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Transfer Mechanisms for Lean Implementation with OHS Integration in the Garment Industry

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Abstract:

Purpose: Lean manufacturing has the potential for simultaneously improving the competitiveness and the social sustainability of the apparel industry in developing countries. However, there is limited research on the ways to a successful lean implementation in developing countries and with an emphasis on occupational health and safety (OHS) improvement.

Methodology: The paper investigates four cases of lean implementation in garment factories and uses the design science research strategy, building on the context-intervention-mechanism-outcome framework to identify explanatory mechanisms that can be used for designing future action.

Findings: The study identifies tangible mechanisms that can lead to successful lean implementation. The most important mechanisms relate to practical top management support, worker involvement, application of lean tools, and training.

Practical implications: The findings of this study can guide better lean implementation for the many garment factories in the developing countries.

Originality/value: While the lean literature provides general recommendations for lean implementation, knowledge about the transfer mechanisms in developing countries as well as the connections between lean and OHS is limited. This paper contributes to lean implementation theory and to the discourse of positive lean by integrating efficiency and working conditions. In addition,

the paper identifies transfer mechanisms for lean implementation in the garment industry in a developing country.

Keywords:

Productivity, design science, garment, developing countries, occupational health and safety.

1. Introduction

Over the past two decades, there has been a significant expansion in lean production outside its origins in the automotive industry (Womack & Jones, 2005). Lean originates from the Toyota Production System (Liker, 2004), and has proved to be beneficial for productivity in manufacturing industries. Higher productivity achieved through decreased lead time, reduced inventories, and improved knowledge management, inter alia, are some of the key benefits of adopting lean (Melton, 2005). Lean has therefore turned into a basis for ensuring competitive advantage and economically sustainable development in the manufacturing industry (Pakdil & Leonard, 2014; Thomas et al., 2012). The literature about lean implementation is dominated by studies from industrialized countries, and research on lean in developing countries has been limited to date. Nevertheless, a growing body of research from developing countries indicates that lean has significant potential in these countries (Panizzolo et al., 2012; Sinha & Matharu, 2019). This is also the case for the garment industry (Chauhan and Geeta Nema, 2017; Hamja et al., 2019a; Maalouf et al., 2018; Wickramasinghe and Wickramasinghe, 2020).

Despite its many advantages, lean has also been criticized in the literature for intensifying work and impairing the health and well-being of employees, even though it clearly entails both possibilities and risks for well-being in relation to its implementation (Hasle, 2014). Although studies report both positive and negative results for changes in the work environment, and in health and well-being (Edwards et al., 2010; Hamja et al., 2018; Hasle et al., 2012), few integrate the perspective of improving productivity and occupational health and safety simultaneously. Hopp (2018) therefore calls for a new discourse on lean implementation, which he refers to as positive lean. Positive lean should integrate an impact on both operational effectiveness and workforce satisfaction in all its elements. This discourse is aligned with Edwards and Jensen (2014), who promote the design of systems for productivity and well-being and Hansen (2015), who demonstrates how a lean improvement strategy should consider both short-term realization and long-term capability building, which can be promoted by using positive practices such as appreciative inquiry built into the improvement processes.

Lean research also reveals that successful implementation is a difficult task, and that barriers hamper many factories from achieving the expected results from lean – especially in the long run (Arlbjørn & Freytag, 2013; Hopp, 2018). This does not come as a surprise, since the majority of all organizational change projects fail to reach their goals (Aiken & Keller, 2009; Beer & Nohria, 2000). However, lean implementation may be an even more difficult task than many other organizational change projects, because lean is a transformational process involving organizational development together with process improvement (Pearce & Pons, 2013), which needs to be embedded as a continuous process. In principle, therefore, it never ends. In addition, lean has a number of incorporated paradoxes such as a requirement for both standardization and creativity (Maalouf & Gammelgaard, 2016), changes in organizational behavior among stakeholders (Achanga et al.,

2006) and strong worker engagement (Lucey et al., 2005). Several authors (Almeida Marodin & Saurin, 2015; Hopp, 2018; Mostafa et al., 2013) have studied the tangible reasons for failure. For example, Hopp (2018) categorizes them into lack of top management commitment, resistance to change, and overreliance on tools lacking a deeper understanding of the philosophy behind lean.

As successful lean implementation has proved to be difficult in industrialized countries, it may be even more difficult in developing countries, where productivity development faces additional challenges. For example, the manufacturing industry has shorter history; its stakeholders have more limited experience with the organization of efficient production, the labor market is less stable, and the government's workplace regulations are weak. These factors also mean that developing countries have challenges with occupational health and safety. While many factories struggle to comply with OHS regulations and desirable practices, the dynamics of supplier-buyer interactions in global supply chains creates a pressure for reduction of costs leading to low wages. Consequently, the large problems related to OHS levels are not solved, despite the desire from buyers of taking responsibility in the supply chain for decent work (Hasle and Vang, 2021). This means that lean initiatives in developing countries need to consider how to address the OHS responsibility if they are to comply with buyer requirements for social compliance. This point is confirmed by Distelhorst et al. (2017) who analyze 300 factories adopting lean and show that lean does not necessarily lead to improved health and safety standards, but that lean can help build capabilities in factories that reduces noncompliance. Furthermore, with the expectation of even greater difficulties for lean implementation in the developing countries, together with the limited research in this area, it becomes pertinent to study how lean can be successfully implemented in practice in developing countries with a positive impact on both production performance and on OHS.

The garment industry constitutes an important stepping-stone for industrial growth in countries such as Bangladesh, China, Ethiopia, Indian, Myanmar, and Vietnam. Studies of lean in the garment industry indicate that lean has become a preferred methodology to reduce the cost of production (Chauhan & Geeta Nema, 2017), and that the industry can achieve valuable benefits from the application of lean (Hamja et al., 2019a; Wickramasinghe & Perera, 2016; Wickramasinghe & Wickramasinghe, 2017). Bangladesh is an example of a developing country highly dependent on garment production (Kader and Akter, 2014) that also faces severe problems regarding productivity, quality, OHS, and sustainability (Maalouf et al., 2017; Rakib and Adnan, 2015). The garment industry in Bangladesh is therefore turning to lean as a possible solution to these challenges, and the country constitutes a good case for the study lean implementation in a developing country.

This paper contributes to filling the knowledge gap in the literature with regard to successful lean implementation in the context of developing countries. We demonstrate how lean can be implemented in a positive manner that contributes to both productivity and occupational health and safety. We do so by investigating the underlying mechanisms that prove to be important for successful lean implementation in four garment factories in Bangladesh.

2. Background

2.1 Lean implementation

The term *lean production* was first used by Johan Krafcik in 1988 and subsequently by Womack et al. (1990) in their presentation of the lean production, building on the Toyota production system. Lean production is an integrated socio-technical system with the main objective of creating customer value with maximum efficiency by carrying out operations with a minimum of inventory and waste. In order to achieve this, the variability of the whole system needs to be minimized

(Shah and Ward, 2007), the flow efficiency needs to be optimized (Modig and Åhlström, 2012), while building continuous improvement capability for striving towards perfection (Liker, 2004). Lean has been adopted widely throughout the manufacturing and service sectors (Hines & Lethbridge, 2008) even though successful lean implementation is still subject to intensive research because of the difficulty in changing organizational culture and routines (Liker & Morgan, 2011; Sinha and Matharu, 2019b). While the lean literature covers a wide array of practical advice for achieving productivity improvements, e.g. on how to use tools such as 5S, value stream mapping, Kanban, setup time reduction by the single-minute exchange of die (SMED) concept, and visual management (Marodin and Saurin, 2013), the literature on Lean is divided in its definitions of Lean and therefore also in its advice on implementation (Arnbjørn and Freytag, 2008; Hopp and Spearman, 2020).

The basic idea and principles behind lean are relatively simple, and the possible benefits are well documented. However as presented in the introduction, many studies report difficulties with successful implementation. We discuss the implementation difficulties below, based on Hopp's (2018) suggestion of three main factors: lack of top management commitment, resistance to change, and overreliance on tools.

The literature agrees that commitment from top management is the most crucial factor for successful lean implementation (Kleindorfer et al., 2005; Kundu and Manohar, 2012; Lam and Rahma, 2014; Nordin et al., 2012; Scherrer-Rathje et al., 2009). Commercial pressure from the external competitive environment is known to be a factor in successful lean implementation (Netland, 2016). Apparently, this mechanism works by enhancing the value of lean in the minds of senior leaders, and fostering their commitment, including allocation of budget to the endeavor. This is sometimes expressed as business focus (Timans et al., 2012). For top management, commitment

to something is not only to be spoken about, but it is also to be demonstrated. It is by setting an example in their daily actions that top management demonstrate their commitment or lack thereof (Caroline et al., 2016). One example is mentoring others leaders on lean, which a study of the Thai garment industry (Chowdhury et al., 2007) demonstrated as an enabling role of top management commitment leading to superior performance.

Resistance to change is a well-known concept from the change management literature (Nordin et al., 2012; Ortiz, 2012; Sim and Rogers, 2008), which is highly relevant for the implementation of lean. Many researchers point to the fact that transformation from traditional to lean production systems is more of a culture change than a technical issue (Erthal and Marques, 2018; Losonci et al., 2011). Avoiding resistance is often tackled by ensuring the participation of workers (and supervisors) and empowering them in their work. Empowerment has been identified as important in the core of lean programs (Marodin and Saurin, 2013). Participation can happen if employees are considered as partners and empowered to make local decisions. Successful lean implementation requires delegation of authority along with capability (Netland, 2016). It also requires managers to be facilitative in their support of the workers and less controlling, and self-managed teams is a useful way of establishing participation and commitment among workers (Pakdil and Leonard, 2015). In the opposite situation, a culture of rules that stifles creativity, neglects safety and creates a poor quality of life for workers (Mehri, 2011) create negative reactions from employees, such as reduced organizational commitment and employee satisfaction (Parker, 2003), as well as detrimental effects on attitudes, health at work, and worker satisfaction (Bouville and Alis, 2014; Moraros et al., 2016; Stewart et al., 2016). As the participation of workers in developing countries is frequently very low, due to cultural constraints, we expect that there may be extensive although

probably most often passive resistance to change among workers, supervisors, and middle managers alike.

Hopp (2018) points towards overreliance on tools as a key mistake in the implementation of lean, which especially inhibits sustainability of changes. The general finding is that successful implementation of lean is less about the tools and more about the people behind the tools (Liker, 2004). This implies that tools should be selected relative to the maturity of the organization in its lean journey (Netland, 2016; Pearce and Pons, 2013). The skills and expertise of the staff are important (Achanga et al., 2006), including knowledge of how the tools are to be used (Bhasin and Burcher, 2006; Dora et al., 2013). In addition, training is also important (Netland, 2016). Education and training help with improving employee capability to implement lean effectively (Pakdil and Leonard, 2015).

Given the difficulties inherent in lean implementation, a more in-depth understanding of the mechanisms for successful implementation is crucial for further progress in the application of lean. Apart from the success factors mentioned above, research on lean implementation finds that successful companies have an organizational culture characterized by higher levels of institutional collectivism, human orientation, and future orientation (Netland, 2016). But literature shows that little attention is given to the human-centric issues in lean implementation (Magnani et al., 2019) and its impact on worker outcomes still remains a controversial topic. Successful companies favor soft lean practices, such as small-group problem solving, supplier partnerships, and training employees to perform different types of tasks (Bortolotti et al., 2015). Further examples of such practices include non-financial rewards, such as town hall meetings to celebrate employee achievements or frequent feedback and evaluation on the shop floor with visualized performance (Magnani et al., 2019; Netland et al., 2015).

In addition, lean is found to impose greater work pressures on employees, which can be mitigated with OHS and ergonomics considerations (Akhter et al., 2019; Hamja et al., 2019b; Hoque et al., 2020).

2.2 Lean practices in the garment sector of developing countries

The ready-made-garment sector is one of the most labor-intensive industries in the world. (Scott, 2006), and the abundance of inexpensive workers is the key advantage in developing countries. However, the industry in these countries has weaknesses associated with a lack of skills of both management and workers, as well as a weak infrastructure, which has resulted in a status as a producer of low-value apparel (Ansary and Barua, 2015). Furthermore, the market position is simultaneously challenged by increasing labor costs and buyer requirements for lower prices, shorter lead times, smaller lots, higher quality, and social compliance (Kader and Akter, 2014; Marudhamuthu et al., 2011). Therefore, in order to meet global business challenges and to sustain itself, the garment industry needs to increase productivity without jeopardizing compliance (Kader and Akter, 2014). Lean is regarded as a solution to many of the production problems regarding productivity, waste reduction, and product quality management in apparel industries throughout the world (Chauhan and Geeta Nema, 2017). The literature already includes examples of tool-based lean applications in the garment industry that have made a positive contribution to productivity (Bashar et al., 2021; Hamja et al., 2019a). However, almost all such studies deal only with pilot lean projects or lean in the early phases of implementation; there is a dearth of studies on more mature lean applications in the garment industry. While the effects of lean on OHS are subject to debate in the literature (Hasle et al., 2012), the recent review of the effects of lean in the garment industry (Hamja et al., 2019a) suggests a positive influence on OHS. However, the results also indicate ambiguous effects, and long-term health effects have not been studied.

The reviewed studies of lean in the garment industry have very limited reflections on the implementation process as such (Hamja et al., 2019a), even though implementation can be expected to be difficult in developing countries (Andersson et al., 2019). Industrial experience both in general and in relation to the garment industry is low, as is the educational level. Since company owners have learned that competitive power is secured through low salaries, they even tend to display – in Bangladesh, for example – a lack of interest in developing technical knowledge, training and innovation (Rakib and Adnan, 2015). This situation translates to a low capacity of the industries to innovate, which leads to low success rates in adopting tools and techniques for higher productivity such as lean (Akter and Ahmad, 2019). The low innovative capacity of firms has been proved to directly affect their operational performance (Kafetzopoulos and Psomas, 2015), and hence weakens the adoption and transfer processes of tools, techniques and technologies for improvement in the garment industry.

2.3 Key factors for lean implementation in developing countries

The presented literature suggests that key factors for unsuccessful implementation are lack of top management commitment, resistance to change and overreliance on tools. Furthermore, in the context of developing countries such as Bangladesh, lean implementation is constrained by low capability in industrial engineering, a workforce with limited industrial experience and hierarchical structure hampering worker engagement. Drawing from the literature, we suggest the following key factors for designing the lean implementation:

- 1) Top management demonstration of commitment through action, e.g. mentoring on the shop floor
- 2) Workers and middle manager's participation as much as possible to be empowered in new ways of working, e.g. by allowing local decision making and self-management

- 3) Tools selected to match the current maturity level of the company and extensive training focused on a lean mindset rather than on only the tool
- 4) A focus of the implementation activities on institutional collectivism, the human dimension and future orientation, e.g. by using soft lean practices and non-financial rewards, such as town hall meetings, frequent feedback, evaluation on the shop floor, and a supportive management structure.

2.3 Researching lean

Despite using the above mentioned success factors, there are large differences in the outcomes of lean implementations, and there is a need to explain why some organizations are successful in implementing lean and others are not. This is particularly pertinent for developing countries to provide guidance, which can facilitate lean implementation in a context with considerable barriers.

However, such a study is challenging from a methodological point of view. Lean implementation studies that uses quantitative surveys to investigate enabling or inhibiting factors, target employees in larger organizations (Sim and Rogers, 2008) or in a number of organizations that have implemented lean (Bashar et al., 2021; Doolen and Hacker, 2005; Wickramasinghe and Wickramasinghe, 2020). This methodology is by nature limited to the closed answer items and the respondents' opinions, and while the answers can give an overview of enabling and inhibiting factors, they are limited when it comes to explaining the causal factors for the experience. For example, quantitative surveys have established that top management support is crucial for lean implementation (see, for example, Bloom et al., 2013), but do not explain how the general concept of top management support can be transformed into a practice that influences the lean implementation. Moreover, these studies are criticized for not acknowledging the complexity of lean and that it is necessary to study lean as an emergent system in a dynamic evolving process. Therefore,

studies who rely on one slice of time in order to study lean implementation will not help us understand the transfer mechanisms in their real complexity. It is necessary to find other ways to study the evolving culture of lean in which people's thinking is an essential part of the study (Liker and Morgan, 2011).

Lean implementation studies using qualitative case studies (Bortolotti et al., 2015; Brown et al., 2006; Hansen and Møller, 2016; Liker and Morgan, 2011) can provide important information about the whole process of implementation and insights into the stakeholders' actions and experiences. However, as the implementation of lean is very context-dependent, individual case studies have difficulties in generalizing which factors have a decisive influence on the outcome of the implementation process.

The limitations of these traditional approaches to identify mechanisms that can guide practitioners has led to the call for new research strategies. One is the design science research strategy (Van Aken et al., 2016), which aims to discover knowledge that can be used in a predictive way for action. A methodology utilizing the context-intervention-mechanism-outcome framework (CIMO) (Van Aken, 2004; Denyer et al., 2008) can support the identification of explanatory mechanisms that can be used for designing future action. The idea in design science research is to use the CIMO framework to study real-life interventions, and to use the rich data from different sources to extract mechanisms that can be generalized for future use.

3. Methodology

In this study, we use the CIMO framework to analyze lean implementation in four garment factories in Bangladesh to identify mechanisms that can guide future action. Each company carried out

a lean intervention integrated with OSH improvements, designed in collaboration with the researchers. The data covers the context of the companies, before and after measurements, observations, and interviews. The application of a multiple case study method (Yin, 2016) facilitates comparison of differences in context, intervention practices, and outcomes to identify the mechanisms (Denyer et al., 2008) that can increase the possibility of a successful lean implementation in the garment sector, contributing to an improvement in both productivity and OHS.

3.1 Sample selection

The case companies were selected based on the following criteria:

- 1) A top management expression of commitment to support the change, among others due to pressure from buyers inter alia;
- 2) An export-focused approach with the sewing of basic ready-made garments as the main activity; and
- 3) Availability of factory lines that produce the same type of basic garment products (basic T-shirt and polo T-shirts) for the pilot implementation.

[Table 1 near here]

3.2 Intervention Procedure

The intervention included four phases: introduction, baseline data collection, intervention, and post measurements. The intervention process was carried out in two waves, where experience from the first wave was used to improve the second wave. The first wave ran from March 2017 to January 2018, and the second wave from November 2017 to September 2018. A research team consisting of a PhD student and a research assistant, supported by two senior researchers and an expert in lean in garment, were responsible for data collection and intervention activities. The first author

was in control of carrying out the intervention in all four factories. Prior to the start of the intervention, the researchers designed an overall intervention plan in four phases for introducing lean and OHS content to the factories.

Introductory phase:

The introductory phase started with a meeting presenting the project to the factory's management and alignment of expectations from both sides. This was followed by establishment of a core management team for the overall supervision of the project. Furthermore, the management established an operational team responsible for tangible implementation. The team included industrial engineers (IEs), human resource and compliance managers, production managers, quality managers, in addition to line supervisors and workers' representatives. A production line was selected as pilot line for implementation of the intervention in the factory. The researchers concluded the introduction phase by interviews with managers in factory to collect their views on the upcoming implementation process and to collect general information about the factory.

Baseline data collection phase:

The baseline covered data on production and OHS KPI in the pilot line prior to the start of lean implementation. Production data included: productivity, time and motion studies (TMS), efficiency, value-added ratio, single minute exchange of die (SMED), and 5S. OHS data included working postures, workstation design, and survey data about worker health. The factory operational team assisted by the researchers collected the data.

Intervention phase:

The researchers started by organizing focused training on lean tools and OHS, which involved both on-the-job and formal training. The formal training encompassed four half days and covered

lean theory, practical tools such as value stream mapping (VSM), 5S, TMS, SMED, workstation design, ergonomics, and other OHS topics. The findings from the baseline measurements formed the basis for the intervention priorities, which were decided in collaboration between the factory management and the researchers. After priorities were decided, the operational teams of the factory initiated implementation of the changes with support from the researchers. In addition to supporting the implementation process, the team of researchers collected production data and carried out observations of the change processes, as well as conducted interviews with managers and workers during the process.

Post measurement phase:

The post measurement phase included collection of the same metrics as measured at the baseline, as well as further observations and interviews. This phase was concluded with a presentation of the overall results of the intervention to the core management team, with suggestions on how to continue the work and sustain the changes.

3.3 Data collection

Data including production measurements, semi-structured interviews, participant observations, and worker questionnaires, as well as data and written documentation provided by the factories is shown in table 2 (for further details, cf. Hamja et al., 2019b).

[Table 2 near here]

We visited the pilot line of each factory 36 times, including twice a week for the first month, and once a week for the remaining intervention period (March 2017 to September 2018). A follow-up visit was made for a sustainability assessment 3-6 months after completion of intervention. The

assessment included whether the improvements in the pilot lines were maintained and possibly further improved and whether the changes have been extended in other production lines in factory.

3.4 Data analysis

All collected data was store in a project database. Semi-structured interviews were recorded and transcribed immediately afterwards. Interviews were carried out in the local language, and the researchers translated and transcribed into English.

The analysis was carried out in two parts to facilitate the use of the CIMO model. The first part dealt with the establishment of the intervention outcome. It includes a basic analysis of the difference observed before and after data. In this paper, we report only the main outcomes, using a scale for the relative changes from baseline. N: No change (<+5%), L: Low (5% to 15%), M: Medium (15% to 25%), H: High (>25%) (see Table 4,5). Furthermore, to gain a better understanding of the overall score (Table 7), we calculated an index from 0 to 3 adding all measured change factors with N= 0, L= 1, M= 2, H= 3. In addition, we assessed the intervention fidelity of the factories in relation to their implementation of the suggested lean changes. This assessment was based on our observations of the extent to which the suggestions were implemented, and we used a similar scale, namely no implementation N=0, L=low fidelity, M=medium fidelity, and H=high fidelity (see Table 3). An analysis was also carried out regarding sustainability, with a view to establishing whether the factories were able maintain results and to expand the positive changes from pilot lines to other lines.

The second and more extensive part of the analysis followed the CIMO logic to identify possible mechanisms for implementation (Van Aken et al., 2016; Denyer et al., 2008). In making this analysis, we undertook an iterative process of combining data from the intervention with our theoretical

knowledge, practical experience, and causal logics about lean implementation and the national context. We therefore used a strategy similar to that suggested by van Aken et al. (2016):

“Unfortunately, no straightforward approach exists for establishing the material and social mechanisms producing the outcomes and performance of a generic design. Neither is there one for gathering evidence on how these mechanisms affect outcomes and performance. Establishing mechanisms is rather a matter of ‘bricolage’, combining one's social and technical expertise, logic, generic explanatory theory on the phenomena in play and conscientious cross-case analyses of design instantiations.” p. 6.

We started by examining the differences between the four factories regarding the outcomes and compared them on the basis of the two intervention iterations, the intervention fidelity and their context; thereby identifying a number of suggestions for mechanisms that could facilitate lean implementation. The results of the analysis structured after the CIMO model are presented in the next section.

4. Analysis

4.1 Context

The factories generally share the same basic external and internal context. Externally, they are fighting to meet buyer requirements for shorter lead time, higher quality, lower cost and higher compliance.

With regard to the internal contextual factors (cf. Table 1), a number of relevant factors are worth pointing out: there is a considerable size difference, only one factory has an active labor union, worker turnover rates are quite different, two factories consistently fail to pay salaries on time, two

factories exchange knowledge with other factories, and only one factory has substantial industrial engineering competencies available.

Overall, the most important contextual factor seems to be the lack of qualified staff at management, professional and worker level. A shortage of qualified industrial engineers, in particular, constitutes a problem for both general operations and for lean implementation. Two factories had no engineers employed at all, while F-1 had a few engineers, but experienced frequent job changes. The industrial engineer responsible for the implementation of lean left in the middle of the intervention period, and the intervention almost stalled. F-3 was slightly better off, with approximately five engineers. In addition to the engineers involved in operations, all four factories employed middle managers with a textile or industrial engineering degree, and F-2 and F-4 also hired foreign personnel with an engineering background as managers.

4.2 Intervention

We have depicted the basic intervention model in figure 1, used in the two first wave factories. The intervention activities can be specified to 11 initiatives to implement lean as listed below,

[Figure 1 near here]

The intervention covered three main elements, included in both waves

1. Establishment change organization

- Establishment of a core team consisting of top management to support the intervention
- Establishment of the operational team for carrying out the intervention

2. Use of tools to improve factory lines

- Bottleneck improvement for efficiency

- 5S application on the shop floor
- Workstation redesign based on International Labor Organization (ILO) guidelines
- Value Stream Mapping
- SMED to improve change-over time
- Change-over six-day plan
- OHS training

3. Training

- Formal training
- On the job training

A number of barriers to implementation were experienced during the first-wave intervention. These included low commitment from the top management, limited understanding of the need for management of the intervention on the shop floor, weak coordination between stakeholders, unfocused attention to in-house training, limited or no follow up by the industrial engineers at the floor level, limited or no maintenance of intervention records and weak or no involvement of workers. We used these observations for suggesting additional activities to strengthen the outcome in the second wave of the intervention. The specific initiatives include:

- Establishment of specialized groups for each lean tool
- Additional training sessions off-site for operational team and focused training of workers
- Weekly team meetings
- Systematic idea suggestion system for workers
- Encouragement of worker participation
- Worker involvement in problem-solving

- Follow up when workers faced problems
- Systematic collaboration between departments
- Gift for workers

[Figure 2 near here]

The application of the intervention activities in the four factories varied considerably (table 3). Obviously, the application of second wave suggestions did not happen in first wave, but even for the included initiatives, they were only applied at a low or medium level in first wave, whereas more initiatives in second wave were applied at a high level.

[Table 3 near here]

4.3 Outcomes

The productivity results (table 3) demonstrate that F-1 achieved almost no improvements, whereas the other three experienced some improvements, with F-3 experiencing the greatest improvements.

[Table 4 near here]

With respect to the OHS improvement (Table 5), the outcome varies across the factories, with F-1 and F-3 demonstrating greatest improvements. In the second wave it was also possible to establish before-and-after results for workers' pain and discomfort, which were reduced in both factories (Hamja et al., 2019b).

[Table 5 near here]

Our assessment of the likelihood of sustaining and expanding the lean application (Table 6) indicates that it is unlikely that F-1 will sustain the lean initiatives, whereas F-2 and F-4 may have some chance of doing so, especially in relation to maintaining the productivity achievements in the pilot lines. However, it is clear that the possibility of further gains is limited, since the follow-up visit – undertaken after the intervention had ended – demonstrated that no expansion to other lines had been implemented. On the other hand, F-3 has greater potential to sustain results, and has already started to expand the lean activities to other lines in the factory.

[Table 6 near here]

Finally, we calculated an overall average for all the changes measured by the indices summarized in tables 4-6. All scores as well as the average aggregate score are shown in figure 3. The results show that F-3 on average was the most successful intervention, F-2 and F-4 were in the middle, and F-1 was the least successful. However, F-1 had the largest improvement on OHS and ergonomics.

In figure 4, we show the four factories' improvements on the three dimensions relative to the highest score between the four, i.e. index from 0 to 1, where 1 is the highest score from table 4-6, respectively. The figure shows that F-1 has an imbalanced outcome of the intervention with a very high OHS and ergonomics score, but almost no change on productivity and sustainability. However, the three other factories show a balanced relationship between improvements of productivity and OHS and ergonomics. This indicates that it is possible to improve both dimensions simultaneously and that a more successful implementation, such as F-4, can yield higher results on both dimensions.

[Figure 3 near here]

[Figure 4 near here]

4.4 Mechanisms

We used the considerable differences between the outcomes in the four factories to make a cross-case analysis for explanations, where certain mechanisms could play a role for a more successful lean implementation. In this analysis we built on causal logics, theoretical knowledge and practical experience as specified in the design science literature (Van Aken, 2004). As a sensitizing device for the analysis, the five factors from the literature on successful lean implementation serve as an organizing framework. Altogether, we identified 23 mechanisms distributed on the five factors (Table 7). We have included additional organizational mechanisms suggested for the second wave, as they stretch beyond the traditional lean intervention activities. Furthermore, we have included mechanisms applied by the factories (in particular F-3) but not suggested by researchers.

For each of the 23 potential mechanisms, the research team assessed a score for the level of application: N=0 (no application); L=1 (low application); M=2 (medium application); H=3 (high application). Finally, an aggregate of the total mean score was calculated to demonstrate the indication of success in the application of the mechanism for lean implementation. The aggregate scores were classified as low, medium and high according to a scale where 0-1=low, 1-2= medium and 2-3=high. The mean of the scores indicated that F-3 had a high level of application of the mechanisms, F-2 had a medium level, and the two final factories had only a low-level of application of mechanisms.

[Table 7 near here]

The most obvious difference is the way top management in F-3 has transformed verbal commitment to the lean implementation into practice, demonstrating to middle managers, supervisors, and workers that lean was their top priority. There are also considerable differences between the application of the other mechanisms among the four factories. However, the mechanisms cannot alone explain the differences between the factories. It is worth noticing that F-1 and F-4 on two dimensions had the most challenging context. They had few industrial engineers, and they had a more constrained economy with failure to pay salary to workers in time. While these two factories have the lowest aggregate scores on application of the mechanisms, F-4 had a much better result of the intervention. Analyzing the differences in application of the mechanisms, we identified training, workers' awareness of OHS, and open discussion of top management with line supervisors as the explaining factors.

5. Discussion

This article began by identifying challenges for lean implementation in the garment industry. It is generally observed in studies from industrialized countries that lean implementation fails in many cases. With limited industrial experience and a lack of qualified staff, the constraints on successful lean implementation can also be expected to be present in an amplified manner in developing countries. Yet, several studies from developing countries have identified short term improvements related to specific lean tool implementation (Bashar et al., 2021; Wickramasinghe and Wickramasinghe, 2020). However, long term consequence of lean implementation with a bundle of tools is not covered by these studies. Moreover, the effect of lean implementation on OHS conditions is also not considered earlier. In this study, four factories received extensive support from researchers for their lean implementation, but only one achieved what can be assessed as a

successful result; one completely failed, and two achieved mediocre results with little expectations for sustainability of lean.

Top management commitment is generally identified as important, but it acquires even greater importance in a strongly traditional top-down culture such as in Bangladesh. It is therefore a crucial key to convert the traditional verbal top management commitment into a practice that is trusted by middle managers, supervisors and workers. Our findings demonstrate the importance of tangible activities such as top management personally paying daily visits to the shop floor, having direct discussions with the workers and supervisors, and ensuring immediate follow up when problems are raised.

The literature found that communication is an important aspect for successful lean implementation (Pavnaskar et al., 2003). Moreover, miscommunication may lead to misunderstanding and misapplication of the lean concept and tools. Top management from three factories initially gave verbal commitments, but the researcher subsequently found that there was a significant difference between a verbal commitment and practical implementation. In the last factory (F-3) top management was very positively committed and gave tangible support, which ultimately yielded a positive result. Following the top management commitment, the three traditional lean implementation factors (worker involvement, lean tools application methods and training) can be applied as illustrated in figure 5. However, there are also specific mechanisms related to these factors that our study finds to be important for the implementation of lean in the garment industry, including the top management practices at the shop floor of daily visits, discussions with workers and supervisors and immediate follow up on problems raised.

It is a standard element in lean implementation to promote worker involvement – both to qualify the lean changes and to avoid resistance. In a developing country such as Bangladesh, worker involvement is traditionally very low (Bhuiyan, 2010) and most workers have very little industrial experience. It is therefore to be expected that there will be a low feeling of psychological safety among workers to raise their voice with suggestions or to identify problems. Consequently, it is important to build trust and psychological safety. The data from the best performing factory shows that the workers whose top managers visit them, ask questions and follow up on suggestions they have, potentially pave the way for some of the more traditional lean methods for involvement. These methods include visual boards and meetings for comments and suggestions.

Largely standard implementation procedures were followed in the intervention for the application of lean tools. An additional important activity proved to be division into smaller topic-focused teams, as collaboration across responsibilities and disciplines is difficult in the Bangladesh context. However, the division into more narrow topics also highlighted the traditional barriers to cross-unit coordination, and additional coordination activities need to be initiated.

The third standard element is training of both managers and workers. As indicated previously, the analyzed training mechanisms can explain most of the difference between the outcomes of the interventions, as these are the largest difference between F-1 and F-4. However, as three of the factories did not get much out the training activities, these mechanisms may have a large untapped potential for improved interventions. In the first wave, training was organized as classroom training in the factories but it proved to have little effect. Managers were unfocused, talked on the telephone, or left, while workers listened in silence and did not get much benefit from the process. In the second wave, training of managers and staff took place outside the factories in order to secure the necessary focus, while worker training included both classroom training and on-the-job

training. However, only F-3 fully accepted this mechanism; the other factories regarded training partly as a waste of time – especially worker training, which they experienced as bringing production to a halt, resulting in the loss of certain pieces of produced garment.

It was only possible to study the sustained implementation of lean in the four factories after a few months, and the long-term sustainability of the lean application is therefore an open question. Nevertheless, at all the factories the researchers suggested mechanisms that could introduce a learning culture, which could support the future application of lean. Some of the mechanisms included new idea generation and execution by supervisors, material in-house follow-up culture, weekly or monthly production planning, weekly meeting with minutes and follow up, and benchmarking with other factories. Again, F-3 utilized these possibilities.

[Figure 5 near here]

However, it is important that further studies be undertaken on the diffusion of lean from pilot lines to the factory as a whole. The subsequent sustainable embedment of lean is also important, as is the determination of the extent to which the intervention measures, in combination with the identified mechanisms for lean implementation, can help to facilitate sustainability. Furthermore, it would be relevant with more studies of the suggested mechanisms. It could both be in mixed methods case studies and survey a larger group of companies, asking about the occurrence of the mechanisms and comparing with lean implementation outcomes. It would be particularly relevant to study in other developing countries such as China, India, Sri Lanka, and Vietnam with a different context among other by a more experienced and educated mid-level factory management compared to Bangladesh (Andersson et al., 2019; Wickramasinghe and Wickramasinghe, 2020).

6. Conclusion

This study investigates mechanisms for successful lean implementation with positive effects on both productivity and OHS. Based on design science research and interventions at four garment factories in Bangladesh, the paper made use of the CIMO framework to identify mechanisms for successful interventions.

The study demonstrates that a lean intervention can simultaneously improve both efficiency and OHS conditions. When both elements are integrated in the intervention, they are complementary rather than contradictory.

The analysis confirms that the standard headings for lean implementation in the form of top management commitment, worker involvement, training, tools and methods, and learning culture as expected are valid, but that they need specific tangible mechanisms that fit the national context in order to create a successful lean implementation. The mechanisms for transforming verbal top management commitment into practice are particularly important – also to involvement of workers who are not used to having any level of voice or participation. The paper therefore contributes to the theory of lean implementation and to the recent discourse on positive lean by demonstrating how the barriers expected in a developing country context, can be countered. However, more empirical studies are required to investigate the extent to which the results of this study can be applied at a more general level. Nevertheless, the results can already be used to guide managers and industrial engineers in designing improved lean implementation for the many garment factories in developing countries. The implication for society of these improved interventions is contribution to economic development and development of more decent work.

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7. References:

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Table 1: Context of the four factories

Contextual Factor	F-1	F-2	F-3	F-4
Year of establishment	1979	2007	1996	2010
Number of workers	7500	1800	850	350
Average efficiency	42%	46%	50%	36%
Turnover of employees per month	4-5%	3-5%	2-3%	5-7%
Trade union	+	-	-	-
No. of industrial engineers (IE)	1-3	0	4-6	0
No. of middle management with IE experience	1	0	3-5	1-2
Lean experience for IE personnel	Limited	Some	Some	Limited
Payment of workers' salaries within the deadline	Not always	Yes	Yes	Not always

Table 2: Data collection

Data	Format	Collection method
Time and motion studies	Measurement of cycle time for each operation by stop-watch and video recording of bottleneck operations	Interviews at each work station on pilot line (207 to 220 stations)
5S scoring sheet	Scores for area around pilot line including workstations	Interview of each worker in pilot line (207 to 220 workers)
VSM	Measurement of total time of each bundle (25 to 50 pieces) operation of each workstation, and finally measuring single product throughput time	Throughout the pilot line (207 to 220 workers)
SMED	Total time measurement of every workstation or process to get final product without any defect	Interview of each worker in pilot line (207 to 220 workers)
Worker questionnaire	10 questions including pain and fatigue of workers according to body map	Interview of each worker in pilot line (207 to 220 workers)
Observations of work	Workstation design, ergonomics posture	207 to 220 workstations
Semi-structured interviews	The main topics covered were problems experienced during the intervention and the overall support received from management	12 interviews with middle management recorded and transcribed. In addition 220 short interview with workers and supervisors with written summaries
Logbook with change observations	Every factory visit is recorded with a detailed description of activities, interviews, and collected data	Four logbooks

Table 3: Adoption of intervention initiatives

Intervention initiative for lean implementation	1 st wave		2 nd wave	
	F-1	F-2	F-3	F-4
Change organization				
• Establishment of core team	M	M	H	L
• Establishment of operation team	L	M	H	M
• Sub-operation team (specialized group)	N	N	H	M
• Weekly team meeting	N	N	M	L
• Systematic documentation of weekly meetings	N	N	H	L
• Systematic collaboration between internal departments	N	N	M	M
Training				
• Training in-house	L	M	H	L
• Training outside factory	N	N	H	L
• Training of all workers (pilot line)	N	N	H	L
• OHS training	M	M	H	M
• On-job training	M	M	H	M
• Quality training	N	N	M	M
Lean tools				
• Bottleneck improvement for efficiency	L	M	H	M
• 5S application on sewing floor	M	M	H	M
• Workstation redesign by ILO guideline	L	L	M	M
• Value Stream Mapping	L	L	H	L
• Change-over time by SMED concept	L	M	M	L
• Six-days-ahead plan for change-over	L	L	M	M
Worker involvement				
• Encourage workers to raise problem during operation	N	N	M	L
• Problem follow up	N	N	H	L
• Group work between workers	N	N	M	L
• Gift for workers from factory	M	N	L	N
H=High, M=Medium, L=Low, N= No application				

Table 4 : Productivity assessment

Tools	F-1	F-2	F-3	F-4
Efficiency	N	M	H	L
5S	L	L	M	L
VSM	N	M	H	H
SMED	N	M	H	M
Productivity aggregate Score	0.25	1.75	2.75	1.75

Table 5: OHS and ergonomics assessment

Assessment of Ergonomics and OHS		F-1	F-2	F-3	F-4
Ergonomics Assessment	Head position	H	M	L	L
	Arm position	L	N	N	N
	Back position	H	N	H	N
	Leg position	L	N	N	N
OHS Assessment	Enough space between workstation	N	N	M	L
	Easy to pick up and drop up material	N	L	N	N
	Machine safety (belt cover, needle guard, eye guard, and machine light)	N	L	N	L
	Housekeeping	N	N	N	N
Final Assessment (Overall) Aggregate score		1	0.5	0.75	0.38

Table 6: Sustainability indicator assessment

Assessment	Factory			
	F-1	F-2	F-3	F-4
Productivity	L	M	H	M
OHS and Ergonomics	N	L	M	L
Expansion in other lines	N	L	H	L
Final Assessment (Overall) Aggregate score	L (0.33)	M (1.33)	H (2.67)	M (1.33)

Table 7 : Mechanisms for successful lean implementation in the ready-made garment industry

Local Factor for successful lean implementation	Mechanisms	F-1	F-2	F-3	F-4
Top Management (TM) commitment	Daily visit of TM to production floor	L	M	H	N
	Daily informal talks with workers when TM walks around the production floor	N	L	H	N
	Open discussion of TM with line supervisors	N	L	H	L
	Attention of TM for instant solutions of worker problems	N	N	M	N
	TM decision to ensure one IE always present during production time on the floor	L	M	H	L
	Empowerment of the worker (Share their problems)	N	M	H	N

Worker involvement	Workers' awareness of OHS and knowledge sharing with others (Own physical health)	N	H	H	L
	Provision for small gifts to workers for best performance of every month	L	N	H	N
	Respect among workers (not shouting)	N	N	M	N
Training	Formal training for workers	N	H	H	L
	Floor level implementation after formal training	N	L	H	L
	Offshore training	N	L	H	N
	Using more visual and adaptive training methods	N	L	H	L
Tools and methods	Dynamic Operation team	L	L	H	L
	The practice of best methods in sewing	N	M	M	N
	Standing maintenance team during change-over	N	L	H	N
	Adoption of new auxiliary tools	N	L	H	N
Learning culture	New idea generation and execution by supervisor	N	L	H	N
	Materials in-house follow-up culture	N	M	M	M
	Monthly to weekly production planning	L	N	M	N
	Weekly meeting and for problem-solving	L	M	H	N
	Benchmarking new ideas from another factory	N	L	H	N
	Collaboration between inter and external factory	N	L	H	N
Total mean aggregate score		L (0.30)	M (1.34)	H (2.1)	L (0.3)

Figure 1: The basic intervention model for wave 1

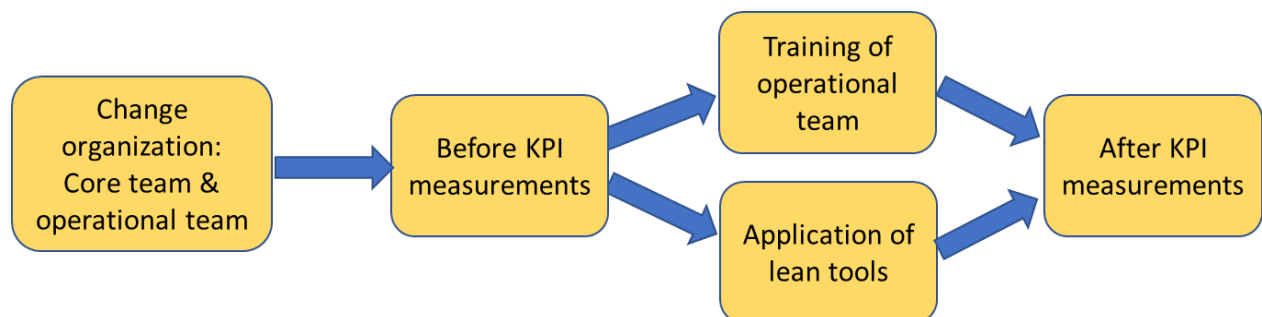


Figure 2: The adapted model for wave 2

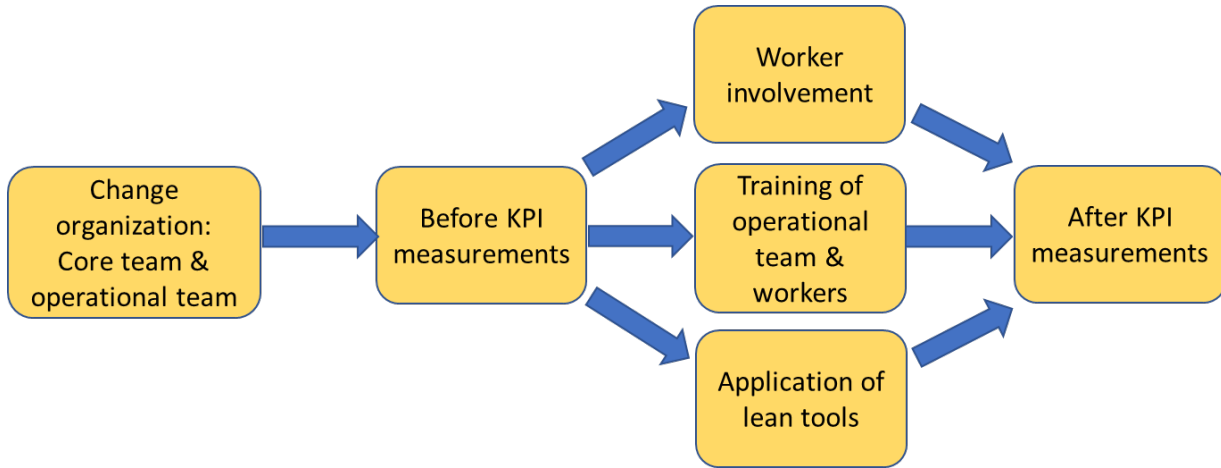


Figure 3: Overall assessment

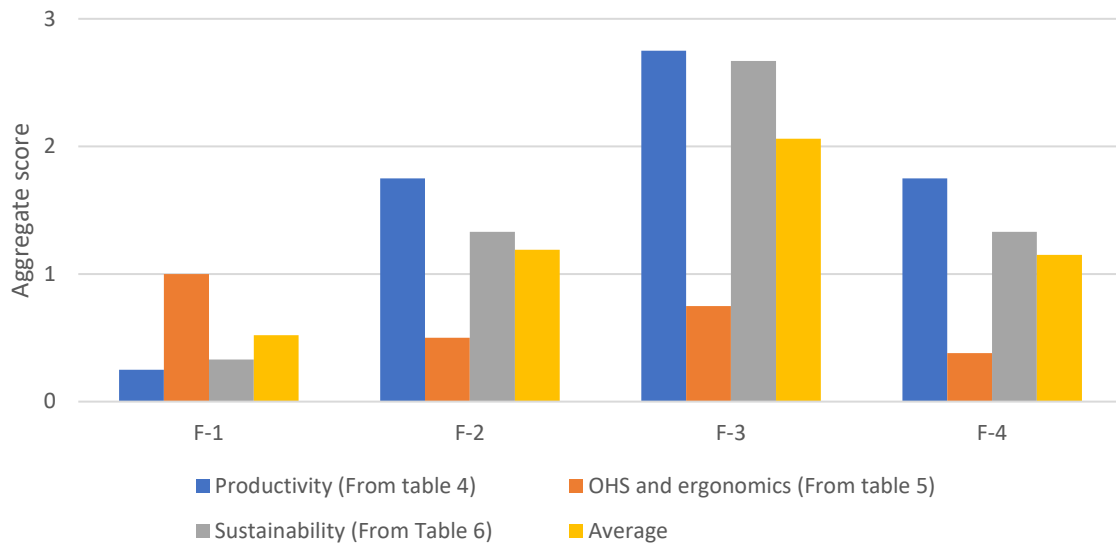


Figure 4: Relative improvement

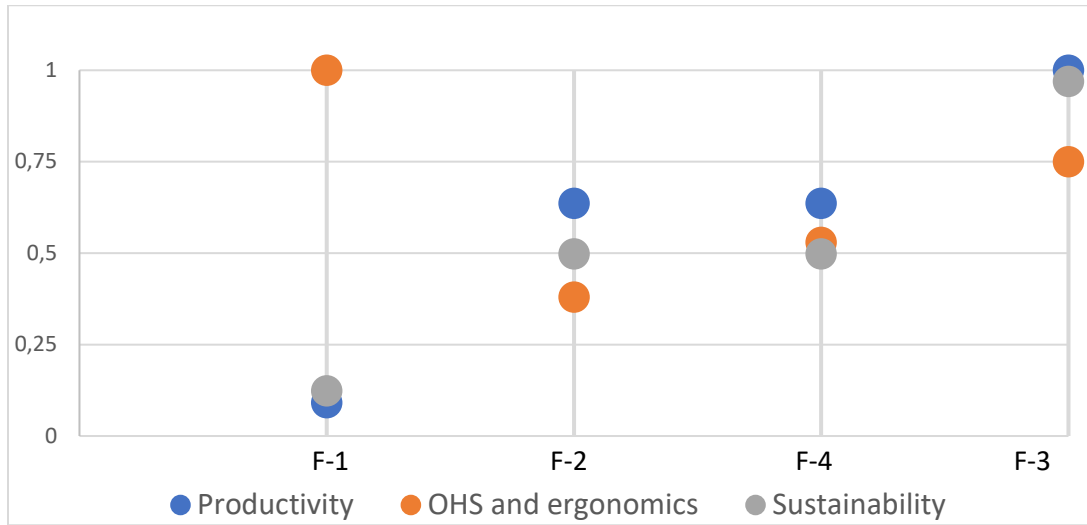


Figure 5: Model for sustainability of lean implementation in the RMG sector

