Discrete-event system simulation on small and medium enterprises productivity improvement

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Abstract. Small and medium industries in Indonesia is currently developing. The problem faced by SMEs is the difficulty of meeting growing demand coming into the company. Therefore, SME need an analysis and evaluation on its production process in order to meet all orders. The purpose of this research is to increase the productivity of SMEs production floor by applying discrete-event system simulation. This method preferred because it can solve complex problems die to the dynamic and stochastic nature of the system. To increase the credibility of the simulation, model validated by cooperating the average of two trials, two trials of variance and chi square test. Afterwards, Benferroni method applied to development several alternatives. The article concludes that, the productivity of SMEs production floor increased up to 50% by adding the capacity of dyeing and drying machines.

Keywords: productivity improvement, SME, discrete-event system simulation

1. Introduction

The economic and trade openness resulted created challenges and opportunities among countries. Open trade between one country and another extend market access of domestic products in the international market as well as challenges to the competitiveness of the domestic industry not to mention small and medium enterprises (SME). SME is define as a company that has maximum asset of 10 billion IDR, not more than 50 billion IDR revenue, and employed less than 100 workers [1]. Based on data from the ministry of cooperatives and small and medium enterprises in mind that over the years the number of small and medium enterprises always increases, in the year 2013 there were 57,895,721 units of small and medium enterprises in Indonesia [2]. In order to compete, SME should improve the quality and service available. These are the obstacles often faced by small and medium enterprises, (a) poor system used, and (b) the lack of service. Other issues faced by SME include trade liberalization, such as the ASEAN-China Free Trade Area (ACFTA). On the other hand, Indonesian Government has agreed on an ACFTA cooperation agreement or other agreement, without considering the readiness of SMEs to compete [1]. Successful SME is the one who have the ability to utilize its available resource, and leverage the low economic value (including waste) to higher economic value commodities [3].

This article analyzes the production system improvements in on one of the SMEs engaged in craft bag in Yogyakarta as a case study. SME marketing program's success in taking chances causes increased production target to 1,200 units of bags for 20 working days. With the existing conditions, the target is difficult to achieve by the company. As an attempt of meeting the target,
the company practice overtime. By doing so, the company reach the target. Nonetheless, it had to incur additional costs, which reduce its profit.

2. Methodology

Efforts to increase productivity on the production floor already investigate by some previous researchers. Productivity achieved by using a goal programming production planning in order to meet market demand. Goal programming method production companies can minimize costs while maximizing the available resources [4]. Another attempt to increase the productivity of SME’s production floor exhibit by applying nonlinear optimization on its supply chain planning. However, the nonlinear optimization method has several disadvantage. One of them is it requires quite a lot of scenarios that result in the longer computing time [5]. In addition, productivity improved by increasing the quantity and quality of the product. Interviews and direct observations produced some recommendations, namely: (1) the supply of electricity fabric cutting machines (2) procurement cutting tablemat, and (3) procurement walking foot machine. The recommendations implemented by companies with good results [6]. However, this method has a risk of failure if applied directly in the real system. Other efforts made through the analysis of customer fulfillment management using system dynamics modeling. From this analysis, we found the factors that influence the production process of SMEs. Thus, a series of improvements made to increase productivity [7]. Another method to improve SME’s productivity is discrete-event system simulation. Simulation is capable to solve the problems occur in companies productivity through schedule planning. With discrete systems, modelers can specify standard time subsequent impact on the productivity of the production floor 6. The previous studies have produced findings that are beneficial for the company. Nevertheless, discrete-event system simulations carried out previously intended to test the results of a specific method of analysis. This article applies discrete-event system simulation with the aim of seeking alternative and determine the best alternative in the face of complex system problems.

Discrete-event system simulation is widely used in manufacturing industry, business, logistics and supply chain management. Simulation applied because the problem cannot solved by the complex dynamic equations of analytical methods [8]. It is powerful to solve problems in a complex system, which incorporated numbers of interrelated variables [9–12]. It is suitable for capturing the potential improvement regarding wide area of logistics by cooperating the analysis of complex and stochastic process [10,13]. Modeler can use simulation to review alternatives in process design, scheduling, resource allocation, and management change [14]. Other use of simulation is to assess the effects on productivity of a supply chain [15].

The execution steps of discrete-event system simulation are vary. A study in input modeling consider it involve eight level of reiterative steps. They are identify problem, state objectives, collect/prepare data, formulate model, modify/refine model, verify/validate model, experiment/interpret results, and conclude/implement [16]. The framework to conduct discrete-event system simulations developed to serve its unique purpose. Nonetheless, they share major similarities [9,17,18]. This article runs a resembling framework as shown in Figure 1.

In order to build a robust and credible model, they should verified. Verification is the step to make sure that the program is actually works. In addition, model should validated. It means to make sure that the model is a representation of the real system. Thus, modeler could run one or more experiment toward it [9]. Validation also means to compare both model and actual system, and then improve the model credibility based on its gap. This activity is iterative until the
modeler consider it accurate enough [19]. This paper used mean test and Chi-square goodness of fit test for validation. Once a robust model developed, alternatives designed by applying what-if analysis. Afterwards, alternatives analyzed in order to determine which one is the best to implement. The methods to perform such task is Bonferroni test. It is useful in model alternative design runs with both independent sampling or with common random numbers. The Bonferroni approach recommended only when the research have a small number of comparisons. The practical upper limit is 20 comparison [17].

![Figure 1. Discrete-event system simulation steps](image)

### 3. Discussion

Flexsim is cooperated to build the model and after the necessary runs, it provide a rigorous report. An evaluation made accordingly. The data collected from 30 workday's observation. In order to build the model the following data are required. Total output, which is the overall units produced in each day. In this case, the outputs average is 44.83 units per day as shown in Table 1. Processing time, it is the amount of time needed to process a single work in every process. There are five processing times recorded, they are layer sewing, zipper sewing, accessories sewing, handle sewing, and cutting. Location capacity include warehouse capacity1,000 unit, cutting capacity 25 unit/roll, coloring capacity 15 unit/batch, machine capacity 1 unit. Arrival events, the arrival in this research are fabrics, work in process, zipper, handle, and accessories. Those entities arrive once in every day. The fabric arrival are 20 units per day. Work in process, zipper, and accessories are each arrive in 100 unit per day. As for handle, it arrive in 150 unit per day. Resources, the resource in this model are two operators assigned to inspect finished goods prior to store in warehouse.

Every input analysis required to establish probability distribution. This research use Expert Fit to complete the task. The model constructed, consist of three source, nine queue, three processor, eight combiner, one separator, and two operator. Modeling in Flexsim start with defining the source. There is only one arrival in fabric arrival and work in process. Therefore, arrival sequence was chose in arrival style. Nine queues made to hold entities from source. This SME has warehouse to storage fabric, work in process, accessories, and finish goods. All storage that has queue can hold up to 1,000 units. Three machines in the production line modeled using processor, one coloring and two sewing machine with the processing time johnsonbounded probability distribution. Eight machines modeled using combiner because it involve join activity. The processing time in these machines, follow inversegaussian probability distribution. The cutting process is executed bay one machine. It is modeled using separator
because from one roll of fabrics can be divided in twenty-five units of materials. The process time follow johnsonbouned probability distribution. The workhour in this company is 7.5 hours. To model the workhour, timetable is used.

### Table 1. Real system and simulation output in units

|                  | Real system | Simulation result |
|------------------|-------------|------------------|
| Mean             | 44.83       | 43.5             |
| SD (v)           | 3.69        | 1.04             |
| n                | 30          | 30               |

Series of output validation test performed to ensure that the model represents the real system. Based on those test, the simulation model constructed has the same behavior of the real system. The tests are:

- **Mean test.** This research use level of significance 0.05. Since \(-Z_{0.025} < Z < Z_{0.025}\) which is \(-1.96 < 1.90 < 1.96\), therefore Ho is accepted. It means that statistically the real system’s mean is not different with the simulation’s mean.

- **Chi-square goodness of fit test.** This test determines if a sample data matches a population. The results shows that the calculated chi-square value (5.76) is less than the critical value from a chi-square table (42.55). Thus, the simulation distribution fits the real system’s distribution.

Analysis and evaluation in article this is based on the summary report and the state of model the simulation for one working day (27,000 seconds). The simulation report shows high value of idle at the body sewing machine number one (59%) and two (50%), as well as in mounting accessories station number one (60%) and two (49%). Both machines placed after the handle sewing machine because it waits the entities from staining and drying machines. The condition worse by the 83% block on the mantle sewing machine number one and two. It means, the process could not continue to staining machine. In addition, the processing percentage on staining machine is already quite high (85.71%). Therefore, the problems occur on floor shop, is inefficiency due to long-range of process time in coloring and drying machines.

Developing alternatives are essential to address the problem. This article proposed two alternatives. Figure 2 and figure 3 shows the comparison of those alternatives.

- **First, increase the capacity of dyeing and drying machines.** This scenario proposed because dyeing and drying machines are critical for the overall manufacturing times due to their long process time. By doing so, sewing machine idle dropped to 35% - 55% and 31% - 49%. In addition, the total output generated is increasing to 49-50 units per day.

- **Increase the capacity on the coloring and drying machine whilst reducing the number of sewing machine.** This scenario proposed as a reaction to the first scenario. Even though decreased, the idle still considered high. This scenario managed to reduce idle time and increase the output value of the company up to 50% of the initial conditions.
In order to determine which alternative is the most suitable, Bonferroni test is perform. Scenario 1 is the existing model, scenario 2 is the first alternative, and scenario 3 is the second alternative. Bonferroni test shows that scenario 1 is inferior to scenario 2 nor scenario 3. Nonetheless, scenario 2 and 3 are not significantly different. The most suitable alternative is scenario 2. The reason is, adding capacity means buying new equipment.

4. Conclusion
Based on the results, discrete-system system simulation method is suitable to increase SME’s productivity. Therefore it satisfy SME’s consumer demand. The chosen alternative is adding capacity on staining and drying machines. Therefore, the staining machine can work more quickly. Parallel to that, SME can reduce the number of sewing machine due to its high idle time. It can lead to high maintenance costs, which will be a burden to the company if the output generated from the engine is quite low.

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