Human error assessment in batik enterprises located in North Sumatera using HEART method

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Abstract. Industry of batik has been growing since The United Nations Educational, Scientific and Cultural Organization (UNESCO) established the Indonesian batik as a world cultural heritage on October 2, 2009. Batik’s business began to develop in Java and extended to Sumatra, especially North Sumatra. North Sumatra’s Batik comes with a variety of distinctive ethnic motifs which appear attractive with ornamental motifs from various tribes in Sumatera Utara. In order to improve that industrial excellence, North Sumatra batik SMEs are required to further improve the performance, one of them through the supply chain management which are owned. The role of humans in the supply chain of the batik industry tends to be dominant, due to their role as producers, workers, and consumers. Errors caused by humans that have been found in the North Sumatra’s batik industry, such as design or color mistakes that are not in accordance with the wishes of the customer. This study aims to identify human error in the supply chain of North Sumatra batik SMEs in Medan City by adopting the Supply Chain Operations Reference (SCOR) model, namely plan, source, make, deliver, and return. The data processing was conducted by HEART (Human Error Assessment and Reduction Technique) method. The contribution of this paper is to demonstrate the use of HEART method to analyze human error in North Sumatera’s batik industry. The results of the study showed that the highest human error probability is in the process of batik motif design, cutting fabric, dyeing motif, dyeing cloth, and release wax from cloth.

1. Introduction

In facing the digital era, the Ministry of Industry has drawn up an Industry 4.0 roadmap by establishing five manufacturing sectors that will become a pilot and priority in its development, namely the food and beverages, textiles and clothing, automotive, electronics and chemical industries (press release by the Head of Research Agency and Industrial Development on March 22, 2018) [1]. Batik industry is one of the sub-sectors of the textile and apparel that have a rapid development.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) established Indonesian batik as a world cultural heritage on October 2, 2009, and that date was set as a day of batik by government. The Batik’s business is growing, it makes Indonesia has had many kinds of batik. North Sumatra’s Batik comes with a variety of distinctive ethnic motifs which appear attractive with ornamental motifs from various tribes in Sumatera Utara, such as ornaments Batak Toba, Mandailing, Tapanuli Tengah, Simalungun, Pakpak, Dairi, Karo, Melayu Deli and Nias [2].

In the framework of regional economic development aimed at improving the welfare of the community, the local economic development according to its potential is one of the important key. With the advantages possessed, the role of SMEs becomes very important to realize it [3]. Supply chain management is one way to improve excellence and performance of SMEs.

Supply chain is a network of companies that jointly work to create and deliver a product into the end users [4]. Based on the definition of the supply chain, the success of economic development
through SMEs products based on local culture is determined by the performance of each of the parties involved, including the workers in it.

SMEs based Local culture as one of the sectors in the creative industries need the creativity and skills of workers, so that the human role is quite dominant. In the creative industries, workforce skills strongly influence the quality of the products which produced, due to the potential for human error [5]. Human error is a deviation from a predetermined performance standard that causing delays due to difficulties, problems, incidents, and failures. Human error is a mistake at work caused by a mismatch of achievement with what is expected [6].

Activities that take place in the supply chain has the potential to experience the impact of human error [5]. Research on supply chain management of wood from forest products has risks related to human error so that the risk management is carried out by developing a model of human error improvement in the wood warehouse area so that the possibility of human error can be anticipated [7].

An organization that is concerned with the development of the supply chain in the world is Supply Chain Council (SCC), has developed a model for measuring the performance of supply chain operations, called the SCOR (Supply Chain Operations Reference) model. The performance appraisal process is based on certain stages of classification. This model has been recognized able to conduct performance assessment process based industry supply chain [8]. Adoption of operation classification in the SCOR model can be used as a basic guide to identify human errors in various supply chains [5]. Human Error Assessment and Reduction Technique (HEART) is one of the quantification techniques in calculating the probability of human error based on assessment of data and work performance influencing factors or called error producing conditions. The analyst select a set of supplied error producing conditions that are relevant to the task which assessed [9].

In this research, human error identification in the supply chain of the North Sumatra’s batik industry was carried out by adopting the SCOR model and human error analysis using the HEART method, so that the most frequent human error in the supply chain can be obtained.

2. Method
This research was conducted as a job and activity analysis, that’s is a descriptive study aimed at investigating in detail the activities and jobs of a person or group of people in order to get recommendations for various purposes such as getting a balance of workload between employees, determining wage standards, work performance standards and others.

This research was conducted in 4 SMEs which produce North Sumatra’s batik in Medan City. The object observed was the activity in the supply chain of North Sumatra batik SMEs, especially in the production section. Data which collected and used in this study is data of human error in batik SMEs with the adoption of the model SCOR (Supply Chain Operations Reference) that plan, source, make, deliver, and return. The steps of data processing using the HEART method, namely:
1. Identified all types of work to be done by the worker.
2. Categorized each work item to one of the eight categories in the Generic Task Type (GTT) table.
3. Identified Error Producing Conditions (EPCs) in accordance with the conditions that exist in the table HEART EPCs.
4. Determine the Assessed Proportion of Effect (APOE) and calculates the value of Assessed Effect (AE) of each of EPCs has been identified using this formula:
   \[ AE = ((\text{Maximum Value Effect} - 1) \times \text{ApoE} ) + 1 \] (1)
5. Calculated the total value of AE.
   \[ \text{Total AE} = \text{AE1} \times \text{AE2} \times \text{AE3} \times \ldots \times \text{AEn} \] (2)
6. Calculated the value of Human Error Probability (HEP) using this equation: [10]
   \[ \text{HEP} = \text{Nominal Human Unrealibility} \times \text{Total AE} \] (3)

3. Result and discussions
In North Sumatra Batik small medium enterprise, a questionnaire was given to obtain strengths, weaknesses, opportunities and threats, as shown in Figure 1.
Figure 1. Strengths, weaknesses, opportunities, and threats factors of Batik enterprises in North Sumatra.

From the figure above can be seen each strengths, weaknesses, opportunities, and threats in the SMEs of North Sumatra’s batik, where the human factor is one of the weakness of the business. Identification of human error using the adoption of the SCOR model can assist in the determination of a series of supply chain planning (plan), procurement of raw materials (source), the production process (make), shipping (deliver) and batik returns (returns). The results of human error identification in the supply chain of North Sumatra’s batik SMEs can be seen in Table 1.

Table 1. Identification of activities in North Sumatera Batik supply chain.

| No. | Model SCOR | Code | Job description | Number of Errors |
|-----|------------|------|-----------------|------------------|
| 1   | Plan       | 1.1. | Batik motif design | 3                |
|     |            | 1.2. | Production planning |                |
|     |            | 1.3. | Storage Capacity Planning |         |
| 2   | Source     | 1.1. | Financial |                |
|     |            | 1.2. | Ordering raw materials from suppliers | 4 |
|     |            | 1.3. | Receiving raw materials from suppliers |         |
|     |            | 1.4. | Storage of raw materials |              |
| 3   | Make       | 1.1. | Fabric cutting |                |
|     |            | 1.2. | Fabrics tasting |                |
|     |            | 1.3. | Dyeing motifs |                |
|     |            | 1.4. | Fabric Dyeing |                |
|     |            | 1.5. | Release wax from the cloth | 7 |
|     |            | 1.6. | Drying |                |
|     |            | 1.7. | Packaging Batik |              |
| 4   | Deliver    | 1.1. | Checking order’s invoices | 4 |
|     |            | 1.2. | Checking consumer address |         |
|     |            | 1.3. | Selection of shipping courier |         |
|     |            | 1.4. | Payment transactions |              |
| 5   | Return     | 1.1. | Checking return agreement | 3 |
|     |            | 1.2. | Determination of product return time |         |
|     |            | 1.3. | Confirmation of product repairment |         |
|     |            |      | Number of Errors | 21 |

Number of Errors
The results of identification of human error in the supply chain as shown in Table 1, North Sumatra batik SMEs already have a systematic record that contains a job description as documentation that was not previously owned. The human error identification model resulting from the adoption process of the SCOR model also provides convenience in identifying the types of errors based on the classification of operations in the supply chain. The HEA method is a method used to obtain the value of human error probability (HEP) for each activity in the supply chain of North Sumatra’s batik SMEs. After obtaining a job description in Table 1, then each job description is categorized by Generic Task Type (GTT) as in Table 2.

Table 2. General task type and nominal value of human unreliability.

| Code | GTT / Nominal Human Unrealibility |
|------|----------------------------------|
|      | Plan | Source | Make | Deliver | Return |
| 1.1. | C / 0.16 | D / 0.09 | C / 0.16 | E / 0.02 | E / 0.02 |
| 1.2. | D / 0.09 | E / 0.02 | D / 0.09 | E / 0.02 | D / 0.09 |
| 1.3. | E / 0.02 | E / 0.02 | C / 0.16 | D / 0.09 | E / 0.02 |
| 1.4. | - | E / 0.02 | C / 0.16 | E / 0.02 | - |
| 1.5. | - | - | C / 0.16 | - | - |
| 1.6. | - | - | E / 0.02 | - | - |
| 1.7. | - | - | E / 0.02 | - | - |

The table above categorizes each activity into Generic Task Type (GTT) respectively, such as sample activity codes 1.1. namely batik motif design included into category C with a nominal human unreliability of 0.16, which is category C is a complex job that requires a high level of ability and attention. The next step, based on observations and direct interviews, can be described EPCs that affect the work failure rate of workers in the North Sumatra’s batik SMEs supply chain, then an Assessed Proportion of Effect (APoE) is assessed to obtain the Assessed Effect (AE) value. Then next step is calculated the total value of AE by using the equation (2).

Table 3. The assessed proportion of effect (APoE) and calculation of AE in supply chain of North Sumatra’s Batik SME.

| SCOR Model | Category | Error Producing Condition | Maximum Value Effect | APoE | AE | Total AE |
|------------|----------|---------------------------|----------------------|------|----|---------|
| Plan       | 1        | 5                         | 8.00                 | 0.30 | 3.10 | 5.43    |
|            | 2        | 19                        | 2.50                 | 0.50 | 1.75 |         |
| Source     | 1        | 10                        | 5.50                 | 0.50 | 3.25 | 6.66    |
|            | 2        | 19                        | 2.50                 | 0.70 | 2.05 |         |
| Make       | 1        | 17                        | 3.00                 | 0.40 | 1.80 |         |
|            | 2        | 5                         | 8.00                 | 0.30 | 3.10 | 6.03    |
| Deliver    | 1        | 16                        | 3.00                 | 0.70 | 2.40 | 3.84    |
|            | 2        | 19                        | 2.50                 | 0.40 | 1.60 |         |
| Return     | 1        | 16                        | 3.00                 | 0.40 | 1.80 | 2.88    |
|            | 2        | 19                        | 2.5                  | 0.4  | 1.6  |         |
The Assessed Proportion of Effect (APoE), the value of Assessed Effect (AE) of each EPCs, and the total value of AE that have been identified can be seen in Table 3. Human Error Probability (HEP) values is calculated by using the equation (3), so that the value of Human Error Probability can be seen in Table 4.

### Table 4. Calculation of the value of human error probability (HEP).

| Code | Plan | Source | Make | Deliver | Return |
|------|------|--------|------|---------|--------|
| 1.1. | 0.868 | 0.600  | 0.964| 0.077   | 0.058  |
| 1.2. | 0.488 | 0.133  | 0.542| 0.077   | 0.259  |
| 1.3. | 0.109 | 0.133  | 0.964| 0.346   | 0.058  |
| 1.4. | 0.133 | 0.964  |      | 0.077   |        |
| 1.5. |      | 0.964  |      |         |        |
| 1.6. |      | 0.121  |      |         |        |
| 1.7. |      | 0.121  |      |         |        |

In the calculation of probability using the HEART method, the biggest error obtained is in the make process, namely cutting fabric, dyeing motif, dyeing cloth, and release wax from cloth and batik motif design from plan process. By knowing the highest error, the SMEs of North Sumatra’s Batik can anticipate errors so that they can reduce errors in the future.

### 4. Conclusion and future research

The conclusions of the research are:

1. Identification of human error in the supply chain of North Sumatra’s batik SMEs with the adoption of the SCOR model resulted 21 types of errors, where in the process plan there are 3 types of errors, in the source process there are 4 types of errors, in make process there are 7 types of errors, in deliver there are 4 errors and in deliver return there are 3 errors.

2. Based on the results of research using HEART method, obtained by Human Error Probability (HEP) is highest in the process of batik motif design with value 0.868 and process of cutting fabric, dyeing motif, dyeing cloth, and release wax from cloth, with a value of 0.964.

3. The focus of this research just on the North Sumatra’s Batik SMEs, while the success of the batik supply chain is influenced by suppliers and distribution activities, so the recommendation for the further research is to involve all stakeholder in the supply chain of batik industry.

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