



# Article Barriers of Lean Accounting Implementation in Polish Enterprises: DEMATEL Approach

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Abstract: Many manufacturing units make unsuccessful attempts to implement Lean Accountings in their management systems. Hence, such units must eliminate the prevailing lean accounting barriers to accomplish successful lean implementation. Moreover, the contextual relationship of lean accounting barriers must be studied to understand the effect of such barriers. The purpose of this study is to identify and analyze lean accounting implementation barriers. The analysis is going to determine how individual barriers interact to each other. The conclusions of this analysis are necessary for more effective implementation of lean accounting and moreover efficient lean management. The methodology consists of two stages. First it conducted literature review in order to identify barriers to implementing lean accounting in manufacturing companies. Then, analyzed connections between barriers using the DEMATEL method. The DEMATEL lean accounting barrier evaluation method helps companies better understand the barriers and their levels of importance in lean accounting implementation. Based on obtained results, it occurred that manufacturing companies should primarily address the issue of aversion to change to successfully implement lean accounting. This research supports managers in effectively implementing lean accounting in manufacturing companies by identifying implementation barriers and their interconnectedness. This exploratory study initiates a discussion on the barriers to implementing lean accounting in Polish enterprises and their mutual relations.

Keywords: lean; lean management; lean accounting; DEMATEL

# 1. Introduction

Effective management of an organization depends on appropriate information. Therefore, the role of IT systems, including the accounting system, in creating this information is extremely important. At the same time, management accounting systems are strongly determined by the conditions in which companies operate and the strategic values that determine the directions they follow. Managers' demand for actual information about desired features often forces the implementation of diametrical changes in the accounting information system, especially in its subsystem—management accounting.

Bakar and Majid [1] see the possibility of creating organizational value in the proper use of information, creating a logical sequence: selected information will allow managers to improve decisions, which, in turn, lead to increased value for the customer and ultimately to greater value created for shareholders. This logic is coherent with the conceptual elements of lean management. Accepting the legitimacy of the above reasoning is tantamount to recognizing that the conceptualization of lean accounting requires setting a framework with a specific structure, assumptions, and goals aimed at providing the stakeholders of the organization with reliable information about the company's achievements for value creation. At the same time, accounting practices cannot be viewed or shaped in separation from changes in the way production is approached. The development of the concept of lean accounting is the result of adapting accounting information systems to the principles of lean management.



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**Copyright:** © 2023 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). The term "lean accounting" was used for the first time by J. Womack and D. Jones [2], but the origin of the lean strategy is commonly associated with the Toyota Production System (TPS). With time this term has begun to be referred to wider context of company management conception—lean management (LM). The basis of LM is the creation of improved high-quality system that realizes production in response to customer demand, reducing the amount of waste [3]. According to lean management, companies should determine their strategies based on the value delivered to the customer by systematically eliminating waste inside the enterprise, as well as along the supply chain.

During implementation of LM many companies noticed that traditional systems of management accounting are unable to support this kind of projects. Changes of philosophy in company management towards lean became the basis of management accounting aims and tasks change. Its techniques, tools, and concepts have undergone both transformations on a theoretical and practical level [4–8].

The conventional accounting system needs radical changes to make it reflective of the changes in the manufacturing strategies emanating from the lean philosophy [7,9,10]. The nature and value of lean accounting (LA) have been thoroughly discussed in the literature. An LA system is commonly considered an important ingredient of a lean management system. However, it is a complex process, the success of which can depend on many factors. Little of the research done studies have addressed why LA systems fail [5,11,12], although efforts to implement or maintain a successful lean accounting system have failed many times. Also, definitely, not much is known about the mutual relations of barriers to implementing LA in manufacturing companies.

The field of lean accounting has seen widespread exploration in numerous countries [11–15], with a predominant focus on separated methodologies. While individual lean accounting methods have gained substantial attention in the literature, the broader context of barriers that influence the real extent and triumph of implementation has often remained unexplored.

Only a handful of studies have delved into the barriers impeding the integration of lean accounting in manufacturing companies, and remarkably, the interconnections among these barriers have never been explored. Moreover, such in-depth studying have not yet been conducted in Poland, leaving void in the current form of knowledge.

Hence, this study endeavors to bridge this gap by identifying and examining the multifaceted barriers that obstruct the widespread adoption of lean accounting in manufacturing industries.

By meticulously analyzing existing literature and employing the DEMATEL model to unravel the contextual links between these barriers, we aim to offer valuable insights into how these obstacles can be effectively navigated.

Managers with knowledge about that subject will be able to efficiently affect barriers, which have crucial influence on lean management implementation in manufacturing enterprises.

Through this research, we aspire to empower managers and organizations to confront these barriers with astute strategies, ultimately fostering a more seamless and comprehensive implementation of lean accounting practices. This approach will release the full potential of lean accounting, driving organizations towards heightened operational efficiency and sustainable growth.

In essence, while lean accounting has undergone considerable scrutiny, an inclusive understanding of the barriers that impede its integration is of paramount importance. This research endeavors to illuminate these barriers, guiding organizations towards embracing lean accounting in its entirety and releasing its transformative potential in nowadays dynamic business surroundings.

# 2. Literature Review

# 2.1. Lean Management

The term "lean," as a concept of production management, was popularized as lean manufacturing [2,16]. It has its roots in the Toyota Production System (TPS) and has been successfully applied in diverse sectors since then.

The scope of lean orientation has expanded beyond just production and started being utilized in other areas of activity, such as trade and administration. This evolution led to the term "lean management" (LM). LM is a performance improvement philosophy with the primary objective of eliminating waste throughout a system. The lean approach is focused on constant process improvement and employs various tools and methods to implement these improvements. The core principle is the elimination of waste and unnecessary activities while ensuring seamless value creation at each step.

According to LM methodology, the quality of a product is solely determined by what the customer actually needs and is willing to pay for [17]. In this concept, lean advocates for a rule where every process can be further rationalized, leading to the elimination of often unnoticed waste.

Authors present a lean approach to the production process in the form of five rules, which can be applied both to the entire enterprise and to individual processes or the actions of specific employees [18]. These principles are: (1) specify value, (2) identify the value stream, (3) avoid interruptions in the value flow, (4) let customers pull value, and (5) constantly pursue perfection.

In a lean company, the traditional vertical organizational structure is abandoned in favor of an organization centered around value streams, representing the paths of product streams throughout the enterprise. The concept of lean management is oriented towards internal process improvement, the aspiration to eliminate waste, and the fostering of respect for people and other stakeholders within the organization [19] (p. 35). The wide use of this concept is attributed to its ability to contribute to the elimination of repetitive problems.

## 2.2. Lean Accounting

For the results obtained to meet expectations, organizations that have adopted the lean manufacturing system must apply the lean thinking model at all levels, including the accounting activity.

According to the literature, the success of lean transformation depends on its application throughout the organization. Therefore, accounting, as the main source of decisionmaking, plays a crucial role in the success of the lean transformation process [20], hence the need for lean accounting.

Implementing the lean philosophy demands the introduction of new performance assessment measures that allow for control and lead to continuous process improvement [21].

Effective management concepts within enterprises cannot function without proper performance measurement techniques. To make the right operational or strategic decisions, it is necessary to precisely understand costs in all possible dimensions and conditions, as well as their dependence on specific factors, both internal and external. This level of cost knowledge can only be achieved through an efficiently organized accounting system, particularly the management accounting system. Lean management implementers recognize the potential of this concept in identifying and eliminating waste. However, the effects of these activities are not directly reflected in the information provided by traditional accounting systems. Past research on lean management has repeatedly emphasized the need to modify accounting methods and tools in companies implementing lean principles, to ensure consistency between the applied cost management systems and accounting principles, and the implemented strategy [4,7,9,22]. E. Zarzycka also notes that "positive and long-term effects are a consequence of covering the implementation of all elements of the enterprise management system, not only the production part" [23] (p. 48). Therefore, changes in the philosophy of business management towards lean management have become the basis for redefining the goals and tasks of management accounting. Its techniques, tools, and concepts have changed, both in theoretical and practical terms [8]. This adaptation involves either modifying existing solutions or creating new solutions and practices not used so far. These dependencies can be summarized by quoting the opinion of A. Kamela-Sowińska: "Original, modern solutions and ideas are currently one of the most important, highest-valued components of an economic entity's resources, and therefore there is no doubt that accounting solutions should be a derivative of changes taking place in the real world" [24].

Lean accounting is defined as an alternative system of measurement based on cost accounting of the value stream, connected with an analysis of resource use levels. Its task is to support decision-making, which is oriented towards the implementation of lean management. The tools applied within its scope enable the evaluation of the profit resulting from future state maps projects, as well as the assessment of the implementation outcomes of specific lean management methods and techniques [25] (p. 103).

The Institute of Management Accountants (IMA) has presented key assumptions of the Lean concept in accounting in the form of five fundamental principles of lean accounting, which simultaneously provide realization of traditional accounting functions [10] (pp. 8–9):

- lean accounting uses lean methods in accounting processes to reduce losses embedded in transaction processes, reports, and accounting methods,
- accounting processes focus on measuring and understanding the value created for clients through a focus on the entire value stream, rather than on particular products or services,
- information is provided clearly and punctually, as evidenced by accounting reports that are not locked into a monthly reporting cycle, and their frequency is adapted to the needs caused by the implementation of the lean concept,
- planning from a lean perspective involves individuals responsible for achieving results and actively engaged in setting goals,
- reinforce internal accounting control by eliminating transactions through careful planning.

Despite the benefits of lean management [26], researchers have found a very low success rate of lean management [27]. This happens for many reasons [27]. One of them is that lean management has not been adequately supported by lean accounting [28]. Authors [5,6,29,30] have highlighted that overlooking lean accounting barriers or not fully understanding them significantly contributes to implementation failures. Considering that successful lean implementation demands continuous and consistent efforts [26,31], comprehending these barriers and their importance throughout the implementation process becomes crucial to ensure a seamless transition [14].

#### 2.3. Research Gap

The review of the existing literature indicates that the concept of lean management is not new to Polish enterprises, but lean accounting still remains an area that requires greater research attention. While LM methods and practices have been the subject of numerous studies and implementations, the implementation of LA in manufacturing firms continues to be a challenge. There is a research gap regarding the identification and understanding of the mutual relationships between various barriers to the implementation of LA in the Polish context. Previous studies on LA implementation have primarily focused on analyzing individual barriers, with little attention given to understanding the interconnections between them. Therefore, conducting research that concentrates on identifying common factors and connections between barriers can provide valuable insights into the obstacles that may affect the effectiveness of LA implementation in manufacturing companies. In particular, there is a lack of research on LA implementation in the Polish context, where such studies have never been conducted. Conducting a detailed analysis of these barriers in Polish enterprises can provide valuable information regarding specific challenges and issues related to LA implementation in this country. Hence, the main objective of this study is to identify and understand the mutual relationships between various barriers to LA implementation in manufacturing firms in the Polish context. The findings of this study may contribute to a better understanding of the obstacles that impact LA implementation and can assist managers in effectively managing this process in manufacturing enterprises.

## 3. Methodology and Framework

The complete structure of the research framework adopted in this study is presented in Figure 1. The barriers to the effective implementation of LA were identified from the existing literature while the contextual relationships among the barriers were examined with the help of the DEMATEL method.



Figure 1. Proposed framework of study.

## 3.1. Identifcation of Bariers of LA Implementation

In the first step, for the collection of relevant data, an thorough literature review, identified 8 barriers of LA implementation.

## 3.1.1. Lack of Accounting Staff (B1)

Research [32], conducted on sample of 137 enterprises has shown that implementation barrier of lean accounting concept could be background of accounting specialists. Main reasons for this approach include: lack of substantive preparation of accountants, distrust of new measurement methods, additional workload caused by parallel keeping of records in a current and a new approach, as well as observed insufficient number of implementations of some methods (e.g., value stream account) in other entities.

Accountants also face educational, professional, and other personal barriers that inhibit their embracing a cooperative culture and the transition to lean accounting [6].

## 3.1.2. Lack of Adequate Computing Resources (Software) (B2)

According to the resource-based view, companies can acquire competitive advantages through the use of unique, non-imitable resources. The IT applications can be one of those resources. In earlier research IT has been shown to cause management accounting change [33,34].

Many companies invested into enterprise resource planning (ERP), to increase their potential, broaden possibilities and efficiency of analysis, as well as collecting data and reporting. Other enterprises have less integrated software with more or less independent accounting information systems (AIS) and production support systems. Because significant

majority of companies acts according to traditional accounting practices, creators of ERP, AIS and production support software designed them for traditional management environment. Involved managers supervising implementation of the lean concept often observe that their systems are not adapted for LM [6] (p. 185).

#### 3.1.3. Management Inertia (B3)

Lean management is a combination of two aspects: cultural excellence (often defined in the literature as respect for people) and process excellence [18,35]. Cultural excellence refers to human resources and strategy, encompassing leadership, adaptation, maintenance, position reinforcement, and involvement. This excellence is crucial for the successful and permanent implementation of lean, leading to operational excellence [36].

One of the leading barriers in the implementation of both Lean Management (LM) and Lean Accounting (LA) practices is the lack of involvement from top management [37]. For the successful implementation of lean practices, a competent leader in management is necessary. The commitment and willpower of top management play a critical role. Moreover, continuous employee motivation is essential for adopting newer practices in manufacturing operations. The manufacturing industry can effectively implement its lean initiatives if top management demonstrates solid commitment and support.

#### 3.1.4. Poor Communication between Operational, Financial and Accounting Areas (B4)

The basic area in which the introduction of changes related to lean begins is the area that carries out production activities. Research conducted on a group of 244 enterprises [5] shows that the order of implementation matters. The changes were more effective when they concerned production first, then other areas of activity, and only then the applied accounting methods.

When a lean strategy is holistically designed to include both lean manufacturing and lean accounting practices, the performance is likely to be enhanced [38]. Often, however, rather than treating lean as a holistic business strategy, many companies choose the tools that are most conveniently applied or can have a big impact on their accounting profits. But ultimately, they are disappointed with the results because, in isolation, the tools are not as effective as they can be in combination [39].

Grasso [6] argued that accountants have difficulty with lean transformation because of their interdependent relationships with managers who do not comprehend the cultural change that must accompany a lean transformation.

The problem also lies in the fact that accounting topics are viewed by the operational cadre as a hermetic field of practices, little known to them and ruled by different principles than LM methods [29]. Additionally, accountants are not accustomed to significant interaction with operations people, so they may be uncomfortable in their expanded role [40]".

3.1.5. Lack of Appropriate Knowledge and Competences of the Department Responsible for Management Accounting (B5)

Previous research has identified accounting staff as a facilitator which influences the potential for accounting change [41]. To support a lean accounting transformation, accountants must understand the lean management system [30]. Financial accounting and auditing dominate the curriculum of business schools, and promote a command-andcontrol business philosophy [30]. Moreover, there is no clear consensus among accountants about the catalog of appropriate accounting methods for lean producers [42].

Adequate training and knowledge of both managers and operational staff is needed to implement LA practices. Training can play an important role in developing organizational skills and knowledge in LA practices [32]. Training becomes urgently needed to make the industry more resource-efficient and environmentally sustainable. Implementing LA approach requires adequate knowledge and training for both managers and employees [14]. There is also need for training to sustain and monitor development of these implementations [43].

#### 3.1.6. The Need to Meet Statutory Requirements (B6)

Lean accounting developments are essentially directed towards management accounting, since the information for financial reporting follows very strict rules. On the other hand, financial information cannot in any way be considered a waste since it stems from a legal obligation.

Accountants to be quite conservative and conventional with their behavior, therefore they hardly seek improvements and innovations in the accounting system [40].

Although lean accounting does not violate GAAP [44], some resistance to change comes from a misconception that any costing method, other than a detailed standard costing system by unit, is not compliant with accounting principles.

#### 3.1.7. Dependency on Parent Company (B7)

Evidence suggests that the adoption of new management accounting practices in subsidiary organizations may be influenced by pressure from the group [45]. Management accounting change in a subsidiary organization has been the subject of repeated research [28,46,47].

The internal workings of the subsidiary company are influenced by interrelated forces, both inside and outside the organization. The direction of change in management accounting often depends on the top-down vision of the system adopted in the parent company [48], which may pose a barrier in the implementation of lean accounting.

## 3.1.8. Resistance to Change (B8)

Resistance to lean accounting has little to do with accounting and is rather caused by resistance to lean management, a culture of collaboration, and continuous improvement [6,49]. The implementation of lean, accompanied by lean accounting, can have both positive and negative impacts on the working environment [50]. Research conducted by S. Tillem and M. van der Streen on changes in control systems caused by the implementation of lean production led to the conclusion that psycho-social barriers emerging during the implementation stage and tensions arising during the implementation phase of the change also apply to management accounting practices. These researchers, based on observations of several companies implementing lean management accounting practices, identified organizational impacts indicating emerging tensions [51].

Implementation of LA is often met with resistance from employees due to fear of change, lack of knowledge about lean and its objectives, mistrust of employees towards management, and negative experiences from previous implementations of other concepts and initiatives. LA also introduces greater measurement of work results and intensity. The occurrence or not of a negative impact of lean accounting on the work environment and the workers' resistance associated with it depend to a large extent on how it is implemented by management [52].

Change is an ongoing process affecting both the organization and the people. To successfully implement any change project, the organization's strategy must be aligned with the personal goals of its members. Implementation of LM in company requires a change in structure, system, processes and employees' behavior.

The final list of barriers to be analyzed under DEMATEL method is shown in Table 1.

The identified barriers were summarized in tables and presented to a panel of experts for their evaluations and recommendations. The group of experts consisted of six individuals from the manufacturing industry sector and two experts from the academic environment. The industry experts have more than ten years of working experience at the managerial level in various manufacturing industries in Poland, while the academic experts have more than ten years of experience in teaching and research in the domain of management accounting.

Experts mentioned above approved choice of barriers.

S.N.	Barriers to the Implementation of Lean Accounting	Sources
B1	Lack of accounting staff	[6,32]
B2	Lack of adequate computing resources (software)	[6,33,34]
B3	Management inertia	[18,35–37]
B4	Poor communication between operational, financial and accounting areas	[5,6,29,38-40]
B5	Lack of appropriate knowledge and competences of the department responsible for management accounting	[14,30,41-43]
B6	The need to meet statutory requirements	[40,44]
B7	Dependency on parent company	[28,45–48]
B8	Resistance to change	[6,49–52]

Table 1. Barriers of LA implementation and their sources.

## 3.2. Presence of Identified Barriers in the Surveyed Enterprises

In the second step occurrence of identified barriers in Polish manufacturing companies was verified, as well as it was checked how they are perceived by specialists.

The concept of lean management permeates enterprises in the form of various types of system, such as:

- Toyota Production System (TPS),
- Achieving Competitive Excellence (ACE),
- Continuous Improvement Project (CIP),
- World Class Manufacturing (WCM),
- Six-Sigma.

Companies participating in the survey declared one of above-mentioned systems or application of methods and tools specific to LM.

The questionnaire survey yielded 128 complete responses from manufacturing industries through email, representing small companies (3.12%), medium-sized companies (32.81%), and large companies (64.06%). Despite the differences in size and employment levels of the surveyed units, these differences did not affect the quality of the surveys.

An analysis of the structure of the capital characteristics of the enterprises represented by the respondents shows that they are entities based on both Polish and foreign capital, but the dominant part represents mixed capital. Most of the participating enterprises were members of capital groups (75.8%), but the majority of them have a separate management accounting system (68%).

The respondents were individuals representing different areas of the company's operations (Table 2), with the predominant group being employees from the departments of production (30.47%), and quality (28.13%).

	Sample %
Department	
Production	30.47
Marketing and sales	0.78
Product development	12.50
Purchase	7.03
Quality	28.13
Finance	8.59
Logistics	3.91
Other	8.60

Table 2. Respondent characteristics.

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Table 2. Cont.

	Sample %
Hierarchy position	
CEO/Owner	2.34
COO	7.03
CFO	4.69
Mid-level managers	38.28
Specialist (including lean)	46.09
Other (or if in doubt, state your own)	1.56
Time in the company	
above 10 years	7.03
7–10 years	29.69
5–7 years	41.41
3–5 years	18.75
1–3 years	3.13

Respondents were asked to refer to statements designed to diagnose the causes of barriers to the transformation of management accounting towards lean (Table 3). Responses were given on a 5-point Likert scale where: 1—strongly disagree, 2—disagree, 3—undecided, 4—agree, 5—strongly agree.

Table 3. Barriers of LA implementation in manufacturing enterprises.

<b>Barriers of LA Implementation</b>	$\frac{-}{x}$	σ
Lack of accounting staff (B1)	2.92	1.032
Lack of adequate computing resources (software) (B2)	2.95	1.041
Management inertia (B3)	3.68	0.913
Poor communication between operational, financial and accounting areas (B4)	3.86	0.791
Lack of appropriate knowledge and competences of the department responsible for management accounting (B5)	2.84	1.228
The need to meet statutory requirements (B6)	3.02	1.079
Dependency on parent company (B7)	3.04	1.455
Resistance to change (B8)	4.11	0.872

According to respondents, the factor that represents the biggest obstacle to adopting lean accounting principles is resistance to change. The average indication of opinion for this statement was  $\bar{x} = 4.11$ . As many as 55 respondents agreed and 47 strongly agreed (totalling 79.69%), that it is barrier for lean transformation of management accounting in surveyed companies. Only 2 respondents (1.56%) strongly disagreed with this opinion. In turn, 102 (78.69%) respondents cited poor communication between operational and financial-accounting areas as a barrier to LA implementation ( $\bar{x} = 3.86$ ). Interestingly, none of the respondents strongly disagreed with the existence of a "two-way street" between these areas of the companies surveyed.

Dependence on the parent company as a barrier was identified by 55 (42.97%) respondents. At the same time, it should be pointed out that 75.8% of the entities surveyed operate as part of a group, with 43.8% declaring that they have a separate management accounting/controlling system. A certain inconsistency can be seen here, apart from the 32% of companies that due to being in corporate group share a common management accounting/controlling systems (reasonable indication of dependency), this barrier was also indicated by entities creating management accounting solutions on their own.

Management inertia, perceived in the surveyed companies, is also a serious problem. As many as 87 respondents agreed or strongly agreed that they perceived this type of barrier (mean response  $\bar{x} = 3.68$ ).

However, respondents mostly did not see the problem with the implementation of lean accounting in the shortage of accounting staff. Among the people surveyed, 48 people (37.47%) disagreed or strongly disagreed with this statement.

Similarly, the lack of adequate computing resources (software) does not appear to be a factor weighing on the implementation of lean management accounting, the average response in this case being  $\bar{x} = 2.95$ , with 34 people (27.34%) indicating no opinion in this regard.

Very interesting are the indications for the factor 'Lack of appropriate knowledge and competences of the department responsible for management accounting' as a barrier to the transformation of management accounting towards lean. A majority of 62 respondents (48.44%) disagreed or strongly disagreed with this opinion.

Respondents perceive as a barrier the need to meet statutory requirements (mean of indications  $\overline{x} = 3.02$ ).

#### 3.3. DEMATEL Based Model Barriers of Lean Accounting Implementation

To find the interrelationship among the identified barriers, the DEMATEL (Decision Making Trial and Evaluation Laboratory) method is incorporated in the present study. This tool basically helps in analyzing the factors of the problems within two different groups, namely, the cause group and the effect group [53,54]. The main aim of DEMATEL is to determine the intensity of the effect and the causal relationship between the direct and indirect variables of a complex system using matrix calculations [55].

The method of DEMATEL was initially introduced in 1971 by the Geneva Research Centre at the Battelle Memorial Institute [56,57]. This technique visualizes complicated structural and causal relationships using matrices or digraphs and can convert the causeand-effect relationships of criteria into a unique structural model, clarifying the root causes of problems and defining strategies for resolving core issues. DEMATEL reflects the interrelationships among various factors, highlighting their causes and effects, and provides a structural framework for the system. One advantage of DEMATEL over other models is its ability to generate meaningful insights with minimal information [58]. As a result, it is particularly suitable for studies involving a small number of respondents or, in some cases, groups of respondents (such as project teams).

The DEMATEL method seems suitable for this study for several reasons [53,55,59–61]:

- Allows the identification of cause-and-effect relationships between different variables. This enables researchers to better understand how various factors interact and influence the analyzed problem.
- Is appropriate for analyzing complex and multifactorial issues. It accommodates multiple variables and assesses their mutual relationships, providing a more comprehensive and versatile picture of the research problem.
- Supports decision-making: The DEMATEL method provides information about key factors affecting the analyzed problem. This can assist decision-makers in making more informed decisions and developing effective strategies.
- The results obtained through this method can offer directions for further research and analysis. Discovering specific connections between variables may encourage other researchers to delve deeper into the analysis in the given area.
- Allows for comparing results between different groups or cases. This can aid in identifying similarities and differences, as well as in identifying patterns that are relevant to the study.
- Utilizing expert knowledge allows for the inclusion of subjective assessments and opinions, which can be valuable in analyzing complex issues. Experts can provide

unique insights into the relationships between variables, significantly enriching the research findings.

• Is flexible and applicable in various research fields. It can be used to analyze relationships between factors in different contexts, making it useful across various scientific domains.

The results of the DEMATEL analysis can be presented graphically, facilitating understanding and interpretation. The graphical representation of relationships between variables can enhance communication and presentation of research results.

The DEMATEL method converts the interdependency relationships into a cause-andeffect cluster via matrices and discovers the critical factors of an intricate system of factors with the aid of impact relations [55]. The premise of the method assumes that there are three types of relationships between the two factors:

- (1) the first factor determines the second,
- (2) the second factor determines the first,
- (3) the factors do not affect each other.

The method, thanks to the utilization of matrix transformations, enables the consideration of internal interdependencies between factors when they occur bidirectionally. Although the method is founded on the analysis of relationships among factors, the selection of factors and their initial values, which serve as the reference point for the model, are determined by expert input and rely on Delphi methods.

When compared to other modeling approaches (Total Interpretive Structural Modeling (TISM), Graph Theory and Matrix Approach (GTMA), etc.), this approach assists the researchers in understanding the contextual relations among the included factors within the problem structure and helps in identifying the strength of their interrelationships.

Calculation steps and structure of DEMATEL is compiled and are described as below e.g., [56,58,62]:

Step 1

Based on either interviews or surveys, data is collected among experts on the values of the interaction between pairs of n factors, where the dependence of the impact of factor i on j is defined by the relation  $z_{ij}$  [13]:

Development of direct relation matrix is done from the response collected from the experts. The responses are in the form of Likert scale in the order of 0 to 4. Value corresponding to the meaning is:

- 0—no influence,
- 1—very low influence,
- 2—low influence,
- 3—high influence
- 4—very high influence.

The average matrix Z is represented as shown in Equation (1).

$$Z = \begin{bmatrix} z_{11} \dots z_{1j} \dots z_{1n} \\ \vdots & \vdots & \vdots \\ z_{i1} \cdots z_{ij} \cdots z_{in} \\ \vdots & \vdots & \vdots \\ z_{n1} \cdots z_{ni} \cdots z_{nn} \end{bmatrix}$$
(1)

## Step 2

Using the data collected from experts, compute the average matrix. Normalize initial direct relations matrix *D* by  $D = Z \times S$ , where:

$$S = \min\left[\frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} |z_{ij}|}, \frac{1}{\max_{1 \le j \le n} \sum_{i=1}^{n} |z_{ij}|}\right]$$
(2)

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Each element in this matrix falls between zero and one. **Step 3** 

The total influence or total relation can be obtained by summing up D,  $D^2$ ,  $D^3$ , ...,  $D^{\infty}$ . The final relation matrix is represented by T and computed by (Equation (3))

$$T = \lim_{m \to \infty} (D + D^2 + \dots + D^m) = \sum_{m=1}^{\infty} D^m$$
(3)

## Step 4

Calculate sum of rows and columns *R* denotes the sum of rows and *C* denotes the sum of columns of total relation matrix "*T*":

$$R_i = \sum_{1 \le j \le n} t_{ij} \tag{4}$$

$$C_j = \sum_{1 \le i \le n} t_{ij} \tag{5}$$

 $t_{ij}$  = corresponding values in matrix *T*.

Step 5

Finally, (R+C, R-C) is calculated separately for each factor to create the effect-relationship map, which is the end goal. Here, the further the (R+C) value of the criterion is from the center, the more important the criterion would be. If the (R-C) of the criterion is positive, it is in the group of affecting factors; if it is negative, it is in the group of affected factors.

Since matrix T provides information on how one factor affects another, it is necessary for a decision maker to set up a threshold value to filter out some negligible effects. In doing so, only the effects greater than the threshold value would be chosen and shown in digraph. In this study, the threshold value is set up by computing the average of the elements in matrix T. The digraph can be acquired by mapping the data set of (R+C, R-C).

After the identification final barriers LA, these were evaluated through a questionnaire from case industrial managers. Barriers were assessed by using a five-point Likert scale (0–4) of importance, 0 representing no influence, and 4 implies very high influence. We received responses from 8 experts. After the pair-wise comparison of barriers from case industrial managers, it was further processed for evaluation through DEMATEL.

# 4. Results and Discussion

Expert opinion was taken in for building the relationship among the barriers and carry out the analysis. The barriers to LA implementation identified in the previous section were presented to the experts.

The experts were asked to make the relationship comparisons of the barriers. Each expert was asked to make separate comparisons and later, using Equation (1), an average direct relationship matrix (Table 4) was developed by taking mean of all the judgements made by the experts for all the comparisons separately.

	B1	B2	<b>B</b> 3	<b>B4</b>	<b>B</b> 5	<b>B6</b>	<b>B</b> 7	<b>B</b> 8
B1	0.00	0.50	2.25	2.40	1.65	0.90	0.00	3.00
B2	0.15	0.00	2.00	2.25	0.15	0.15	1.15	2.15
B3	2.65	2.25	0.00	2.40	1.40	0.00	1.75	2.90
<b>B4</b>	0.90	1.15	1.75	0.00	0.75	0.00	0.90	3.15
B5	1.15	2.25	1.90	2.00	0.00	0.00	0.00	2.75
<b>B6</b>	1.40	0.50	1.40	1.75	1.50	0.00	0.65	3.00
<b>B</b> 7	2.25	2.40	2.65	1.65	1.00	0.40	0.00	2.75
<b>B</b> 8	3.00	3.00	3.75	3.50	3.25	0.15	2.00	0.00

Table 4. Average direct relation matrix of barriers of LA implementation (matrix 'Z').

In the next step, based on the initial direct-relation matrix, the normalized direct relationship matrix (Table 5) was obtained.

	B1	B2	B3	B4	B5	B6	B7	B8
B1	0.00	0.03	0.11	0.12	0.08	0.05	0.00	0.15
B2	0.01	0.00	0.10	0.11	0.01	0.01	0.06	0.11
B3	0.13	0.11	0.00	0.12	0.07	0.00	0.09	0.15
<b>B</b> 4	0.05	0.06	0.09	0.00	0.04	0.00	0.05	0.16
B5	0.06	0.11	0.10	0.10	0.00	0.00	0.00	0.14
<b>B</b> 6	0.07	0.03	0.07	0.09	0.08	0.00	0.03	0.15
<b>B7</b>	0.11	0.12	0.13	0.08	0.05	0.02	0.00	0.14
<b>B</b> 8	0.15	0.15	0.19	0.18	0.16	0.01	0.10	0.00

Table 5. Normalized direct-relation matrix of barriers of LA implementation (matrix 'D').

Next, by following the procedure described in the previous section, the total relations and direct-indirect relationships (Table 6) that were the R and C values for all the comparisons was used.

Table 6. Total relation and direct-indirect relation matrix of barriers of LA implementation (matrix 'T').

	B1	B2	<b>B</b> 3	<b>B4</b>	<b>B</b> 5	B6	<b>B</b> 7	<b>B</b> 8	R
B1	0.12	0.15	0.26	0.27	0.19	0.05	0.07	0.32	1.43
B2	0.10	0.10	0.21	0.23	0.09	0.02	0.11	0.24	1.10
<b>B</b> 3	0.25	0.25	0.18	0.30	0.19	0.02	0.17	0.35	1.72
<b>B4</b>	0.14	0.17	0.22	0.14	0.13	0.01	0.11	0.29	1.21
B5	0.16	0.22	0.23	0.24	0.10	0.01	0.07	0.29	1.32
<b>B6</b>	0.18	0.15	0.22	0.24	0.18	0.01	0.10	0.31	1.38
<b>B</b> 7	0.24	0.26	0.30	0.27	0.18	0.03	0.08	0.34	1.70
<b>B</b> 8	0.31	0.32	0.41	0.41	0.31	0.02	0.20	0.29	2.26
С	1.50	1.62	2.02	2.09	1.36	0.18	0.91	2.44	-

The threshold value represents the mean value of all the final values obtained in the total relation and direct-indirect matrix. All the values above the threshold values have influence on the other barriers. The threshold value represents how one barrier affects other barrier, this is why the threshold value allows to differentiate between the significant and insignificant results [59]. The gray fields in the Table 3 indicate the relations greater than threshold values (threshold value = 0.19).

From the T matrix, by analyzing the values of sum of column and rows the cause and effect relationship is explored. The sum and difference values of row sum (R) and column sum (C) are plotted below in the Table 7. The negative values of (R-C) represent the effect relationship and its positive values represent the cause relationship.

From the above Table 7 it is that 2 barriers are under category of cause and 6 barriers are in effect category.

Finally, the causal diagram (Figure 2) could be acquired by mapping a data set of (R+C, R-C). All the barriers above the x-axis were causal drivers and the drivers that were below the x-axis were effect drivers.

Bi	R+C	R-C	Rank	Relationship
B1	2.93	-0.06	4.00	effect
B2	2.72	-0.53	5.00	effect
B3	3.74	-0.30	2.00	effect
B4	3.30	-0.88	3.00	effect
B5	2.69	-0.04	6.00	effect
B6	1.55	1.20	8.00	cause
<b>B</b> 7	2.62	0.79	7.00	cause
<b>B8</b>	4.70	-0.18	1.00	effect

Table 7. Prominence and influence of each concern.



Figure 2. Causal influential diagram for barriers of LA implementation.

An observed illustration of the essential aspects and the interconnection among them is the causal relationship diagram. On the basis of Table 6 in the Figure 3 is shown representation of the interrelationships of each barrier with the others. The diagraph is plotted by calculating average values of T matrix. The direction of arrow from each barrier is decided from this threshold value. If the entries in the T matrix is greater than the threshold value, then the arrow is plotted from this barrier to the corresponding other barriers.

According to the data set (R–C) values, 8 barriers, sector have been classified into cause and effect group (Table 7). From the above table it is clear that 2 barriers are under category of cause and 6 barriers are in effect category. Two barriers of cause category are: The need to meet statutory requirements (B6), Dependency on parent company (B7). Six barriers of effect category are: Lack of appropriate knowledge and competences of the department responsible for management accounting (B5), Lack of accounting staff (B1), Resistance to change (B8), Management inertia (B3), Lack of adequate computing resources (software) (B2), Poor communication between operational, financial and accounting areas (B4).



Figure 3. Causal relationship diagram for barriers LA implementation.

Among the entire cause group, the need to meet statutory requirements (B6) has the highest value of (R-C), i.e., 1.20 which signifies that (B6) has the highest influence on the whole system. However, the value of (R+C) for that barrier is relatively low which means that this barrier is not influenced by other barriers (it has few drivers)

Focusing on the causal performance indicators (the ones in the upper part of the influence map), it is worth highlighting that those barriers are perceived as "external", i.e., imposed from the company's environment.

The index (R+C) measures the intensity of the influence, meaning that the barriers to lean accounting implementation for which this index is closer to zero are the ones that have the lowest intensity of influence, and the ones with a higher value have a greater intensity of influence. On the basis of importance according to (R+C), the identified barriers are ranked as (Table 5): Resistance to change (B8), Management inertia (B3), Poor communication between operational, financial and accounting areas (B4), Management inertia (B3), Poor communication between operational, financial and accounting areas (B4), Lack of appropriate knowledge and competences of the department responsible for management accounting (B5), Dependency on parent company (B7), The need to meet statutory requirements (B6). We can see in Table 5, that Resistance to change (B8) is ranked 1st on the basis of (R+C) with the value of 4.70, while Management inertia (B3) is ranked 2nd with (R+C) value of 3.74.

It is very important that Resistance to change (B8) is affecting all of the other barriers except The need to meet statutory requirements (B6). In the past studies also concluded that, "Resistance to change" is very significant barrier [23,43], therefore, it must be solved first to implement LA practices [63].

# 5. Conclusions

The research has significant implications for the business practice of manufacturing units, as it was empirical in nature, relied on ownership experience and feedback, and was based on a proper theoretical framework [64].

In this paper, an attempt has been made to identify barriers to the implementation of lean accounting in manufacturing companies through a literature review and analyze the interrelationships among selected barriers. Identifying barriers can help organizations allocate resources more efficiently and make informed decisions about the appropriate timing and approach for LA implementation. It allows them to tailor their implementation strategies according to their specific needs and circumstances, increasing the chances of successful adoption [22]. Additionally, understanding barriers to LA implementation can foster a culture of continuous improvement within the organization. By pinpointing areas that need improvement, companies can engage in targeted training, change management, and process reengineering to enhance their readiness for LA adoption.

Furthermore, identifying barriers can contribute to knowledge-sharing and collaboration among industry practitioners and researchers. The insights gained from studying implementation challenges can be shared through academic publications, conferences, and industry forums, facilitating the advancement of knowledge and best practices in LA adoption.

This study contributes to the existing literature in three ways. Firstly, it identifies the list of barriers to lean accounting implementation in previous literature. Secondly, it categorizes the most relevant barriers in Polish industrial enterprises into cause and effect groups. Thirdly, it presents the degree of impact of these barriers on each other.

The factor identified as the most significant barrier to adopting lean accounting principles is resistance to change. Although this barrier was classified in the effect group, it has the strongest influence on other barriers. Managers aiming to successfully implement lean accounting should prioritize creating an organizational culture that is conducive to change.

In conclusion, identifying barriers to Lean Accounting implementation is crucial for organizations seeking to implement Lean Management effectively. It empowers them to overcome challenges, optimize resources, and foster a culture of continuous improvement, ultimately leading to the successful integration of LA and the realization of its benefits in streamlining production and improving overall organizational performance.

The presented DEMATEL technique can also be applied in other areas where critical factors among different influencing components need to be identified. It is also applicable to situations that require group decision-making with complex variable segmentation in an ambiguous setting.

Although the proposed method shows potential in evaluating and analyzing the interaction of barriers in lean accounting implementation, further research expansion is recommended.

The limitations of this research should be considered when interpreting its results. One limitation is the possibility of bias in expert decisions and differences in opinions during the scaling of barriers. Another limitation could be the selection of barriers to lean accounting implementation in manufacturing companies, as the analyzed barriers are not specific to a particular type of manufacturing company.

Based on these limitations, future research directions can be suggested, which should primarily include studying the barriers to the diffusion of lean management accounting methods and researching the long-term impact of situational factors, particularly the SARS-CoV-2 pandemic (COVID-19), on lean management accounting practices.

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