Material Supply Model with the Perspective of Capacity Planning and Material Limitations to Minimize the Risk of Production Uncertainty in SMEs Tanggulangin Sidoarjo

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DOI: https://doi.org/10.31284/j.jtm.2026.v7i2.9247
Received July 13th 2025; Received in revised July 15th 2026; Accepted July 28th 2026; Available online July 29th 2026

Abstract

SMEs are a very important pillar of the Indonesian economy, because apart from being able to produce various types of community needs and being a contributor to regional income, they are also able to absorb non-formal workers with low education. In Sidoarjo Regency, East Java, there is an SME cluster area in Tanggulangin village with a total of 328 SMEs with 18,464 workers. This UKM produces various types of handmade crafts which are in great demand by local, non-provincial and overseas consumers. This research is very important for SMEs in Tanggulangin because with the existence of a material supply model that takes into account the perspective of capacity planning and material limitations, it will really help SMEs to purchase materials effectively and efficiently in order to meet consumer demand according to the number of orders so that the profits obtained by SMEs are optimal. The MRP method is used for material requirements planning, RCCP for rough-cut capacity validation, CCR for bottleneck identification, TOC for bottleneck optimization, and Monte Carlo for risk analysis. The integration of Monte Carlo, RCCP, TOC, CCR, and MRP results in a capacity planning system that is structured (spanning from planning to risk evaluation), constraint-based (avoiding over-optimism), and adaptive to uncertainty. Monte Carlo simulation models the operation of two machines handled by a single operator with an optimal operating time of 5 hours; RCCP indicates an optimal production process of one batch with a 45 kg capacity; and the ideal TOC value falls within a range where process transitions must occur between a minimum of 3 minutes and a maximum of 45 minutes. In the work element of cutting rolls of tanned leather into patterned leather pieces one by one at the leather craft product work center 1, the capacity requirements cannot be met using only 2 work shifts. To anticipate capacity shortages that will occur throughout 2024, this can be done by adding overtime hours, extra days, MRP revisions, and MRP revisions with overtime. If proposed strategy 1 (additional overtime hours) is implemented, it would cost IDR 153,266,618 in one year. And if proposed strategy 2 (extra day) is implemented, it will cost IDR 219,513,728 in one year. The third proposed strategy, namely MRP revision, requires no costs at all to implement. The costs incurred if strategy 4 (MRP revision with over time) is implemented is IDR 145,687,500 in one year.

Keywords: *Capacity, Constraint, Materials, Requirement, Strategy*

1. Introduction

Competition between companies engaged in manufacturing in Indonesia, especially for the SME industry, is increasingly high, one example of a business that is currently developing is SMEs engaged in the leather craft business [1]. This is because leather craft products such as belts, shoes, wallets, bags, hats, jackets and so on are daily fashion necessities. This leather craft product is a product made with good tanning quality with a soft surface so it is comfortable when used. Apart from that, the models produced are the latest models with neat stitching and affordable prices [2]- [3]. The products produced by UKM Tanggulangin, even though they are located in Sidoarjo, already have marketing areas outside the city such as in various other cities in East Java, outside Java such as Sumatra, Kalimantan, Sulawesi and so on, even markets abroad such as Malaysia, Brunei Darussalam, Japan, South Korea, Singapore, Thailand and so on. Products from UKM Tanggulangin are known as exotic leather craft. The Tanggulangn Sidoarjo UKM Cluster was founded in 1984 but became known to consumers in 1987 with increasing demand.

The increase in demand for leather craft products is starting to be felt by craftsmen in UKM Tanggulangn with an increase in orders because the basis of their business at that time is make to order where leather craft products are produced according to consumer orders even though there are several products on display or models proposed by consumers via picture taken [4]. Based on observations, UKM Tanggulangin has achieved a production target of 49,500,000 pcs per month, but this has not yet been realized due to several factors, one of which is that the large production target is not balanced with the increase in the amount of capacity available to carry out the production process. The available capacity at UKM Tanggulangin in the period January to December 2013 was 46,000,000 pcs.

The problem that occurs is that in the 2023 period, UKM Tanggulangin experiences an inability to meet consumer demand for leather craft products [5]- [6]. This inability is due to the actual production of leather craft products not being in line with consumer demand. This discrepancy is caused by fluctuations in demand which tends to increase while the capacity of machines or production equipment owned by UKM Tanggulangn is limited so that UKM is unable to provide leather craft products that meet consumer demand [7]. The shortage in the number of leather craft products has an impact on delays in order delivery, which will result in the risk of SMEs being penalized if orders for leather craft products are not delivered in accordance with the purchase agreement [8]- [9].

This problem can be solved by calculating current capacity and carrying out capacity planning to meet demand [10]. In this research, working time was measured directly using the stopwatch time study measurement method to determine the processing time of each work element in the form of standard time in the production process of leather craft products [11]- [12]. Capacity Requirement Planning (CRP) functions to determine, measure and adjust capacity limits. CRP is a process of measuring the number of workers and machines needed to complete production needs [13]- [14]. Using the CRP table can help work center parts that need to be made improvements in meeting production capacity [15]. The existence of this method can help in analyzing and providing solutions in solving production constraints in the research object, so that the current production capacity can be in line with purchasing demand [16]- [17].

2. Methods

The implementation of this research uses research that focuses on solving actual problems when the research is carried out by searching and collecting data to obtain clear facts related to various conditions and situations that exist within the company.

2.1 Data Collecting

The method used to collect data in this section consists of:

a. Interviews
   Interviews involve asking questions directly when the company is holding an activity or during working hours. In this research, interviews were conducted with workers at the leather craft product production work station and employees in the production section
b. Observation
   Observation, namely by making direct observations at the work station of the leather craft product production process regarding the actual situation by measuring time

2.2 Data Processing

a. Determine the standard time for the production process of leather craft products
   In determining standard time, use the normality test, test data uniformity and data adequacy, determine process time by adjusting performance rating values, adding work allowance values, determining normal time, and determining standard time or standard time.
b. Calculation of available capacity every year (seconds) of the leather craft product production process
   After knowing the standard time for the work elements of the leather craft product production process, proceed with calculating the available capacity. The results of the standard time calculation are used to determine the available capacity in seconds per year of the leather craft product production process. Apart from that, the second capacity per year can also show the available capacity if done with 1 shift, 2 shifts and overtime hours.
c. Calculation of capacity requirements using the Capacity Requirements Planning (CRP) method

Standard time in this research is also used as a reference for calculating the capacity requirements for the production process of leather craft products. The products used to calculate capacity requirements are leather craft products. Capacity calculations are carried out using the Capacity Requirements Planning (CRP) method. The calculation results of this method are used to determine the total production capacity requirements for the production process of leather craft products according to demand in 2024, Data from 2024 is used because the research was conducted in 2024, and the company owner granted permission to conduct the study during that year. Before calculating the CRP value, the Rough Cut Capacity Planning (RCCP) value must first be determined by comparing capacity requirements with available capacity. This step is taken to ensure the production plan is realistic, avoid capacity overloads, and identify bottlenecks at an early stage.

3. Results and Discussion

3.1 Data collection

Based on the results of observations and interviews with UKM Tanggulangin, it is known that the production process in each shift runs for 7 hours with a break of 30 minutes. In Table 1. is data on the production target for UKM Tanggulangin leather craft products in the period January to December 2024.

Table 1. Planned Order Release for UKM Tanggulangin Leather Craft Products in the 2024 Period

Month	Demand (pcs)
Januari	49,186,780
Februari	48,797,620
Maret	50,415,670
April	50,813,650
Mei	50,245,890
Juni	49,700,440
Juli	50,450,760
Agustus	50,817,060
September	49,549,970
Oktober	48,736,270
November	49,940,840
Desember	50,901,210

SMEs Tanggulangin plans and carries out the production process based on demand data from consumers so that there are no delays in manufacturing and delivery. The unit for order quantity is pcs. In Material Requirement Planning you can see when the production process starts and ends as scheduled. By preparing the Material Requirement Planning, it is hoped that the production process can run according to schedule and there will be no delays in delivery. Planned order release also functions as an indicator of the due date of the leather craft product production process.

3.2 Data Processing

1. Capacity Requirements Planning (CRP) Method

The calculation of the required capacity is obtained from multiplying the planned order release for leather craft products on that working day with the processing time for each work element that has been prepared. The following are the results of calculating the capacity required for the production process of leather craft products on the 1st to 10th working days of January.

Table 2. Results of capacity calculations for January

Work Element	Process Time	Capacity Needed in January (meter)									
		1	2	3	4	5	6	7	8	9	10
Unrolling of skin	10,84	1652676	1652676	1652676	1652676	1652676	1652676	1652676	1652676	1652676	1652676
Installation of chuck on leather roll	10,73	1436254	1436254	1436254	1436254	1436254	1436254	1436254	1436254	1436254	1436254
Laying rolled	10,74	1455929	1455929	1455929	1455929	1455929	1455929	1455929	1455929	1455929	1455929

Work Element	Process Time	Capacity Needed in January (meter)									
		1	2	3	4	5	6	7	8	9	10
leather on uncoiled tanned leather											
Formation of leather craft pattern	90,74	1455929	1455929	1455929	1455929	1455929	1455929	1455929	1455929	1455929	1455929
Measuring the size of leather crafts	72,81	1593652	1593652	1593652	1593652	1593652	1593652	1593652	1593652	1593652	1593652
Separation of skins based on skin size	19,21	1000951	1000951	1000951	1000951	1000951	1000951	1000951	1000951	1000951	1000951
Cutting the leather rolls one by one	53,48	367261	367261	367261	367261	367261	367261	367261	367261	367261	367261
Adding color to pieces of leather	33,5	368901	368901	368901	368901	368901	368901	368901	368901	368901	368901
Sewing pieces of leather into a series of leather crafts	142,21	263149	263149	263149	263149	263149	263149	263149	263149	263149	263149

In the leather craft product production process, the capacity shortage is in the leather craft product work center 1 (the work element of cutting packaging rolls into packages one by one). Apart from that, there are also work elements that have a positive value, which means that the capacity available for that work element is greater than the capacity required. Table 2 shows that production capacity is lower than the demand capacity indicated in Table 1. This is because, despite high demand, the number of production machines available at the company is limited to just four units making it impossible to meet demand with a shortfall of at least two units. Additionally, there are shortages or limitations regarding materials.

Capacity calculations using the Capacity Requirements Planning (CRP) method show results where there are still processes in work elements that experience capacity shortages. However, some are still below the available capacity level. There are two factors contributing to this capacity shortage. The first involves a specific workstation experiencing a capacity deficit: Work Center 1, which handles the task of cutting material rolls into individual patterned leather pieces. The primary cause is that the existing two-shift work system—totaling 13 hours of networking time after deducting breaks cannot accommodate the surge in customer demand or order volumes. The second factor is the magnitude of the quantitative capacity deficit observed in January 2024; calculations using the Capacity Requirements Planning (CRP) method indicate a time deficit across all working days that month. Specifically, a capacity deficit of 44,762 seconds occurred between the 1st and 13th working days, while a deficit of 31,686 seconds occurred between the 14th and 25th working days.

In all work centers in the leather craft production process, the work system uses 2 work shifts with each shift having 30 minutes of rest time so that the production process runs for 13 hours. There are several alternative proposals so that the available capacity can meet the required capacity. Determining this strategy is based on implementing the easiest strategy to implement, namely over time, extra days, and equal distribution of workload. Based on a fairly large shortage with a fairly long period of time, the first strategy that can be used is over time followed by an extra day.

2. Proposed Strategy 1 (Over Time)

Strategy 1 to meet the production process capacity of leather craft products in 2023 is to increase overtime hours. Additional overtime hours are carried out after the second shift is finished, starting at 22.00. This is because the available machines are limited, namely 37 which can operate normally. Overtime hours in the leather craft product production process are a maximum of 3 hours per day. Additional overtime hours are applied to work elements that still experience a lack of capacity. Based on the results of interviews with production supervisors.

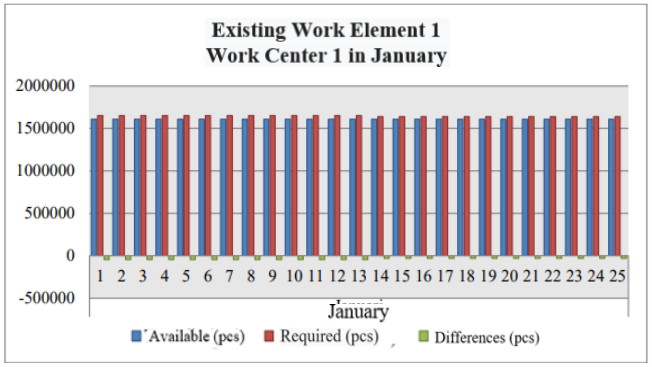

Figure 2. Capacity Comparison before Repair

Before improvements with Strategy 1 there was a capacity shortage for all periods in January. On the 1st working day to the 13th working day there was a capacity shortage of -44762 seconds, while on the 14th working day to the 25th working day there was a capacity shortage of -31686 seconds. This is because in this period there was an increase in the number of requests for leather craft products from consumers.

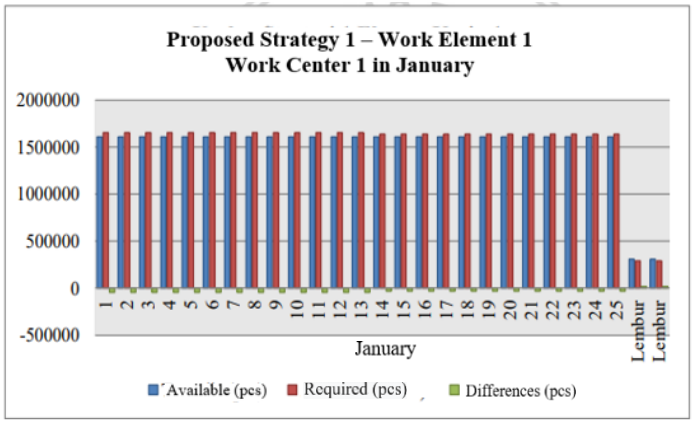

Figure 3. Comparison of Capacity after Repair

In Figure 2. the situation after improvement with strategy 1 did not experience a capacity shortage for all periods in January. After improvements were made using Strategy 1, there was a positive capacity difference, namely 18740 seconds.

3. Proposed Strategy 2 (Extra Day or Additional Working Days)

Proposed Strategy 2 is used as a comparison to meet the production capacity of leather craft products in 2023 by adding working days on Sundays. The additional working days in the leather craft product production process are carried out by 1 work shift in 1 day with a break of 30 minutes. The Sunday used for the extra day is the Sunday that based on the production target should have been scheduled for completion.

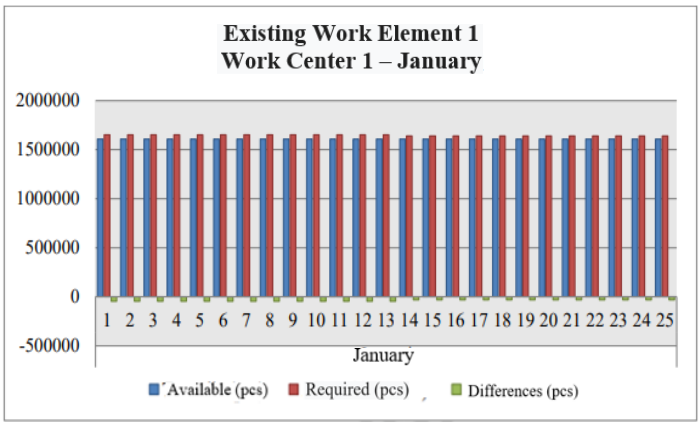

Figure 4. Comparison of Capacity before Improvement with Strategy 2

In Figure 4, it can be seen that the situation before improvements with Proposed Strategy 2 experienced a capacity shortage for all periods in January. On the 2nd working day to the 13th working day there was a capacity shortage of -44762 seconds, while on the 14th working day to the 25th working day there was a capacity shortage of -31686 seconds. This is because in this period there was an increase in the number of requests for leather craft products from consumers.

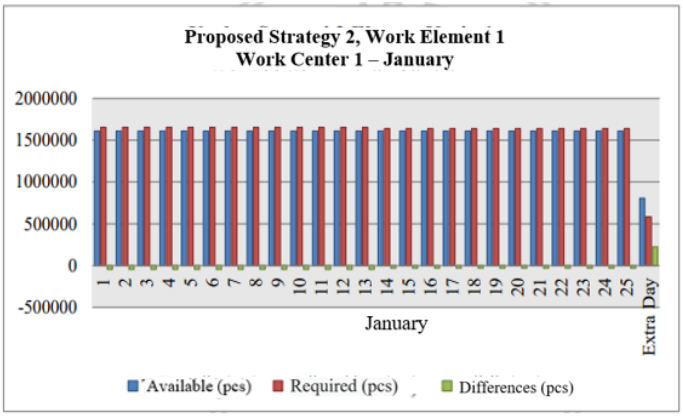

Figure 5. Comparison of Capacity after Improvement with Strategy 2

In Figure 5, it can be seen that the situation after improvements with Strategy 2 did not experience a capacity shortage for the period in January. Capacity shortages in the period from the 1st working day to the 25th working day can be overcome by having an extra day. Extra days are carried out on Sundays in months that experience a capacity shortage with 37 operators whose work schedules alternate.

4. Proposed Strategy 3 (Revised Material Requirements Planning)

Proposed Strategy 3 is to correct the capacity shortage, so that the production load is evenly distributed in each period. This will change the planned release order in Material Requirements Planning (MRP).

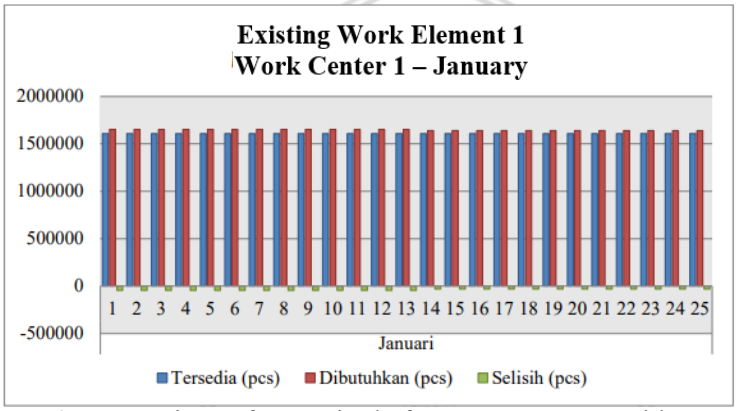

Figure 6. Comparison of Capacity before Improvement with Strategy 3

In Figure 6, it can be seen that the situation before improvements with Strategy 3 experienced a capacity shortage for all periods in January. On the 3rd working day to the 13th working day there was a capacity shortage of -44762 seconds, while on the 14th working day to the 25th working day there was a capacity shortage of -31686 seconds. This is because in this period there was an increase in the number of requests for leather craft products from consumers.

4. Conclussion

A major capacity shortfall occurs at Work Center 1 during the process of cutting material rolls into patterned leather pieces. Under current conditions utilizing a two-shift system (13 effective working hours) time deficits arise in January: -44,762 seconds during workdays 1 through 13, and -31,686 seconds during workdays 14 through 25. Four proposed capacity management strategies were evaluated. Proposal 1 (overtime) adding up to three hours of overtime daily after the second shift successfully covered the deficit (resulting in a capacity surplus of +18,740 seconds) at an estimated annual cost of Rp 153,266,618. Proposal 2 (extra day) adding a Sunday workday (one shift) successfully resolved the capacity shortage at an estimated annual cost of Rp 219,513,728. Proposal 3 (MRP revision and load leveling) involved rescheduling order releases within the MRP to ensure an even distribution of workload across periods; this strategy successfully resolved the deficit at no additional cost (Rp 0). Meanwhile, Proposal 4 (MRP revision with overtime) a combination of MRP schedule leveling and a small amount of overtime incurred an annual cost of Rp 145,687,500. The most efficient and economical solution for the Tanggulangin SME is the implementation of Strategy 3 (MRP Revision), as it eliminates the capacity shortage without incurring additional operational costs.

A limitation of this study is that the in-depth analysis focused solely on Work Center 1, while the sewing and final assembly stations were not comprehensively addressed in the production line balancing chart. Therefore, the researcher proposes further study involving the practical implementation of Monte Carlo simulation to model consumer demand uncertainty and real-world process time variability stochastically, rather than relying on linear assumptions. A second proposal involves using the Theory of Constraints (TOC) approach to identify Capacity Constraint Resources (CCR) more systematically and implementing the Drum-Buffer-Rope mechanism to control raw material flow and prevent the accumulation of Work-in-Process (WIP) inventory. A third proposal suggests comparing overtime or extra-day strategies against a capital budgeting analysis—such as purchasing a new leather-cutting machine—to determine whether acquiring long-term assets is more cost-effective than incurring ongoing overtime expenses. Additionally, workload balancing across stations (from Work Center 1 through the sewing and finishing stages) should be performed to prevent the emergence of new bottlenecks at subsequent stations following improvements to Work Center 1.

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How to cite this article:
Prabowo R, Vangesti W. Material Supply Model with the Perspective of Capacity Planning and Material Limitations to Minimize the Risk of Production Uncertainty in SMEs Tanggulangin Sidoarjo. *Jurnal Teknologi dan Manajemen*. 2026 July; 7(2): 176-184. DOI: 10.31284/j.jtm.2026.v7i2.9247