Economic Analysis Development and Provider Elective Decision Model on Auto-ID Technology Investment

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Abstract. In the last few years, the warehousing system use Auto Identification technology to manage the warehouse operation. Auto-ID is often used to obtain the information about amount, location, content, and condition of part or product. However, some industries still use manual warehouse management. Manual warehouse management systems usually cause some problem like inventory shrinkage and stock out. The investment and application of Auto-ID technology on the warehouse system can reduce the effect of the manual system. The use of Auto-ID technology in warehousing systems has a significant effect on the reduction of human error, the reduction of loss of goods, the accuracy of inventory stock, and can handle the product in large quantities, the speed of acceptance, and improve the delivery process. In this research, the cost and benefit analysis was carried out to assess the Auto-ID technology investments. The cost of inventory shrinkage reduction, labor and stock out, and the increase of productivity and maintenance on the spare parts warehouse management system used to analyse the cost benefit. To determine the expected NPV value in Auto-ID technology investments used Monte Carlo analysis. Furthermore, a company’s evaluation for selecting an Auto ID provider is a significant aspect. The evaluation of decision making for selecting Auto ID vendors is based on three criteria. This is referred to as many criteria decision making. Vendor performance, service after installation, and system attributes are the criteria employed in the decision-making model. Evaluation of Auto-ID vendor selection is done by using AHP. Based on the results of AHP analysis for the selection of Auto-ID suppliers, it was found that supplier PT C was the main priority (39.3%) for best suppliers, and the last priority was PT B (13.8%).

Keywords: Cost-benefit analysis, Provider Decision Making, RFID, Barcode

1. Introduction

In recent years, Auto-ID (automatic identification) technology is a popular technology in manufacturing or industrial companies, especially in warehousing, purchasing, or goods delivery systems. Auto-ID technology provides information about human, animal, and product data. There are several types of Auto-ID technology. Barcode and RFID (Radio frequency identification) technology are two types of Auto-ID that are often used in the manufacturing or service industries. Barcode technology is a cheaper technology, but barcodes can only be used in simple problems and cannot be reprogrammed [1]. RFID is often referred to as a smart card. RFID technology systems provide information via radio waves. At this time, many manufacturing companies have implemented RFID
technology. RFID technology is widely used in the mobile phone and cordless telephone industrial sectors [1]. In addition, although RFID technology is a new technology, many companies realize the potential of RFID to deal with complexity globally and to be able to balance cost and performance in the supply chain [2].

RFID technology has been identified as one of the top 10 technologies in the last 21 years [3]. In 1999 Wal-Mart implemented RFID to replace the existing barcode system [4]. Wal-Mart uses RFID to track inventory. In addition, RFID is also used to obtain information about the location, content, location, and condition of goods or products. Several community service centers such as hospitals have also implemented Auto-ID technology. With the aim of reducing costs and improving patient and service safety, several health care centers are implementing RFID systems to track patient data, medications, mattresses, blood, and medical history [5]. RFID technology is also widely applied to manufacturing companies, especially in the supply chain. The implementation of RFID is growing very quickly since several companies have succeeded in implementing RFID in logistics activities.

Some studies only focus on the general description of RFID or the application of RFID in the fashion, service, retail, manufacturing, healthcare, and automotive industries [2]. This is because RFID technology can minimize inventory errors or inventory inaccuracy in retail companies [6]. Constraints such as inaccuracies in warehousing operating systems that often exist can be minimized by implementing the right information technology. Although the cost of implementing or investing in information technology is quite expensive, with this information technology, companies can reduce losses and increase profits or company performance. Companies can invest in Auto-ID (RFID and/barcode) information technology in the company's operating system. Investment in Auto-ID technology is expected to reduce management operating costs and also make a good contribution to business processes [7]. However, some studies also say that RFID technology does not provide many benefits even with good planning.

Ustundag [5] conducted an economic analysis to increase the profits from the use of Auto-ID in companies. The increase in profit is the sum of reductions in labor costs, inventory costs, shrinkage costs, and revenue increases. However, in the research conducted by Ustundag (2010), calculations have not been carried out to reduce stock-out costs. The cost of stock out is one of the costs of the warehousing system that can affect the company's production process. The costs included in the cost of stock out are backorder costs, lost sales opportunity costs, and lost profit costs. The result of stock out is lost sales, and customer dissatisfaction occurs because customers cannot get the goods they need. With the help of RFID technology, companies can always monitor the amount of stock available in the warehouse. RFID technology can provide an alert when the amount of stock available in the warehouse is at a minimum. Srivastava says that reducing stock-outs can increase company profits and customer satisfaction [8]. Therefore, in this study, a model was developed to get an increase in company profits by taking into account the reduction of stock-out costs.

Based on research conducted by [5] it recommends making decisions to evaluate RFID investments. The research conducted by Ustundag has not provided a solution for selecting the best RFID supplier according to the company’s conditions. The selection of suppliers or suppliers is one of the success factors for manufacturing companies. According to Ghoddsypur [9] supplier selection is an important decision-making problem for smooth business or industrial processes and company competitiveness. Based on Cebi strategy and operational factors such as tangible and intangible factors must be considered in the analysis of supplier selection decisions. Meanwhile, Amid in [9] said that the selection of suppliers must include quality and quantity factors.

The complexity of the decision problem is not only caused by imperfections or information uncertainty but the many factors that influence the choices, with various selection criteria in conflicting situations is another factor that can cause the complexity of making a decision. With so many alternatives in conflicting situations, the multi-criteria decision-making method can be used to get the optimal solution [10]. The analytical hierarchy process (AHP) method is the method most often used to solve multi-criteria problems. The hierarchical approach was developed based on the theory of preference measurement by conducting pairwise comparisons for all quantitative and qualitative
decision criteria [10]. The purpose of using AHP is to determine the weight of the relative importance of each criterion; then, this criterion is used as a basis for reference for evaluating the relative determination of decision alternatives.

This study aims to conduct an economic analysis of Auto-ID investment in the ROL (re-order level) spare part warehouse system and the decision to select the best RFID supplier according to the company's conditions. Auto-ID technology investment in the spare part warehouse system is expected to help warehouse staff in the warehouse management process. So far, the warehouse management system still uses a manual system. Inventory shrinkage and spare part shortages are caused by the manual system. Spare parts that are in the warehouse beyond the time limit of use are categorized as inventory shrinkage. The amount of inventory shrinkage and stock out resulted in equipment breakdown, and the maintenance process did not run smoothly. Thus, the production level cannot reach the targeted production quantum, and the company does not get the maximum profit.

2. Method

In this research, cost and benefit analysis are used for the economic analysis of Auto-ID investment, and supplier selection is used for the selection of Auto-ID solution providers. The economic analysis carried out is a cost-benefit analysis of the Auto-ID investment in the ROL spare part warehouse system. The total benefit is the sum of the reduction of stock-out costs, inventory shrinkage costs, labor costs in the ROL spare part management system. In addition, it is hoped that reducing the number of ROL spare part stock-outs and the length of maintenance time can increase the amount of production, so as to increase the total profit company too. By investing in Auto-ID, it is hoped that the company will be able to reduce costs in the warehousing system and also increase the amount of production, which will affect the increase in total profit or company profits.

Misinformation on the number of spare parts available is often one of the causes of end-users being unable to carry out the maintenance process on time. Data on the number of spare parts at the end-user and the actual number in the warehouse are often not the same. When the spare part data at the end user is available, when a request is made for the spare part that is needed, it is not available in the warehouse. This is because demand forecasting is uncertain. The sudden demand in large quantities causes the warehouse to have a shortage of spare part inventory, so when the required spare parts are not available, the end-user must wait to be able to carry out the repair or maintenance process. Therefore, in this study, the fuzzy rules-based system method was used to calculate the percentage increase in orders for spare parts and productivity increases for the total profit from the integration of Auto-ID technology. The NPV and IRR values are used to assess investments for the next 5 years.

Furthermore, after an economic analysis of the Auto-ID investment has been carried out, the Auto-ID supplier is selected. Auto-ID supplier selection decisions aim to assist company managers in choosing the best Auto-ID suppliers according to company conditions. The AHP method is used to make decisions on the best Auto-ID supplier to choose.

2.1 Auto-ID Investment Analysis

Cost and benefit analysis (cost and benefit analysis) is used to perform economic analysis in this research. Cost and benefit analysis was also carried out in research conducted by Ustundag [5]. The benefits of investing in Auto-ID technology used in this study are based on previous literature reviews. According to Ustundag [5], RFID implementation can reduce inventory costs, shrinkage, labor, and lost sales. However, Srivastava [8] also stated that the implementation of RFID could affect the minimization of stock out, inventory shrinkage and also affect correct pricing. Figure 4.1 shows the benefit structure of implementing Auto-ID technology. When the number of stock items in the warehouse is small, the possibility of stock-outs will be even greater. Likewise, with lost production and inventory shrinkage. The greater the possibility of stock-outs lost production and inventory shrinkage, the greater the costs that must be incurred.
2.2 Auto-ID Investment Model Analysis

In this study, the economic analysis model of Auto-ID technology investment used refers to the mathematical model used by Ustundag [5]. Ustundag conducted a cost-benefit analysis which was also carried out in this study. Ustundag used the FRBS method and Monte Carlo simulation to calculate NPV. In this study, in addition to calculating the reduction of labor costs and inventory shrinkage, it will also calculate the reduction of stock-out costs.

Inventory shrinkage is an item that has been in the warehouse for a long time and has not been used (dead inventory). With the inventory shrinkage, the company must incur storage costs and also the cost of loss because the item is considered unused or lost in the ROL spare part warehouse management system, which is now still manual. Jobs such as calculating the number of ROL spare parts, searching for, and routinely checking the number of ROL spare parts are still done manually by employees. This causes high labor costs because workers need a long time to do these jobs. By investing in Auto-ID, it is expected to reduce labor costs because it can minimize worker time in doing ROL spare part warehouse management jobs.

Stock-out costs are costs caused by the unavailability of goods when needed. The consequences of stockouts can cause the production process to stop. This is because when the factory requires ROL spare parts during maintenance, the required ROL spare parts are not available. In this study, the occurrence of stock out of ROL spare parts will result in large losses to the company's system, one of which can cause a decrease in productivity levels. By reducing the cost of stock out can increase the company's profit. This is because, with the availability of the number of ROL spare parts and the fulfillment of end-user demands, the maintenance process can run smoothly so that productivity increases. Furthermore, the basic model created is used to analyze the benefits obtained by the company by investing in Auto-ID technology in the warehouse system.

2.3 Proposed Model Analysis

In this study, the costs of Auto-ID are divided into three areas such as hardware cost (C_H), middleware cost (C_M), software cost (C_S), and service cost (C_Z). The Auto-ID benefits are broken down into two parts: cost reduction and increase productivity and maintenance. The total value of the benefit is calculated by using Eq. (1), which is developing a model of Ustundag [11]. The cost reduction is computed considering the increased spare part order (Q'), cost/unit (c), and cost reduction rate (r). Cost reductions are calculated in Eqs. (2) – (4).
\[ T_B = \Delta C_{IS} + \Delta C_{lab} + \Delta C_{sto} + \Delta P - C_{tag,n} \]  

(1)

\[ \Delta C_{IS} = Q' \times c_{IS} \times r_{IS} \]  

(2)

\[ \Delta C_{lab} = Q' \times c_{lab} \times r_{lab} \]  

(3)

\[ \Delta C_{sto} = Q' \times c_{sto} \times r_{sto} \]  

(4)

Where \( \Delta C_{IS} \) is a reduction of inventory shrinkage cost, \( \Delta C_{lab} \) is a reduction of labor cost, \( \Delta C_{sto} \) is a reduction of stock-out cost, \( \Delta P \) is production and maintenance increase, and \( C_{tag,n} \) is tag cost in year- \( n \).

The increase spare part order \( (Q') \) and productivity and maintenance increase \( (\Delta P) \) are calculated by:

\[ Q' = Q(\mu, \sigma) \times (1 + d) \]  

(5)

\[ \Delta P = p \times C_{prod} \]  

(6)

Where \( Q \) is the actual demand for spare parts, \( d \) is the increase order of spare part ROL, \( p \) is increased productivity (%), and \( C_{prod} \) is production cost per year.

The NPV and IRR [12] value of the total Auto-ID investment is calculated using Eq.7 and Eq.8, respectively. The NPV and IRR value is used to estimate the likely financial outcome of the investment. The NPV Monte Carlo simulation is utilized in this study to reduce the random variable’s error probability.

\[ NPV = -(C_H + C_M + C_S + C_Z) + \sum_{n=1}^{n} \frac{T_B}{(1+i)^n} \]  

(7)

\[ IRR = -1 + \sum_{t=0}^{n} \frac{CF_t}{(1+IRR)^t} \]  

(8)

Where I used the term "discount rate" as an index.

The rules established for the increase in spare part ROL orders are shown in Table 1.

| Rule | Delivery Time | Type Accuracy | Amount Accuracy | Increase Order |
|------|---------------|---------------|----------------|---------------|
| 1    | If Short      | AND High      | AND High       | THEN High     |
| 2    | If Short      | AND High      | AND Medium     | THEN Medium   |
| 3    | If Medium     | AND Medium    | AND High       | THEN Medium   |
| 4    | If Medium     | AND High      | AND High       | THEN High     |
| 5    | If Long       | AND Medium    | AND Low        | THEN Low      |
| 6    | If Low        | AND Low       | AND Low        | THEN Low      |

2.4 Selection of Auto-ID solution supplier

In this study, vendor selection decisions the Auto-ID refers to the research that has been conducted by Sari (2013) [13]. Figure 1 shows the hierarchical structure of the decision model. The model aims to help managers of a company for deciding the best provider of Auto-ID.
3. Result

3.1 The benefit of Auto-ID Investment

By using a 10% discount rate and an average ROL demand for critical spare parts of 66,654 units with a standard deviation of 80,776%, the total benefit value is Rp 1,462,764,326.60 for RFID investment and Rp 269,305,292.29 for barcode investment. With the same discount rate (10%), NPV RFID (3,659,844,069.75) > NPV barcode (913,723,450.85), but the percentage value of IRR RFID (29%) < IRR barcode (55%). With RFID investments with a faster payback time compared to RFID investments.

| Table 2. Auto-ID Cost Benefit Investment |
|-----------------------------------------|
| RFID                                   | Barcode                              |
| **Total benefit (Rp)**                  | 1,462,642,632.83                     | 269,614,104.90 |
| **NPV (Rp)**                            | 3,659,237,181.61                     | 915,270,294.29 |
| **IRR (%)**                             | 29.00%                               | 55.49%         |

With the same expenditure for inventory shrinkage, labor, and stock-out costs for both types of technology, but the amount of value reduced after investing in different technologies. Auto-ID technology investment in ROL spare parts warehouse aims to increase company profits and benefits. Based on [14] said that in the case of mutually exclusive projects, the project with the larger NPV should be accepted. By using a discount rate of 10% and an average ROL demand for critical spare parts of 66,654 units with a standard deviation of 80,776%, the total benefit value is Rp 1,462,764,326.60 for RFID investment and Rp 269,305,292.29 for barcode investment. With the same discount rate of 10%, NPV RFID (3,659,844,069.75) > NPV barcode (913,723,450.85), but the percentage value of IRR RFID (29%) < IRR barcode (55%). Based on the IRR value, barcode technology investment can provide a higher level of certainty of profits compared to RFID investments with a faster payback time compared to RFID investments.

3.2 Monte Carlo Simulation Analysis

The actual demand for ROL spare parts (Q) is a variable with a random value; this is due to the level of uncertainty in demand for ROL spare parts. The company cannot ensure the number of requests for
ROL spare parts in the next period because end users can request ROL spare parts at any time when there is a problem with the machine and repairs or maintenance must be carried out.

By implementing the input data into the model, the results of the cost-benefit of Auto-ID investment are determined. The average amount of yearly spare part ROL demand of the company is 60,954 units with a standard deviation of 913%. The NPV and IRR value of Auto-ID investment in five years horizon is positive. The distribution of the NPV of RFID investment has the mean of Rp 3,660,399.54 and standard deviation of Rp 4,487,890.00 shown in Fig. 2.

Managers of industry manufacture can use this research study to perform a better analysis of possible Auto-ID providers and then choose the best solution provider for their organization. As shown in Fig.3 the output of alternative Auto-ID provider is determined. Now, based on Fig.4, we can rank the solution providers from best to worst as PT P, PT Z, PT Y, and PT X. On average, Provider P is the better alternative.

![Histogram of NPV Monte Carlo Simulation (RFID)](image1)

**Figure 3. Histogram of NPV Monte Carlo Simulation (RFID)**

![Histogram of NPV Monte Carlo Simulation (Barcode)](image2)

**Figure 4. Histogram of NPV Monte Carlo Simulation (Barcode)**
Based on the simulation results, the total cost saving for RFID is between Rp. 66,750,000.00 - Rp. 72,000,000.00, and the total benefit for RFID is between Rp. 1,453,500,000.00 and Rp. 1,458,750,000.00. Meanwhile, the total cost saving for barcodes is between Rp. 12,150,000.00 and Rp. 13,050,000.00, and the total benefit for barcodes is between Rp. 268,050,000.00 and Rp. 269,100,000.00. The NPV distribution of RFID technology investment has an average value of Rp. 3,660,399.54 and a standard deviation of Rp. 4,487,890.00 with an interval between Rp. 3,645,000,000.00 and Rp. 3,676,500,000.00, and the NPV of barcode investment has an average value of Rp. 915,724,808.00 and a standard deviation of Rp. 852,550.00 with an interval between Rp. 913,600,000.00 and IDR 917,600,000.00.

Based on the simulation results obtained, it can be concluded that the NPV of Auto-ID technology investment provides a positive value with a high degree of certainty. Therefore, company managers can decide to invest in RFID or barcode technology.

3.3 Auto-ID Supplier Analysis
After doing the calculations, the percentage value of the weights for each Auto-ID supplier is obtained. Figure 5.8 shows that supplier PT P has the highest weight value of 44.2% compared to the other three alternative suppliers. The next global weight ranking in order is PT Z, PT Y, and PT X, with 26.5%, 16.4%, and 12.9% weights. Supplier PT P has a value that is in accordance with what the company wants. With the advantage of being able to provide cost-effectiveness to consumers, PT P's suppliers are able to increase the company's profit according to the conditions desired by the company. In addition, PT P also provides customized tag services that can be adapted to the conditions and wishes of the company. Thus, supplier PT P is the best supplier that can be chosen by company managers.

4. Conclusion
The cost and benefit analysis is used to evaluate the economic analysis of Auto-ID investments within a corporation in this study. Hardware, middleware, software, and service charges are all included in the cost of deploying Auto-ID. The key advantages are cost savings, increased productivity, and easier maintenance. The goal of this study is to develop an integrated model that takes into account the increased productivity and maintenance that Auto-ID brings. The Auto-ID solution provider choice model is designed to assist managers of an organization or corporation in efficiently evaluating possible Auto-ID solution providers and then selecting the best one for their specific situation. The
greater the cost reduction and the greater the increase in productivity and maintenance, the greater the total benefit obtained. Likewise, with the value of NPV and IRR. However, even though the production costs incurred are greater, the company will get big profits too, this is because production runs smoothly. Based on AHP weight calculation, the optimal suppliers is PT C with a weight of 39.3%, then PT A with a weight of 27.2%, PT D with a weight of 19.7%, and the last priority was PT B Indonesia with a weight of 13.8%. Company managers can make decisions to choose suppliers based on the criteria and according to the different interests. The criteria will have an effect on reducing production costs, increasing productivity, and user satisfaction.

5. References
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