment rented as much as 110 units per 5 years. Revenue per year is calculated from the amount of demand for filtration materials per year multiplied by the selling price of filtration added with equipment rental income. Calculation of the amount of income and profits obtained with the following formula:

Filtrations Income = Demand * Price of Filtration Materials (1)
= 145,200 packages/5 years * IDR 29,250
= IDR 4,247.100.000/5 years

Tool Rental Income = Time of Demand*Number of equipment*Rental Rates (2)
= 6,600 hours *110 units * IDR 1667/hour
= IDR 1,210,242,000/ 5 years

*Supplier's* Total Revenue = Filtration revenue + Equipment rental income (3)
= IDR 4,247,100,000 + IDR 1,210,242,000
= IDR 5,457,342,000/ 5 years

So,the total *supplier* income in 5 years is IDR 5,457,342,000. In an effort to know the profits of a business, total revenue and total costs become the main parameters. The total cost incurred by *the supplier* is based on the following calculations:

Total Cost = Fixed Cost + Variable Cost + Investment Cost (4)
= IDR 466,165,000 + IDR 351,500,000 + IDR 1,340,000,000
= IDR 2,157,665,000/ 5 years

The total cost incurred by *the supplier* for 5 years is IDR 2,157,665,000. So that the advantages of batik waste water treatment equipment are:

Total Profit = Total Revenue – Total Cost (5)
= IDR 5,457,342,000 – IDR 2,157,665,000
= IDR 3,299,677,000/ 5 years

## 4.1 Payment Options

The initization payment system is done with three types, namely cash payments, credit payments and rental payments. Of the three types, the payment system is chosen that can most likely be forwarded into the model formulation.

### 4.1.1 Cash Payment

Cash payment is a direct payment in cash and in full without any remaining payment fees made at the time of delivery of goods between the seller and the buyer. If the price of batik wastewater treatment equipment is Rp. 20,000,000, then the buyer must pay the amount of money at a time. This is considered burdensome batik SMEs because the price offered is quite expensive.

### 4.1.2 Credit Payment

Credit means the ability to provide a loan with an appointment to be paid following the agreed time. In this case, the principal of the loan is IDR 20.000.000 with a period of 5 years or 60 months and capital interest of 2% per month (KUR BRI).

According to the formula of simple capital interest: i = 2%

$$F = P\,(1 + N.i) \quad (6)$$

$$F = \text{IDR } 20.000.000\ (1 + 60.\ 0{,}02)$$

$$F = \text{IDR } 44.000.000$$

So the value to be paid until the 60th period is IDR 44,000,000. The amount to be paid is double the price of batik wastewater treatment equipment.

### 4.1.3 Rental Payment

The specified rental payment is by calculating the time in hours. Rental rates are determined based on the following calculations:

$$\text{Rent} = \frac{equipment\ price}{use\ 5\ years} \quad (7)$$

$$= \frac{IDR\ 11.000.000}{6600}$$

$$= \text{IDR } 1.667/\text{hour}$$

The amount rental rate is quite affordable for batik SMEs. In one day, for one wastewater treatment equipment, batik SMEs only spend IDR 8.335.

## 4.2 Break Even Point (BEP)

BEP or Break Even Point is the point where the income is equal to the capital issued, there is no loss or profit. Total profit and loss is at the position of 0 break even point which means that at this point the company does not suffer losses or profit.

$$\text{BEP} = \frac{\text{Fixed Cost}}{Rental\ rate/hour}\ x\ unit \quad (8)$$

$$= \frac{\text{IDR } 466.165.000}{IDR\ 1667/hour}\ \text{x unit}$$

$$= 279.643 \text{ units/hour}$$

So, the minimum requirement for production to be more economically profitable is 279.643 units/hour.

## 4.3 Return of Investment (ROI)

Return of Investment (ROI) is a measurement of the company's overall ability to generate profit with the total number of assets available in the company. ROI is also defined as the ability of invested capital in overall assets to generate net profit (Riyanto, 2004). ROI ratio can be used as an indicator in assessing the company's performance in this case to assess its influence on the value of the company reflected in the share price. ROI can be calculated using the following formula:

$$\text{ROI} = \frac{\text{Net Income}}{\text{Total Investment}}\ \text{x } 100\% \quad (9)$$

$$= \frac{\text{IDR } 3.299.677.000}{IDR\ 1.340.000.000}\ \text{x } 100\%$$

$$= 246{,}24\%$$

So, the return on investment to be generated is 246,24%.

## 4.4 Payback Period (PBP)

The payback period analysis aims to find out how long (period) investment will be refundable when the break even-point condition occurs.

$K_{(PBP)} = \sum_{i=0}^{k} CFt \geq 0$ (10)

$K_{(PBP)} = \frac{Total\ Investasi}{Total\ Benefit - Total\ Cost}$ x *periode*

$K_{(PBP)} = \frac{IDR\ 1.340.000.000}{\text{IDR } 5.457.342.000 - \text{IDR } 2.157.665.000}$ x *year*

$K_{(PBP)}$= 0,5 year

Because the value of PBP is smaller than the predetermined time horizon of PBP = 0,5 years ≤ 5 years, then this investment is worth running.

## 4.5 Net Present Value (NPV)

Net Present Value (NPV) is a method of calculating the net value (net) at present. The present assumption is to explain the initial time of calculation to coincide with the time of evaluation conducted or in zero years (0) in the calculation of cash flow investment.

Tabel 7. *Net Present Value* Jika i = 10%

| Year | *Net Cash Flow* | *Discounted Factor* | *Present Value* |
|---|---|---|---|
| 0 | IDR 1.340.000.000 | 1,00 | IDR 1.340.000.000 |
| 1 | IDR 3.299.677.000 | 0,91 | IDR 2.999.706.364 |
| 2 | IDR 3.299.677.000 | 0,83 | IDR 2.727.005.785 |
| 3 | IDR 3.299.677.000 | 0,75 | IDR 2.479.096.168 |
| 4 | IDR 3.299.677.000 | 0,68 | IDR 2.253.723.789 |
| 5 | IDR 3.299.677.000 | 0,62 | IDR 2.048.839.809 |
| NPV | | | IDR 11.168.371.915 |

PV calculation if i = 10% is as follows:

$$PV = \sum_{t=0}^{N} \frac{Rt}{(1+i)^N} \quad (11)$$

$$= \sum_{t=0}^{5} \frac{\text{IDR } 3.299.677.000}{(1+10\%)^5}$$

= IDR 2.048.839.809

NPV = Total of PV year 0 to year 5
= IDR 11.168.371.915

Npv value is positive or ≥ 0, thus the investment is worth running.

## 4.6 Model Development

Model Development is carried out, first identified influence diagrams and model components as a step to facilitate the design of models.

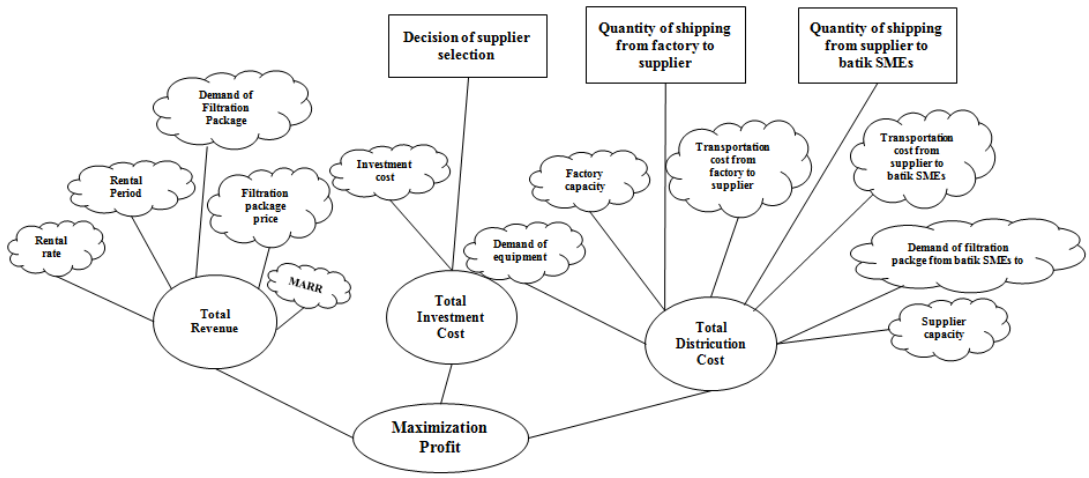


Figure 1. Influence Diagram

**Mathematical Notation :**

**Index :**

i = factory index
j = supplier index and recycling center
k = batik SMEs index
t = period

**Parameters :**

M = MARR
P = Profit of filtration package
Ctij = Transportation costs from factory *i* to supplier *j*
CTjk = Transportation costs from supplier *j* to IKM batik *k*
Djk = Demand from batik SMEs *k* to supplier *j*
CAPi = Factory capacity *i*
CAPj = Supplier capacity *j*
ICj = Investment cost of supplier opening *j*
ILt = Equipment rental income and sale of filtration package
FCt = Fixed cost in period *t*
VCj = Variable costs incurred by supplier *j*

**Variable Decision :**

Xj = Value 1 if supplier *j* opened
Value 0 if otherwise
Yij = Quantity of filtration package sent from factory *i* to supplier *j*
Zjk = Quantity of filtration package sent from supplier *j* to batik SMEs *k*

**Mathematical Model**

Based on the development of the model that has been done, then obtained mathematical model as follows:

**Objective Function :**

$$\text{Maximization } Z = \left(\sum P + Zjk\right) + \left(\sum_t^T \frac{ILt}{(1+M)^t}\right) - \left(\sum_i^I CTij.Yij\right) - \left(\sum_k^K CTjk.Zjk\right) - \left(\sum_t^T FCt\right) - \left(\sum_j^J VCj.Zjk\right) - \left(\sum_j^J ICj.Xj\right) \quad (12)$$

**Constraints:**

$$\sum Y_{ij} \leq CAP_i \quad (13)$$
$$Y_{ij} \leq CAP_j.\ X_j \quad (14)$$
$$\sum Z_{jk} = D_{jk} \quad (15)$$
$$\sum Z_{jk} \leq CAP_j.\ X_j \quad (16)$$
$$\sum Y_{ij} = \sum Z_{jk} \quad (17)$$

## 5. Result and Discussion

This section will display the results of the output model, analysis and discussion of the output of the model that has been obtained. The results will be known answers to the purpose of this study.

### 5.1 Numerical Results

Numerical results will show the results of the output model in the form of facility opening decisions, the number of shipments, total profit and total costs incurred in the batik wastewater treatment equipment business. the result is processed from coding on ILOG CPLEX.

Table 8. Output Decision Variable

| Supplier | Binary | Decision |
|---|---|---|
| Petarukan | 1 | Opened |
| Kramat | 1 | Opened |

Based on table 9 it is known that the decision to open a supplier, both were decided to open.

Table 9. Quantity of Filtration Packages from Factory to Supplier

| Supplier | Petarukan (Package) | Kramat (Package) |
|---|---|---|
| Factory | 113200 | 32000 |

From table 9, it is shown that the number of filtration packages sent from factory to Petarukan supplier is 113,200 packages, while the number of filtration packages sent from factory to Kramat supplier is 32,000 packages. In table 10 will be shown the details of total revenue based on output software. It is known that the total revenue is obtained based on the amount of revenue between the total rental income of the equipment and the sale of filtration packages. Where the total profit obtained through the batik wastewater treatment equipment business is IDR 1.253.309.940 per 5 years.

Table 10. Total Revenue

| Explanation | Value |
|---|---|
| Total Revenue of Filtration Packages | IDR 2.831.400.000 |
| Total Revenue of Rental Equipment | IDR 1.009.300.000 |
| Total Transportation Cost from Factory to Supplier | IDR 1.190.500.000 |
| Total Transportation Cost from Supplier to batik SMEs | IDR 56.914.000 |
| Total Investment Cost | IDR 1.340.000.000 |
| Total Revenue | IDR 1.253.309.940 |

In this study, investment feasibility analysis was conducted by technical-economic methods. Methods used include BEP, ROI, PBP, and NPV. Based on the calculations that have been done, the value of BEP is 279.643 units/hour that must be sold so that suppliers do not suffer losses with a period of PBP 0,5 years. For ROI value obtained 246,24% with NPV of IDR 11.168.371.915. The results showed that the opening of suppliers/businesses worth running because the value of NPV is more than 0 or positive value. Based on the method of calculating the feasibility of investment that has been done, all methods indicate if the establishment of a supplier is feasible.

This study successfully identified payment options that may be optimal if considered. There are three options described in this study: cash payment option, credit payment option and rental payment option. As a result, the rental payment option is optimal if considered to be a model component. It happens because if making cash or credit payments, batik SMEs objected to the selling price of wastewater treatment equipment offered. Therefore, the rental option is considered the best possible because it relieves batik SMEs in its payment. In this study, the recommended rental rate was IDR 1667/hour.

This study successfully developed a supply chain network model intending to know the maximation of profits if the model is used. The model developed also decides the results of the selection of supplier establishment. Quantity of filtration packages sent from factory to supplier and quantity of filtration packages sent from supplier to batik SMEs are also obtained by the model. From these results, the model can provide recommendations on the policy of the supply chain of batik wastewater treatment equipment.

## 5.2 Graphical Results

This section shows the effect of changes in demand on profit maximization, investment value to ROI and NPV as well as changes in selling price to ROI and NPV. Changes made are -50%, -25%, -10%, +10%, and +25%. The results of the query changes are shown in the following figure.

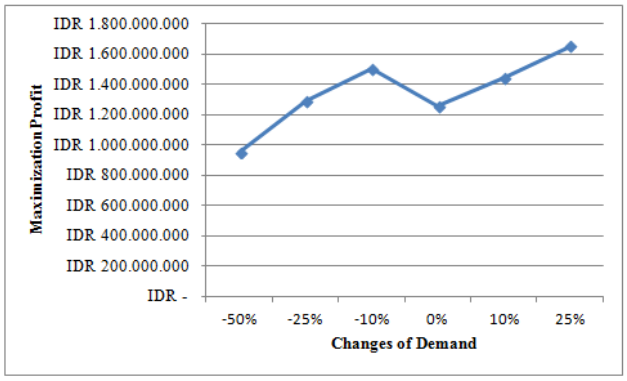


Figure 2. Graph of Changes in Demand for Profit

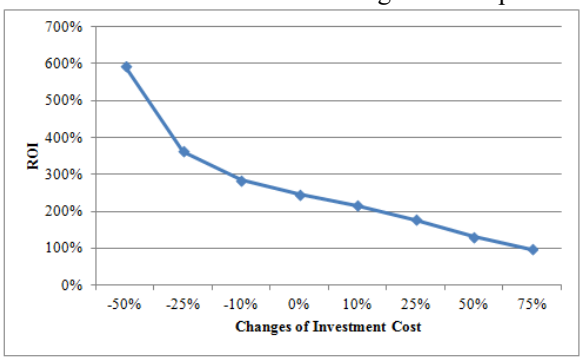


Figure 3. Graph of Changes in Investment for ROI

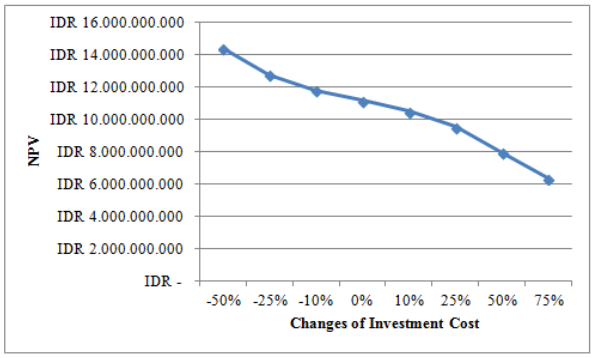


Figure 4. Graph of Changes in Investment for NPV

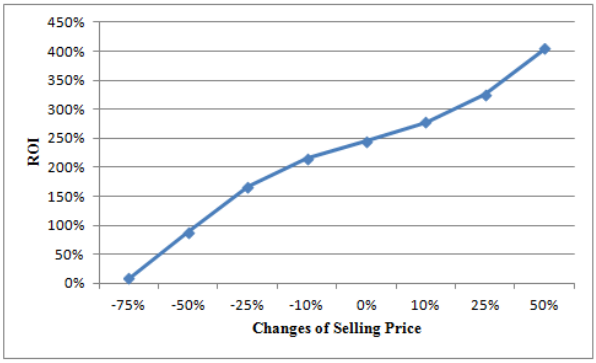


Figure 5. Graph of Changes in Selling Price For ROI

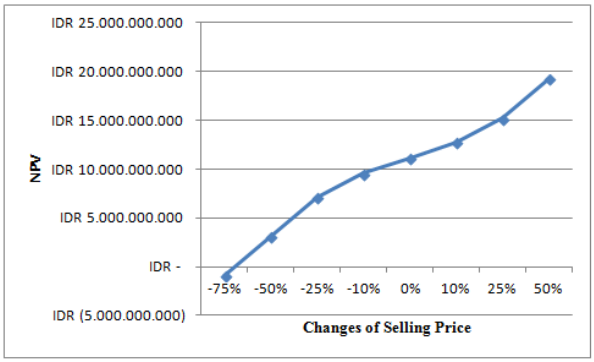


Figure 6. Graph of Changes in Selling Price for NPV

## 5.3 Proposed Improvements

The limitation of this study is that it has not produced a model with three payment options. The model can only calculate one option at a rate that is the rental rate. It would be better to consider three options because the profit comparison will be clearer. This research is also limited to the decision of models that have not been able to determine the number of consumables sent to the recycling center. Further research is expected to develop a model by adding collection centers to accommodate and even reprocess waste from consumables used.

## 6. Conclusion

The conclusion of this study is based on the feasibility analysis of supplier establishment investment that has been done by techno-economic method, it is known that the supplier is worthy to be established. Alternative solutions as an effort to accelerate the recommended commercialization are to apply rental options at predetermined rental rates. The mathematical model of the supply chain network that has been developed successfully answers the problems and objectives of this study.

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