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# How to foster Sustainable Continuous Improvement: A cause-effect relations map of Lean soft practices

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ABSTRACT

Lean Management (LM) represents a complex socio-technical system where both technical and social practices should be consistently implemented and integrated in order to foster a Continuous Improvement (CI) culture. Despite initial gains in operational performances due to the implementation of the most common and well-established Lean techniques, the great majority of the companies approaching Lean Manufacturing fail in achieving sustainable outcomes in the long term, and most of them eventually come back to their traditional way of doing business. Recognized the pivotal role of soft practices, the purpose of this study is to investigate the role played by the human factor in fostering the establishment of a Sustainable Continuous Improvement (SCI) environment.

Starting from surveying the literature, a comprehensive framework including all the relevant soft practices related to LM has been developed. Then, authors proposed, for the first time, Decision-Making Trail and Evaluation Laboratory (DEMATEL) analysis applied to soft practices of SCI, that provides an innovative understanding of the relevant soft practices which foster SCI by showing cause-effect association among them.

The proposed methodology reveals precious insights for scholars and practitioners who intend to approach and apply SCI. The impact relations map shows that some soft practices are initiators and some others enablers of the SCI and allows to identify the most relevant Critical Success Factors (CSF) and interrelationships amongst them. Results show that the key for a SCI is represented by a full engagement of the workforce, which must be triggered and supported by Top Management with the use of some leverages such as an effective communication, training and use of Kaizen events.

## 1. Introduction

Since its birth during ‘50s in Japan, Lean Manufacturing (LM) has been defined in several ways by researchers and practitioners. Many of these definitions refer to LM as a complex socio-technical system composed of a combination of synergetic and mutually reinforcing practices, where both technical and human aspects must be carefully integrated [1]. The goals of such system are related to the achievement of best in quality products at the lowest cost and with the shortest lead time through shortening the production flow by eliminating wastes and deeply engaging the workforce [2]. Driven by the successful path trodden by Toyota and other Lean enterprises, several companies established all over the world and competing in the most varied sectors have been adopting LM practices to reach superior performance, reduce costs and gain an edge over competitors [3]. The performance advantages that LM can enable are strictly related to a strong commitment to Continuous Improvement (CI) enabled by people development [4]. CI consists of highly frequent minor changes that, added up, may entail a revolution [5], and result in a positive impact on performance [6].

Despite the evidence widely demonstrates the strong operational performance improvements that LM practices entail, many companies struggle with its implementation, meaning that the simple utilization of the different tools does not ensure sustainable increased performances in the long term. The evidence suggests that two out of three organizational change processes fail [7] and in many cases companies that fail in implementing LM return back producing according to their traditional means. Other studies state that less than 10 per cent of companies succeed at properly implementing LM practices and at a CI philosophy [8]. The isolated use of tools such as 5S, SMED, JIT and other

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techniques, could bring strong improvement of performances that cannot be sustained over time if the company is not able to change the organizational culture [3]. A fundamental issue that must be considered when implementing Lean is related to the correct adoption of the so called “Soft Practices”, which represent the heart of the Toyota Production System [9]. Indeed, [10] define sustainability as nothing other than an employee-based process improvement. The scarce attention to Lean soft practices is the undermining cause of failures in Lean and CI programs [9,11]. Organizations aiming at implementing TPS and CI with sustainable outcomes in the long-term must consider the strong involvement of all the individuals, otherwise the risk is to fail and nullify the results obtained at the very beginning.

For these reasons researchers in Operations Management literature have been placing increased attention on the human issues affecting sustainability. However, a clear understanding of the “soft” factors that enable the establishment of a CI culture is still missing. Pearce et al. [12] gave a better understanding of some qualitative human factors that affect the success of Lean implementation, however, as authors mentioned, since the variables are qualitative, it is more difficult to express the complex relationships of causality between the variables. Moreover, for many of the factors that is possible to find in literature it is sometimes hard to agree about their effect towards sustainability, being them presented as successful factors in some researches or barriers that hinder the successful implementation of Lean in some others. In order to address these challenges, different techniques related to decision science and operations research can be useful. For example, Pearce et al. [12] identify critical success factors for Lean implementation using two case studies in SME companies, while Jadhav et al. [13] investigate barriers to Lean implementation using an extensive literature review methodology. One such technique, Decision Making Trial and Evaluation Laboratory (DEMATEL), that takes into account both quantitative data as well as a variety of qualitative data, has been proposed in this study in order to address its objective. DEMATEL is, in fact, one of the best tools to deal with the importance and causal relationships among evaluation criteria. The reason for the DEMATEL choice comes from its ability to confirm interdependence among considered factors, and its ability to derive a direct graph showing the interrelationships among factors [14]. The DEMATEL approach has been used successfully to identify causal relations among the research factors in several research fields, including Lean Manufacturing [15,16].

On these premises, this research study is aimed at identifying a comprehensive framework of “soft” practices essential to a proper and successful LM implementation. It will provide researchers and practitioners with a bundle of Critical Success Factors (CSF), understanding their relevance towards the achievement of a successful and sustainable CI culture and especially discovering their interrelationships. In order to do so, authors choose the DEMATEL technique as it is perfectly suitable with the aim of the study and it represents an element of novelty, since no application in this area of investigation exists.

Therefore, the objective of this research is twofold: on the one hand, authors want to identify the most important CSF related to Lean soft practices that are essential for a successful Lean transformation and for the sustainability of CI programs. On the other hand, the objective is to understand the main causal interrelationships that exist among these identified CSFs, in order to better exploit them when implementing Lean, towards a SCI environment.

To achieve this objective a Systematic Literature Review has been carried out to identify and expand the body of knowledge concerning variables associated with the implementation and sustainability of LM and CI. Then, DEMATEL [14,17] study is proposed to investigate the importance and interrelations among the CSFs identified from the literature review. This research presents some relevant aspects of novelty, as it tries to build a comprehensive framework including all the most relevant softer characteristics of a Lean initiative. The most important aspect is that it comes up with a way of establishing the interdependences between these factors using DEMATEL, overcoming the difficulty of expressing causality relationships between qualitative variables [12] and therefore providing new insightful guidelines to Lean practitioners.

The paper is organized as follows: the systematic literature review and the main outcomes are discussed in Section 2. The research method is presented in Section 3, the analysis of results is shown in Section 4 and the discussion of the results is presented in Section 5. Finally, in Section 6, conclusions are drawn.

## 2. Systematic literature review (SLR)

The research study carried out a systematic literature review because it is a comprehensive and reproducible method for identifying, evaluating and synthesising works produced by researchers, scholars and practitioners [18].

The approach in this research study included a nine-step systematic literature review, divided into three stages [19,20].

The SLR purpose [20,21] has been addressed in Section 1 and the protocol was outlined and organized to conduct the systematic literature review steps to achieve the purpose of this study. The focus is placed on the variables that enable the implementation and sustainability of Lean and CI, which could be considered pivotal for the improvement of firm's performances.

### 2.1. Planning the review and searching the literature

The objective of this SLR is to analyse and expand the body of knowledge related to Lean and CI in order to identify the soft practices affecting the success in Lean implementation and sustainability. Then, the review protocol was structured and organized thoroughly to conduct the steps of the SLR towards the achievement of the purpose of the study.

The literature search was carried out through the examination of reputed referred scholarly sources, including journal articles, books, conference proceedings and reports. The most efficient way for searching the literature is utilizing electronic databases [22], therefore the authors decided to rely on searching engines such as Scopus, Elsevier Science Direct, Emerald, Google Scholar, Taylor & Francis, IEEE Explorer and JSCOR. The search on databases was conducted using the following set of primary keywords: “Lean Production”, “Continuous Improvement”, “Lean”, “Lean Manufacturing”, “Lean Management”, “Kaizen” and “TPS”. Keywords were combined to create different search strings using Boolean connectors (AND, OR and NOT).

Once articles were reviewed, other cited articles were added following the principle of snowballing [23]. The research has been carried out from the year of publication of [24] book “The machine that changed the world” until 2018. Indeed, this book has been credited as the first document to coin the name Lean production [25], although the concepts of JIT, TQM and TPS were already known almost a decade before its publication [26,27]. Therefore, this document had a crucial role in spreading and disseminating the concept of LM all around the world.

Detailed information about the literature search is provided in Table 1.

### 2.2. Screening

The next screening step involved removing all duplicates according to the title and author. This study determined research inclusion and exclusion criteria to ensure fidelity and comprehensiveness. These criteria are critical to the quality assessment of papers [28]. Authors examined research articles by title, abstract and keywords. By this means, all articles that met the inclusion criteria were selected.

Authors excluded articles not belonging to the following areas of research: business, management & accounting, engineering, decision

**Table 1**
Literature search criteria.

| Period of publication | Electronic databases | Primary keywords | Secondary Keywords Group 1 | Group 2 |
|---|---|---|---|---|
| From 1990 to 2016 | Scopus | Lean Production | Success factors | Implementation |
| | Elsevier science direct | Continuous improvement | Soft practices | Sustainability |
| | Emerald | Lean | Soft skills | Failure |
| | Google scholar | Lean manufacturing | Barriers | |
| | Taylor & Francis | Lean management | Enablers | |
| | IEEE explorer | Kaizen | CSF | |
| | JSCOR | TPS | | |

sciences, social sciences, industrial engineering, manufacturing engineering, and operations research.

Only well-known academic databases were searched for academic journals and papers that contained a robust and profound analysis of findings. Some of the collected articles were excluded because out of scope of research study's object.

The research study used secondary keywords to focus on the objective of the study and so on the sustainability of CI programs through correct soft practices. The first group of secondary keywords includes the following ones: “Success Factors”, “Soft Practices”, “Soft Skills”, “Enablers”, “Barriers”, “CSF”. While the second group of secondary keywords includes “Implementation”, “Sustainability”, “Failure”.

Searching the online databases and firstly addressing primary keywords and then considering secondary keywords, the authors read the abstracts and reviewed the full papers, focusing on soft practices affecting Lean Implementation and CI sustainability, that are represented by 74 papers.

Screening the list of papers produced by the SLR, authors have been able to identify 24 variables which are referred to soft practices affecting Lean and CI implementation and its sustainability. Variables and the related citations are listed in Table 2.

### 2.3. Thematic analysis

As a first step of the thematic analysis, the variables were coded, analysed and sorted according to some categories. In particular, authors identified commonalities between variables that allowed to define three categories: cultural, organizational and managerial variables as shown in Table 3. Moreover, the SLR produced a set of 24 variables, which represent a very high degree of complexity to be incorporated in the study. Therefore, authors referred to the principle of reductionism [98], in order to build a framework of CSF including the lowest possible number of variables. This allows to increase simplicity of understanding as well as the effectiveness of the research. Exploiting the categorization shown in Table 3, it has been possible to merge the variables within each category and to achieve a final classification including 14 CSFs used to perform further analysis. The result of this process of rationalization of variables is shown in Table 4.

## 3. Methodology

The SLR led to the identification of 24 variables that influence the implementation and sustainability of Lean and CI. Thus, through a detailed analysis of the selected literature, 14 CSFs were deployed and recognized as the most relevant and they have been used for the DEMATEL analysis.

**Table 2**
24 CSFs identified from the SLR.

| Serial no. | Variable | Resources | Total Resources |
|---|---|---|---|
| 1 | Employee engagement | [29]; [30]; [31]; [32]; [33]; [34]; [10]; [35]; [36]; [37]; [38]; [39];[40]; [41]; [42]; [43];[44]; [45]; [46]; [47]; [48]; [49];[50]; [51];[52];[53];[54]; [55]. | 28 |
| 2 | Training for employees | [56]; [30]; [33]; [57]; [31]; [34]; [58]; [59]; [13]; [1]; [38]; [36]; [37]; [40]; [41]; [60]; [61]; [48]; [62]; [63]; [49];[50]; [51];[64];[54]. | 25 |
| 3 | Top management commitment | [65]; [33]; [66]; [66]; [67];[68]; [69]; [34]; [58]; [70];[13]; [36]; [38];[39]; [41]; [42]; [3]; [46]; [61]; [48]; [62];[50]; [64]. | 22 |
| 4 | Leadership | [56]; [30];[33]; [66];[67]; [68]; [69]; [34];[13]; [70];[13];[13]; [36]; [39]; [37];[13]; [46]; [62]; [64];[54]. | 21 |
| 5 | Teamwork | [29]; [65]; [56]; [30]; [31]; [71]; [72]; [73]; [10]; [74]; [39]; [42]; [43]; [75]; [52];[53];[54]; [55]. | 18 |
| 6 | Communication | [56]; [76]; [33]; [66];[69]; [77]; [34]; [59]; [41]; [78]; [43]; [46]; [61];[64];[54]; [55]. | 16 |
| 7 | Decentralized decision-making | [65]; [30]; [31];[70];[13];[38]; [39]; [43]; [60]; [44]; [45]; [49]; [54]; [55]. | 14 |
| 8 | Performance measurement system | [56]; [31];[69]; [68]; [77];[79]; [80]; [41]; [43]; [47]; [61]; [51]; [54]. | 13 |
| 9 | Working conditions/environment | [33]; [81]; [82];[83];[1];[40];[43];[61];[63];[52];[53];[55]. | 12 |
| 10 | Bottom-up vs Top-down approach | [84];[67];[85];[59];[10];[47];[45]; [46];[48]; [54]. | 10 |
| 11 | Kaizen Events (Jishuken) | [32]; [66];[57]; [68];[69];[86]; [87];[46]; [88]. | 9 |
| 12 | Consultants | [89]; [66];[13];[44];[45]; [46]; [61];[64]. | 8 |
| 13 | Training for management | [31];[33];[90];[68];[34];[13]; [61]; [51]. | 8 |
| 14 | Cultural mindset | [67];[85];[72]; [13];[42];[78];[3]; [55]. | 8 |
| 15 | Employee resistances | [30]; [13]; [41];[43];[44]; [48];[63];[64]. | 8 |
| 16 | Non-Financial Rewards | [1];[36];[91];[78];[62];[52];[51]; [53]. | 8 |
| 17 | Mutual Trust between management and employees | [56];[30]; [76];[92]; [13];[78];[54]. | 7 |
| 18 | Financial rewards | [56]; [91];[40];[41];[60]; [54]. | 6 |
| 19 | Cross-functional teams | [66]; [92];[13]; [44];[54]. | 5 |
| 20 | Employee ambidexterity | [30];[93];[94];[95];[45]. | 5 |
| 21 | Unionized workforce | [29];[96];[33];[97]. | 4 |
| 22 | Dedicated lean implementation teams | [57];[91]; [97];[61]. | 4 |
| 23 | Knowledge transfer | [57];[79]; [45]. | 3 |
| 24 | Top management resistances | [13]; [44];[63]. | 3 |

**Table 3**
Definition of the three categories used to classify the 24 CSFs identified from the SLR.

| Category | Description | Variables Included |
|---|---|---|
| Cultural | Variables in this category refer to behavioral aspect of each individual within the organization, comprising both shop-floor employees, Top Management and executives. With individual behaviors, it is intended the way each individual relates himself with respect to other individuals as well as with the organizational environment, especially in evolving contexts that require mental flexibility and engagement, as LM does. In addition, this category also considers general cultural aspects at the whole organization level, related to values, norms and behaviors that are rooted in the organizational culture and characterize the actions of all the individuals. | 1, 3, 4, 14, 15, 17, 20, 24 |
| Organizational | This category refers to macro-organizational mechanisms that are necessary for a successful introduction of LM principles, as well as for sustaining Continuous Improvement contexts. This category also comprises external aspects that influence the way the change process of Lean introduction is implemented as well as its probability to succeed. | 5, 10, 11, 12, 19, 21, 22 |
| Managerial | This category comprises variables that represent levers available to the management for stimulating the involvement of all employees towards Continuous Improvement. Moreover, it includes those variables related to the organization and coordination of the work at the level of each single individual, including also the empowerment of each employee. | 2, 6, 7, 8, 9, 13, 16, 18, 23 |

To identify interviewees with an adequate knowledge and experience in the field of LM and CI, a "purposive sampling" approach was used. Purposive sampling enables researchers to meet the goals defined by the research aim in conjunction with controlling the level of variation among the interviewees [99]. Authors selected a preliminary list of organizations with certified experience in the field of LM. Fifteen Lean Six Sigma (LSS) Master Black Belts (MBB) from twelve organizations agreed to take part in the study. Authors decided to target experts

**Table 4**
14 CSFs resulted from the rationalization process submitted to a DEMATEL study.

| Code | CSF | Definition | Variables Encompassed |
|---|---|---|---|
| C1 | Employee engagement | Regular participation of employees in the definition and standardization of new operating procedures. Participation in decision-making processes, goal setting, planning and monitoring of performances. A motivated employee shows physical and emotional engagement as well as strong awareness and commitment towards the CI. | 1, 14, 15, 20 |
| C2 | Top management commitment | Direct participation of Top Management in CI programs, dedicating time to teamwork participation, setting the goals of CI, providing resources and intellectual support to the employees through coaching and mentoring. Top Management should be physically present in the shop-floor transmitting engagement and motivation to employees. | 3, 24 |
| C3 | Leadership | Lean Leadership is a methodological approach to the sustainable implementation of continuous improvement in Lean Production Systems. It is the ability to perceive cultural limitations of individuals and to make them evolve and adapt to different situations. A leader is able to establish a clear vision and to share it through coaching and mentoring. He is able to act using creativity in complex situations, being an inspiration for other employees. | 4, 17 |
| O1 | Teamwork | Capability to organize the work in teams, in order to support CI processes. Teamwork requires that each member has the responsibility and the capability to co-operate, to communicate honestly, to share ideas, to provide constructive feedbacks and to ensure the comprehension and engagement of all the team members, overcoming any type of personal conflict. | 5, 22, 19 |
| O2 | Consultants | Hiring consultants or external expert collaborators, especially in early stages of LM implementation, who provide methods, expertise and specialized knowledge to the organization establishing a well-defined and structured process of CI. | 12 |
| O3 | Unionized workforce | Rooted presence of one or more labor unions in the organization, to which the employees adhere. Decision-making power of these unions in case of a change in working conditions of employees. | 20 |
| O4 | Kaizen events | A Kaizen event ("jishuken" in Japanese) is a well-focused project that uses dedicated cross-functional teams in order to bring quick radical improvements in a specified area of work, with specified objectives, in an extremely limited period (usually less than a week), using limited capital investments. The Kaizen event is opposite to the more general concept of Kaizen, which according to the Japanese definition represents the continual and incremental process of CI. | 11 |
| O5 | Bottom-Up approach | The bottom-up approach to CI requires the direct and proactive participation of every employee and process owner, in order to let problems emerging and suggesting ideas for improvement. | 10 |
| O6 | Top-Down approach | The top-down approach requires the application of solutions which have been studied and defined by a small group of experts. It is based on the application of specific techniques devoted to the achievement of precise objectives. | 10 |
| M1 | Working conditions/ environment | The introduction of LM entails a change in working conditions for employees. This variable is related to the perception that the workers have with respect to their safety on the job, their health, stress and in particular their fear of losing job due to the introduction of the new managerial philosophy. | 9 |
| M2 | Training and job empowerment | Training for employees - as well as for the management itself - it is necessary in order to transmit the principal concepts and techniques of LM, to gain the awareness and responsibility necessary to sustaining the CI. Moreover, the employees must be able to perform a multitude of tasks in order to be flexible and interchangeable, and above all they must be given the possibility to make decisions autonomously, experimenting new ideas without appealing to the usual bureaucratic procedures dictated by the hierarchy. | 2, 7, 13 |
| M3 | Non-Financial rewards | Recognitions for employees which can represent a strong source of motivation, such as public celebration of employees who achieve excellent performance applying Lean techniques and principles; meetings to celebrate the good work of employees and encouraging constructive cooperation between them; etc. | 16 |
| M4 | Financial rewards | Bonus payments based on operational improvements related to CI programs and aimed at encouraging participative behaviors of employees. | 18 |
| M5 | Communication | To communicate, to inform and to discuss about LM implementation, to listen to employees and to explain the needs of change, clarifying and developing a shared comprehension of goals. Implementation of mechanisms that improve communication within the whole organization in order to spread the results achieved thanks to CI programs. | 6, 8, 23 |

with this specific LSS certification for three main reasons: firstly, practitioners with a MBB must have at least ten years of experience in the field of Lean Six Sigma; secondly, they must have a successful experience in at least 10 Lean implementation projects and, thirdly, during their training program, they receive a solid preparation in terms of soft practices and leadership [100], which is the central focus of this paper. Six out of the fifteen respondents are expert consultants coming from three different consultancy firms specialized in Lean transformation, while the remaining ones come from different industrial sectors: automotive, electromechanical, electronics, food and beverage and textile. The level of homogeneity amongst interviewers, since they possess the same LSS certification and they are all expert representatives of firms in the manufacturing and services industry, ensures to reach the level of saturation as suggested by Guest et al. [101]. According to Mason et al. [102], the size of the sample in qualitative research becomes irrelevant due to the fact that the value of the study is based on the quality of data [103,104]. Moreover, the willingness of these fifteen interviewees to be involved in the study was one of the major reasons for recruiting them. According to Simms and Rogers [105], implementing this approach increases the richness of data due to the commitment of the interviewees. In addition, Chen [106] stated that for multi-criteria decision-making models such as DEMATEL, the optimal number of interviewees ranges from 5 to 15.

### 3.1. Application of the DEMATEL technique

The 14 CSFs identified in this study as the most relevant for the successful implementation of LM have been undergone to a DEMATEL study in order to identify their relative importance and their interrelations. DEMATEL has been applied to solve problems concerning decisions in order to clarify the essential features of problems and help to develop countermeasures [107]. It is recommended for situations like this, where scarce evidence is available from few case studies, as an instrument to support holistic and qualitative analysis.

The DEMATEL method illustrates the interrelationships among criteria, finds the central criterion to represent the effectiveness of factors, and avoids "overfitting" for evaluation. It works through the structuring of complicated causal relationships matrices or digraphs that portray relationships between systems components with the strengths of relationships quantitatively portrayed [108]. Although other approaches may be used, such as Interpretative Structural Modelling (ISM) or the Analytical Hierarchy Process (AHP), the DEMATEL digraph structural evaluation technique has some advantages [109]. It allows for a broader discrimination of measures (ISM only has 0–1 levels) and multiple directional relationships (AHP has a unidirectional relationship and multiple separate matrices requiring integration). Moreover, the DEMATEL approach does not need large amounts of data and is capable of revealing the relationship among factors influencing other factors [110].

Literature suggests that this method can be used in many application fields, including industrial planning and decision-making issues, for the analysis of interrelationships between criteria. Lin et al. [111] used DEMATEL for the analysis of design service of Integrated Circuit, while Najmi [112] used it for understanding the relationships between performance metrics of supply chain and finally [113] used DEMATEL to support organizations in selecting the most suitable initiatives for performance improvements in manufacturing industry.

### 3.2. Calculation steps of DEMATEL

***Step 1: Generation of average matrix***

Suppose, in a problem that considers $n$ criteria, that binary relations and the strength of each relation are investigated. An $n \times n$ matrix $Ak$ from the $kth$ expert's questionnaire is derived. The $aij(k)$ represents the degree of influence of criterion $Ei$ on $Ej$, which then forms the influence matrix $Ak$. The pairwise comparison scale designates five levels with the scores of 0, 1, 2, 3, and 4 representing "no influence", "low influence", "moderate influence", "high influence", and "very high influence", respectively. The same respondents were asked to assign the scores according to their opinions.

Suppose $m$ is the number of experts consulted. The $n \times n$ average matrix $Z$ is found by averaging all the experts' scores.

***Step 2: Normalized initial direct-relation matrix***

On the basis of the average matrix $Z$, the normalized initial direct-relation matrix $X$ can be obtained through expressions (1) and (2).

$$S = \max\left(\sum_{j=1}^{n} zij,\ \sum_{i=1}^{n} zij\right) \tag{1}$$

[116]

$$X = \frac{Z}{S} \tag{2}$$

[116]

***Step 3: The total relation matrix (T)***is determined by expression (3), where $i$ represents an $n \times n$ identity matrix. Matrix N indicates only direct relations. A continuous decrease of the direct effects of problems along the powers of matrix $X$, for example, $X\hat{}2$, $X\hat{}3$, $X\hat{}4$, and so on, guarantees convergent solutions to the matrix inversion, similar to an absorbing Markov chain matrix [114]. The total relation matrix T is an $n \times n$ matrix as follows:

$$T = \sum_{q=1}^{\infty} X^i = X + X^2 + X^3 + \cdots + X^q = \frac{X(I - X^q)}{(I - X)} = \frac{X(I - X^\infty)}{(I - X)} = \frac{X}{(I - X)} = X(I - X)^{-1} \tag{3}$$

[114]

***Step 4: Prominence and Relevance***

***Step 4a:*** Determine row *(Ri)* and column *(Dj)* sums for each row I and column J from the total relation matrix (T). That is:

$$Dj = \sum_{j=1}^{n} tij \quad \forall\, j \tag{4}$$

[114]

$$Ri = \sum_{j=1}^{n} tij \quad \forall\, i \tag{5}$$

[114]

The row values $Ri$ are the overall direct and indirect effects of the barrier $i$ on other barriers. Similarly, the column values $Dj$ represent the overall direct and indirect effects of all barriers on barrier $j$.

***Step 4b:*** Determine the overall prominence *(Pi)* of barrier i and the net effect *(Ei)* of barrier i using expressions (6) and (7).

$$Pi = \{Ri + Dj | i = j\} \tag{6}$$

[114]

$$Ei = \{Ri - Dj | i = j\} \tag{7}$$

[114]

The larger the value of $Pi$, the greater the overall prominence (visibility/importance/influence) of barrier $i$ in terms of its overall relationships with other barriers. If $Ei > 0$, then barrier $i$ is a net cause, or foundation, of other barriers. If $Ei < 0$, then barrier $i$ is a net effect of other barriers [115].

***Step 5: Set a threshold and draw the cause–effect diagram***: In order to explain the structural relationship among the criteria while keeping the complexity of the system to a manageable level, it is necessary to set a threshold value to filter out negligible relationships in matrix $T$. If the value is too low, the diagram will be too complex to show the necessary information for decision-making. If it is too high, many criteria will be presented as independent criteria, without showing the relationships

**Table 5**
Average matrix A.

| | C1 | C2 | C3 | O1 | O2 | O3 | O4 | O5 | O6 | M1 | M2 | M3 | M4 | M5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 0,00 | 1,60 | 1,20 | 1,40 | 3,60 | 1,27 | 2,00 | 3,40 | 3,67 | 1,60 | 2,67 | 2,67 | 1,87 | 1,27 |
| **C2** | 3,53 | 0,00 | 1,60 | 3,20 | 3,07 | 2,53 | 2,07 | 3,20 | 2,93 | 3,13 | 3,13 | 3,33 | 2,93 | 2,60 |
| **C3** | 2,27 | 1,80 | 0,00 | 2,40 | 2,13 | 1,27 | 1,33 | 1,93 | 2,13 | 2,20 | 1,67 | 1,80 | 0,87 | 0,73 |
| **O1** | 3,73 | 3,20 | 1,60 | 0,00 | 3,33 | 1,60 | 1,80 | 3,33 | 3,53 | 2,80 | 2,67 | 3,13 | 2,40 | 1,93 |
| **O2** | 3,60 | 2,13 | 0,87 | 2,27 | 0,00 | 1,27 | 1,07 | 3,33 | 3,73 | 2,33 | 2,00 | 2,47 | 1,73 | 0,73 |
| **O3** | 2,40 | 2,80 | 1,00 | 2,47 | 2,53 | 0,00 | 0,40 | 3,40 | 2,60 | 2,80 | 1,40 | 3,13 | 1,07 | 0,80 |
| **O4** | 2,07 | 1,47 | 1,00 | 1,20 | 1,20 | 0,40 | 0,00 | 1,07 | 1,73 | 1,47 | 2,20 | 1,80 | 1,33 | 2,27 |
| **O5** | 3,73 | 2,73 | 1,47 | 2,67 | 3,80 | 2,00 | 1,00 | 0,00 | 3,73 | 2,13 | 2,53 | 3,13 | 1,73 | 1,20 |
| **O6** | 3,80 | 2,27 | 1,67 | 2,67 | 3,73 | 1,47 | 2,00 | 3,40 | 0,00 | 1,80 | 2,67 | 2,27 | 2,33 | 1,60 |
| **M1** | 1,87 | 3,33 | 1,73 | 2,27 | 2,00 | 2,60 | 1,33 | 2,00 | 1,67 | 0,00 | 1,80 | 2,80 | 1,93 | 2,47 |
| **M2** | 3,20 | 2,20 | 1,40 | 2,13 | 2,93 | 1,13 | 2,80 | 2,00 | 3,07 | 1,80 | 0,00 | 1,87 | 1,33 | 1,07 |
| **M3** | 3,40 | 2,40 | 2,13 | 3,20 | 3,07 | 1,93 | 1,67 | 3,13 | 3,40 | 2,60 | 2,67 | 0,00 | 1,87 | 1,13 |
| **M4** | 2,60 | 1,73 | 1,47 | 1,67 | 2,33 | 0,60 | 1,47 | 2,07 | 2,67 | 1,53 | 2,27 | 1,60 | 0,00 | 0,73 |
| **M5** | 2,53 | 2,13 | 1,67 | 1,47 | 1,27 | 0,73 | 2,13 | 1,33 | 1,93 | 2,00 | 1,73 | 1,13 | 0,87 | 0,00 |

with other criteria. An appropriate threshold value is necessary to obtain a suitable cause–effect diagram as well as adequate information for decision-making [114].

In the discussion results, two different cases will be presented which will take into account two different thresholds set by following two different methodologies.

The threshold value can be chosen by the decision maker or through discussions with experts. Therefore, each researcher will obtain the threshold value in a different way. The threshold in the first case is set up using the Maximum Mean De-Entropy Algorithm (MMDE). This algorithm is based on the notion of information entropy, which is used as a criterion to understand the amount of disorder or uncertainty represented by a discrete probability distribution. By contrast, the information de-entropy provides a measure of the amount of useful information embedded in a given dataset. Following the detailed description, provided [114], the MMDE algorithm is used to derive a set of dispatch-nodes, whose corresponding CSFs strongly influences other factors, and a set of receive-nodes, which are easily influenced by another factor. According to these two sets, a unique threshold value can be obtained for the impact-relations map. This algorithm differs from the traditional methods through which the threshold value is decided by searching for a suitable impact-relations map.

The threshold in the second case is calculated by taking into account the mean and standard deviation of the values *tij* from the matrix *T* and adding one standard deviation to the mean [17].

The MMDE uses the approach of entropy but also uses two other measures for the stability of information: “de-entropy” and “mean de-entropy”. MMDE is mainly used to decide whether a node is suitable for inclusion in the impact-relations map. With this method, a unique threshold value can be obtained, solving the problem of choosing the threshold value in the traditional way.

Based on a calculated total relation matrix T, the steps of the proposed MMDE algorithm to determine a threshold value are described as follows [114]:

a) Transform the *nxn* total relation matrix T into an ordered set *T {t11, t12, …, t21, t22, …, tnn}*, rearrange the element order in set *T* from large to small, and transform it into a corresponding set of ordered triplets *(tij, xi, xj)* denoted by *T**. Every element of set *T, tij*, can also be considered as an ordered triplet *(tij, xi, xj)* as (influence value, dispatch node, receive node).
b) Take the second element, the dispatch-node, from the ordered triplets of the set *T**, and then obtain a new ordered dispatch-node set, *Tdi*.
c) Take the first *t* elements of *Tdi* as a new set *Tdit*, assign the probability of different elements, and then calculate the *Hd* of the set *Tdit, HTdi*. Calculate the mean de-entropy using the following equation:

$$MDE_t^{Di} = H_t^{Di}/N\,(T_t^{Di}) \tag{8}$$

d) Considering the mean de-entropy values *(TtDi)*, choose the maximum mean de-entropy and its corresponding *TtDi*. This dispatch-node set, with the maximum mean de-entropy, is denoted as *Tmax Di*.
e) Similarly, to Steps b–d, an ordered receive-node set *Tre* and a maximum mean de-entropy receive-node set *TmaxRe* is determined.

Take the first *u* elements in *T** as the subset, *Tth*, which includes all the elements of *TmaxDi* in the dispatch-node and all elements of *TmaxRe* in the receive-node, the minimum influence value in *Tth* is the threshold value.

## 4. Analysis of results

***Step 1: Average matrix***

The respondents were asked to give scores of 0, 1, 2, 3 or 4 representing “no influence”, “low influence”, “moderate influence”, “high influence”, and “very high influence”, respectively, to indicate the influence of each relationship between the CSFs. By calculating the arithmetic average of respondents’ opinions, the average matrix *A* has been defined as follows in Table 5.

***Step 2: Normalized initial direct-relation matrix***

On the basis of the average matrix *A*, the normalized direct-relation matrix *N* is obtained through expressions (1) and (2). The *N* matrix is shown in Table 6.

***Step 3: The total relation matrix T***

The total relation matrix *T* is determined by expression (3), where I represents an $n \times n$ identity matrix, and it is presented in Table 7. Then the sum of rows and columns has been computed to obtain *D* and *R* values as presented in Table 8.

**Step 4: *Prominence and net effect***

Prominence and net effect: to calculate *(D + R)*, the *D* value and *R* value are taken from Table 8 and *Pi* and *Ei* were calculated and presented in Table 8 according to formulas (6) and (7).

The larger the value of *Pi = (D + R)*, the greater the overall prominence or importance of CSF*i* in terms of overall relationships with other CSFs. Therefore, this measure allows to identify the ranking of relative importance of the 14 CSFs. On the other hand, if the net effect *Ei > 0* (with *Ei = D – R*), then CSF*i* is a net cause or foundation of other CSFs (those values are highlighted in bold). If *Ei < 0*, then CSF*i* is a net effect of other CSFs [115]

**Step 5**

The threshold value obtained using MMDE is 0.31. Values equal to or higher than the threshold are presented in bold in the total matrix *T*, as shown in Table 7.

For example, the value obtained from the second row and the first

**Table 6**
Normalized initial direct-relation matrix N.

| | C1 | C2 | C3 | O1 | O2 | O3 | O4 | O5 | O6 | M1 | M2 | M3 | M4 | M5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 0,000 | 0,038 | 0,028 | 0,033 | 0,085 | 0,030 | 0,047 | 0,081 | 0,087 | 0,038 | 0,063 | 0,063 | 0,044 | 0,030 |
| **C2** | 0,084 | 0,000 | 0,038 | 0,076 | 0,073 | 0,060 | 0,049 | 0,076 | 0,070 | 0,074 | 0,074 | 0,079 | 0,070 | 0,062 |
| **C3** | 0,054 | 0,043 | 0,000 | 0,057 | 0,051 | 0,030 | 0,032 | 0,046 | 0,051 | 0,052 | 0,039 | 0,043 | 0,021 | 0,017 |
| **O1** | 0,088 | 0,076 | 0,038 | 0,000 | 0,079 | 0,038 | 0,043 | 0,079 | 0,084 | 0,066 | 0,063 | 0,074 | 0,057 | 0,046 |
| **O2** | 0,085 | 0,051 | 0,021 | 0,054 | 0,000 | 0,030 | 0,025 | 0,079 | 0,088 | 0,055 | 0,047 | 0,058 | 0,041 | 0,017 |
| **O3** | 0,057 | 0,066 | 0,024 | 0,058 | 0,060 | 0,000 | 0,009 | 0,081 | 0,062 | 0,066 | 0,033 | 0,074 | 0,025 | 0,019 |
| **O4** | 0,049 | 0,035 | 0,024 | 0,028 | 0,028 | 0,009 | 0,000 | 0,025 | 0,041 | 0,035 | 0,052 | 0,043 | 0,032 | 0,054 |
| **O5** | 0,088 | 0,065 | 0,035 | 0,063 | 0,090 | 0,047 | 0,024 | 0,000 | 0,088 | 0,051 | 0,060 | 0,074 | 0,041 | 0,028 |
| **O6** | 0,090 | 0,054 | 0,039 | 0,063 | 0,088 | 0,035 | 0,047 | 0,081 | 0,000 | 0,043 | 0,063 | 0,054 | 0,055 | 0,038 |
| **M1** | 0,044 | 0,079 | 0,041 | 0,054 | 0,047 | 0,062 | 0,032 | 0,047 | 0,039 | 0,000 | 0,043 | 0,066 | 0,046 | 0,058 |
| **M2** | 0,076 | 0,052 | 0,033 | 0,051 | 0,070 | 0,027 | 0,066 | 0,047 | 0,073 | 0,043 | 0,000 | 0,044 | 0,032 | 0,025 |
| **M3** | 0,081 | 0,057 | 0,051 | 0,076 | 0,073 | 0,046 | 0,039 | 0,074 | 0,081 | 0,062 | 0,063 | 0,000 | 0,044 | 0,027 |
| **M4** | 0,062 | 0,041 | 0,035 | 0,039 | 0,055 | 0,014 | 0,035 | 0,049 | 0,063 | 0,036 | 0,054 | 0,038 | 0,000 | 0,017 |
| **M5** | 0,060 | 0,051 | 0,039 | 0,035 | 0,030 | 0,017 | 0,051 | 0,032 | 0,046 | 0,047 | 0,041 | 0,027 | 0,021 | 0,000 |

column is 0.34, which means that C2 will affect C1.

Observing values inside the total relation matrix *T*, it is possible to notice that there are many relationships whose value is just below the MMDE threshold. That could arbitrary hide from our analysis some relationships that could be meaningful for our purpose. Therefore, in order to get a broader analysis of influences, authors computed a sensitivity range including as lower bound the threshold value 0.26 computed by adding one standard deviation to the mean of the values [17]. Values equal to or higher than the threshold value 0.26 and lower than MMDE threshold are underlined in the total relation matrix *T,* as shown in Table 7.

Finally, the impact relations map is drawn by plotting the coordinate values of each CSF on a scatter plot with a horizontal axis *(D + R)* and a vertical axis *(D − R)*, as shown in Fig. 1. Therefore, reading the map along the x-axis it is possible to recognize the CSF of higher importance on the righter side of the graph, while more marginal factors are displayed on the left. The map clearly shows a bundle of eight CSFs with a prominence level higher than 6, which are the most influential in the framework. This group includes in order of prominence Bottom-Up Approach (O5), Employee Engagement (C1), Top Management Commitment (C2), Kaizen Events (O4), Leadership (C3), Teamwork (O1), Communication (M5) and Training and Job Empowerment (M2). Whilst, it is possible to recognize four marginal factors on the left side of the map. These include Consultants (O2), Non-Financial Rewards (M3), Unionized Workforce (O3) and Financial Rewards (M4). On the other hand, the y-axis displays the most influencing factors on top of the map, while at the bottom it is possible to identify those factors that are more likely to be influenced in the model. Considering the eight CSF with the highest prominence it is possible to label Top Management Commitment (C2) and Leadership (C3) as “causes” in the framework, being them placed in the upper part of the map. Instead, Employee Engagement (C1), Teamwork (O1) and Bottom-Up Approach (O5) can be labelled as “effects”, being them at the bottom of the graph.

**Table 8**
Prominence and net effect.

| | D | R | Prominence D + R | Net Effect D-R | Ranking |
|---|---|---|---|---|---|
| **C1** | 27849 | 3697 | 6482 | −0912 | 2 |
| **C2** | 35804 | 2853 | 6434 | 0727 | 3 |
| **C3** | 34291 | 2769 | 6198 | 0660 | 5 |
| **O1** | 27879 | 3399 | 6187 | −0611 | 6 |
| **O2** | 27335 | 1824 | 4557 | 0910 | 11 |
| **O3** | 18157 | 2056 | 3871 | −0240 | 13 |
| **O4** | 31569 | 3244 | 6401 | −0087 | 4 |
| **O5** | 30331 | 3568 | 6602 | −0535 | 1 |
| **O6** | 27079 | 2656 | 5364 | 0052 | 10 |
| **M1** | 26166 | 2854 | 5470 | −0237 | 9 |
| **M2** | 31377 | 2988 | 6126 | 0150 | 8 |
| **M3** | 21768 | 2192 | 4369 | −0015 | 12 |
| **M4** | 18969 | 1722 | 3619 | 0175 | 14 |
| **M5** | 30545 | 3090 | 6144 | −0035 | 7 |

Alongside with the reading of the map according to the positioning of each CSF, the most important insights can be deduced reading the relationships existing between the factors. In the impact relations map, the lines with arrows indicate the direction of the relationship between CSFs that have a matrix value higher than the threshold value. In particular, since the matrix highlighted 35 relationships included in the sensitivity range, authors identified three separate areas in the impact relations map, through which it is possible to describe the majority of the relationships.

The first area, labelled as “Area 1", includes the CSFs Top Management Commitment (C2) and Leadership (C3). These two

**Table 7**
Total relation matrix T.

| | C1 | C2 | C3 | O1 | O2 | O3 | O4 | O5 | O6 | M1 | M2 | M3 | M4 | M5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C1** | 0,20 | 0,19 | 0,18 | 0,27 | 0,13 | 0,16 | 0,25 | 0,28 | 0,18 | 0,21 | 0,22 | 0,16 | 0,12 | 0,23 |
| **C2** | **0,34** | 0,20 | 0,26 | **0,31** | 0,18 | 0,19 | 0,30 | **0,31** | 0,25 | 0,27 | 0,28 | 0,22 | 0,18 | 0,29 |
| **C3** | **0,33** | 0,26 | 0,19 | 0,30 | 0,16 | 0,18 | 0,29 | **0,32** | 0,24 | 0,25 | 0,27 | 0,20 | 0,16 | 0,29 |
| **O1** | 0,28 | 0,20 | 0,20 | 0,19 | 0,13 | 0,14 | 0,25 | 0,28 | 0,20 | 0,20 | 0,22 | 0,16 | 0,11 | 0,24 |
| **O2** | 0,25 | 0,22 | 0,21 | 0,24 | 0,10 | 0,12 | 0,25 | 0,25 | 0,21 | 0,18 | 0,23 | 0,14 | 0,11 | 0,23 |
| **O3** | 0,18 | 0,13 | 0,13 | 0,15 | 0,07 | 0,07 | 0,14 | 0,16 | 0,13 | 0,15 | 0,14 | 0,11 | 0,11 | 0,14 |
| **O4** | **0,31** | 0,24 | 0,23 | 0,30 | 0,16 | 0,15 | 0,20 | 0,30 | 0,21 | 0,23 | 0,25 | 0,18 | 0,13 | 0,26 |
| **O5** | 0,30 | 0,22 | 0,22 | 0,28 | 0,14 | 0,17 | 0,27 | 0,21 | 0,20 | 0,23 | 0,23 | 0,18 | 0,14 | 0,24 |
| **O6** | 0,24 | 0,23 | 0,20 | 0,22 | 0,16 | 0,14 | 0,22 | 0,23 | 0,14 | 0,19 | 0,22 | 0,16 | 0,15 | 0,22 |
| **M1** | 0,26 | 0,19 | 0,19 | 0,24 | 0,12 | 0,17 | 0,21 | 0,25 | 0,18 | 0,15 | 0,19 | 0,14 | 0,11 | 0,21 |
| **M2** | 0,30 | 0,23 | 0,24 | 0,28 | 0,16 | 0,16 | 0,27 | 0,30 | 0,22 | 0,23 | 0,18 | 0,18 | 0,13 | 0,25 |
| **M3** | 0,22 | 0,16 | 0,16 | 0,20 | 0,09 | 0,12 | 0,19 | 0,21 | 0,15 | 0,17 | 0,16 | 0,09 | 0,09 | 0,17 |
| **M4** | 0,19 | 0,15 | 0,14 | 0,16 | 0,09 | 0,13 | 0,15 | 0,18 | 0,14 | 0,15 | 0,14 | 0,10 | 0,07 | 0,13 |
| **M5** | 0,30 | 0,24 | 0,23 | 0,27 | 0,14 | 0,17 | 0,26 | 0,29 | 0,21 | 0,23 | 0,24 | 0,17 | 0,12 | 0,19 |

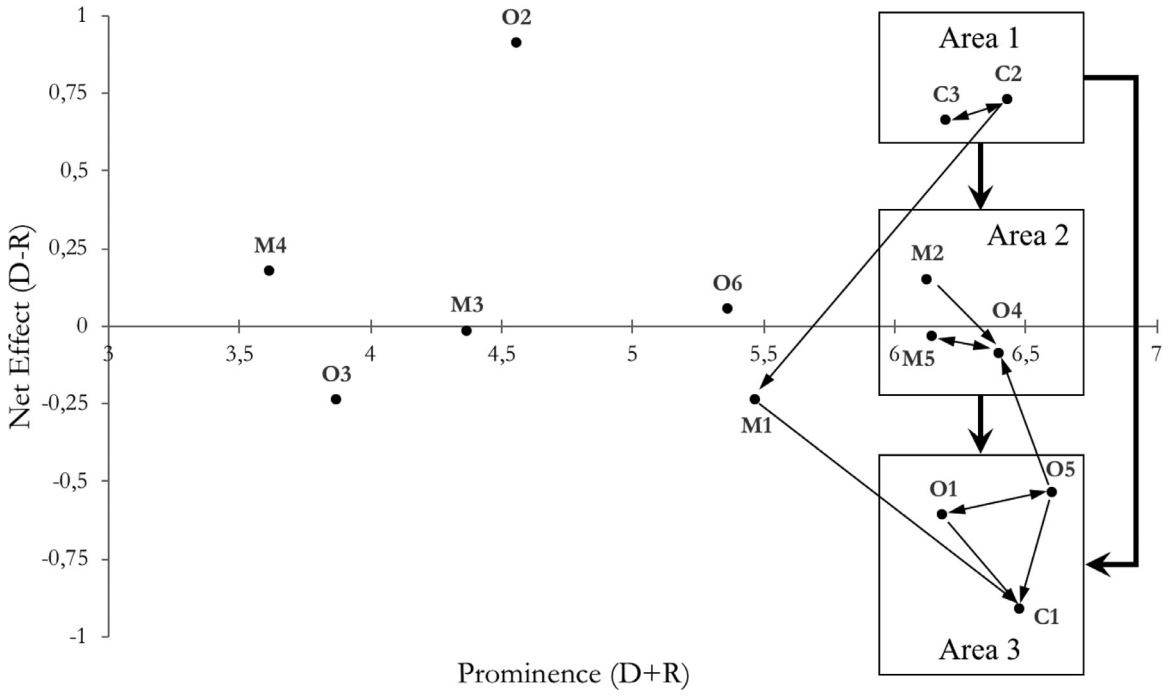


**Fig. 1.** Impact relations map.

variables are among the most prominent and they are the strongest influencers. The two thicker arrows that from “Area 1" point “Area 2" and “Area 3" highlight that both CSFs influence all the CSFs of the other two areas, covering twelve relationships in the Total Relations Matrix (***T***).

Area 2 includes Kaizen Events (O4), Communication (M5) and Training and Job Empowerment (M2). They are characterized by an average net effect, as they are influenced by “Area 1" and influence the three CSFs included in “Area 3".

Finally, “Area 3" includes Bottom-Up Approach (O5), Employee Engagement (C1) and Teamwork (O1), which are among the most prominent, yet the most influenced CSF.

Among all the relationships included in the map it is worth mentioning the six of them that have been identified with the MMDE algorithm and therefore represent the strongest ones. Three of them involve the CSF Top Management Commitment, which exerts an influence towards Employee Engagement (0.34), Bottom-Up Approach (0.31), and Teamwork (0.31). Two relationships involve Leadership that influences Employee Engagement (0.33) and Bottom-Up Approach (0.32) and the last one describes the influence exerted by Kaizen Events towards Employee Engagement (0.31).

## 5. Discussion

As the Impact-relations map shows, Top Management Commitment (C2) and Leadership (C3) are net causes of all the other CSFs with both factors influencing each other. This is an interesting finding since it is possible to lead all the most prominent variables to the same root causes, meaning that, acting and working on these two main CSFs, benefits on all the most prominent variables derived, helping in successfully implementing LM and achieving a sustainable CI. Looking at the bottom of the graph amongst the most prominent variables we see that Employee Engagement (C1) is the main effect followed by Teamwork (O1) and Bottom-up approach (O5), meaning that Employee Engagement (C1) is affected by all the other variables in a direct or indirect manner. Top Management Commitment and Leadership directly affect Employee Engagement while Area 2 variables (Training and Empowerment M2, Kaizen Event O4, Communication M5) have an indirect impact on the main effect, or better they are mediators of the Area 1 variables on the main effects. In other words, Area 1 variables can be seen as initiators variables for the SCI and they are both cultural while Area 2 variables (Training and Empowerment (M2), Kaizen Event (O4) and Communication (M5)) can be considered, taking into account their prominence and net effect values, as enablers of the SCI. In fact, looking at the prominence and causal relationship graph they are in between what we have called root causes and the main effects variables. Amongst the enablers, there are two managerial variables: Communication and Training/Empowerment and the organizational aspect concerning the Kaizen event. Thus, Communication, Training/Empowerment and Kaizen event represent the levers in leaders and management's hands to achieve Area 3′s main effects variables and, above all, Employee Engagement (C1). For what concern Area 3 variables, as already mentioned we find Employee Engagement, as the main effect variable, Teamwork and Bottom-up approach. These two latter variables are organizational and both affect the main effect that is a cultural variable. It emerges that the bottom up approach is the organizational way of managing the organization that has a beneficial impact on the main effect that is the engagement of the employees. It is worth to mention here that the opposite organizational approach (Top-Down approach) emerged to be rather weak in terms of prominence as well as in terms of net effect, meaning that what mostly enables the engagement of employee as the main effect to achieve a SCI is a bottom-up approach powered by a conduction of day by day tasks and activities run in teamwork. A bottom-up approach emerged to be the organizational way to manage the organization, however Leadership and Top Management Commitment remained the CSFs that influence all the CSFs in Area 3; this means that the direct and proactive involvement of employee in improvement projects is the key for SCI as organizational lever, however the leadership and the top management have to be exerted continuously. Every employee proactively contributes with its own ideas to the improvement process and is actively engaged in continuous improvement projects with the constant steering of the top management and leaders that are engaged in carrying forward the continuous improvement approach in the organization. A self-engagement element for employees is represented by their environmental/working conditions. The impact relations map revealed it to have a

lower value of prominence and net effect if compared with CSFs belonging to the three areas identified. It acts as cause on employee engagement and it is affected by top management commitment, meaning that the change for a better environment/working conditions is an engaging element for employees since they are in charge and ultimate responsible for changing in better way the environment where they operate every day, with the willingness and the approval of the management. Worthy of notice is the position that the rewards financial and non-financial have in the Impact-relations map. Both the CSFs, Financial Rewards (M4) and Non-Financial Rewards (M3) have a low prominence if compared to the other CSFs and a net effect value that is very close to zero, meaning that they do not represent either a cause and an effect. Financial and non-financial rewards to employee do not have a relation with employee engagement, and the graph shows that non-financial rewards have a higher prominence value with respect to financial rewards. Even if rewards (both M4 and M3) result to have a very weak relation with the main effect in achieving the SCI what is interesting to mention is that employees' success in improvements if celebrated, recognized and shared throughout the company have a higher importance on the achievement on SCI with respect to monetary rewards to employee.

The variable in the framework with the highest level of net effect is O2 Consultants. This result is totally consistent since the variable "Consultant" is external to the environment of the organization and can hardly be affected by the other CSFs that are mostly endogenous to the company. What is mostly interesting instead, is the fact that variable O2 is not involved in any relationships in the impact relations map, especially towards Area 3 variables. This means that, although external consultants can bring specialized expertise during the early stages of a Lean transformation, they are not essential for the long-term sustainability of CI initiatives. Instead it is required to have a profound cultural change at all the levels of the organization that needs to be pushed and supported internally. Lastly, the presence of a unionized workforce (O3) has no influence on the main effect, as observed from the Impact-relations map in Fig. 1, and it presents a very low level of prominence together with an average value of net effect. Therefore, results show that this variable is very marginal to the successful implementation of CI program.

## 6. Conclusions and further developments

In this article, the DEMATEL technique has been proposed to identify the relative importance and influence of each CSF, amongst the soft practices of LM, and establish the interrelationship amongst the most important CSFs. The outcomes of the study suggest that the implementation of LM entails a complex integration of both hard and soft practices that must be equally considered in order to guarantee a successful roll out. This managerial practice entails a profound cultural revolution as each individual becomes a fundamental resource for the company. Therefore, in order to achieve sustainability, each CI Program cannot disregard the deep engagement of each and every employee, building an environment in which workers represent the fuel that pushes the daily continual incremental improvements matching with the "Kaizen" philosophy. Daily improvements should become a natural behaviour for all the employees and must be inspired by leaders who live the culture of CI and instil it in other members of the organization. In order to obtain this full employee engagement, it is crucial the role of Top Management, which especially during the early stages of the implementation, must create the best conditions for the diffusion of Lean. Thus, the fundamental task of the management is to show deep physical and emotional commitment in order to motivate employees to participate proactively in this journey. The commitment of executives ensures that the importance of CI is understood by all the stakeholders within the organization building trust and communication, thus triggering employees' motivation and commitment as well in deploying procedures that enable the fast and effective transformation towards a more sustainable system. The empowerment of each single individual is fundamental to sustain Continuous Improvement in the long-term, which means investing in training so that employees can become "thinking people" and strongly contribute to the daily improvement and development of the organization, thus making training as the basis for a successful Lean implementation [116]. All the companies' intent on becoming Lean and continuously improving should first train employees and also managers as well, in order to create awareness and interest to implement Lean elements and encourage people achieving vision and mission of Lean principles. On the other hand, the empowerment of individuals requires that the maximum number of tasks and responsibility are transferred to shop floor workers, in order to create the need for employees to be strongly encouraged to think actively and proactively [117]. Delegating the power of choosing and autonomy can improve the quality and the quantity of knowledge transferred, increase people's willingness to be involved in CIP, and favour the adaptation of new Lean knowledge to plant's strategic goals, objectives, problems, and priorities.

This continual process of individual and organizational learning must be supported daily, as it is a never-ending process that aims at reaching perfection in the long term. Hence, top managers must spend time in that part of the plant where the actual work is done, demonstrating their physical commitment to employees and directly participating in the day-to-day work with shop floor workers. In doing so, managers can also rely on the exploitation of Kaizen events, with the aim of stimulating the "Kaizen thinking" and improve the operational efficiency of teams towards sustained improvement efforts. Indeed, this kind of operational workshops are useful as they are able to show the value and benefits of Lean in a relatively short time, that is good in order to keep the momentum especially in early stages of the implementation.

All the initiatives mentioned are useless if they are not accompanied by a well-structured and effective communication aimed at conveying the vision of change to employees and aligning their goals with the ones embedded in the change. Communication is a fundamental mean of the Lean transformation as it consists of disseminating sound pills of Lean knowledge, thus enabling fast and effective transformation towards a more sustainable system and connecting the long-term goals with the everyday work. Communication has also a strong motivational impact on employees when it is used to share best practices and positive outcomes related to Lean initiatives. Similarly, a performance measurement system should be used to assess whether the Lean implementation is compliant with the plan and to monitor the evolution of performances. Indeed, monitoring and auditing performances using assessments and regular meetings to follow up the implementation of Lean is widely recognized as a very important critical success factor for its sustainability.

Some practical implications can also be drawn for practitioners willing to make their path towards Lean sustainability successful. First, any attempt to implement Lean cannot be successful if there is not a full agreement and commitment from executives and top management [70]. The role of executives is to define and refine the strategic vision of CI program. This vision must be transferred to every individual in the organization, and every worker must be provided with the tools and skills to make autonomous decision-making in order to daily support the CI. This process of aligning strategic vision to operational execution is called "hoshinkanri" and it is a fundamental framework that must be constantly updated in order to keep the momentum of CI [118].

The research also highlighted some leverages available to practitioners to facilitate the alignment between top managers and operators towards Lean sustainability. The first is communication, which must be both verbal, through the communication on best practices and the sharing of good results, but also visual, being frequently present at the "gemba". The second is training, which is fundamental to ensure that workers know the tools and the problem-solving methodology to autonomously run daily CI activities. The last leverage is represented by

Kaizen events, which are workshops useful for practitioners at the beginning of the Lean journey in order to rapidly transfer knowledge about Lean tools and see encouraging results.

This study provides an innovative contribution in mapping the CSFs that leads in achieving the sustainability of the continuous improvement. Thanks to DEMATEL methodology used, it gives a new understanding in terms of interrelationship amongst the most important CSFs, considering the relative importance and the influence of each CSF. However, some interesting issues remain open for future research.

Firstly, authors have been able to get in contact with Italian practitioners, due to the ease of reaching them. Hence, it would be interesting to expand the analysis of DEMATEL to other foreign Lean experts operating in different countries, in order to remove influences of national cultures and make the result of the analysis generic.

Finally, our focus has been placed on very specific profiles with managerial roles or highly experienced consultants. Yet, since we understood by listening their point of view that shop floor workers are the very heart of a Lean Production System and their deep engagement is the only way to guarantee long term sustainability, authors think it could be interesting for future researcher in this field also to investigate shop floor workers' opinions. Indeed, in this way it could be possible to understand what are the real means by which employees feel motivated to participate in Continuous Improvement Programs, thus ultimately understanding what are the factors that incentivize their engagement in accordance with their point of view.

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