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EMPIRICAL VALIDATION OF LEAN IMPLEMENTATION BARRIERS IN ENGINEER-TO-ORDER COMPANIES: AN EXPLORATORY STUDY

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ABSTRACT

Enterprises employing an Engineer-to-Order (ETO) manufacturing strategy produce complex products designed specifically to customer requirements, on a project basis, under time and cost constraints. As a result of this complexity, wastes and inefficiency occur within the internal and external supply chain. To improve productivity, companies are striving to implement Lean practices in ETO environments but encounter implementation barriers. Based on the comprehensive literature study on Lean implementation barriers in ETO companies, this study empirically validates the occurrence of these barriers in practice. For this purpose, empirical evidence was gathered using a survey questionnaire followed by semi-structured interviews with 15 companies from the ETO sector in construction, mechanical engineering, and shipbuilding. As a result, the barriers mentioned in the literature are compared with the barriers that occur in practice. Simultaneously, new barriers not described in the literature are also identified. This study can guide Lean professionals in the ETO environment in their Lean efforts to identify corresponding barriers in their own organizations while trying to understand the relevant causes and fields of action to mitigate them. Future research should aim to explore other methods and strategies along with emerging technologies of Industry 4.0 that could help overcome Lean implementation barriers.

KEYWORDS

Lean construction, barriers, engineer-to-order (ETO), complexity, waste

INTRODUCTION

Engineer-to-Order (ETO) companies design and manufacture highly customized products such as machines, plants, buildings, and ships according to customer requirements. These goods are often characterized by low volumes, a low rate of order recurrence and project-by-project procedure (Løkkegaard et al., 2022). ETO projects are characterized by high cost and delivery time pressure, a high degree of individualization, and high complexity in relation to planning and coordination activities, which lead to a large proportion of non-value-added activities resulting in productivity losses and lower competitiveness (Aslam et al., 2020; Schulze & Dallasega, 2021).

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To remain competitive and improve efficiency, ETO companies are forced to rethink their operation strategies and reassess the implementation of verified approaches and technologies to improve productivity (Mayr et al., 2018; Sanders et al., 2016; Schulze & Dallasega, 2021; Strandhagen et al., 2018). The improvement in productivity and reduction of waste in companies with an ETO strategy using Lean thinking has already been shown in various studies (Buer et al., 2018; Sanders et al., 2016; Schulze & Dallasega, 2021; Strandhagen et al., 2018). Originally developed in the automotive industry, Lean processes and principles are applied in mainly product-centered repetitive production settings characterized by stable demand for large volumes of related products (Jünge et al., 2021; Schulze & Dallasega, 2021). Lean thinking, also known as Lean Manufacturing or Lean Construction, intends to maximize customer value by reducing non-value adding activities, forming a pull-based flow induced by customer requirements, and reducing excessive process variability (Jünge et al., 2021; Salem et al., 2006).

However, the adoption of Lean methods and tools to the ETO environment is limited and very challenging due to the low volume of customized products and non-repetitive manufacturing setting (Schulze & Dallasega, 2021). Some of the Lean tools and principles are suitable to the ETO environment, while others require adaptation (Schulze & Dallasega, 2021), still most ETO companies face barriers in implementing Lean in their environment (Kumar & Kumar, 2014; Schulze & Dallasega, 2020; Zhang et al., 2017). These implementation barriers can be related to organization, management, knowledge, culture, finance, as well as non-context causes (Schulze & Dallasega, 2021).

The literature on barriers when implementing Lean methods and tools in companies with an ETO strategy is relatively limited in comparison to industries with repetitive manufacturing strategies (Birkie & Trucco, 2016; Schulze & Dallasega, 2021) and a framework that discusses inputs, tools, techniques and barriers regarding Lean for the ETO sector is still missing (Basu & Dan, 2020). Therefore, research discussing Lean implementation barriers in repetitive manufacturing does not support for conclusions to be drawn for non-repetitive environments like ETO.

This paper aims to empirically validate the barriers to Lean implementation that companies in the ETO environment face in practice. Based on a detailed literature review (Schulze & Dallasega, 2021) this paper proposes an empirical validation of Lean implementation barriers in the ETO-industry. For this aim, a survey questionnaire followed by semi-structured interviews with 15 companies from the construction, mechanical engineering, and shipbuilding sectors were used. As such, this article contributes to the growing body of research discussing Lean principles and their implementation in the ETO environment.

LITERATURE REVIEW

In previous research seven Lean implementation barrier categories were identified by means of a systematic literature review (SLR) (Schulze & Dallasega, 2021). The Scopus database has been used with a search string containing the following keywords: “Lean” OR several Lean methods such as ‘LPS’, ‘LMBS’, ‘Kanban / CIP’, ‘JIT’, ‘Poka-Yoke’, ‘Prefabrication’, ‘Modularization’, ‘Pull scheduling’, ‘Pull planning’, ‘Visual Management’, ‘IPD’, AND “barrier” OR synonyms such as ‘obstacles’, ‘difficulties’, ‘constraints’, ‘failure factors’, ‘challenges’, ‘hurdles’, ‘hindrances’, and ‘critical success factors’, AND “Engineer-to-Order” OR “ETO”. From a total of 362 articles identified, 115 article were duplicates, leaving 247 papers to be analyzed according to title and abstract fitness. Inclusion criteria were applied to identify relevant works for the content

analysis. These included: articles referring to the ETO industry, articles focusing on the implementation of the searched Lean tools and methods, articles reporting on the barriers during the implementation process, articles published in scientific journals and conference proceedings, articles published within the time range between 2010 and 2020. As a result, 79 articles were deemed inadequate topics leaving 168 articles to be further analyzed. Based on an independently chosen selection of articles, which were analyzed in-depth by the two authors, further inclusion criteria were applied: articles listing implementation barriers supported by data and articles describing barriers with reference to an ETO context. Consequently, 113 were excluded, leaving 55 articles for an in-depth content analysis. 19 articles were further included via backward and forward snowballing, a search strategy using the references and the citations respectively, resulting in a final set of 74 articles for an in-depth content analysis.

The following section briefly summarizes the barrier groups and subgroups identified in the SLR.

1. Organization related barriers relate to the lack of a supportive organizational culture for Lean. These include the (1.1) resistance of the workforce to change to new ways of working and unwillingness to engage in Lean processes (Huaman-Orosco & Erazo-Rondinel, 2021; Lodgaard et al., 2016; Murguia, 2019; Salonitis & Tsinopoulos, 2016). Another factor is the (1.2) lack of effort to build a supportive organizational culture for a successful Lean adoption (Abu et al., 2019; Haque et al., 2003; Lodgaard et al., 2016). Further, companies in the ETO sector often (1.3) ignore the systematic approach of Lean by only concentrating on certain tools (Almeida Marodin & Saurin, 2014; Zhang et al., 2017). A (1.4) lack of communication of all Lean efforts and results across the organization is another organizational related barrier (Almeida Marodin & Saurin, 2014; Bayhan et al., 2019).

2. Management related barriers include the (2.1) absence of commitment from the top management to the Lean implementation process, which is critical factor for a successful Lean adoption (Huaman-Orosco & Erazo-Rondinel, 2021; Lodgaard et al., 2016; Valente et al., 2020; Zhang et al., 2017). Also, top management often only (2.2) focuses on short-term results rather than the implementation process (Huaman-Orosco & Erazo-Rondinel, 2021; Salonitis & Tsinopoulos, 2016; Tezel et al., 2017). In addition, (2.3) different hierarchical levels must deal with contrasting views on Lean implementation barriers during their day-to-day operations, making adoption even more difficult (Lodgaard et al., 2016; Salonitis & Tsinopoulos, 2016).

3. Knowledge related barriers consist of an (3.1) insufficient understanding of Lean concepts and tools as well as a lack of implementation know-how and practices (Abu et al., 2019; Huaman-Orosco & Erazo-Rondinel, 2021; Salonitis & Tsinopoulos, 2016; Valente et al., 2020; Walter et al., 2020). In addition, ETO companies often neglect to properly (3.2) train employees (Abu et al., 2019; Lodgaard et al., 2016). Another aspect is that managers often (3.3) lack the ability to quantify the benefits of the implemented Lean methods in terms of key performance figures (KPIs) (Almeida Marodin & Saurin, 2014; Erthal & Marques, 2018).

4. Cultural related barriers entail a (4.1) lack of awareness and understanding of Lean and the corresponding change in one's own organization towards a Lean culture (Haque et al., 2003; Lodgaard et al., 2016). Employees are often not empowered enough to adapt to certain Lean methods (Aslam et al., 2020; Huaman-Orosco & Erazo-Rondinel, 2021). Additionally, (4.2) organizational cultures that emphasize internal competition and

corporate hierarchy are less conducive to implementing Lean than those that favor collaboration and teamwork (Dominici & Palumbo, 2013; Erthal & Marques, 2018).

5. Financial related barriers comprise of a (5.1) lack of financial resources for training the workforce or external consultants and investment in innovation (Gupta & Jain, 2013; Zhang et al., 2017). Further, not all Lean methods implemented generate (5.2) quantifiable advantages, but rather intangible benefits such as employee satisfaction and improved safety (Zhang et al., 2017).

6. Non-context specific related barriers are those barriers that cannot be assigned to any of the other barrier groups. These include obstacles such as a (6.1) lack of Lean adaption from the repetitive production environment to the non-repetitive setting of ETO firms (Birkie & Trucco, 2016; Huaman-Orosco & Erazo-Rondinel, 2021; Tezel et al., 2017). The low volumes, wide variety of products, and lack of long-term forecasting make it difficult for an ETO organization to sustain Lean implementation processes (Salonitis & Tsinopoulos, 2016). In addition, companies with an ETO strategy are affected by high environmental uncertainty, such as unpredictable customer and demand fluctuations, varying performances of suppliers and subcontractors, and ever-changing rate of innovation (Birkie et al., 2017). This (6.2) lack of process reliability poses another barrier for implementing Lean.

7. Customer related barriers include either the (7.1) lack of customer support in Lean implementation efforts or pressure from clients to implement Lean. This (7.2) forced approach often leads to futile implementations due to a lack of motivation, assistance, and determination from ETOs management (Hussain, 2016; Zhang et al., 2017).

RESEARCH METHODOLOGY

Design: A sequential explanatory mixed-method design was adopted to collect data using survey questionnaire and qualitative semi-structured interviews. Survey methods targeted to collect primary data from the participants (Mathers et al., 2013), while semi-structured interviews gathered qualitative data that enabled the exploration of subjective experiences, understanding, and personal beliefs (Bray et al., 2014). First, the quantitative data was collected by sending a questionnaire to the targeted key individuals, followed by semi-structured interviews which were conducted with the companies' participants to gain a better in depth understanding of their answers (Harrell & Bradley, 2009).

Data Collection: A structured survey questionnaire was used to gather self-reported data on the Lean implementation barriers encountered in practice to the participants. The questionnaires and interviews were collected between the end of November 2021 and the end of February 2022.

Development of questionnaire: To collect data for this study, a questionnaire was developed consisting of various parts including: (A) the background information provided by the respondents and the company itself, (B) the occurrence of losses and wastes during an ETO project, (C) the Lean methods and tools applied, and (D) the actual Lean implementation barriers encountered, which were structured according to the barrier groups and subgroups summarized in the previous chapter. Useful information about the study is contained in the header part of the questionnaire. The last part of each segment has some space for the interviewees to provide some comments or additional information if any. The questions were designed to be simple yet easy to understand for the respondents.

Sample selection: Based on the realization that companies in the ETO environment are reluctant to share confidential information, the research is exploratory, and the

findings are preliminary, justifying the use of non-probability sampling (Malhotra, 2008). Purposive sampling was utilized to select the companies to be questioned, as this non-random technique allows respondents to be explicitly selected based on the necessary information they can provide on the concepts and topics at question (Campbell et al., 2020; Tongco, 2007). Furthermore, purposive sampling helps to better match the objectives of the research with the sample, thereby increasing the rigidity of the study and the reliability of the data and results (Campbell et al., 2020). Table 1 shows the companies that participated to the study using code names to protect identity. A total of 15 companies from the ETO sector, namely construction (7 companies), mechanical engineering (4 companies), and ship building (4 companies), were selected. The ETO companies are located in Italy, Germany, and Norway. About half of the companies are small and medium sized enterprises (SMEs) with 60 to 500 employees and annual sales between €10 million and €500 million. The other half are large companies with more than 500 employees and annual turnover between €700 million and €4.6 billion. Since the barriers of Lean implementation were to be researched, the respective companies interviewed assigned us the relevant persons responsible for the subject of Lean. Respondents were typically the corresponding 'Lean experts' or 'Lean managers' in their company, or held equivalent positions, such as 'Production manager' or 'Head of digitization and innovation management' occasionally also the respective high-level business executives of the company. Interviewees' work experience ranges from 5 to 28 years.

Table 1: Sampled companies

Case company	ETO sector	Size	Country	Interviewee's position	Expe-rience
A	Construction	SME	Germany	Head of BIM and Innovation	7
B	Construction	Large	Germany	Expert Production Systems	10
C	Construction	SME	Germany	Head of Lean Management	10
D	Construction	Large	Germany	Head of BIM Department	16
E	Construction	Large	Germany	Head of Lean Construction	8
F	Construction	SME	Germany	Head of Project Management	20
G	Construction	SME	Norway	CEO	20
I	Mech. Engineering	Large	Italy	Production Manager	26
J	Mech. Engineering	Large	Italy	Head of work preparation	16
K	Mech. Engineering	SME	Italy	Production Manager	12
L	Mech. Engineering	Large	Germany	Production Manager	28
Q	Shipbuilding	SME	Germany	CEO	18
R	Shipbuilding	Large	Germany	Digitization / Innovation head	20
S	Shipbuilding	SME	Germany	Process & Project Manager	5
T	Shipbuilding	Large	Norway	Deputy Managing Director	15

Testing and validation of the questionnaire: After the structure and questions were defined, this instrument was validated against the criteria by experts from different ETO companies, who assessed and scored the entire questionnaire. Any corrections and suggestions were implemented accordingly in the questionnaire.

Interviews: To examine the collected primary survey data, as well as to explore the participants subjective experiences and believes, individual interviews were conducted in a semi-structured form. Semi-structured interviews (SSI), which are both a data collection strategy and a qualitative research method (McIntosh & Morse, 2015) aim to establish and verify the perspective of participants in order to confirm, correct or discover new knowledge related to the focus of the research (McIntosh & Morse, 2015). The interviews were conducted by the two members of the research team either face to face in the interviewed company or over the internet via a video conferencing tool depending on the participants' preference and location. All interviews were audio or video recorded with the participant's consent.

Data Analysis: After the interview, the data collected from the semi-structured interviews was summarized in a protocol and sent back to the interviewees for validation. The validated protocols and questionnaires were then summarized and analyzed. The responses received were compiled in an Excel spreadsheet and the data analyzed using quantitative research methodologies.

RESULTS

To achieve the main objective of this study, respondents were asked about the specific Lean implementation barriers that they encounter in their organization. The results are shown in Table 2 and ranked according to their frequency of mentioning.

Amongst the (1) organizational related barriers, (1.1) "Employee's resistance to change" is the most frequently cited barrier subgroup amongst the interviewees. "*At first it was difficult to gain the acceptance of the employees and especially the suppliers for Lean*", Case company R quotes the first phase of Lean implementation in their organization. Similarly, case company A describes that "*The traditional way of working is a major obstacle*" is a major hindrance to their Lean efforts. Furthermore, the barrier subgroup (1.3) "Fragmented implementation" is named by case company K as: "*Isolated solutions are a barrier to the introduction of Lean with us*".

The barrier subsection (1.4) "Insufficient information management" was especially emphasized by bigger construction companies. Case company E takes this into account with the quote: "*The size of the company means that Lean efforts spread differently and therefore more slowly in the various company units*". Case company B also openly addresses this barrier by saying: "*Each area has its own Lean boss, which requires a lot of communication effort*". (2.1) "Limited management commitment" is the most discussed barrier subsection under (2) management related barriers. This becomes clear in case companies I and G, which state: "*Mainly, the interest of the top management in Lean is missing*" and "*We lack the commitment from the management*". Even after the successful introduction of some lean methods and tools, company S still complains: "*The lack of top management commitment is still a problem […] Support is missing in certain areas, but it is also there in certain areas*".

(3.3) "Missing quantitative measurement indicators" is the most stated barrier subcategory amongst the (3) knowledge related barriers. This becomes clear in case study C, which perceives the improvements of Lean but cannot measure them directly: "*Qualitative indicators are also missing. Lean provides what feels like better processes but no increased financial output*". This is also emphasized by companies B and J: "*It is difficult to measure the added value of Lean methods*" and "*It's hard to identify measurable benefits from certain Lean practices*". Company Q complains that Lean-

related improvements in important key figures are not directly measurable: "*We are observing difficulty quantifying of lead time and improved adherence to deadlines*".

Table 2: List of Lean implementation barriers in ETO companies

Barrier	Case Company	# Mentions
6.2 Lack of process reliability	A, B, C, D, E, G, J, L, Q, S, T	11
3.3 Missing quantitative measurement indicators	A, B, D, E, F, I, K, Q, S, T	10
1.1 Employee's resistance to change	A, B, D, E, F, G, Q, R, S	9
4.1 Lack of Lean culture	A, B, D, E, J, L, Q, R, T	9
6.1 Lack of adaptability of Lean methods from other production environments	A, B, G, J, Q, R, S, T	8
1.2 Insufficient organizational structure for Lean	B, E, J, K, Q, R, S	7
1.3 Fragmented implementation	C, E, F, Q, R, T	6
2.1 Limited management commitment	E, F, G, I, Q, S	6
2.2 Short-term focus	C, F, Q, R, S, T	6
3.2 Insufficient training of workforce for Lean	A, D, I, L, Q, T	6
5.2 No direct financial advantage	A, E, J, K, Q, T	6
1.4 Insufficient information management	B, D, L, Q, T	5
3.1 Insufficient know-how about Lean	A, J, I, Q, T	5
4.2 Country related cultural differences	Q, S, T	3
5.1 Lack of financial resources	A, E, J, K, Q, T	3
7.1 Lack of customer support	E, G	2
3.4 *Internal fluctuation of key Lean personal*	C, E	2
3.5 *Long Project duration*	D, E	2
7.2 Forced Lean adoption by customer	Q	1
2.3 Hierarchical differences	D	1

The barrier subsection (3.1) "Insufficient know how" is stated by case company I as one of the crucial obstacles in their Lean efforts: "*There is a lack of knowledge to introduce Lean in our production*". The issue of (3.2) "Insufficient training of workforce for Lean" is emphasized by Company E: *"Due to the long duration of the projects, it takes time for learning effects to set in regarding Lean*".

When it comes to (4) cultural related barriers, (4.1) "Lack of Lean culture" is the most mentioned hurdle. The interviewed case company G points out that Lean thinking is mostly missing in all areas in their organizations: "*Lean methods are easy to understand, but hard to implement, which makes it difficult to gain its acceptance throughout the company*". (5.1) "Lack of financial resources" is the frequent cited barrier subgroup among (5) financial related barriers. As case company Q addresses the issue in terms of finances and involvement of top management for Lean: "*Lean implementations often lack short-term successes, but they are necessary for its acceptance. […] But if these two goals [more sales and lower costs] are addressed with the increase in efficiency [via Lean tools], then the management is also interested in Lean*".

In the (6) non-context related barrier group, the barrier subgroup (6.2) "Lack of process reliability" was cited the most amongst the interviewed companies. Especially the interviewed construction companies emphasized this barrier. As case company B puts it: "*A lack of process reliability in the construction industry is a major barrier to Lean*". Case company E emphasizes the subject of fluctuating subcontractors: "*Due to the high fluctuation of the subcontractors, there is a lack of process stability*". "*Every project is different, which makes it difficult to compare established Lean methods*" is described by case company Q as a decisive issue in this regard. Case company J adds here: "*Own improvements, achieved through Lean, are difficult to pass on to subcontractors*".

In the barrier group (7) customer related barriers, the interviewed companies mention the (71.) "Lack of customer support" in their Lean endeavors. Case companies C and K complain about the lack of customer support: "*On the customer side, almost nothing is demanded or supported in terms of Lean*" and "*The customer is needed for Lean, but they often do not participate*". The additional effort involved in proving certain lean certificates is often not appreciated by customers: "*Customer orders nowadays require more and more evidence of Lean, but rarely support implementation*", as case company G criticizes.

During the interviews several new implementation barriers emerged, previously not mentioned in the literature, especially among the construction companies. (3.4) "Internal fluctuation of key Lean personal" is described by case company E: "*Important employees who are familiar with Lean often change companies, which means that there is a lack of sustainability in Lean activities.*" Further, (3.5) "Long Project duration" was described as an issue for case company D: "*Due to the fact that the construction project often run for several years, the learning effects and best practices [regarding Lean] that have been gained cannot be processed and passed on quickly enough to other projects*".

DISCUSSION

As the survey findings indicated, (6.2) "lack of process reliability" is the primary obstacle mentioned by the ETO companies surveyed, indicating that the non-repetitive environment of ETO characterized by high complexity and unpredictable demand fluctuations still represents a key hindrance to the implementation of Lean methods and tools from the repetitive manufacturing setting. This was also confirmed in the work of Birkie et al. (2017) and Alfnes et al., (2016), who observed that complexity (varying factors that influence decision making) and dynamism (degree to which these factors change) in ETO organizations have a strong influence on the implementation of Lean.

The survey results also implied that (3.3) "missing quantitative measurement indicators" is a major obstacle for ETO companies to evaluate the benefits of Lean and therefore to implement it. As interviewee T expressed it: "*However, the great difficulty of Lean is measuring the monetary and qualitative benefits*". This finding is consistent with the statement from the literature that managers often cannot measure the impact and benefits of most Lean methods (Almeida Marodin & Saurin, 2014; Erthal & Marques, 2018; Schulze & Dallasega, 2021; Tezel et al., 2017).

The study findings also indicate that (1.1) "Employee's resistance to change" is a key barrier mentioned by the interviewees. As interviewee S stated: "*I encounter resistance to change regarding Lean practices daily in my work*", and also mentioned by Interviewee D: "*Getting the workforce behind Lean is crucial*". This is also evident in the literature, where employee's adherence to traditional working methods and skepticism towards new processes and technologies are one of the biggest barriers to the introduction of Lean in

an organization (Gupta & Jain, 2013; Lodgaard et al., 2016; Salonitis & Tsinopoulos, 2016; Schulze & Dallasega, 2021). Previous research shows that employees resist implementing Lean practices and tend to revert to pre-Lean habits in the absence of a clear vision, commitment from top management, and an understanding of the underlying performance benefits (Birkie et al., 2017).

An operational implication of this study is that managers who want to implement Lean in their organizations should use the results obtained here as starting points for their own Lean activities. Any efforts to mitigate Lean implementation barriers should not only focus on the barriers mentioned most often in this study, but also on considering the respective specific situation of the company, researching the underlying causes of the barriers, and looking at possible connections between the barriers. For example, the barrier "Lack of process reliability" can have different causes, such as frequent customer changes, the fragmentation of the construction industry, low level of standardization and digitization, which must be considered separately

This study also has limitations. As an empirical study in a profoundly dynamic and intricate environment, 15 ETO cases were used via questionnaire surveys and semi-structured interviews. Responses from all respondents relate to their individual company and situation and there may be different perspectives within the broader ETO sector. Further, due to the Covid-19 situation, some interviews could only be conducted online. The specific company tour was missing here, where internal organization issues could have been better explained.

Future research may continuing investigate the occurrence of Lean implementation barriers in different sectors of ETO businesses. Companies with and ETO strategy in different sectors are so diverse that it is not easy to generalize findings. More empirical validation is recommended. Further, research may examine other strategies and methodologies besides Lean to overcome barriers in Lean implementation. Further investigation could also explore the potential of new technologies such as virtual and augmented reality, big data, artificial intelligence and other Industry 4.0 tools and concepts to overcome traditional barriers to lean implementation.

CONCLUSIONS

This study examined the real-world occurrence of Lean implementation barriers in Engineer-to-Order (ETO) companies. The Lean implementation barriers were determined through a literature review, mainly based on the work of Schulze & Dallasega (2021). The study was conducted based on questionnaire survey and subsequent semi-structured interviews developed to collect data with 15 companies from the ETO sector. The key contribution of this research is the empirical validation of the occurrence of Lean implementation barriers in companies with an ETO strategy practice. Further, new barriers not previously mentioned in the literature have also been identified through this research, which should be further investigated in theory and practice. The findings of this study could be used as a starting point to help researchers, practitioners, and companies in the ETO environment seeking to mitigate their own Lean implementation barriers, by investigating the exact causes and interrelationships of the barriers in their organizations.

Limitations of this research are the size of the sample, which can affect the validity and reliability of the research findings, as well as that not all interviews could be conducted on site in person. Future research would include exploring the occurrence of Lean implementation barriers in practice and in different sectors of ETO, also

investigating methods and strategies, as well as new technologies to mitigate Lean implementation barriers.

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