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A Lean, Green and Six Sigma (LG6σ) for SMEs in the leather industry in Bangladesh

MD MAHABUBUR RAHMAN
University of the West of Scotland (London Campus), United Kingdom

JAMES OGUNLEYE
Middlesex University, United Kingdom
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ABSTRACT The study explores the use and implementation of Lean, Green and Six Sigma (LG6σ) in small and medium-size enterprises (SMEs) in the leather manufacturing industry in Bangladesh. The study adopts mixed research methods combining a non-systematic review of literature, survey questionnaires and interviews involving 25 survey questionnaires and 16 in-depth interviews respectively. The study finds that SMEs in the leather industry in Bangladesh use some of the lean tools such as 5s, Total productive maintenance, Just in time but not the Six Sigma. The study also finds a lack of motivation and right tools for the implementation of LG6σ as the results found no significant difference between using lean tools in the process and non-process industry. This study contributes to an understanding of LG6σ amongst SMEs in the leather industry in Bangladesh. The paper highlighted the importance of management's active involvement and commitment, clear vision and successful communication as key success factors for SMEs in the leather industry. The paper's expectation is that the findings from this study will deepen practitioners' knowledge and understanding of, and managerial practice in LG6σ in the Bangladeshi leather manufacturing industry.

Keywords: Lean, Six Sigma, Green management, framework, leather industry

Introduction

Globally, in 2017, the Bangladeshi leader industry accounted for 0.6% of export market and under '1.0% of gross value added in domestic manufacturing' (Hong, 2018, p.2). The industry is second only to the apparel industry in term of the emerging market exports (Textnation, 2018). Nationally, the leather industry contributed about US$1.4 billion to the Bangladeshi's gross domestic products (GDP) in the 2016-17 financial year according to the Bangladesh Central Bank (2018) and employed a total of 200,000 workers by the end of the 2015-16 financial year (Mamun *et al.,* 2016; LFMEAB, 2016). According to Hong (2018), women constitute 70% of employees in Bangladeshi footwear firms. In this industry, the traditional method of pre-tanning and tanning consumes a huge quantity of energy and chemicals and produces a lot of waste (Okoduwa *et al*., 2017). Similarly, the Bangladeshi leather tanneries in the Hazaribagh (home of 90% of tanneries) discharges approximately 22,000 litres of toxic water every day into the open environment (Worst Polluted, 2016; Okoduwa *et al*., 2017). Energy, chemicals and other resources could be wasted if these are not managed efficiently during the leather manufacturing process. Therefore, increasing efficiency during the

leather manufacturing process could result in savings on these assets. Given that SMEs face challenges of limited resources, saving on these assets would have a positive impact on organisational finances, and performance.

Exports from SMEs in the leather industry are limited, yet, such SMEs undertake activities that help to alleviate poverty, create jobs, as well supply large organisations (Strasser, 2015; Edobor & Ogunleye, 2015). The SMEs in the leather industry accounted for 25% of the labour force and approximately 40% of gross manufacturing output in Bangladesh, according to Qamruzzaman (2015) – which underline the importance of SMEs to the economy and the need to improve the quality of products produced by, and the organisational practice of SMEs.

Whilst previous studies have focused on how to increase productivity amongst SMEs (Abor & Quartey, 2010; Randelli, & Lombardi, 2014), minimising wastage and improve environmental impact (Yimer, 2013), there is still a dearth of studies that uses Lean, Green and Six Sigma (LG6σ) in combination to bring about a better understanding of SMEs in the leather sector. Considering this, the current study explores the integrating of LG6σ. The intention is to reduce wastage, create environmentally friendly industry and reduce process variation leading to improve quality and productivity amongst SMEs in the leather manufacturing sector. Consequently, this could be a resource for achieving a competitive advantage for the SMEs in the wake of increasing global competition.

Quality management techniques in SME

SMEs are frequently considered as core suppliers of goods and services to large organisation hence the adverse goods and services quality from SMEs eventually has a knock-on effect on the large organisation (Quazi and Padibjo, 1998). Consequently, large organisations only hire goods and services from SMEs who can provide better quality goods and delivery services (Barrier, 1992).

Although it is widely witnessed the practice of quality management (QM) techniques into large organisation long before SMEs perceived the importance of QM (Murphy, 2016). Nonetheless, it is fair to mention that all the quality management techniques such as ISO 9000, TQM, Six Sigma (SS), Lean management (LM), Business Excellent Model (BEM), Balanced Scorecard and others had been invented keeping large organisation into in mind (McAdam, 2000) thus complexity persists and not suitable for SMEs (Yusof and Aspinwall, 2000; Murphy, 2016). In addition, lack of familiarity and knowledge about the QM techniques precluded QM adoption by SMEs (Anthony et al., 2005; Kumar et al., 2014).

Despite the importance and perceived advantages of QM, SMEs sector yet to witness its presence. By 1980s, it came under the spotlight the need for QM technique in SMEs, mostly because of pressures were coming from the large organisation (Murphy, 2016). Since then up until the 2000s, many research studies have been conducted on ISO and TQM implementation (Price and Chen, 1993; Yam and Tang, 1993; Ahire and Golhar, 1996; Lee, 1998) which focused on UK, US and other developed countries but none in developing countries, such as Bangladesh.

The preliminary study found that Bangladeshi leather manufacturing SMEs still uses archaic visual inspection during and after completion of manufacturing. Although there are few large organisations use ISO and lean management however there is no codify industry standard of quality measurement scale presence, currently. Therefore, quality inspection has become very subjective, in many case SME firms affected by thousands due to the rejection from buyers.

Lean, Green and Six Sigma (LG6σ)

Previous studies suggest that LG6σ offer synergy and are complimentary when implemented together (Cherrafi et al., 2017; Fatemi and Franchetti, 2016; EPA, 2017). Furthermore, practising LG6σ would help to eliminate wastages, increase optimisation of resources, create an environmental-friendly organisation as well as increase customers' satisfaction (Banawi and Bilec, 2014; Ng *et al.,* 2015; Graza-Reyes, 2015). Similarly, the Environmental Protection Agency, EPG, (2017), advanced four reasons for integrating green management with Lean and Six Sigma. Firstly, the EPG (2017) suggest that integrating green issues with lean philosophy can produce impressive environmental outcomes within a very short time. It is assumed that a lean project can yield compelling results within 2-5 days, in which lean teams contribute to reducing the lead time and cost while improving products quality and customers' responsiveness which conducive to green management practice. Secondly, the EPA (2017) also suggest that Lean and Six Sigma tools take a holistic approach to ensure employees are engaged in identifying and eliminating non-value-added or wastage in production. Incorporating environmental wastage with Lean and Six Sigma makes even stronger vehicles for engaging employees in identifying and implementing environmental improvement opportunities. Thirdly, the EPA (2017) suggest that integrating "Lean and Green" can help to minimise environmental impacts and navigate regulatory and permitting issues that may arise in operational changes during the Lean and Six Sigma project. Lastly, green management or environmental expertise can share their wealth of environmental resources through connecting with Lean and Six Sigma practitioners who are involved with strategic and fundamental operational changes (EPA, 2017). These knowledge resources are in fact, a source of competitive advantage (Murmann, 2004).

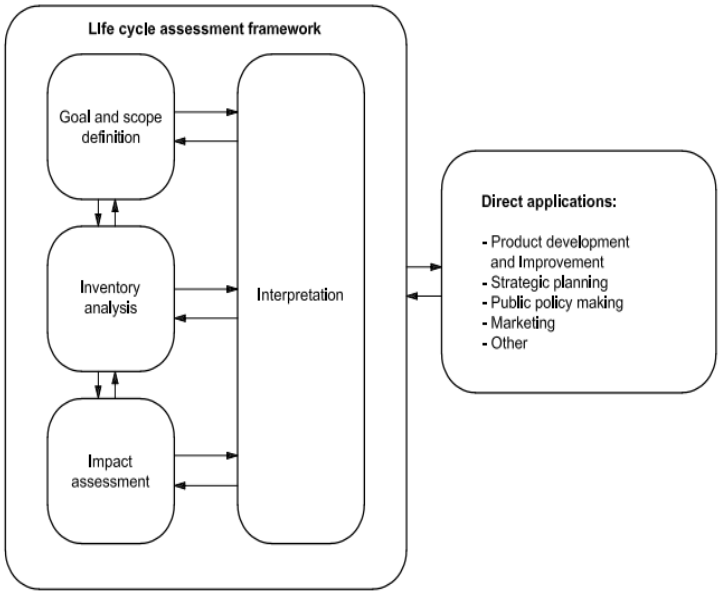
Lean is a 'behaviour-driven' philosophy, what everyone does every day without being told (Bicheno and Holweg, 2009). The thrust of lean philosophy is waste elimination in every 'aspect of a firm's production activities' (Modi and Thakkar, 2014, p.339). According to (Simon and Mason, 2003), lean is a business strategy that helps to do more with less resources through eliminating seven deadly wastage amongst value added activities such as transportation, movement, overproduction and over-processing – and defects, inventory and waiting (Ohno, 1990). The Lean philosophy provides a set of tools which work as a helping hand completely independently from other management tools such as the 5s, 5why, Value Stream Map (VSM), Total Production Maintenance (TPM), Just in Time (JIT), SMED, Kaizen, and Kanban (Bicheno and Holweg, 2009; Hu *et al.,* 2015), among others.

These tools are consistent with lean management (LM) pillars which is to promote respect for people and continuous improvement and LM five principles (Al-Najem, 2014). Therefore, adopting these tools and techniques advances the opportunity to follow LM five principles and achieve LM pillars. Nevertheless, it is not clear whether all tools can be used in all types of industry. As Leather industry is generally as a process industry which involves with mixing, separating, forming and chemical reaction (Dennis and Meredith, 2000; Panwar et al., 2015). Therefore, this research investigates whether there are different lean tools set for the different types of industry hence we hypothesised:

- H0- there is no significant difference in the use of lean tools between process and non-process industry
- H1- there is a significant difference in the use of lean tools between process and non-process industry.

Implementing a lean management philosophy helps an organisation to increase awareness of non-value-added activities that are not perceived by the potential customers (Chiarini, 2014). Considering this attribute, lean is an environmentally friendly philosophy (Franchetti *et al*., 2009; Chiarini, 2014). Of interest is that scholars have also observed a logical synergy between lean and green management (Garza-Reys *et al.,* 2014; Garza-Reys, 2015).

Whilst lean can help managers to identify and eliminate waste (Klotz *et al.,* 2007), it does not quantify the environmental impact (Pampanelli *et al.,* 2014). In this regard, the life cycle assessment (LCA) which represent the green management, is a tool that is widely used by the leather industry to assess the environmental impact (Luthra *et al*., 2013; Daddi et al., 2016; Daddi *et al*., 2017). The intention is to reduce environmental pollution. According to the International Standards Organisation (ISO) 14001, life cycle assessment (LCA) is consecutive and interlink stage of products and services system from raw materials acquisition or generation from the natural resources, design, production, transportation/delivery to final disposal (ISO 2016). It aims to quantify the environmental impacts of products or services from the cradle to grave through goal and scope definition, life cycle inventory analysis, life cycle impact analysis, and validation. This is illustrated in figure 1.

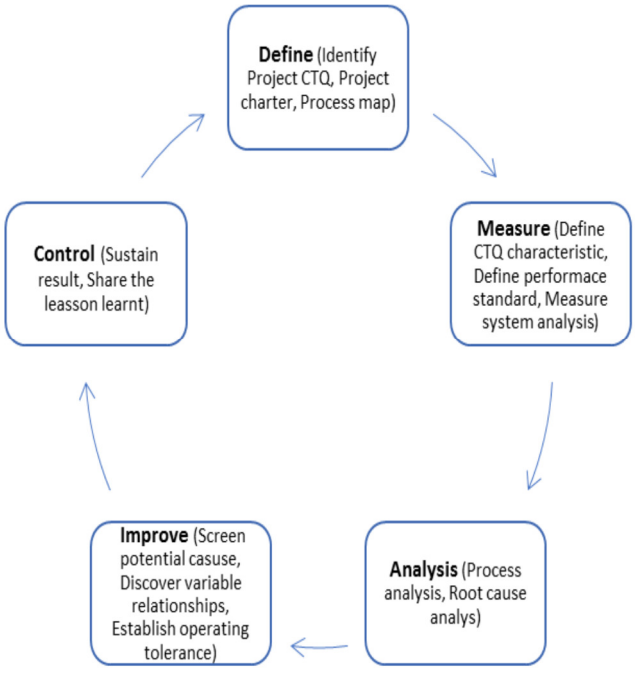


(Figure 1: Stage of an LCA, Source: ISO14040, 2006)

The Eco-label scheme, which began forty years ago (OECD, 2016), is a tool that established based on life cycle by European Commission (EC) to promote the design, production, marketing, and use of products and services that reduced environmental impact (EC Regulation, 2000; see also 'Environmental labelling and information schemes', OECD, 2016). These ecological criteria could be applied to any industry, including the leather industry with the intention of encouraging managers to adopt cleaner technology solutions within their organisational activities. Although Lean and Green could be applied through LCA, integrating both methods together may not help to overcome the inherent limitations of these methods (Garza-Reyes *et al*., 2014; Cherrafi *et al*., 2017). For instance, being pure lean is problematic because lean tools or

methods include statistical data, which at times ignores the daily practices, and up-spoken behaviours. Further, lean is often criticised for a lack of data-driven attribute, and less helpful in the decision-making process (Chauhan and Singh, 2012; Digalwar *et al*., 2013). Similarly, the green approach does not help to make strategic decision-making process related to an investment priority or implementation procedure that is incorporated in the corporate goal of profitability (Nunns and Bennett, 2010). Considering these limitations, the missing link is the Six Sigma method, as this helps to ensure that organisations benefit from triangulation, thereby overcoming the limitations. Thus, using these methods in combination is a strategic resource that can add value to the activities of SMEs in the leather manufacturing sector.

Given that Six Sigma (SS) is a highly structured and data-driven method that uses statistical tools to drive into a decision (Garza-Reyes *et al.,* 2015), it thus has the capacity to overcome the limitations of lean and green approaches. It is a problem solving and improvement method that a business use to achieve and sustain a healthy level of success (Anthony, 2007; Banawi and Bilec, 2014). The principle of SS is to reduce inconsistency or variation from a process and achieve 3.4 defects per million opportunities (Anthony and Banuelas, 2002; Eckes, 2003; Pyzdek, 2003). Considering this, the Six Sigma is a goal or benchmark (Eckes, 2003; Dasgupta, 2003), not a solution and in order to achieve this goal, different organisations adopt different tools (such as process map, control chart, ANOVA, SIPCO, 5s, 5why etc. some popular tools) as well as methods such as Define, **M**easure, **A**nalysis, **I**mprove and **C**ontrol (DMAIC) and **D**esign **F**or **S**ix **S**igma (DFSS) (Antony and Banuelas, 2002; Pyzdek, 2003). This multipronged approach helps to overcome the limitations of lean and green approaches. For instance, DFSS method is used when there is no existing process, therefore, to create new process or product while DMAIC method is performed on an existing process (Pyzdek, 2003), as illustrated in figure 2.



(Figure 2: Six Sigma DMAIC process, Source: Kumar, 2010)

Whilst most of the previous studies have focused on lean, green and six sigma approaches as independent entities (Kumar, 2010; Cherrafi *et al.*, 2017). Banawi and Bilec, (2014) focused more on a combination of Lean, Green and Six Sigma with the intention of helping to reduce wastage during the pile caps process. Another research conducted by Cherrafi *et al.,* (2016), with the nature of the industry and size of the firm unknown, found that combining three methods, Lean Six Sigma and Green management helps to minimise the resource consumption from 20-40% and minimise the cost of energy by 7-12%. It is this newer dimension of looking at lean, green and six sigma that have failed to capture the imagination of many researchers in this area.

Methodology

This study uses mixed methodological approach to draw insights from multiple data sets that include in-depth interviews with leather engineers and green management experts, particularly, and an interview-led survey of the Lean and Six Sigma community. This approach is consistent with Easterby-Smith *et al., (*2015) when they discuss about a mix of closed and open-ended questions. The latter approach was used to overcome the difficulty of reaching respondents from the Lean and Six Sigma experts. The use of mixed questioning techniques in a survey, help to overcome weaknesses that are embedded in both open and closed ended questions (Zohrabi, 2013). Respondents were also distributed across many countries, and a survey was a most suitable approach to reach them.

The survey questionnaires were purposefully emailed to 350 Lean and Six Sigma experts and academics through the Lean Enterprise Institute, Association for Manufacturing Excellence (AME), American Production and Inventory Control Society (APICS), seven LinkedIn Lean and Six Sigma groups and the first author's personal contact list in the leather industry. 25 questionnaires were returned, a very low response rate. The selection of Lean and Six Sigma experts was based on their "Black belt" certification or prolonged experiences. The survey questions were mainly focused on tools, critical success factors (CSF) and appropriate methods to implement Lean Six Sigma within the SMEs and the processing industry. It was hypothesised that there is no difference in the use of lean tools in the process and non-process industries.

Approximately 22% of the participants were Master Black Belt (MBB) qualified along with their university qualifications, and 37% with more than 15 years working experience at executive level. The experience was derived from working in different countries including Parts of Asia (25%); UK (24%); Other parts of Europe (15%); USA (15%); North America (9%); South America (6%); Latin America (3%); and Australia (3%).

Prior to this article, total of 6 leather engineers, 2 SME owners and 9 LCA professionals. Thus, insights shared are from well experienced respondents whose experience ranged from 9 years to 30 years and have a deeper understanding of the research topic across different parts of the world, as illustrated in appendix 1, 2 & 3. Thematic analysis was used to analyse the qualitative data sets, and a non-parametric statistical method was used to analyse the quantitative data.

Findings

This part is organised into two main sections, that is, the analysis of the findings from the qualitative element of the study, followed by the analysis of the quantitative elements from the study.

Lean and Six Sigma knowledge

Leather engineers were asked whether they were aware of Lean and Six Sigma practices in the industry. 63% of interviewees indicated that they have never heard of Lean, and Six Sigma. Only 38% of them had practical experience of lean and six-sigma from their previous experiences whilst working for large organisations. One of the interviewees had this to say:

> "*…I myself is a master trainer, Kaizen, competency based etc. I am expert on them, but there is no practice in the leather industry…If I am being honest, leather manufacturing is never seen as a good place to work or involve with. There are not many educated people involved during the time of 1st or 2nd generation. However, now in 3rd generation, some educated people are getting involved in this sector. I think, that's the main reason…"* (Interviewee A, Consultant and Leather engineer)

This is interpreted as an expression of resentment of the six-sigma approach. The respondent is a well-trained an experienced professional, but also surprised why six-sigma is not practised in the leather industry. In fact, "*leather manufacturing is never seen as a good place to work or involve with",* and as such, acquiring related knowledge is not of priority. So, may workers seemed not to be bothered about learning as *"there are not many educated people involved during the time of 1st or 2nd generation".* Thus, this respondent sees a generational issue associated with the leather industry. Regardless, there are changes taking place with 3rd generations bringing in more educated people in the sector. We interpret this as an opportunity to spread the knowledge of six sigma in the leather manufacturing industry. Sadly though, the leather industry has been perceived as a place for less educated people, and this has resulted in a lack of innovation and new ideas within the industry.

Status of Lean Six Sigma

It emerges that some of the lean management principles are in practice in the leather industry. And yet, there is a lack of theoretical understanding of these techniques. This is illustrated by the *extracts below:*

> *Interviewer: Have you seen any SME keeping their machinery and working tools (gun machine, dye brush or other tools) at the right place or at the designated place?*
>
> *NI: Yes, they do. There are different stages for leather processing such as wet blue's chemicals at the wet blue section, soaking and liming tools are at the soaking and liming section. There are different types of trolleys we use and those all are organised accordingly like chemicals-equipment-leather.*

This illustrates that the 5***s principle*** in practice in the leather industry. The 5s principle is a mechanism to reduce wastage, improve productivity and quality through organising workplace according to the priority using visual cues (Osada, 1991).

> *Interviewer: Do they practice minimising machinery breakdown and keep it in good shape? And who is responsible for that?*
>
> *BR- Yes, we do. Machine operator is responsible to look after the machines' health however, every tannery has their own workshop or maintenance person who responsible to fix the machineries in the event of break down.*

The principle of total productive maintenance focuses on everyone's involvements in the organisation from operator to management to improve equipment efficiency and effectiveness (Wireman, 2004). This principle has been in practiced in the leather industry too, because BR and many other respondents like him are engaged in this practice. The findings also reveal that the small batch, pull and push strategy

through manufacturing is in use. This is illustrated by YM, a business owner and leather engineer in the extract below:

"…We only manufacture after customer order received…."

In this practice, an order has different criteria or sub-divisions such as tanning chrome, vegetable tanning, chrome free tanning, aldehyde tanning, and so forth. Suppliers must understand these types of tanning because different tanning is performed on different leathers. The size can be 20 sq. ft., some can be 15 sq. ft., and of different colours. With knowledge of these factors, a supplier or tannery's owner can start sourcing or buying raw materials, an attribute consistent with the pull principle (Agus, *et al.,* 2012).

The respondents also confirmed that due to the availability of raw materials, they can adopt just-in-time (JIT) principle. This is illustrated by the extract below:

"*Because slaughter house is always carrying out animals slaughtering than they sale them to raw skin collector every day and then again skin collector brings these raw skins to the Postha and we can get raw skin anytime we want from there, not a problem. In terms of price, we inquire beforehand what is the current market price in term of size and origin of the leather than we proceed the negotiation to buy the raw skin*" (NI, Leather Engineer and small business owner).

The fact that they "*can get raw skin anytime"* is an indication of uninterrupted supply patterns. However, forward planning is needed as the "*inquire beforehand".* Considering this, leather manufacturers can also adopt JIT practices, as they are already in the habit of planning for the supply of the needed materials. This will help them to capitalise on the benefits of the JIT system (Daddi *et al*., 2017).

Awareness of environmental impact

Respondents were aware and conscious of the environmental impact caused by current practices of leather industry. This is illustrated by the extract below:

> *Interviewer: Do you know anything about the environmental impact that the leather manufacturing process is creating?*
>
> *NI: I can see myself that I have been polluting huge amount of water, air and soil…everyone knows but we need more awareness. Like solid waste water we discharge in the open drain/sewerage which is not good at all. Rather than discharging this type of waste, we could easily throw this waste in the designated place after refining them…But sometimes we do not have a choice…. sometimes we just discharge this chrome in open river or sewerage due to shortage of time or if it (chrome) takes longer time to penetrate.*

Although there is an awareness of environmental impacts of waste from the leather industry, informants do not comply with proper waste disposal procedures. Within this context, there is a need to engage in awareness programmes to remind the leather manufactures of waste disposal procedures. It is our contention that mechanisms should be put in place to ensure that noncompliance is penalised. Mechanisms to ensure the enforcement should be developed and implemented effectively. Respondents sometimes "*do not have a choice"* apart from being non-compliant. We interpret this as a lack of compliance enforcements.

Previous studies suggest that Life Cycle Assessment could improve awareness of environmental impact resulting in lower levels of pollution (Ramayah *et al.,* 2012; Luthra *et al.,* 2013; Daddi *et al.,* 2016; Daddi *et al.,* 2017). Nevertheless, LCA is a complex method, time consuming and expensive to use (Le Pochat and Colleagues, 2007).

Barriers faced by SMEs in the leather industry

One of the barriers faced by SMEs in the leather industry is lack of a database system. This is illustrated by the extract below:

> *"…Other difficulties are like the companies they don't have good inventory, they don't have good 'record keeping procedure' of their own usually..." (*SK, Consultant and Leather engineer).

We interpret this as a need for improved and efficient inventory management systems. We found that this was a result of a lack of appropriate technological systems and poor production methodologies. However, we also found that there are a few large leather tanneries which have an effluent treatment plant (ETP), own laboratory as well as well as good practices of documentation. These have an awareness of the implications of the waste chemicals and water on the environment. These systems are expensive to install, and SMEs do not have enough resources to invest in the appropriate ETP. This finding is consistent with Miah (2012) who suggests that the total cost of an ETP system in Bangladesh, with a capacity of 50,000 labour hours is 89,84,000 Bangladeshi Taka, and this is equivalent to 77 830 British pounds.

The cost element explains possibly why Revell and Rutherfoored (2003) study observed that a significant problem in SMEs is the lack of engagement with environmental issues among owner-manager. Rather, it is a lack of resources to purchase and install the ETP systems. Further, the low level of environmental compliance in Bangladeshi is of concern (Revell and Rutherfoored, 2003).

Experts were also asked to share their views about the life cycle assessment. In this regard, one respondent had this to say:

> *"…. If you pay an external company or a consultancy firm, of course you still need to give them the data, it can cost from £10,000-£15,000 for one LCA…".* (IB, Academia and LCA experts in food processing sector)

Thus, cost is a major barrier. This view was shared by many other respondents, suggesting that the cost of running an LCA project is very high for SMEs in the leather manufacturing industry. Because of a lack of expertise, SMEs must hire an external LCA consultant. who can provide the expertise to collect necessary data, analysis them and then recommend a solution to reduce the environmental impact?

It also emerged that there are concerns regarding the sharing of information amongst SMEs in the leather industry. This is illustrated by the extract below:

> *"…Cost and complexity, there are two aspects of it. There is another aspect I think wariness in the supply chain about sharing information which commercially sensitive…".* (AS, CEO and Consultant in SMEs especially in process industry)

Thus, there are concerns about sharing information that is "*commercially sensitive".* However, running an LCA project requires an adequate data recording platform. Yet, such information may not be made available because it is perceived as "*commercially sensitive"* information. Considering this, it is difficult to perform an LCA without supply chain data. Given that most of the SMEs are suppliers to a large organisation, it is difficult to negotiate for the required supply chain data because of limited bargaining power. Thus, SMEs often do not have enough data in their possession.

Another barrier is the lack of expertise and knowledge. This is illustrated by the extract below:

"*…for a SME cost may be the first problem because they are too small to have in-house specialist..."* (IB, Academia)

Because of limited financial resources, some SMEs do not have the capacity to engage the services of an *in-house specialist.* Thus, compliance with environmental safety rules and regulation fail to get the required attention.

Another barrier is time. This is illustrated by the extract below:

> "*…Biggest problem is always time and knowledge. People in SME they don't have time for that. And time means, management commitment, top management need to determine that they want this. And then you need to appoint one of the best skill SME people they have, who understand the production and internal system, and if it's not happening than not happening…"* (MP, LCA consultant).

We interpret this is a lack of time to focus on the demands of the LCA. Earlier studies focused more on the financial problems faced by SME as a barrier to embracing LCA (Le Pochat and Colleagues, 2007; Witczak *et al.,* 2014). However, we find that financial problems are only a part of multiple problems that SMEs face to engage actively with LCA. For instance, we found that if the seller (supplier) is smaller than its buyer or vice versa, the power balance is uneven, and that puts limitations on the type and amount of information to be shared in relation to the supply chain. This is limiting because SMEs do not always have enough data in their possession. Further limitations include a lack of expertise knowledge and shortage of time to engage actively with LCA. Because of these and other associated challenges, SME often fail to comply with environmental safety rules and regulation.

Implementation of LCA

Our findings reveal that the implementation of LCA is done through collaboration (63%), use of LCA software (25%) and alternative approach (25%). Our respondents' use these approaches in isolation or in combination. This is consistent with earlier studies that found complexity in the implementation of the LCA (Le Pochat and Colleagues, 2007; Witczak *et al.,* 2014). For instance, SMEs in the leather industry would have to be trained so that they can acquire skills to use the LCA software. Similarly, they also need financial resources to engage actively in collaborations.

Collaborating with other organisations such as educational institution or research groups would be an opportunity that can be utilised by SMEs implementing LCA. Another way of collaborating approach would be with other fellow organisation in the similar industry. In this way, SMEs could share their LCA findings in a common platform without revealing too much information about their business secrets, as illustrated by the respondents.

Respondents also suggested that SMEs could implement LCA by their own with buying a subscription of LCA software. The software would be able to analyse the impact of the raw materials or input and output materials once the organisation inputs the data. However, this method also requires the organisation to hire an LCA consultant to train them which can cost them at least £15,000-£20,000, as illustrated by respondents AS; IB; MP; MB; and PL.

Other respondents like Interviewee MP and IB suggested an alternative method such as Material Flow Cost Accounting (MFCA). The goal of MFCA is to provide quantification and visualisation of material losses (Viere *et al*., 2011). It depicts overall flow in the process and then shows consequent cost of that flow (Viere *et al.,* 2011). Respondent MP pointed out that using MFCA would provide bigger picture in terms of money value of the LCA. He suggested that SMEs are concerned more about economic issues. Considering this, MFCA would encourage them to become efficient and with the intention of reducing waste. However, previous studies suggest that

MFCA only take consideration of materials and energy flow which have direct monetary impact but others such as air emission or water wastage are not part of the analysis (Viere *et al.,* 2011).

Nevertheless, LCA project could be designed to provide a monetary value of the materials flow that have an impact over the environment. This is illustrated by the extract below:

> *"...LCA in many ways a best methodology I am putting but you just putting a financial methodology very easily as an impact category…. For example, if you measure the energy import KWH (kilowatt Hour), then you can also measure the input in pound or dollar…."* (AS, CEO and Consultant in SMEs especially in process industry).

This suggests that every business organisation is aware of the cost of their input or raw materials. However, SMEs face challenges in accounting for these inputs properly, and keeping accurate records. If these records were kept properly, then, at the end of an LCA project, business owners could easily be aware of the associated financial value and impact. The key issue is one of proper record keeping and accounting practices.

Lean Six Sigma Survey Results

Results from the survey element of the study help us to identify appropriate lean tools. In fact, respondents were asked to identify appropriate Lean tools for Non-process industry SMEs and process industry SMEs based using the measures of "not strongly recommended" and "strongly recommended". Variables of the Value Stream Mapping (VSM), Visual Control (VC), 5why, 5s, and Kaizen were evaluated. The results of the evaluation are as illustrated in figure 3 below:

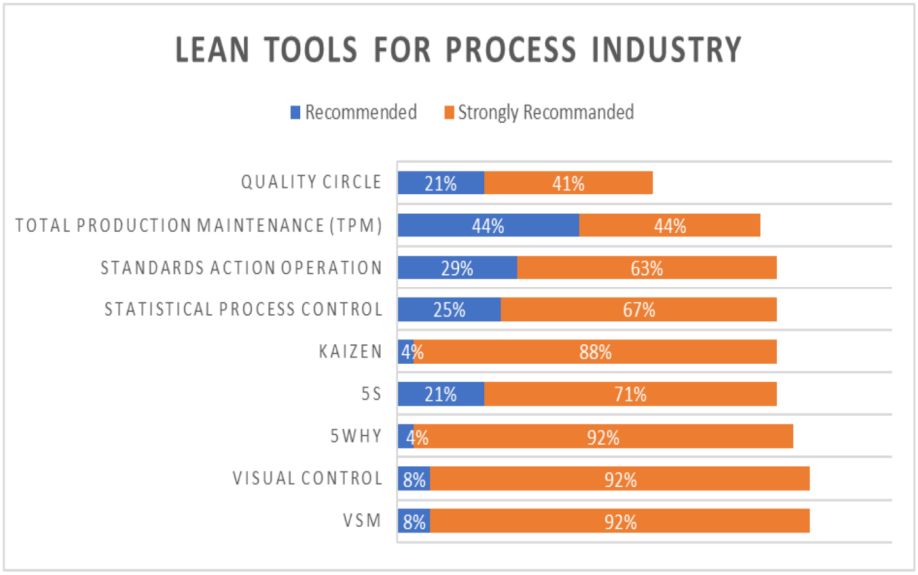


Figure 3: Lean tools based on participants respond for Process industry

These results are consistent with previous studies, such as Bicheno and Holweg, (2009) and Hu *et al.,* (2015) who found that 5s, 5why, Value Stream Map (VSM), Total Production Maintenance (TPM), and Kaizen were the most used tools in the SME sector. Considering these results, we then sought to determine if there was any

difference in terms of using lean tools between the process and non-process industry. It was hypothesised that: Hence the hypothesis as follows:

- *H0- There is no significant difference in the use of lean tools in the process and non-process industries.*
- *H1- There is a significant difference in the use of lean tools in the process and non-process industries.*

The Mann-Whitney non-parametric test was used because the data set did not follow the normal distribution pattern. The results suggest that there is no significant difference between using lean tools in the process and non-process industries. All the lean tools (VSM, 5why, VC, Kaizen, 5s, Standard Action Operation (SAO), Statistical Process Control (SPC), Total Production Maintenance (TPM), and Quality Circle) produced a p-value of between .739 to 1.00 which is greater than a *p*-value of *0.05*. However, Mann-Whitney test also indicated that there is a significant difference of using Total Production Maintenance (TPM) (*p= 0.01)* and Statistical control (*p= 0.00)* tools in terms of using in process and non-process industry where 44% and 63% responded strongly recommended TPM and SPC are more appropriate for process industry than non-process industry respectively.

Test Statistics[a]

	Value Stream Map	Total Production Maintenance	5s	5 Why	Kaizen	Visual Control	Standard Action Operation	Quality Circle	Statistical Process Control
Mann-Whitney U	299.000	151.000	311.500	312.000	286.500	251.000	276.000	246.500	142.000
Wilcoxon W	624.000	476.000	636.500	637.000	611.500	576.000	601.000	571.500	467.000
Z	-.504	-3.276	-.025	-.021	-1.072	-1.783	-.810	-1.343	-3.527
Asymp. Sig. (2-tailed)	.615	.001	.980	.984	.284	.075	.418	.179	.000
Exact Sig. (2-tailed)	.739	.001	1.000	1.000	.360	.106	.480	.204	.000
Exact Sig. (1-tailed)	.370	.000	.500	.500	.180	.053	.240	.102	.000
Point Probability	.195	.000	.054	.130	.125	.013	.041	.007	.000

a. Grouping Variable: Types of Industry

Table 1: Mann-Whitney Test between process and non-process industry in terms of using lean too

Critical success factors (CSF)

The Lean Six Sigma (LSS) experts were asked to rate the importance of CSFs to implement LSS in the organisation with 1 corresponding to "not very important" and 5 as "very important" The purpose of this question also was to find the gap between the importance of CSF and actually implemented (1 refers to "not fully implemented" and 5 as "fully implemented), as illustrated in table 3, within the organisations. The result indicated that the leadership active involvement and commitment, clear vision, as well as successful communication has highest and similar mean score of 4.79. While successfully usage of advance technology has lowest mean of 2.54. This result agrees with previous research conducted by Kumar, (2010). Notwithstanding, this study shows that there is no significant difference between the importance of CSFs and actu-

al practice in the participants organisations. These findings are contrary to the work of Kumar (2010).

Statistics for degree of importance of CSFs

		Management Clear Vision	Management Active Involvement and Commitment	Training and Education	Quality Management Tools Integrated with Business Strategy	Quality Management Tools Integrated with Customers' Needs	Quality Management Tools Integrated with Employees' Perception	Project Management Skills	Successful Communication	Successful Usage of Advance Technology	Successful Use of Statistical Tools	Organisational Working Culture	Organisational Structure
N	Valid	24	24	24	24	24	24	24	24	24	24	24	24
	Missing	0	0	0	0	0	0	0	0	0	0	0	0
Mean		4.79	4.79	4.46	4.38	4.42	4.00	4.17	4.79	**2.54**	3.63	4.50	3.54
Median		5.00	5.00	5.00	4.50	5.00	4.00	4.00	5.00	3.00	3.50	5.00	4.00
Mode		5	5	5	5	5	4	5	5	3	3	5	4
Std. Deviation		.415	.509	.658	.711	.717	.780	.816	.509	1.141	.824	.722	1.062

Table 2: Frequency table for degree of importance of CSF

Statistics for level of actual implementation of CSF

		Management Clear Vision	Management Active Involvement and Commitment	Training and Education	Quality Management Tools Integrated with Business Strategy	Quality Management Tools Integrated with Customers' Needs	Quality Management Tools Integrated with Employees' Perception	Project Management Skills	Successful Communication	Successful Usage of Advance Technology	Successful Use of Statistical Tools	Organisational Working Culture	Organisational Structure
N	Valid	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**
	Missing	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Mean		**4.67**	**4.75**	**4.42**	**4.50**	**4.46**	**4.00**	**4.13**	**4.71**	**2.75**	**3.83**	**4.63**	**3.79**
Median		**5.00**	**5.00**	**5.00**	**5.00**	**5.00**	**4.00**	**4.00**	**5.00**	**3.00**	**4.00**	**5.00**	**4.00**
Mode		**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**3**	**3**	**5**	**5**
Std. Deviation		**.565**	**.442**	**.776**	**.659**	**.721**	**.722**	**.947**	**.624**	**1.294**	**.963**	**.647**	**1.215**

Table 3: Frequency table for level of actual implementation of CSF

CSF	Important	Implementation level	Gap
Management Clear Vision	4.79	4.67	0.12
Management Active Involvement and Commitment	4.79	4.75	0.04
Training and Education	4.46	4.42	0.04
Quality Management Tools Integrated with Business Strategy	4.38	4.5	-0.12
Quality Management Tools Integrated with Customers' Needs	4.42	4.46	-0.04
Quality Management Tools Integrated with Employees' Perception	4	4	0
Project Management Skills	4.17	4.13	0.04
Successful Communication	4.79	4.71	0.08
Successful Usage of Advance Technology	2.54	2.75	-0.21
Successful Use of Statistical Tools	3.63	3.83	-0.2
Organisational Working Culture	4.5	4.63	-0.13
Organisational Structure	3.54	3.79	-0.25

Table 4: Gap analysis between two mean importance of CSF and actual implementation

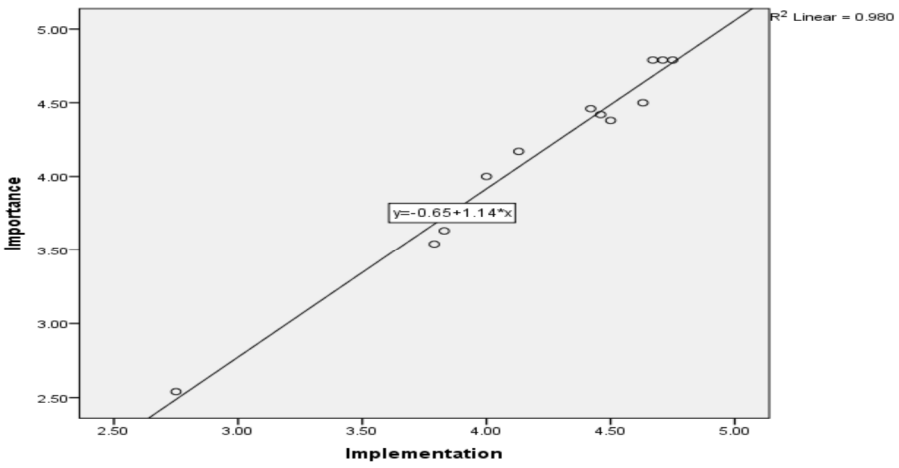


Figure 4: Correlation analysis between importance of CSFs and actual practice of CSF

Discussion

Despite the importance and widely perceived advantages of quality management (QM), Bangladeshi SMEs yet to witness QM presence. Many believe unfavourable government rules, lack of support from local trade association Bangladesh Tanners Association (BTA), Bangladesh Finished Leather, Leathergoods and Footwear Exporters Association (BFLLFEA) and Leathergoods and Footwear Manufacturers & Exporters Association (LFMEAB), financial support from local financial institution as well as lack of research, could be the reasons behind this lack of awareness of well-known QM system i.e. Lean Six Sigma (Lee, 1997; Human Rights Watch, 2012, 2013; Mamun et al., 2016; Sajib et al., 2016; Bosri 2016; Strasser, 2015). The interview result reveals similar information that 63% of interviewees have never heard of Lean Six Sigma. According to Anthony et al., 2005; Kumar et al., 2014, lack of awareness is one of the barriers that preventing developing countries to adopt quality initiative.

Consequently, there is lack of exposer of quality management system such as Six Sigma however, survey results showed that lean management principles are in practice in the leather industry in absence of their knowledge. That illustrated that the leather industry has a capability to adopt QM system with an introduction of appropriate guidance and awareness. This consensus with many authors' opinion who believes size of an SME plays in favour to embrace lean management across the business environment due the very nature of less complexity than larger organisation (Brown and Inman,1993; Anthony et al., 2008). Furthermore, despite a positive contribution of leather industry, it has been always considered to be a dirtiest industry and ranked 4th polluted industry in the world (Worst polluted, 2016). Subsequently, *leather manufacturing (sector) is never seen as a good place to work (Interviewee A).* Nonetheless, this study understood that participants have awareness of harmful wastage *solid waste water we discharge in the open drain/sewerage which is not good at all (Interviewee NI).* The findings of this study show that regardless of awareness, there is still no proper disposal procedure or regulations.

From the findings we conclude there is needs of active engagement with the environmental awareness programme as well as required a compliance mechanism to ensure non-compliance is penalised (Pamminger, 2011). This finding also depicted lack of motivation "*sometimes we just discharge this chrome in open river or sewerage due to shortage of time or if it (chrome) takes longer time to penetrate"* respondents find less rewarding than saving environment. Literatures showed SMEs' this kind of attitude toward environmental pollution due to the belief that SMEs' action does not endanger the environmental compare to larger organisation (Revell and Rutherfoord, 2003; Pamminger, 2011) hence cumulative impact of SMEs toward environmental pollution is not documented resulting lack of awareness of their action (Nulkar, 2014). This study identified Life Cycle Assessment (LCA) is one of the most implemented green management tools including in SMEs in the leather industry (Luthra et al., 2013; Daddi et al., 2016; Daddi et al., 2017). Nonetheless, both, existing literature and findings of this research acknowledge the complexity associate with the LCA implementation (UNEP,2005; Witczak et al., 2014) *"Cost and complexity, there are two aspects of it. There is another aspect I think wariness in the supply chain about sharing information which commercially sensitive''.* (Interviewee AS).

Therefore, collaborating or networking other SMEs *because SME only learn from another SME leader* (Interviewee MP) or academia or *connection with good University in Bangladesh who is doing LCA study (Interviewee IB),* seems to be most cost-effective way of implementing LCA.

On the other side, it was found that management active involvement and commitment, as well as clear communication of their vision, are the most important elements for the implementation of Lean Six Sigma method. Similar findings were reported in the previous studies management support and commitment, effective communication, employees' support (Kumar and Anthony, 2008; Kumar, 2010). Additionally, value stream mapping (VSM), visual control (VC), 5s, Kaizen, and Six Sigma tool DMAIC are most popular toolsets within the SMEs in the process industry. These findings are consistent with the works of Rose et.al., (2011); Glass *et al.,* (2016), when they proposed similar lean tools for SMEs in the process industry.

Conclusion

The purpose of this study was to explore the use and implementation of Lean, Green and Six Sigma (LG6σ) in small and medium enterprises (SMEs) within the leather industry in Bangladesh. Results suggest that the Bangladeshi leather industry has the capability to adopt lean management. However, there was no evidence to indicate the use of the Six Sigma method amongst SMEs in the leather industry in Bangladesh. Of interest is the practice some of the lean management tools such as 5s, pull system and TPM. Though there was an awareness of environmental pollution, there was no evidence of using green management tools to create an environmentally friendly industry. Further, increased awareness programmes will help to remind managers of their environmental responsibilities.

Besides the environmental issue, the leather industry in Bangladesh also faces competition from neighbouring countries. Considering this, the product quality if of importance as a resource to help achieve competitive advantage. Given that product quality is of essence, the implementation of Lean Six Sigma together with green management (LG6σ) tools are the tools needed by SMEs to help reducing waste, reduce costs, and then curve out a sustainable competitive advantage.

Therefore, moving forward, LG6σ is critical to the future of the Bangladeshi leather industry. What is also critical is a step-by-step LG6σ implementation guideline or readiness index that can be used across the Bangladeshi SMEs sector of the leather industry. The implementation guideline can also be extended to SMEs operating in the Ready-Made Garment sector in the industry.

Limitations of the study

Although a central of the strength of this research study lies in the use of mixed methods, survey questionnaire and interviews, the very low rate of response to the survey questionnaire is a limitation that ought to be recognised. Additionally, future research in a similar area can use content or document analysis, as a data collection method, to complement low response to survey questionnaire. Document analysis will examine participating firms' strategic policy on lean, tools and the implementation of lean – and compare with questionnaire results as well as interviewees' responses to research questions—to aid data triangulation.

Correspondence
Md Mahabubur Rahman
University of the West of Scotland (London Campus)
235 Southwark Bridge Road
London SE1 6NP
United Kingdom
Email: mahabubrahman1@gmail.com

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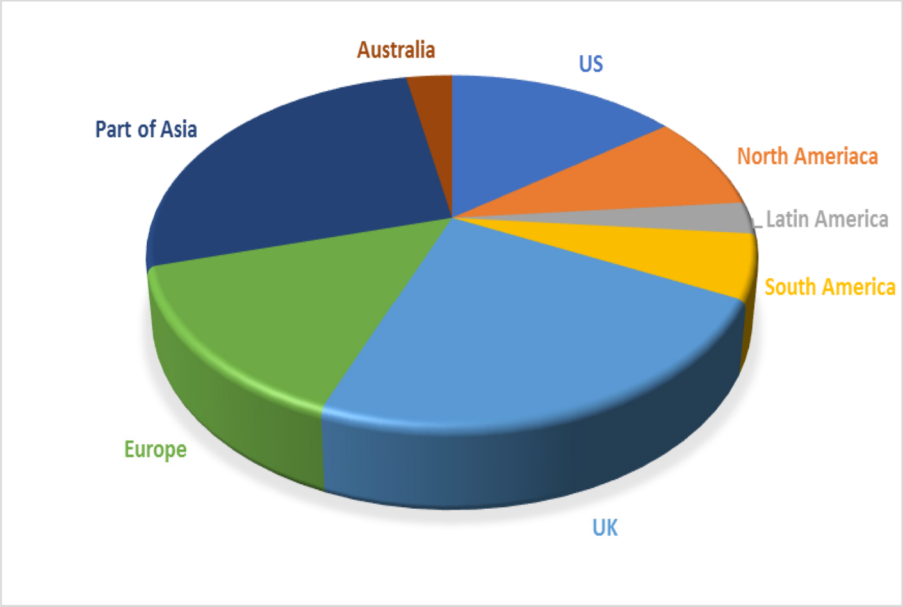
Appendices

Appendix 1: Participants' countries of experience



Appendix 2: Interviewees' working experience in the leather industry

Interviewee	Years of experience	Business owner	Leather Engineer	
		Leather	Consultant	
BR	30	Yes	No	Yes
A	23	No	Yes	Yes
NI	20	Yes	No	Yes
YM	17	Yes	No	Yes
SK	17	No	Yes	Yes
AR	9	No	No	Yes
MU	25	Y	No	Yes
M	9	Y	No	Yes

Appendix 3: Green management experts interviewees' characteristics

Interviewee	Industrial Experience
IB	Academia, LCA experts in food processing sector
MP	Consultant
MB	Academia, LCA experts in Leather, Textile and construction sector
AK	Consultant in various sector
BH	Consultant in various sector
AM	Lead Environmental Engineer in leather industry
SK	LCA project manager in leather industry
AS	CEO and Consultant in SMEs especially in process industry
PL	LCA Consultant especially in construction sector