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Barriers to Lean Manufacturing Implementation in the Bakery Industry: An Empirical Study from Indonesia

Caroline Felicita Aurelius, Saiful Mangngenre*, Irwan Setiawan

Department of Industrial Engineering, Hassanuddin University, Jl. Malino No. 8 F, Gowa, Sulawesi Selatan, Indonesia

*saiful.ti@unhas.ac.id

Abstract. The implementation of lean manufacturing is essential for companies to minimize waste by reducing non-value-added activities while maintaining product quality and customer satisfaction. Despite its advantages, various barriers hinder its optimal application. This study aims to identify the factors that impede the implementation of lean manufacturing and determine the most dominant factors in bakery factories in Indonesia. The research was conducted across 14 bakery factories on the islands of Sumatra, Java, Kalimantan, and Sulawesi. Data was collected using a survey questionnaire and analyzed using factor analysis and the Decision Making and Evaluation Laboratory (DEMATEL) method. The results reveal seven key factors with significant influence, with technology emerging as the most dominant factor (1.404), followed by organizational culture (0.497). These findings underscore the importance of addressing the technological limitations and organizational culture to enhance lean manufacturing efficiency. The practical implications of this study suggest that bakery companies should focus on improving their technological infrastructure and fostering a culture supportive of lean principles to optimize production efficiency. Theoretical implications include the extension of lean manufacturing frameworks to address sector-specific challenges in the bakery industry, contributing to the broader field of sustainable manufacturing practices.

Keywords: Lean Manufacturing, Implementation Barriers, Factor Analysis, DEMATE, Bakery Industry.

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1. Introduction

The rapid development of technology has triggered the growth of increasingly fierce competition, which requires companies to improve operational efficiency to reduce waste and increase value for customers. [1]. Consumers are increasingly selective in choosing products, so companies must have strategies to maintain product quality, build customer trust, and meet diverse needs [2]. Productivity, both in terms of revenue and production output, is the main indicator of a company's success. [3]

Concept *Lean Manufacturing* It is becoming an increasingly popular approach in the manufacturing industry due to its ability to optimise the production process through the elimination of activities that do not provide added value (non-value added activities) without sacrificing product quality and customer satisfaction. [4]. However, despite the many benefits offered, the implementation of Lean Manufacturing often faces various challenges, both from internal and external factors, that can hinder its success [5, 6].

Several previous studies have identified the main inhibiting factors in the implementation of Lean Manufacturing, including: organizational culture that does not support change, lack of understanding and training of employees, lack of human resources in the furniture industry [7], lack of support from top management, production scheduling, lack of human, social and environmental resources in the manufacturing industry, and limitations of technology and infrastructure, lack of evaluation and procedures, lack of knowledge in the garment industry [8,9]. However, research that specifically explores the factors that hinder the implementation of Lean Manufacturing in the bakery industry is still limited, so further studies are needed to understand the challenges faced by this sector [10,11].

One of the largest bakeries in Indonesia has implemented Lean Manufacturing principles, including Just-In-Time (JIT) and Good Manufacturing Practices (GMP). However, the effectiveness of its implementation is still not optimal, with various obstacles that hinder production efficiency. The problems identified include excess stock (bad stock), dough formulation errors, decreased Order to Factory (OTF) levels, coagulation of raw materials, foreign matter contamination, and machine damage that has an impact on smooth production. In addition, the inconsistent implementation of the First Expired First Out (FEFO) system and errors in the management of raw material inventory also lead to waste and reduce the company's profitability. Therefore, an in-depth analysis is needed to identify the main obstacles in the implementation of Lean Manufacturing in the bakery industry and determine the factors that have the most influence on its success [12,13].

Although many previous studies have identified barriers to the implementation of lean manufacturing, most of these studies have focused on other industries, such as automotive and electronics manufacturing, while the application of lean in the bakery industry in Indonesia remains highly limited. This study aims to fill this gap by identifying the factors that hinder the implementation of lean manufacturing in Indonesia's bakery sector, which has unique characteristics and challenges distinct from those in other manufacturing sectors. Additionally, this research seeks to explore which factors are most dominant in hindering the successful implementation of lean manufacturing in bakery factories [14,15].

Lean manufacturing is not only related to production efficiency but also holds great potential to support sustainability. The lean concept, which aims to reduce waste, aligns with sustainability principles that emphasize reducing environmental impact through resource efficiency and emission reduction. Lean implementation can reduce energy consumption, minimize waste, and enhance the efficient use of materials. Therefore, the application of lean manufacturing not only brings benefits in terms of production efficiency and cost reduction but also contributes to broader sustainability goals, which are becoming increasingly important amidst growing awareness of environmental and social issues in the industrial world.

2. Methods

This study uses a quantitative approach to analyse the inhibiting factors in the implementation of lean manufacturing in bakery companies in Indonesia. This study involved 14 factories spread across four main islands, namely Sumatra, Java, Kalimantan, and Sulawesi. Data was collected through surveys and questionnaires distributed to supervisor-level employees, which were specifically designed to match the scale of factor analysis and processed using the DEMATEL method.

Factor analysis is a multivariate statistical method used to identify the latent structure of several interrelated variables. This technique aims to reduce a large number of variables to a few simpler and mutually independent main factors. In the context of research, factor analysis is used to obtain evidence of construct validity as well as to explore or confirm relationships between items in a questionnaire.

This method is commonly applied in various fields such as information systems, social sciences, psychology, business, and education, especially in analysing and interpreting survey data. [16],[17].

In this study, factor analysis is used to group and simplify the factors that hinder the implementation of lean manufacturing so that it can be analysed more systematically. This method was chosen because of its ability to reduce the complexity of variables into a more meaningful and representative construct of the phenomenon being studied.

2.1. Sampling Technique

The sampling technique used is purposive sampling, aimed at selecting respondents who have relevant knowledge and experience regarding the implementation of lean manufacturing in the bakery industry. Respondents were specifically chosen among supervisors involved in the production process, who are familiar with the challenges and barriers faced in implementing lean manufacturing at their respective factories.

2.2. Respondent Criteria

The criteria for respondents in this study are as follows:

1. The respondent is an employee in a supervisory position in the production department or is directly involved in the implementation of lean manufacturing in the bakery factory.
2. The respondent has a minimum of 1 year of work experience in the bakery industry.
3. The respondent has a sufficient understanding of lean manufacturing principles and the challenges associated with its implementation.

2.3. Questionnaire Validation

The questionnaire used in this study underwent a validation process using expert judgment. Several experts in the field of lean manufacturing and quantitative research were asked to assess the relevance and completeness of the items in the questionnaire. Additionally, a pilot test was conducted on a small sample to ensure that the instrument was clearly understood by the respondents and that no ambiguities existed in the questions [18]. The results of the pilot test were used to revise the questionnaire before distributing it to a larger respondent group.

2.4. Methodology Steps

The methodology of this research was carried out through several key steps as follows:

1. Data Collection: Data were collected through the distribution of questionnaires to 14 bakery factories.
2. Factor Analysis: Data processing was performed using the factor analysis method to identify the factors that hinder the implementation of lean manufacturing.
3. DEMATEL: After the factors were identified, the DEMATEL method was used to determine the cause-and-effect relationships between the factors and to map the most dominant factors.
4. Results Interpretation: The results of the analysis were used to suggest actions that can be taken to address the main barriers in the implementation of lean manufacturing.

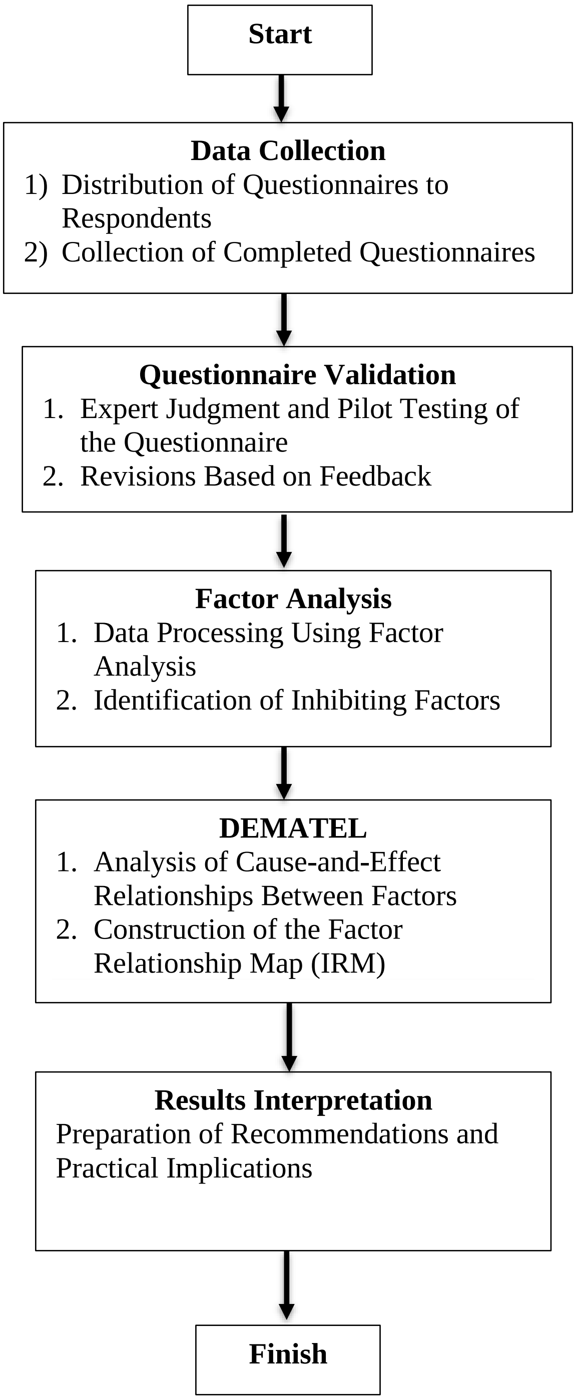

Figure 1. Methodology Flowchart

3. Results and Discussion

The following factor analysis tests are carried out with the help of statistical software, generated as follows:

3.1. The Emperor Meyer Olkin Test (KMO) and Bartlett's Test.

Table 1 shows the results of sampling adequacy and correlation analysis between variables. Based on the table below, the value of the KMO is 0.715, and the significant value of Bartlet's Test of Sphericity is 0.000. The data in this study is suitable to be processed using the factor analysis method.

Table 1. KMO and Bartlett's Test Results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.715
Bartlett's Test of Sphericity	Approx. Chi-Square	955.433
	Df	351
	Sig.	.000

3.2. Factor Extraction

The Extraction value of the 27 factors used has a > value of 0.5, so it can be concluded that all factors can be used to explain the factors. The result of this extraction process is Total Variance Explained. Total Variance explained is useful for determining how many factors are formed. This can be seen from the Initial Eigenvalue, which ≥ 1. Eigenvalues are factors that represent their sub-factors. Table 3 shows that out of the 27 factors analysed, seven major factors were successfully identified as major barriers in the implementation of lean manufacturing [19].

Table 2. Total Variance Explained

Initial Eigenvalues			
Component	Total	% of Variance	Cumulative %
1	8.120	30.073	30.073
2	4.221	15.633	45.706
3	2.952	10.934	56.640
4	1.362	5.043	61.684
5	1.250	4.630	66.314
6	1.152	4.265	70.579
7	1.049	3.887	74.465

3.3. Rotated Compound Matrix

Table 3 shows the number of factors formed as well as the correlation between the sub-factors.

Table 3. Rotated Component Matrix

	Component						
	1	2	3	4	5	6	7
F1	0.798	-0.012	0.219	-0.277	-0.086	-0.071	-0.126
F2	-0.763	-0.006	0.038	0.052	-0.277	-0.070	-0.217
F3	0.569	-0.259	0.656	-0.199	-0.130	0.147	-0.001
F4	-0.796	0.087	-0.014	0.041	0.089	0.205	0.284
F5	0.731	0.035	0.296	0.022	0.411	-0.021	0.087
F6	-0.654	0.099	-0.094	0.141	-0.305	0.012	-0.144
F7	0.593	0.094	0.408	-0.150	0.177	0.372	0.109
F8	-0.403	-0.107	0.001	0.776	0.050	0.142	0.182
F9	0.558	0.135	0.278	-0.335	-0.075	0.354	0.044
F10	-0.692	0.011	-0.185	0.080	-0.011	-0.146	0.085
F11	-0.167	0.520	-0.103	0.593	-0.117	-0.082	-0.070
F12	-0.066	-0.427	0.207	-0.626	0.232	0.241	-0.224
F13	-0.303	0.281	0.096	0.619	0.057	-0.107	-0.365
F14	0.257	-0.393	-0.117	-0.202	0.103	0.687	-0.197
F15	-0.164	0.717	-0.023	0.338	-0.111	0.006	0.009
F16	0.084	0.880	0.006	-0.056	0.060	0.118	0.115
F17	0.167	0.890	-0.105	-0.005	-0.023	0.116	0.045
F18	0.053	0.663	-0.309	0.381	-0.101	-0.087	0.146
F19	-0.208	0.814	-0.056	0.009	0.035	-0.277	0.103
F20	0.260	-0.018	0.306	-0.074	0.757	0.002	0.068
F21	-0.030	0.403	-0.054	0.078	-0.122	-0.041	0.787
F22	0.030	-0.054	0.336	0.018	0.718	-0.086	-0.418
F23	-0.170	0.221	-0.298	0.146	-0.422	0.651	0.188
F24	-0.172	0.114	-0.543	0.019	-0.286	0.278	0.191

	Component						
	1	2	3	4	5	6	7
F25	0.188	-0.185	0.813	0.009	0.217	-0.081	0.051
F26	0.038	0.079	0.823	0.069	0.240	-0.020	-0.170
F27	0.385	-0.158	0.642	-0.243	0.086	-0.017	0.133

3.4. *Interpretation of factors*

The results of the factor analysis showed that of the 27 factors analysed, seven main factors were identified. The determination of the factors that support each factor after rotation is then reselected by looking at the largest correlation value between the factors and the components formed [20]. The next stage is the stage of naming the factors for the seven factors presented in Table 4.

Table 4 . Naming of Lean Inhibiting Factors Manufacturing

No.	Inhibiting Factors	Inhibiting Sub-Factors
1	Organizational Culture Factors	Organizational Culture
		Communication
		Internal relationships
		Factory Relations
		Perseverance
		Evaluation and procedures
		Just in time and production scheduling system
		Independent
2	Knowledge Factor	Knowledge
		Informational
		Performance measurement system
		Audit
		Manufacturing process
3	Fund Factor	Funds
		Supplier
		Infrastructure
		Economy of the country
		Market and business context
4	Human Resource Factors	Human Resources
		Employee resistance
		Cooperation
		Quality control
5		Top management

No.	Inhibiting Factors	Inhibiting Sub-Factors
	Top Management Factors	Risks of implementing sustainable practices
6	Technology Factor	Technology
		Systematization
7	Social and Environmental Factors	Social and environmental

3.5. *Identify Inhibiting Factors in Lean Manufacturing*

This study identifies seven main factors that hinder the implementation of lean manufacturing in bakeries in Indonesia. These factors are obtained from the results of factor analysis and include:

3.5.1. *Factor: Organizational Culture*

Organizational culture plays a big role in the successful implementation of lean manufacturing. However, obstacles that often arise include a lack of internal regulations, resistance to change, and suboptimal production facilities and layouts. In bakery companies, semi-modern production systems still face challenges in aligning work culture with lean principles. Although some companies have adopted more advanced production technologies, long-established operational habits can hinder the effective implementation of lean. If the company has a culture that is difficult to change, then the lean concept will be difficult to apply optimally. In addition, the limitations of supporting information systems can also hinder the success of lean. Previous studies have shown that failure to adopt lean manufacturing can lead to a decline in product quality. [21], decreased productivity [8], and increased operational costs due to inefficiencies [22].

3.5.2. *Factor 2: Knowledge*

A good understanding of lean manufacturing principles and practices is essential to ensure successful implementation. However, bakeries often experience obstacles such as lack of training for workers on the production line, low diligence in implementing lean, and lack of understanding of the benefits of lean for production efficiency. Many workers in this industry are familiar with conventional methods and are unaware of the potential efficiency gains that can be obtained through lean. If employees and management do not have enough understanding, then the full potential of lean manufacturing cannot be utilised to the fullest. [23]. Therefore, increased education about the financial benefits [24] The environmental impact of lean manufacturing is indispensable. [4]. Without supportive regulations and ongoing training programs, lean implementation will be difficult to achieve optimal outcomes. [22].

3.5.3. *Factor 3: Funds*

Sufficient and stable funds are essential in the implementation of lean manufacturing because this system often requires a large initial investment. In the bakery industry, the main challenge is investment in automation equipment and improvements to more efficient production layouts. For example, at the bakery where the research was conducted, some production lines still use machines that are not fully automated, so they require increased investment in equipment modernisation. In addition, lean implementation also requires a more sophisticated inventory management system to reduce raw material wastage and improve operational efficiency.

One of the main obstacles is the high upfront costs that often do not directly generate financial benefits. [25]. As a result, many companies have difficulty maintaining lean implementations in the long term. [26]. Another factor that exacerbates this problem is the limitation of financial resources. [23] Lack of budget for lean programs [24], as well as the lack of investors willing to support long-term implementation [27].

Additionally, bakery companies often face price fluctuations in key raw materials such as flour, sugar, and butter, which can affect the allocation of funds for lean implementation. If more funds are allocated to maintain product price stability, then investment in technology and lean training may be delayed. Therefore, companies need to develop better financial management strategies, such as allocating funds gradually to modernise equipment and adopt more cost-effective production technologies. With proper planning, financial barriers in lean implementation can be reduced so that companies can achieve higher efficiency and increase competitiveness in the bakery industry.

3.5.4. Factor 4: Human Resources (HR)

Employees have a very important role in the successful implementation of lean manufacturing. In the bakery industry, a workforce that is undertrained in the application of lean is often a major obstacle. In addition, low employee motivation to engage in continuous improvement programs also hinders the effectiveness of lean implementation. Another obstacle is less effective communication between management and employees in conveying the importance of lean. [4]. Since efficient operations rely heavily on competent human resources, companies must invest more in employee training and development. [22], [27]. Without an adequately skilled workforce, lean implementation will not run effectively.

3.5.5. Factor 5: Top Management

Support from top management is essential in ensuring the success of lean manufacturing. In the bakery industry, management is often more focused on daily production and pays less attention to long-term initiatives such as lean. Lack of management involvement leads to inadequate resource allocation and uncertainty in program sustainability. [25], [22]. Therefore, top management must demonstrate a strong commitment through policies that support lean. [25], providing financial support [26], as well as providing training for employees [4], [23]. With full support from management, companies can create a work environment that is more conducive to the sustainability of lean manufacturing. [22], [27].

3.5.6. Factor 6: Technology

Technology plays a big role in increasing the effectiveness of lean manufacturing, especially in more efficient production systems. In the bakery industry, technologies such as dough automation machines, high-capacity toasters, bread coolers and digital-based inventory management systems can improve efficiency. However, one of the main obstacles in this aspect is the reliance on old technology. [23], lack of integration between production and distribution systems [24], as well as high investment costs [4]. If the company does not have sufficient technology to support lean, then process visibility will be limited and operational efficiency will decrease. [27]. Therefore, companies need to invest in the right technology as well as provide training to employees so that they can adapt to technological changes. [21].

3.5.7. Factor 7: Social and Environmental

Social and environmental factors also affect the implementation of lean manufacturing, especially those related to sustainability and corporate social responsibility. In the bakery industry, these challenges include the management of raw material waste, energy efficiency in the production process, and compliance with environmental regulations. Some of the obstacles that are often faced include difficulties in maintaining environmentally friendly practices [8], incompatibility of product design with sustainability principles [24], and low awareness of energy efficiency [28]. As consumer awareness of sustainability increases, companies must adapt their production processes to be more environmentally friendly and in line with stricter industry standards.

3.5.8. Average Matrix (B)

The average matrix is calculated by looking for the average of each item from each factor. The average matrix in the DEMATEL method is presented in the following table:

Table 5. Average Matrix (B)

Matrix B	A	B	C	D	E	F	G	At
A	0	2,315	2,056	2,463	2,796	2,426	2,315	14,37
B	2,259	0	2,185	2,481	2,611	2,463	2,574	14,57
C	2,111	2,315	0	2,407	2,574	2,222	2,444	14,07
D	2,667	2,741	2,481	0	2,593	1,852	2,537	14,87
E	2,259	2,519	2,500	2,648	0	2,167	2,333	14,42
F	2,519	2,444	2,685	2,463	2,556	0	2,574	15,24
G	2,019	2,593	2,241	2,537	2,389	2,556	0	14,33
Rj	13,83	14,93	14,15	15	15,52	13,68	14,77	

This average matrix reflects the results of filling out the questionnaire, which includes several factors: Factor A related to Organizational Culture, Factor B related to Knowledge, Factor C focusing on Financial Aspects, Factor D covering Human Resources, Factor E related to Top Management, Factor F associated with Technology, and Factor G related to Social and Environmental Factors.

3.6. Normalization of the Mean Matrix

The average matrix B is then normalised into matrix X by summing each of the row and column elements in matrix B. The results of the normalised matrix can be seen in the following table:

Table 6. Normalization of the mean matrix

Matrix X	A	B	C	D	E	F	G
A	0	0,149	0,132	0,159	0,180	0,156	0,149
B	0,146	0	0,141	0,160	0,168	0,159	0,166
C	0,136	0,149	0	0,155	0,166	0,143	0,158
D	0,172	0,177	0,160	0	0,167	0,119	0,163
E	0,146	0,162	0,161	0,171	0	0,140	0,150
F	0,162	0,158	0,173	0,159	0,165	0	0,166
G	0,130	0,167	0,144	0,163	0,154	0,165	0

3.7. Total Relationship Matrix

The total relationship matrix is obtained by multiplying the normalisation matrix X by the inverse of the subtraction of the identity matrix by the matrix X. The results of the total relationship matrix are presented in the following table:

Table 7. Total Relationship Matrix (T)

Matrix X	A	B	C	D	E	F	G	At
A	1,930	2,194	2,086	2,209	2,283	2,045	2,173	14,92
B	2,080	2,089	2,116	2,235	2,300	2,070	2,211	15,10
C	2,013	2,155	1,932	2,167	2,233	2,000	2,141	14,64
D	2,129	2,272	2,160	2,129	2,333	2,071	2,241	15,33
E	2,061	2,209	2,112	2,223	2,136	2,037	2,179	14,98
F	2,167	2,305	2,216	2,315	2,381	2,008	2,290	15,68
G	2,042	2,204	2,091	2,209	2,260	2,048	2,040	14,89
Rj	14,42	15,43	14,71	15,48	15,92	14,28	15,27	

3.8. Central Role Level and Relationship Level

In the DEMATEL method, the analysis is carried out by evaluating the number of elements of rows and columns in the total relationship matrix (T), which helps to understand the cause-and-effect relationship between factors in the system [29]. The number of row elements is symbolised as Di, indicating the total influence that one factor exerts on other factors, while the number of elements in a column is symbolised as Rj, which indicates the total influence that factor receives from other factors.

3.8.1. Central Role Level

The level of the central role or the primary level of a lean manufacturing inhibition factor is calculated as Di+Rj. This value indicates the importance or crucial role of that factor in the overall system. When the value of Di+Rj is high, it indicates that the factor has a significant influence in the context of the system under consideration. Factors with high Di+Rj values tend to be the focus of attention in decision-making due to their important contribution to the performance or objectives of the system. [29]. Thus, the central role is useful for identifying key factors that need to be considered in system improvement or development, such as the implementation of the lean manufacturing concept in the company.

3.8.2. Relationship Level

The degree of relationship is calculated as Di-Rj, which indicates the extent to which a factor exerts more influence or receives influence than other factors in the system. A positive score on Di-Rj indicates that this factor has more influence than acceptance and is therefore referred to as a dispatcher. This factor is a top priority in decision-making as it has a major impact on other factors. On the other hand, a negative value indicates that the factor receives more influence, so it is called a receiver. This factor can be a secondary or final priority, as its role is more as a recipient of influence than other factors. [29]. Table 9 presents the total exerted and received influence of each factor, which makes it easy to understand the relative contribution and priority of each factor.

Table 8. Total influence exerted and received from each factor

Factors Inhibiting Lean Manufacturing	Notation	At	Rj	Di+Rj	Di-Rj
Organizational Culture	FBO	14.920	14.423	**29,343**	**0,497**
Knowledge	FP	15.101	15.428	30,529	-0,327
Funds	FD	14.641	14.713	29,354	-0,072
Human Resources	FSDM	15,335	15.486	30,821	-0,151
Top Management	FMP	14.957	15.925	30,882	-0,968
Technology	FT	15.683	14.279	**29,962**	**1,404**
Social Environment	FSL	14.893	15,275	30,168	-0,382

3.9. Impact-Relationship Map (IRM)

Impact-Relation Map (IRM) is used to visualise the cause-and-effect relationship between factors in the system. To form the MRI, the horizontal axis (x) of the causal diagram is used to describe the level of the central role (Di+Rj) while the vertical axis (y) describes the degree of relationship (Di-Rj) between factors [29]. Based on the Di+Rj and Di-Rj values, IRM allows mapping the interaction of inhibiting factors in the implementation of lean manufacturing in bakery companies in Indonesia. Figure 1 illustrates the relationship of influence between elements in a lean manufacturing inhibitory system.

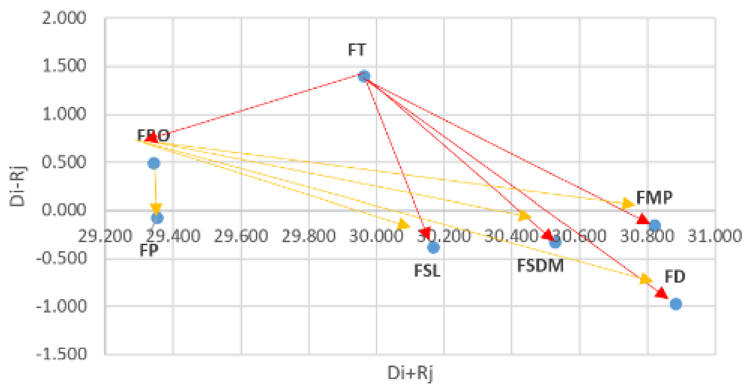

Figure 2. Impact Relationship Map

From Figure 1, it can be seen that the factor with the greatest level of central role is technology, with x coordinates of 29,962 and y of 1,404. This factor has a dominant role as a dispatcher, meaning that technology has a great influence on other factors in the system. As a dominant factor, constraints in technology must be prioritised to ensure the successful implementation of lean manufacturing. Technology barriers often include a lack of modern infrastructure, reliance on legacy systems, and large investment needs, all of which affect operational efficiency [24].

The second dominant factor is organizational culture, with x coordinates of 29.343 and y of 0.497. Organizational culture plays an important role in shaping employees' attitudes towards change, as well as interacting with other factors such as knowledge, social-environment, human resources, top management, and funds. The IRM diagram shows the influence of organizational culture on these factors through the yellow arrow, while the red arrow shows the influence of technology on the organizational culture and other factors.

This diagram is a practical tool for management to prioritise development in the area of technology and organizational culture. With IRM, companies can identify key factors that need to be focused on in the early stages of lean implementation and gradually reduce barriers by implementing specific strategies, such as investing in new technologies and changing organizational culture.

3.10. Analysis of the Dominant Factors Inhibiting Lean Manufacturing

After identifying the seven inhibitory factors, the DEMATEL method is used to evaluate the cause-and-effect relationship between factors, as well as determine which factors have the greatest influence on the system. Based on the Di+Rj and Di-Rj values, two factors were identified as the dominant factors that had the most significant impact on the implementation of lean manufacturing, namely:

3.10.1. Technology Factor

The technological factor is the most dominant obstacle with the highest influence value Di-Rj = 1,404. Technology plays an important role in supporting lean practices, especially in ensuring that the production process runs optimally. In the bakery industry in Indonesia, problems with machine technology often arise, such as inadequate machine capacity, lack of maintenance due to ineffective coordination between production and engineering teams, and the use of machines that are obsolete so that they cannot operate optimally. In addition, delays in the procurement of spare parts also slow down the maintenance process, which ultimately contributes to low operational efficiency.

Investing in new technologies often entails high costs, which is a major obstacle for companies with limited budgets or other financial priorities. The implementation of new technologies is often seen as a cost burden rather than a strategic investment [23]. In addition, rapid technological developments require periodic updates, which can disrupt productivity during the implementation phase. These barriers underscore the importance of a mature technology investment strategy, both in terms of infrastructure and employee training, to ensure technology adoption supports the goal of sustainable lean manufacturing.

The results of this study are in line with the findings [24], stating that delays in technology adoption can slow down the implementation of lean manufacturing principles as well as hinder environmentally friendly innovation. Outdated technologies not only reduce operational efficiency but also hinder the adoption of sustainable practices and resource efficiency. Therefore, a commitment to technology investment, employee competency improvement, and a better planning strategy are needed for companies to effectively address these challenges.

3.10.2. Organizational Culture Factors

Organizational culture has an influence value of Di-Rj = 0.497, placing it as the second most dominant factor. This happened because of cultural and organizational problems that occurred in the implementation of *Lean* manufacturing, such as lack of regulations and policies, resistance to change, slow market response, existing organizational culture, and inadequate information systems. Organizational culture factors are the second priority factor that hinders lean manufacturing because of the important role of organizational culture in determining employee attitudes, norms, and behaviours related to change. This is also explained by Alayón et al. [26], who state that there are several organizational culture problems, such as the lack of support from top management, resistance to change from employees, and the inability to build cross-functional cooperation. As a result, efforts to implement *Lean Manufacturing* It is often hampered because the necessary changes are not well internalised within the organization's culture. Without a supportive culture, *Lean Manufacturing* will simply be a series of formal procedures that are not implemented effectively, thus failing to achieve the expected results. If the values embraced by the organization's culture are not in line with lean principles, such as prioritising cost efficiency over improving quality or reducing waste, then change will be difficult to implement.

The mismatch of these values can result in resistance or distrust of lean concepts. Overcoming organizational culture barriers requires a commitment from top management to change an unsupportive culture, as well as an ongoing effort to engage and support employees in the process of change. This can involve education and training, open communication, recognition of employee contributions, and the creation of a work environment that supports collaboration, innovation, and learning. These various factors can be important factors in a company. Previous research by [26] emphasized that resistance to lean implementation often stems from deeply embedded organizational values and lack of employee involvement. Similarly, [26] found that companies that foster a learning-oriented culture and provide continuous support to their workforce are more likely to succeed in lean transformation. Moreover, [26] demonstrated that leadership commitment, consistent communication, and inclusive engagement significantly influence the effectiveness of lean initiatives. These studies underline the importance of aligning organizational culture with lean principles to ensure sustainable improvement and employee acceptance.

The results of this study indicate the presence of seven main factors that hinder the implementation of lean manufacturing in bakery factories in Indonesia: organizational culture, knowledge, funds, human resources, top management, technology, and social and environmental factors. Based on the factor analysis results, technology and organizational culture were found to have the most dominant influence in hindering lean manufacturing implementation. These findings align with previous studies that have shown that technological barriers, such as limited infrastructure and slow technology adoption, as well as cultural barriers, such as resistance to change and lack of management support, are often the primary obstacles to lean implementation across various industrial sectors.

However, although this study provides comprehensive quantitative findings regarding the factors that hinder lean manufacturing, the discussion could benefit from a deeper engagement with previous studies to enrich the interpretation of the results. For instance, [26] highlighted that barriers to lean adoption in various manufacturing sectors often stem from organizational cultures resistant to change similar to one of the main challenges identified in this research. [26] also emphasized that without cultural readiness and top-management commitment, lean practices are likely to encounter resistance and ultimately fail. Nevertheless, our findings contribute more specifically to the bakery industry context by uncovering that outdated technological infrastructure and limited investment in technological advancement represent more dominant obstacles compared to those in other manufacturing settings. This suggests that while cultural barriers are a recurring theme, industry-specific factors such as technological maturity play a critical role in lean implementation.

Moreover, an important dimension that warrants further exploration is the relationship between lean manufacturing implementation and sustainability. In this context, sustainability should not be confined merely to operational efficiency, but should also encompass environmental impact, which lean principles inherently address through waste reduction. According [26], lean practices can positively influence environmental sustainability by minimizing waste, reducing resource usage, and improving energy efficiency. Lean methodologies, by minimizing overproduction, excess inventory, and inefficient processes, align closely with sustainability goals such as reducing energy consumption and minimizing the carbon footprint. This study affirms that integrating modern technologies and efficient management systems not only facilitates lean implementation but also contributes significantly to broader environmental objectives.

However, the presence of technological limitations poses a significant barrier to advancing sustainability-oriented innovation. Companies operating with outdated systems often face difficulties in adopting cleaner and more efficient production processes. This technological stagnation hinders both lean transformation and environmental progress. As observed by [26], technological capability and innovation are key enablers in aligning lean manufacturing with green practices. Consequently, to successfully implement lean practices and achieve long-term sustainability, firms especially within traditional sectors like bakeries must prioritize investments in modern, eco-efficient technologies. These investments are critical not only for enhancing productivity but also for meeting the growing environmental expectations of stakeholders and regulatory bodies.

4. Conclusion

This study successfully identified seven key factors that hinder the implementation of lean manufacturing in Indonesia's bakery industry: organizational culture, knowledge, funds, human resources, top management, technology, and social and environmental factors. The analysis revealed that technology and organizational culture are the most dominant barriers, with technology being the primary factor influencing the overall implementation of lean manufacturing. These findings provide valuable insights for companies in their efforts to improve operational efficiency through the adoption of lean manufacturing.

However, although the quantitative findings are adequate, the discussion needs to place more emphasis on the practical implications of this research, particularly in the context of sustainability. Lean manufacturing, which focuses on waste reduction, aligns with sustainability principles aimed at improving resource efficiency, reducing waste, and minimizing the environmental impact of production processes. Therefore, companies adopting lean manufacturing can not only enhance cost efficiency but also make a positive contribution to broader sustainability goals.

Recommendations

Based on the findings of this study, several concrete recommendations can be provided for practitioners and policymakers as strategic steps to overcome the identified barriers and promote more effective implementation of lean manufacturing:

a. Investment in Modern Technology
Companies should focus on investing in more efficient and environmentally friendly technologies to support the sustainable implementation of lean manufacturing. Technological upgrades, such as machine automation and digital-based inventory management systems, can reduce waste and enhance production efficiency.

b. Development of an Organizational Culture that Supports Lean
Building an organizational culture that supports change and innovation is key to the successful implementation of lean manufacturing. Top management must act as change agents by providing full support through employee training, clear communication, and policies that promote a culture of continuous improvement.

c. Formulation of Policies to Support Sustainability
Policymakers should create policies that encourage companies to integrate sustainability principles into their lean manufacturing strategies. This could include incentives for companies that adopt environmentally friendly practices, as well as facilitating access to technologies that reduce the environmental impact of production processes.

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References
[1] J. Björkdahl, "Strategies for Digitalization in Manufacturing Firms," Calif. Manage. Rev., vol. 62, no. 4, pp. 17–36, 2020. https://doi.org/10.1177/0008125620920349.
[2] A. Rosário and R. Raimundo, "Consumer marketing strategy and E-commerce in the last decade: a literature review," J. Theor. Appl. Electron. Commer. Res., vol. 16, no. 7, pp. 3003–3024, 2021.
[3] R. Pozzi, T. Rossi, and R. Secchi, "Industry 4.0 technologies: critical success factors for implementation and improvements in manufacturing companies," Prod. Plan. Control, vol. 34, no. 2, pp. 139–158, 2023. https://doi.org/10.1080/09537287.2021.1891481.
[4] K. M. Qureshi et al., "Exploring the Lean Implementation Barriers in Small and Medium-Sized Enterprises Using Interpretive Structure Modeling and Interpretive Ranking Process," Appl. Syst. Innov., vol. 5, no. 4, pp. 1–21, 2022. https://doi.org/10.3390/asi5040084.
[5] A. Akmal et al., "Understanding resistance in lean implementation in healthcare environments: an institutional logics perspective," Prod. Plan. Control, vol. 33, no. 4, pp. 356–370, 2022.
[6] F. A. de Lima, S. Seuring, and P. C. Sauer, "A systematic literature review exploring uncertainty management and sustainability outcomes in circular supply chains," Int. J. Prod. Res., vol. 60, no. 19, pp. 6013–6046, 2022. https://doi.org/10.1187/cbe.18-04-0064
[7] E. Skorupińska, M. Hitka, and M. Sydor, "Surveying quality management methodologies in wooden furniture production," Systems, vol. 12, no. 2, p. 51, 2024.
[8] T. D. Fernando and V. Ratnayake, "Barriers for lean implementation in apparel industry," MERCon 2021 - 7th Int. Multidiscip. Moratuwa Eng. Res. Conf. Proc., pp. 620–625, 2021. https://doi.org/10.1109/MERCon52712.2021.9525806.
[9] O. McDermott et al., "Lean six sigma in healthcare: a systematic literature review on challenges, organisational readiness and critical success factors," Processes, vol. 10, no. 10, p. 1945, 2022. https://doi.org/10.1080/09537287.2021.1891481

[10] V. Cirillo et al., “The adoption of digital technologies: Investment, skills, work organisation,” Struct. Chang. Econ. Dyn., vol. 66, pp. 89–105, 2023 https://doi.org/10.3390/asi5040084.
[11] A. Lutfi et al., “Evaluating the D&M IS success model in the context of accounting information system and sustainable decision making,” Sustainability, vol. 14, no. 13, p. 8120, 2022.
[12] M. Alagaraja and A. M. Herd, “Understanding multi-level learning in organizations: a comparison of lean and the learning organization,” Perform. Improv. Q., vol. 34, no. 4, pp. 521–546, 2022.
[13] F. Alanazi, “Electric vehicles: Benefits, challenges, and potential solutions for widespread adaptation,” Appl. Sci., vol. 13, no. 10, p. 6016, 2023. https://doi.org/10.1080/09537287.2021.1891481
[14] A. Dixit, S. K. Jakhar, and P. Kumar, “Does lean and sustainable manufacturing lead to Industry 4.0 adoption: The mediating role of ambidextrous innovation capabilities,” Technol. Forecast. Soc. Change, vol. 175, p. 121328, 2022 https://doi.org/10.1108/JM2-12-2019-0276..
[15] M. Ferrazzi et al., “Investigating the influence of lean manufacturing approach on environmental performance: A systematic literature review,” Int. J. Adv. Manuf. Technol., vol. 136, no. 9, pp. 4025–4044, 2025.
[16] H. Taherdoost, S. Sahibuddin, and N. Jalaliyoon, “Exploratory Factor Analysis ; Concepts and Theory 2 Factor Analysis 3 Types of Factor Analysis 4 Exploratory Factor Analyses,” Adv. Appl. Pure Math., pp. 375–382, 2022.
[17] E. Knekta, C. Runyon, and S. Eddy, “One size doesn’t fit all: Using factor analysis to gather validity evidence when using surveys in your research,” CBE Life Sci. Educ., vol. 18, no. 1, pp. 1–17, 2019. https://doi.org/10.1187/cbe.18-04-0064.
[18] B. T. Khoa, B. P. Hung, and M. Hejsalem-Brahmi, “Qualitative research in social sciences: data collection, data analysis and report writing,” Int. J. Public Sect. Perform. Manag., vol. 12, no. 1–2, pp. 187–209, 2023.
[19] V. Hessel et al., “Cutting-edge research for a greener sustainable future,” Green Chem, vol. 24, pp. 399–409, 2022. https://doi.org/10.1108/JM2-12-2019-0276.
[20] I. Mohammadfam et al., “Analysis of factors affecting human reliability in the mining process design using Fuzzy Delphi and DEMATEL methods,” Sustainability, vol. 14, no. 13, p. 8168, 2022. [21] S. S. Sharma, P. Pandey, and B. P. Sharma, “Identification and categorization of lean manufacturing barriers in Indian SMEs,” AIP Conf. Proc., vol. 2273, no. November, 2020. https://doi.org/10.1063/5.0024294.
[22] M. Singh and R. Rathi, “Investigation and modeling of lean six sigma barriers in small and medium-sized industries using hybrid ISM-SEM approach,” Int. J. Lean Six Sigma, vol. 12, no. 6, pp. 1115–1145, 2021. https://doi.org/10.1108/IJLSS-09-2020-0146.
[23] P. Jaiswal et al., “Barriers in implementing lean manufacturing in Indian SMEs: a multi-criteria decision-making approach,” J. Model. Manag., vol. 16, no. 1, pp. 339–356, 2021. https://doi.org/10.1108/JM2-12-2019-0276.
[24] S. Prasad, A. N. Rao, and K. Lanka, “Analysing the Barriers for Implementation of Lean-led Sustainable Manufacturing and Potential of Blockchain Technology to Overcome these Barriers: A Conceptual Framework,” Int. J. Math. Eng. Manag. Sci., vol. 7, no. 6, pp. 791–819, 2022. https://doi.org/10.33889/IJMEMS.2022.7.6.051.
[25] F. Abu et al., “The implementation of lean manufacturing in the furniture industry: A review and analysis on the motives, barriers, challenges, and the applications,” J. Clean. Prod., vol. 234, pp. 660–680, 2019. https://doi.org/10.1016/j.jclepro.2019.06.279.
[26] C. L. Alayón, K. Säfsten, and G. Johansson, “Barriers and Enablers for the Adoption of Sustainable Manufacturing by Manufacturing SMEs,” Sustain., vol. 14, no. 4, pp. 1–34, 2022. https://doi.org/10.3390/su14042364.
[27] R. Ben Ruben, P. Nagapandi, and S. Nachiappan, “Modelling and analysis of barriers of lean sustainability in metal manufacturing organizations,” Mater. Today Proc., vol. 45, no. xxxx, pp. 6807–6812, 2020. https://doi.org/10.1016/j.matpr.2020.12.980.
[28] S. Sahoo, “Lean manufacturing practices and performance: the role of social and technical factors,”

Int. J. Qual. Reliab. Manag., vol. 37, no. 5, pp. 732–754, 2020. https://doi.org/10.1108/IJQRM-03-2019-0099.
[29] M. Yazdi et al., “Improved DEMATEL methodology for effective safety management decision-making,” Saf. Sci., vol. 127, no. March, p. 104705, 2020. https://doi.org/10.1016/j.ssci.2020.104705..