Decision-making model for Auto-ID technology adoption in the banking industry

F Afrizal* and I Vanany

1Department of Industrial Engineering, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia

Email: *fandiafrizal177@gmail.com

Abstract. The justification of investment technology Auto-ID (automatic identification) in banks aims to assist practitioners in solving banking problems. A study is needed to find out the importance of investing in Auto-ID technology in a company. This technology will be made in an integrated system that can be used to monitor important documents and assets in the bank with two alternatives that are suitable for this case namely barcode and RFID. In the process of technology adoption, there are various forms of approaches ranging from strategic, economic, analytical and comprehensive where in the case of IT justification is more suitable to use analytic and comprehensive namely DEMATEL and ANP because it needs to capture intangible factors. In the DEMATEL calculation, the operator criteria group with the highest weight is eternity, followed by IT and economic optimization. In addition, it was also found that the most influential recipient groups were satisfaction, cost savings, and expansion. Then in the ANP method, the calculation results are obtained that the global weighting of the criteria with the highest value is an opportunity, followed by benefits, costs, and risks. So that the alternative decision obtained is RFID is the technology chosen for adoption in the banking industry.

1. Introduction

In a country, banks have an important role in the economy. They are intermediaries among people with a lack of capital and a surplus [1]. Since the digital revolution, information technology has been widely applied to the financial sector and provides impetus to traditional banks to carry out digital transformation. The emergence of the internet and digitalization has caused disruption to the banking industry in the world in general and Indonesia in particular [2]. Research has shown that service quality is increasingly recognized as being critical in the success of any business [3]. Service quality has been widely used to evaluate the performance of banking services [4]. Banks understand that customers will be loyal if they receive greater value than competitors banks can get high profits if they are able to position themselves better than their competitors in certain markets [5].

In the opinion of some experts, needs such as tracking inventory such as laptops, cars, and important customer documents such as principal documents (land certificates, book vehicle owners), agreement documents, and the like that often move between branches become an important focus [6]. Customer documents that are usually in the bank are often processed either for the credit application process or processes that require external parties such as a notary public or the National Land Agency so that this process often creates the risk of slipping documents [7]. According to Ambira & Kemoni [8] the need to strengthen records management as a critical success factor in risk mitigation within banks. So, it is proposed an effort that can be done by banks to use standardized Auto-ID (Automatic Identification) so that the company can monitor the movement of assets and records carried out by employees or couriers. Other factors that cause the use of Auto-ID are due to the speed of reading data, the lack of errors in reading data, and flexibility [9].

Wireless identification technologies such as Auto-ID make it easier to develop finer environments for doing business [10]. This is supported from previous research on smart blood tracking systems in
the health care industry with a type of system that has a web-based platform (online) and is supported by automatic identification technology (Auto-ID) such as barcodes and radio frequency identification (RFID) believed to help companies in developing its business [11]. It was mentioned that there were various kinds of automatic identification systems (Auto-ID) including (1) Barcodes, (2) Optical Character Recognition, (3) Radio Frequency ID, (4) Magnetic Stripe, (5) Voice Recognition, (6) Fingerprint. Of the many Auto-ID technologies suitable for completing document traceability systems are barcode and RFID [12]. The process of document mobilization at banks in Indonesia especially in Surabaya is still classified as using a manual. The process of taking and tracking documents is done and carried out by humans so that the potential for human error is high. In a survey said in 2018, 43% of bankers surveyed were likely to invest in transformation technology in the next 18 months (see Table 1). This is known to get the highest percentage when compared to other factors, namely changing customer needs, competition, operational excellence, risk management, regulation so that the need for technological transformation is in great demand in the banking world.

| Technology Business Transformation | Scoring scale |
|-----------------------------------|---------------|
| Technology                        | 43 %          |
| Changing Costumer Needs           | 34 %          |
| Competition                       | 14 %          |
| Operational Excellence            | 6%            |
| Risk Management                   | 2%            |
| Regulation                        | 1%            |

In each document, a tag will be installed which will be detected by the reader, so that through the tag the document can be monitored through the system [13]. To use this technology an investment cost is needed for the procurement of equipment at the outset. There are various price variations that can be taken into consideration for initial investment [13]. Besides the reliability of the reading level, level of organizational readiness, and the technological risks that may be caused are also a consideration related to the negative impacts in the adoption process [14].

To evaluate the adoption of new technology, a decision analysis process is needed to find out which criteria are most influential. The decision analysis process requires several supporting criteria to determine the alternatives to be chosen. In the process of technology adoption, there are various forms of approaches ranging from strategic, economic, analytical and comprehensive where in the case of IT justification will be more suitable to use analytical and comprehensive, namely MCDM (multi-criteria decision making) because it needs to capture intangible factors [15]. Many researchers believe that a comprehensive approach developed with some integrated techniques is more appropriate when used in the justification of IT investment compared to economic, strategy and analytic approaches [16].

In the case of MCDM, many methods that can be used including the popular one is AHP. The AHP process is a multi-criteria decision-making process used to choose an alternative. AHP has been widely used to reflect the importance of criteria. many studies of AHP have been carried out, including the application of AHP in various fields of planning, choosing the best alternative, and resolving conflicts [14]. In this research, there is a decision-making problem that cannot be structured in a hierarchical manner because it involves interaction and dependency between its elements. In addition, there is also the possibility of interdependence and feedback on the problem. Therefore, the ANP (Analytical Network Process) method was chosen because it is a method for considering this. ANP can also illustrate the strength of interconnectedness so that it can understand complex relationships in the adoption system and find the best alternative [17]. To improve the quality of decisions in determining alternatives, the DEMATEL method was chosen to complete the ANP method as a basis for describing the structure of the ANP network. Although the use of the ANP method has been able to capture the
influence and dependence between the criteria, adopting the DEMATEL method can optimize the causal relationship. The merging of the DEMATEL and ANP (DANP) methods is considered to be complementary to complete complex problems with more accurate results and is able to describe the conditions of the scope under real study [18].

2. Methodology
The object of this study is a decision analysis of the implementation of new Auto-ID technology in the banking industry in Surabaya. While the subjects of this study are experts who work at banks and already have work experience in filing important documents. Interviews will be conducted with the position of the head, deputy head of the Surabaya branch or head of the credit department. In the process of sampling and population, this method needs to be done so that the results obtained can be optimal. In this study, the Delphi method is used for the sampling process. The method used in collecting data is by observation, interview, questionnaire and literature study. The questionnaire used is a semi-open questionnaire. While the data source used is primary data because the data taken is interview data collected directly through experts based on their experience.

2.1 Preparation phase
In this preparation, the stage is preparing everything related to research. The first thing to do is study literature. In this literature, the study is used to study methods and theories as to the initial foundation in thinking. This literature study helps researchers determine the initial dimensions and criteria before submitting them to the expert. This was taken from previous similar studies as well as several journals and supporting books. The second thing is to do a field study. At this stage, the researchers collected supporting data to support subsequent data processing. It also obtains preliminary information from the surrounding environment as a basis for starting a study.

2.2 Data Collection Phase
The criteria were adopted from several previous studies obtained from national and international journals. With this adoption, the researcher finally has a reference to several criteria. Then from the aforementioned criteria, the researcher proposes them to the head of the credit sub-unit in the bank in order to get the criteria that are really needed by the company with the current conditions. So, at this stage, the final criteria will be obtained which will be used at a later stage which of course has been approved by the company. Then the researcher arranged the questionnaire design in 3 (three) types. Questionnaire 1 was used to validate the criteria to the expert, questionnaire 2 was to identify the relationship between the sub-criteria using the DEMATEL method, questionnaire 3 was a pairwise comparison to get the criteria weights. Questionnaires 1, 2 and 3 will be given to the same expert. The interview process will be conducted with experts in the company. The experts will be asked to answer questions relating to the relationship between the influence of criteria. From the results of interviews that have been carried out obtained data which is then processed to see the effect of the relationship between the sub-criteria using the DEMATEL method. In the DEMATEL calculation is only done to see the pairwise comparisons on sub-criteria only. In addition, this method is also to find out which criteria are included as influencers. The details of this process are as follows [19]:

1) Creating a direct relationship matrix
   In this step, a direct relationship matrix will be made using four levels of comparison scale, namely 0 (no influence), 1 (low influence), 2 (moderate effect), 3 (high effect), 4 (very high effect). Previously it is necessary to calculate the number of each column and row of matrix A, then find the maximum value to enter into the formula.
2) Normalization of the direct relationship matrix

Using matrix $A$, normalizing the relationship with matrix $D$ directly can be obtained using the following formulation.

$$D = z \times A$$  \hspace{1cm} (1)

$$Z = \min \left\{ \frac{1}{\max \sum_{j=1}^{n} a_{ij}}, \frac{1}{\max \sum_{i=1}^{n} a_{ij}} \right\}$$  \hspace{1cm} (2)

3) Calculate the Total Matrix $T$

The total $T$ matrix relationship symbolized as an identity matrix can be obtained through the following equation:

$$T = D + D^2 + D^3 + ... + D^h$$

$$= D(I + D + D^2 + ... + D^{h-1})(I - D)(I - D)$$

$$= D(I - D^h)(I - D)$$

Where $I$ can be defined as an identity matrix

$$I = (I - D)(I - D)$$  \hspace{1cm} (3)

$$T = D(I - D)^{h-1}, h \rightarrow \infty, D^h = [0]_{n \times n}$$  \hspace{1cm} (4)

4) Compute vector $D$ (dispatcher) and $R$ vector (receiver)

The number of rows and columns is separately represented as vector $D$ and vector $R$. Then the vector $(D + R)$ is referred to as "prominence" horizontally. This vector was created to add $D$ to $R$ which shows how important a criterion is. Besides that, there is also a vector $(D - R)$ called "relation" into a group of causes and effects. The above can then be formulated as follows:

$$T = [t_{ij}]_{n \times n'}$$

$$D = [r_i]_{n \times 1} = [\sum_{j=1}^{n} t_{ij}]_{1 \times 1}$$  \hspace{1cm} (5)

$$R = [s_j]_{m \times 1} = [\sum_{i=1}^{m} t_{ij}]_{1 \times m}$$  \hspace{1cm} (6)

5) Get an impact-diagram map

From the values obtained from the total relationship matrix, each value provides information on how much influence the group of criteria i with criteria j. So that if you only rely on the results of the total relationship matrix, there will be difficulties in determining decision making. For this reason, a threshold value for the level of influence needs to be given so that only a few elements have values above the threshold in the $T$ matrix that can be entered on the impact-diagram map. This threshold value is usually determined by the expert. Impact-diagram maps can be obtained by mapping values $(D + R)$ and $(D - R)$ so that information can be obtained to make decisions.

2.3 Data Processing Stage

The first step in processing data is to design the ANP structure based on the calculation results obtained using DEMATEL. The design of the ANP model includes the creation of dimensional structures that show relationships between dimensions. The design of this model will later be used to determine what criteria are compared in the comparison matrix at a later stage. Having made the ANP network structure and knowing what criteria should be compared to the interview again to be asked to compare in pairs each of the criteria using the ANP scale. This second interview aims to get the priority weights of each criterion. Then the paired comparison results are performed for each dimension using the ANP principle where the matrix contains the inverse value of the paired comparison results according to expert judgment. After obtaining information about the comparison results of the criteria obtained from the expert, the researcher will then calculate the weight of each dimension. Afterward, a consistency test is performed to see the accuracy of the judgment value given by the expert. The consistency test is carried out twice by looking at the consistency ratio (CR) and the consistency index (CI). A matrix is said to be consistent if the CR value is not more than 10%. If the consistency ratio is getting closer to zero, then the better the value and shows that the matrix is said to be consistent. If the results of the consistency test indicate that the weighting is not consistent, then the number that is rated the most outlier will be eliminated and then will be re-weighted.
2.4 Data Analysis and Interpretation Phase

From the evaluation results, it is known which criteria are good enough and which need to be improved. So with this information, the researcher can analyse the implications or effects of these criteria on the successful implementation of Auto-ID, and the impact that might occur if the criteria are not implemented. Then BOCR analysis is carried out to determine the factors of benefit, opportunity, cost, risk. This analysis is done by looking at the weighting results obtained from comparing the criteria derived from the BOCR.

3. Result and Discussion

3.1 The banking world

The business process of a credit application that occurs within a bank is generally handled by 4 internal parties, namely the credit unit, management, document units, and operational units. The process starts by receiving the debtor who will apply for credit by the document unit in the bank. The debtor conveys the purpose of applying for credit along with collateral that can be provided as a condition. The process continues until the file is stored in a safe. After this process is completed, a memo is made to the operational unit that the documents provided are complete. The operational unit then processes the loan funds submitted by the debtor along with the loan agreement regarding the instalment and repayment process. Business process for submitting credit and business process credit repayment are shown in Figure 1 and Figure 2.

![Figure 1. Business process for submitting credit.](image1)

![Figure 2. Business process credit repayment.](image2)

On repayment of the credit, the process starts from the debtor applying for repayment at the counter, then the counter will crosscheck the customer's personal information and so on until the process ends with the debtor receiving the main documents back from the leader after all administration has been fulfilled. The cloud service architecture system is described in Figure 3.
3.2 Selection Criteria

Criteria consist of (4) four types consisting of benefits, opportunities, costs, and risks. Each criterion will then be reduced to sub-criteria and alternatives. The benefit criterion relates to the benefits to be gained by the company when adopting information technology (IT). While the opportunity criteria relate to opportunities that can be taken in the future. Then the cost criteria are related to the costs that will arise when adopting new information technology (IT) for the company. Furthermore, risk associated with risks that arise with the existence of this technology for internal companies and customers. Table 2 shows the value of prominence and relations.

| Sub-Criteria              | D   | R   | D+R  | D-R  |
|---------------------------|-----|-----|------|------|
| Economic                  | 3.848| 3.764| 7.612| 0.084|
| Satisfaction              | 3.227| 4.208| 7.434| -0.981|
| Effort                    | 3.006| 3.631| 6.637| -0.625|
| Time                      | 3.566| 3.650| 7.216| -0.084|
| Functionality             | 3.929| 3.856| 7.786| 0.073 |
| Cost Saving               | 3.711| 4.023| 7.734| -0.313|
| Expansion                 | 3.029| 3.901| 6.930| -0.872|
| Innovation                | 3.733| 3.655| 7.389| 0.078 |
| Image                     | 2.916| 3.486| 6.403| -0.570|
| Optimization of IT        | 3.951| 3.698| 7.648| 0.253 |
| Infrastructure            | 3.358| 3.258| 6.616| 0.101 |
| Maintenance               | 3.458| 3.194| 6.652| 0.263 |
| Switching                 | 3.657| 3.076| 6.732| 0.581 |
| Service                   | 3.016| 3.556| 6.572| -0.540|
| Human Resource            | 2.650| 3.285| 5.935| -0.636|
| Data Access & Integrity   | 3.543| 3.312| 6.855| 0.231 |
| Lack of Control           | 3.368| 3.158| 6.526| 0.209 |
| Security                  | 3.808| 3.729| 7.537| 0.079 |
| Internet Latency          | 3.785| 3.071| 6.856| 0.713 |
| Permanence                | 4.500| 3.000| 7.500| 1.500 |
| Vendor Lock-in            | 3.503| 3.050| 6.553| 0.454 |
This method is done with the aim to find out how much influence between sub-criteria one with other sub-criteria that exist in a criterion. Respondents (experts) were asked to rate the direct effects of factors using integer scales from 0 to 4 to represent from "absolutely no influence (0)" to "very high influence (4)". The results of the questionnaire then calculated the average value among the three respondents to form the initial relationship matrix. Then the data is processed using Microsoft Excel with five calculation stages. After obtaining a direct relationship matrix, the normalization matrix is calculated. After normalizing the direct relationship matrix, then the total relationship matrix is performed using equations (2.3) and (2.4) in chapter 2 about DEMATEL. After getting the total relationship matrix, the next step is to calculate the vectors D and R. The results of prominence (D + R) indicate the importance of the criteria for the traceability system. While the results of relations show a causal relationship on the criteria. The following is shown in table 3 calculation of vector D, vector R, vector D-R, and vector D + R. The boundary value is obtained by finding the average of the total relationship matrix. In this study, the value of the threshold value is 0.1668. Figure 4 shows hierarchy model of auto-ID technology decision making.

![Hierarchy model of Auto-ID technology decision making](image)

In the DEMATEL calculation is only done to see the pairwise comparisons on sub-criteria only. But by knowing the relationship between the sub-criteria later it will also be known the relationship between the criteria because in the criteria there are sub-criteria which then there are alternatives as well as the decision of this study. So, all three can be described in an ANP network model.
Table 3. Sub-criteria weights.

| Name                | Normalized by cluster | Limiting |
|---------------------|-----------------------|----------|
| Economic            | 0.0975                | 0.0325   |
| Effort              | 0.0953                | 0.0318   |
| Functionality       | 0.2346                | 0.0783   |
| Satisfaction        | 0.4006                | 0.1337   |
| Time                | 0.1719                | 0.0574   |
| Human Resource      | 0.1112                | 0.0120   |
| Infrastructure      | 0.3267                | 0.0351   |
| Maintenances        | 0.0921                | 0.0099   |
| Service             | 0.4037                | 0.0434   |
| Switching           | 0.0662                | 0.0071   |
| Cost Saving         | 0.3246                | 0.1607   |
| Expansion           | 0.2943                | 0.1458   |
| Image               | 0.1127                | 0.0558   |
| Innovation          | 0.1564                | 0.0775   |
| Optimization of IT  | 0.1120                | 0.0555   |
| Data Access & Integrity | 0.2039            | 0.0130   |
| Internet Latency    | 0.0400                | 0.0025   |
| Lack of Control     | 0.0514                | 0.0033   |
| Permanence          | 0.0225                | 0.0014   |
| Security            | 0.6791                | 0.0432   |
| Vendor Lock in      | 0.0031                | 0.0002   |

Table 3 shows the local weights of the sub-criteria found in the Normalized by Cluster column. While the global weights between the criteria and sub-criteria are shown in the Limiting column. Then to get the local weight from the criteria, the weight in the Limiting column is divided by the weight in the Normalized by Cluster column. From the results of the division, the calculation of the average for each grouping is then carried out to get the local criteria weights. Local weight criteria can be seen in Table 4.

Table 4. Criteria weights.

| Name    | Weights |
|---------|---------|
| Benefit | 0.3337  |
| Opportunity | 0.4952  |
| Cost    | 0.1075  |
| Risk    | 0.0636  |

At this stage, the sub-criteria network model calculation is calculated after obtaining the criteria and sub-criteria local weights. Alternative pair comparisons are obtained through network diagrams between sub-criteria. Furthermore, the calculation of the sub-criteria network model is done by filling out a pairwise comparison questionnaire on node elements with the aim of comparing all related alternatives. The pairwise comparison results generated local weights in all alternatives shown in Table 5.
4. Conclusion

Research on the Auto-ID adoption decision model in the banking industry has several conclusions. First, in the process of adopting Auto-ID technology in the banking industry, there are several criteria that can serve as benchmarks in determining decisions. There is 1 sub-criterion which is rejected, that is agility and 1 suggested sub-criterion, image. There are 14 cause sub-criteria (permanence, optimization of IT, & functionality) and 7 sub-criteria due (human resource, image, service). Second, from the comparison of the criteria that have been obtained the relationship between the criteria using the DEMATEL method obtained ANP network relationship that has an inner dependency and outer dependency relationship on each criterion. Then from each comparison of the criteria of the ANP network model that has been made it is known that a reasonable decision taken in adopting technology at the bank is to use RFID technology. This is based on the 3 criteria of benefit, opportunity, and risk being the criteria that affect RFID alternatives as viable alternatives for adoption. For future research, it is better to use more experts who can represent answers from several banking industries in Indonesia. Furthermore, the authors hope this research can be developed into a study to make a decision analysis in the adoption of technology in the banking industry in Indonesia, with the criteria and sub-criteria derived according to this research.

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