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Abstract:	

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ABSTRACT

Purpose – This study aims at investigating the impact of the perceived importance of critical CRFs is on perceived importance of LSS technical CSFs in UK manufacturing sector.

Design/methodology/approach – A survey questionnaire through a multiple embedded case study was conducted. The study involves surveying people in the manufacturing firms followed by non-parametric Kruskal-Wallis test to study the relationships.

Finding – It was found that the people's perception towards impact of CRFs on technical CSFs of LSS projects is different depending upon each CRF, demographic factors and technical CSFs. This means that particular CRFs need to be prioritised to address LSS technical CSFs.

Practical implications – Our study is crucial for managers financially to be ready to invest on a successful LSS project and it helps them to diagnose the cultural causes of failure in a more timely way and effectively.

Research implications - Our study fills the research gap in investigating the perception of people towards inter-relationship of cultural or soft CSFs of LSS and technical or hard CSFs of LSS in manufacturing firms. Nevertheless, we suggest further multi case study analysis covering different manufacturing fields as future studies.

Originality/value - This is a preliminary study focusing on analysing inter-relationship between perceived importance of soft readiness factors and perceived importance of implementing success factors as a missing jigsaw in the current literature.

Keywords – Lean Six Sigma, Manufacturing, Cultural Change, Quality Management, Critical Success Factors

1.Introduction

The transition of manufacturing paradigms towards more customer-centric and cost effective manufacturing during last two decades increased the managerial pressure in order to produce and deliver high-quality products in the most cost efficient way. In this competitive global environment, organisations can achieve long-term competitive advantage through continuous improvement (CI), greater reliability, speed and customer satisfaction (Yadav et al, 2017; Kavcic and Gosnick, 2016; Drohomeretski et al, 2014). Several efficiency improvement initiatives such as Lean and Six Sigma were recommended as essential programmes for total quality perception transformation and CI in contemporary companies with greater emphasis on

customer satisfaction, profitability and cost reduction (Alhiraish et al, 2017; Dixon and Fargen, 2017; and Patil et al, 2017). The combination of these two well-developed Total Quality Management (TQM) initiatives introduced Lean Six Sigma (LSS) as a new organisational change and business improvement method.

Since early 21st century, there has been a noticeable popularity to LSS deployment in manufacturing sectors (Sunder et al, 2020; Gupta et al., 2019; Albliwi et al, 2014; and Andersson, 2014). Therefore, analysing the LSS critical success factors (CSFs) is of imperative for both academia and practitioners. CSFs are those factors that are essential to meet objectives associated to the success of any programme or technique (Shruti et al, 2018; Laureani and Antony, 2018; De Jesus et al, 2016; and Rungasamy et al, 2002). Meeting CSFs is pivotal for meeting strategic goals and avoiding failure for all manufacturing firms (De Jesus, 2016; and Brun, 2011).

Some empirical studies in both literature and practice suggest that the top prioritised CSFs for LSS are management commitment, resources, training, project selection, methodology, team building with psychological safety and linking LSS to customer/strategy (Singh et al., 2021; Parmar and Desai, 2020; Shruti, et al, 2018; Kalashnikov, 2017; De Jesus, 2016; Knapp, 2015; Choo, 2014; Arumugam et al, 2013; and Aboelmaged, 2010). Nevertheless, there are other studies with analysis of cultural readiness factors (CRFs) for implementing LSS, which mainly present the importance of organisational culture to prepare for LSS in manufacturing sector (Sreedharan et al., 2019; Shokri et al, 2016; Prashar, 2014; and Antony, 2014). Despite longitudinal studies published with indication of various CSFs of LSS, the study to analyse the perceived relationship between CRFs and CSFs remains scarce (Singh et al, 2021; Abu Bakar, 2015; and Albliwi et al, 2014). It is also noticeable that there is more research scarcity in manufacturing compared to service sector in terms of empirical research about readiness to embark on LSS (Sunder et al, 2018; Antony, 2014; and Prashar, 2014). We refer to people in this study as any individual working in the organisation including employees and managers.

Due to the high level of failures in LSS projects within manufacturing firms (Albliwi et al, 2014), the research question that we aim to investigate is "how impactful the perceived importance of critical CRFs is on perceived importance of LSS technical CSFs in UK manufacturing sector". This is more of interest for scholars and practitioners to review the readiness and preparation stages of LSS strategic establishment to avoid impeding factors and higher risk of failure. In order to maintain this, we focus on crucial CRFs of LSS and technical CSFs that were addressed by scholars in next section. The technical CSFs are referred to those tangible factors with the need of organisational resources and investment. The objective of our

study is three-fold: i) Identify key ingredients of CRFs through critical literature review (section 2); ii) Investigate impact of perceived importance of ingredients of key CRFs on perceived importance of technical CSFs of LSS through quantitative analysis (sections 3 and 4); iii) Recommend future studies, managerial and research/knowledge contribution of our study (sections 5 and 6).

2. Literature review and research questions development

Many studies recommended the adoption of LSS as a hybrid programme to overcome shortfalls of Lean and Six Sigma individually for performance improvement and cost efficiency in organisations with a proper infrastructure built on leadership and change culture (Costa, 2021; Sunder et al, 2020; Douglas et al, 2017; Anthony and Antony, 2016; Antony et al, 2016; Lameijer et al, 2016; Dora and Gellynck, 2015; Andersson, 2014). LSS was defined by Snee (2010) as "a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and bottom-line result". Laureani and Antony (2018) in their latest research defined LSS as a business improvement methodology that aims to maximise shareholder value by improving quality, speed, customer satisfaction and cost efficiency.

In addition to strategic benefits, the LSS methodology aims to clarify the manufacturing process of identifying opportunities for problem solving, waste reduction, environmental sustainability, learning environment, facilitating innovative minds, as well as reduce variability of defect and improve the quality of the manufacturing process (Gaikward and Sunnapwar, 2021; Ali et al., 2021; Gupta et al., 2019; Cherrafi et al., 2017; Antony et al, 2016; Holmes et al, 2015; Choi et al, 2012; and Thomas et al, 2009). There are some clear gaps in standardisation of LSS principles and benefits such as convergent of divergent views (Juliani and Oliveira, 2020). A number of academics investigated the major and common CSFs of LSS using different methodologies including comprehensive literature review of CSFs for LSS implementation (Abu Bakar et al, 2015), preliminary research conducted in LSS companies (Laureani and Antony, 2018; and De Jesus, 2016), fuzzy structural modelling (Shruti et al, 2018) and some more intensive and focused approach to investigate the CSFs for LSS implementation (Dorohomereski et al, 2014; Kavcic and Gosnick, 2016; Alhuriash et al, 2017 etc.).

Dorohomereski et al (2014) revealed in their empirical research that investment in human resources has the most significant impact on operational success of LSS such as speed, quality and reliability improvement. Similarly, in a separate survey study by Kavcic and Gosnik (2016) in Slovenia, training and education were highlighted as a critical factor to succeed any LSS

project. Alhuriash et al (2017) revealed the CSFs differ depending on whether Lean, Six Sigma or integrated approach of both are going to be deployed in manufacturing sector. Patil et al (2017) listed CSFs for LSS implementation and the academic sources to reflect the extent of this type of study through an extensive literature review. In addition, they referred to some of those CSFs as distinctive cultural and social factors. More particularly, Knapp (2015) in her study revealed a strong relationship between group and hierarchical culture to the success of LSS with more emphasis on teamwork and at the same time guided and controlled procedures. Nevertheless, as suggested by De Jesus et al (2016) there are some differences amongst hierarchical levels in organisations in relation to ranking LSS CSFs.

Having had an extensive literature review and amongst comprehensive list of CSFs for LSS implementation, training, strategic project selection, infrastructure team building and LSS methodology were identified as technical or hard factors with some resources required (Singh et al., 2021; Laureani and Antony, 2018; Patil et al, 2017; Kalashnikov et al, 2017; De Jesus, 2016; Kavcic and Gusnik, 2016; Knapp, 2015; Lam et al, 2015; Choo, 2014; Choi et al, 2012; and Aboelmaged, 2010). This is evident that poor utilisation of any of these factors in the organisation results in LSS failure. In the support of this, the LSS failure is the direct result of the lack of or poor utilisation of above technical factors in any manufacturing firm (De Freitas and Costa, 2017; Zhang et al, 2016; and Albliwi et al., 2015). Notwithstanding, some scholars distinguished between CRFs and critical failure or success factors (Sunders et al, 2018).

LSS readiness means awareness of terminology, principle and benefits, eagerness to change, eagerness to work in team projects and eagerness to work with data and statistics (Sreedharan et al., 2019; Antony, 2014; and Lee et al., 2011). Antony (2014) defined CRFs as those essential ingredients which will increase the probability of success of any CI initiative before an organisation invests its resources heavily on the initiative. This means that failure to establish CRFs in any organisation appropriately leads to possible resistance to change and political and emotional detrimental behaviour that result in failing to effective utilisation of resource-oriented CSFs such as technical CSFs.

Despite various published studies about CSFs for LSS implementation, organisational readiness was stressed as one of the least researched areas in the LSS and CI literature (Sreedharan et al., 2019; Abdul Halim Lim and Antony, 2016). Furthermore, Atkinson and Wilson (2016) identified assessment of readiness as a crucial point for any change management initiative. The readiness of management or the individual readiness to commence LSS was prescribed as the preliminary item to establish LSS management preparation and adaptation that attracted less empirical studies (Haffar et al, 2016; and Choi et al, 2012). In another study,

Romdhane et al (2017) introduced more effective and innovative five – stage organisational approach to LSS implementation with "readiness" and "preparation" as two first crucial stages. Thomas et al (2016) also highlighted the importance of an awareness and readiness programme before venturing into full LSS implementation. Therefore, CRFs may have significant impact on the implementation of technical factors and just investing in these technical factors may not guarantee the success of LSS programme. The general impact of some readiness factors on success of LSS projects was addressed by some scholars (Sreedharan et al., 2019; Knapp, 2015; Dorohomereski et al., 2014; and Antony, 2014) in caveat (figure 1). However, the perceived direct link between the key groups of CRFs and their ingredients and key individual technical factors by individuals in the manufacturing organisations is a missing jigsaw and is not well studied in the literature. This paper aims to fill this gap.

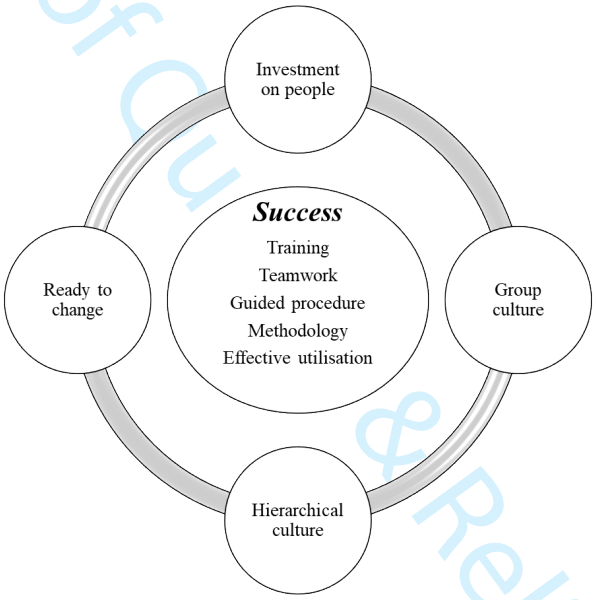

Figure 1 – Some readiness factors important for success factors

To support our analysis, we use the four key groups of CRFs which are referred to by scholars (Shokri et al, 2016; Prashar, 2014; Antony, 2014; and Albliwi et al, 2014) as more common groups: 1) leadership, 2) management commitment and resources, 3) linking LSS to strategy, 4) customer focus. This study also demonstrates the inter-relationship analysis between perceived CRFs as soft elements and perceived technical factors as hard elements of successful LSS implementation in a specific country. Next, we will describe the four groups in detail.

leadership

The common definition of leadership that was agreed by 54 leadership experts from 38 countries is: "influencing, motivating, and enabling others to contribute towards the effectiveness and success of the organisation" (Laureani and Antony, 2018). leadership has been recognised as a mechanism for cultural transformation, organisational readiness and embedding cultural values and norms into an organisation (Laureani and Antony, 2018; Haffar et al, 2016; Dora and Gellynck, 2015; and Yeung et al, 2005). Through their recent study, Laureani and Antony (2018) and Patil et al (2017) recognised successful leadership in LSS as a continuous commitment to process improvement, establishes LSS business strategy and organisational culture. Through her study in impact of organisational culture on LSS implementation, Knapp (2015) stated that leaders are inclined to instil vision and take the risk associated with changes that LSS implementation involves. De Jesus et al (2016) recognised rewards, bonuses, involvement and respect as key leadership values for LSS success in Brazilian manufacturing firms. The whole idea of leadership is to enable the employees to shift from their current working practices to Best-in-Class practice (Antony, 2014). Leadership establishes organisational design and culture to provide psychological safety for an effective LSS infrastructure team building and performance (Arumugam et al, 2013). A study conducted in aerospace manufacturing revealed that failure in LSS projects was down to lack of strong leadership (Thomas et al, 2016). This leads us to an argument that it is imperative in a CI environment that full executive support of an empowering leader who is open to changes is extremely vital for successful LSS deployment. From the extensive list of suggested leadership ingredients for successful LSS implementation, the leadership style, the presence of leaders, support and direction led by leaders, the leader's communication with employees and empowerment were highlighted as key variables (Singh et al, 2021; Romdhane et al, 2017; Knapp, 2015; and Antony, 2014). Therefore, we set Research Question 1(RQ1) to investigate the impact of perceived importance leadership variables amongst people on percieved importance of technical CSFs of LSS in a manufacturing firm with bad experiences of LSS failure:

RQ1 – Does the perceived importance of leadership variables make any significant impact on perceived importance of technical CSFs of LSS?

Management commitment

Top management commitment, support and guidance is essential for any quality implementation project to champion their employees' required skill and training development (Shruti et al, 2018; Sreedharan et al, 2016; and Haffar, 2016). In fact, it was reported as one of

the critical factors of any world-class manufacturing practices (Haleem et al, 2012). Despite great deal of variation in introducing different critical factors for LSS implementation depending upon the size, type and region of organisations, top management commitment was almost unanimously suggested by scholars as the most crucial readiness factor for providing required resources, promoting and qualification polices, and a successful LSS implementation (Patil et al, 2017; Alhuraish et al, 2017; Kavcic and Gosnik, 2016; Albliwi et al, 2014; Choi et al, 2012; Desai et al., 2012; and Delgado, 2010). Lack of top management commitment and resources have been suggested as two major reasons of LSS failure (Yadav et al, 2017; and Albliwi et al, 2014). Top management commitment and support develops a positive culture for further training, appropriate project selection, infrastructure team building and successful LSS methodology deployment (Kanpp, 2015). Long term management commitment to quality, allocating sufficient time to achieve quality, managers' understanding of LSS benefits, involving employees to strategic decision making by managers, visible involvement of managers in progress of projects and setting challenging goals by managers were indicated as key ingredients or variables of top management commitment (Antony, 2014). Therefore, we set RQ2 to investigate the impact of perceived importance of management commitment variables on perceived importance of technical CSFs of LSS in a manufacturing firm with bad experiences of LSS failure:

RQ2 – Does the perceived importance of management commitment variables make any significant impact on perceived importance of technical CSFs of LSS?

Linking LSS to manufacturing strategy

Linking LSS to business strategy was suggested as one of the top CSFs for LSS implementation by many scholars (Patil, 2017; Sreedharan et al, 2016; and De Jesus et al, 2016). Albliwi et al (2014) and Antony (2014) identified a weak link between LSS projects and strategic objectives of any business as part of top four critical failure factors. As suggested by Alhuraish et al (2017), the integration of lean and Six Sigma or sequential implementation alongside other competitive advantage measures must be part of cultural and strategic decision making of managers in any organisation. Manufacturing strategy is a set of tools/practices intended to produce effective manufacturing strengths for enhanced competitive performance (Kulkarni et al., 2019; Sousa and Voss, 2001; and Swamidass and Newell, 1987).

There are many key performance indicators (KPIs) to represent as the manufacturing strategy dimensions. We use studies by Kulkarni et al. (2019), Ang et al (2015) and Sousa (2003) to investigate which of these dimensions would be as priority in the manufacturing firms. They

recommended some of these dimensions are more common in manufacturers than others. These measures include "low price", "consistent quality", "high performance", "on-time delivery", and "quality perfection". Through the same study, Ang et al (2015) also revealed possibility of strong synergy or trade-off between these strategic dimensions, which supports the argument that the role of these manufacturing strategy dimensions of KPIs on competitive performance is not universal. This means manufacturing firms cannot perform well on all of these strategic manufacturing capabilities and they can segment their capabilities in sequential manner. As a result of this, one primary manufacturing strategy dimension for one department or firm could be a secondary dimension for others. Antony (2014) set various types of metrics that are assigned to define successful progress of meeting strategic KPIs by LSS projects that were used in our study. They include importance of strategic manufacturing objectives, strategic project prioritisation, goal setting and data collection to strategic manufacturing objectives. Therefore, we set RQ3 to investigate the impact of perceived importance of variables of linking LSS to manufacturing on perceived importance of technical CSFs of LSS in a manufacturing firm with bad experiences of LSS failure:

RQ3 – Does the perceived importance of linking LSS to manufacturing strategy variables make any significant impact on perceived importance of technical CSFs of LSS?

Customer focus

Customer focus was highlighted as the starting point of any quality initiative to establish the link between customer requirements and internal processes (Dong et al, 2016; Atkinson and Wilson, 2016; and Sousa, 2003). Focusing on customer needs to identify the voice of customer (VOC) to improve critical to quality (CTQ) measures for financial enhancement was suggested by many scholars as top critical readiness factor (Guan and Chen, 2017; De Jesus et al, 2016; Antony, 2014; Handley and Gray, 2013; and Shafer and Moeller, 2012). In fact, lack of alignment of project aim with the customer's requirements was identified as one of the key LSS failure factors by Albliwi et al (2014) in their systematic literature review. Nonetheless, it was reported by some studies that addressing this CRF as the top priority by practitioners and scholars is inconclusive (De Jesus et al, 2016). Being obsessed with customers' needs and VOC to delight them, involving customers in strategic decision making and customising the manufacturing operations were recommended as key ingredients of being customer focus as CRF for success in LSS implementation (Juliani and Oliveira, 2020; Antony, 2014). Therefore, we set RQ4 to investigate the impact of perceived importance of the customer focus variables

on perceived importance of technical CSFs of LSS in a manufacturing firm with bad experiences of LSS failure:

RQ4 –Does the perceived importance of customer-focus variables make any significant impact on perceived importance of technical CSFs of LSS?

We present this conceptual model (figure 2) after our extensive literature review on major CRFs as derivers for technical CSFs of LSS implementation in manufacturing firms. This model represents the impact of CRFs to support the combined technical CSFs for successful LSS implementation that need resources and investment. The selection of each individual ingredient within each factor in this model happened objectively via intensive critical literature review that was evident as per above and in table 1. The primary objective of developing this model is to investigate the current appreciation of people in LSS manufacturing firms with bad experience of LSS failure in order to enlighten cultural readiness gap that they need to consider in their future LSS journey to avoid failure.

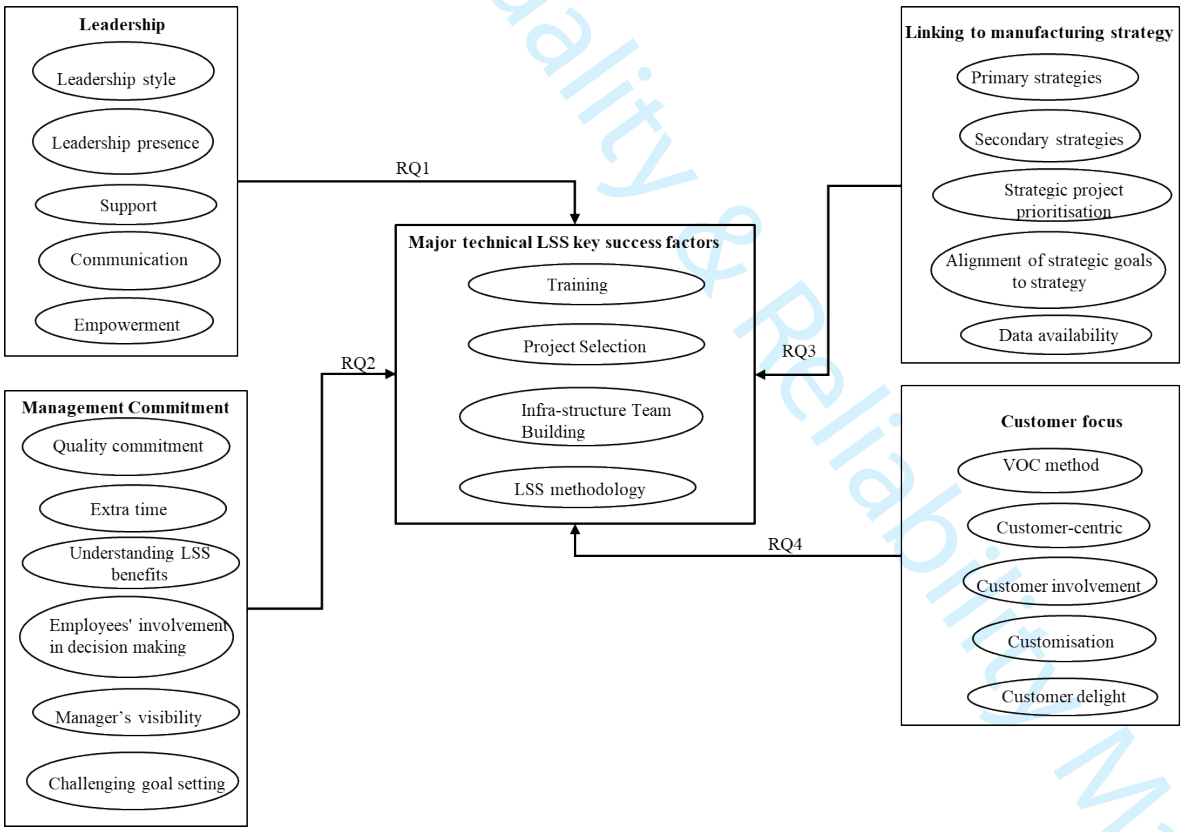

Figure 2 – Conceptual model of impact of each ingredient of CRFs on LSS technical CSFs

3.Methodology

It is crucial for any researcher to understand the research framework or in another term the methodology of the research (Rowlands, 2005). The starting point is to understand the research problem. It was evident to us that managers in some of the original equipment manufacturers (OEM) supplying power supply firms are struggling to make tangible positive results and were experiencing various failures in their LSS projects. We decided to take this forward in the format of a multiple embedded case study in which different sites of OEM will be investigated collectively.

Industrial overview

For this particular research study, we approached OEM supplying heavy duty power supply firms that implemented LSS in some extent with some significant resentments. The highlighted intense competitive market and operational challenges such as balance between quality, reliability, cost and productivity in this sector (Jin et al, 2012) make more justification of the importance of successful LSS implementation in this manufacturing sector to gain competitive advantage. Four UK-based OEM sites as leading technical solution providers that design, manufacture and sell industrial equipment were approached for this empirical study. Continuous improvement and innovation ensure that their products lead the way in quality, safety and performance. Their operational policy relies on local production of high volume/standardised fast-moving and high variety/customised (make-to-order) products with global market with average 400 employees. Their products target the oil & gas, mining, construction & infrastructure, energy & power, food & agriculture, pharmaceutical, chemical & petrochemical and rail industries. They have already implemented LSS projects in different departments including manufacturing and assembly departments with some reported failures.

Research Design

In this research, we took an epistemologically positivist stance with focusing on the relationship between CRFs as independent variables on combined deployment of technical LSS success factors that need resources and investment and are cornerstones of any LSS project.

A survey questionnaire instrument was utilised to cover an appropriate number of people in the OEM sites based in the UK. The regional focus of this study was limited to the UK to avoid any confusion of cultural factors due to possibility of lack of universality of CRFs country-wise (Antony, 2014). The sampling method was purposive sampling with special focus on specific manufacturing sites with significant experience of LSS project failure (Saunders et al.,

2012). The random sampling technique was adopted to ensure responses are as indicative as possible for the whole population with minimum bias. The survey used in this research comprised 14 questions covering the demographic and experience background of respondents in different studied departments and their perception towards importance of ingredients of CRFs and four major technical CSFs for LSS implementation. Table 1 presents selected ingredients of CRFs and technical CSFs for this study with their academic references. The format of the survey questionnaire was close-ended questions to allow for statistical analysis. Questions associated with importance of ingredients of CRFs and CSFs were operationalised on a 5-point Likert scale (1= strongly disagree; 2= Disagree; 3= Neutral; 4= agree; 5= strongly agree). Each ingredient of CRFs and technical CSFs is measured by a dedicated question about perceived importance by people. For example, "Leader's presence" was reflected by the question: "how agree you are that leaders are normally present and approachable when you need them in your operation". The questionnaire was then shared with 10 people as external LSS consultants, academics in the field and some representative practitioners in different departments with different roles. The purpose for this pilot test was to improve the clarity, wording of questions, appropriateness of response options and suitability of questions. Having considered their comments and also common ethical measures and practices, the questionnaire was disseminated both electronically and physically to managers and employees in the major manufacturing sites and their offices in the UK within time window of four weeks. Total number of 350 questionnaires were distributed among relevant people in different departments of these OEM sites.

Quantitative data analysis is appropriate, since previous studies used similar methods to evaluate all TQM soft (cultural and visionary) and hard measures (Haffar, 2016; Do Nascimento Gambi, 2015; Mossadegh Rad, 2015; and Sabella et al., 2014). In contrast to previous research studies that used parametric regression analysis (Haffar et al, 2016), we decided to conduct the non-parametric Kruskal-Wallis analysis using SPSS 26 that was used by previous studies as a suitable analysis technique in the same field (Foster et al, 2011). The rationale behind selecting the Kruskal-Wallis as a non-parametric test was that the normal distribution was not considered as a pre-assumption, the sample size was limited, and dependent variables are ordinal (Likert score) and not continuous (Haffar et al, 2016; and Field, 2013). We recognised the CRFs with their groupings (importance level) as independent variables, whilst technical CSFs of LSS were considered to be dependent variables.

Table 1 appears near here

In this section we present the finding as the result of non-parametric Kruskal-Wallis test to answer all RQs. The questionnaire was disseminated amongst 350 people in various roles from different departments of these OEM sites. Having given plenty time and exhausting the follow up procedures, 151 responses were collected out of which 144 of them (41% response rate) were useable and 7 responded questionnaires were disregarded due to being incomplete and possibility of bias. Having checked through cross-tabulation test, respondents were sporadic in terms of gender, experience, department and LSS knowledge. To assess the potential of non-response bias, the study tested the difference of the available variables between early and late respondents (Zu et al., 2010) through Leven's Homogeneity of Variance for non-responsive sample test. No statistically significant difference (at a 95% significance level) between early (first month) and late responses (second month) was found. The manufacturing and assembly departments comprised 60% of the total responses, whilst the quality, finance and external sales accommodated for 40% of responses. The majority of responses (54%) were departmental managers, team leaders, supervisors and shop floor practitioners and 35% were agency workers. The rest of respondents had other roles including apprentice and sales.

It was reported from a cross-tabulation analysis that 83% of respondents were aware of LSS through different belt system trainings and 60% of them had direct LSS involvement as Black Belt (BB), Green Belt (GB) or Master Black Belt (MSB). Amongst these people with direct involvement, 44% were departmental managers, supervisors and team leaders, 38% were shop floor practitioners and apprentice and 18% were agency workers. It was evident from the analysis that consistent quality, high performance product and on-time delivery were suggested as top three primary and secondary strategic manufacturing objectives by respondents. Table 2 presents the frequency and percentage of the primary strategic manufacturing objectives selected by respondents. The internal consistency and reliability amongst variables in each scaling item needed to be tested by calculating Cronbach's α (Drohomeretski et al, 2014; Calvo-Mora et al., 2014; McDermott and Prajogo, 2012). The result of the Cronbach's α analysis for all variables was 0.885 ranging between 0.876 and 0.903 and therefore acceptable (more than 0.70).

Table 2 appears near here

4. Result

This section presents the result of investigation about the impact of changes in perception towards importance of any CRFs variable on the importance of technical CSFs in LSS project. This is to analyse what CRFs' variable needs to be prioritised in order to extend the chance of LSS success and minimise the failure rate. The perception towards importance reflects the Likert Scores given by each respondent about importance of measures.

RQ1 - *Does the perceived importance of leadership variables make any significant impact on perceived importance of technical CSFs of LSS?*

As the result of Kruskal-Wallis test, it was revealed that amongst leadership ingredients, only the perceived importance of leadership style amongst people in LSS manufacturing sites makes significant impact (Sig value <0.01) on perceived importance of project selection as a technical CSFs of LSS (table 3). No other significant impact was found from differences in perceived importance of presence of leadership, direction and support of leaders, communication and empowerment amongst respondents on perceived importance of any technical CFS of LSS (Sig value>0.01). This means that changing the people's perception towards leadership style should be in the priority for the whole organisation to have more effective project selection and reduce the failure rate to implement LSS in the departments.

Table 3 appears near here

RQ2 *– Does the perceived importance of management commitment variables make any significant impact on perceived importance of technical CSFs of LSS?*

The Kruskal-Wallis test revealed that amongst management commitment ingredients, only the perceived importance of visible managers' involvement in LSS project activities makes significant impact *(Sig value <0.01)* on perceived importance of infra-structured team building and LSS methodology utilisation (table 4). No other significant impact was found from perceived importance of long term commitment to quality, extra time to be given to people, understanding the benefit of LSS and employee's involvement in decision making amongst respondents on perceived importance of any technical CFS of LSS *(Sig value>0.01)*. This means that in order to develop effective infra-structured team building and LSS methodology

in any LSS project, managers should prioritise the changing of people's perception about importance of visibility of managers in each LSS project in any manufacturing firm.

Table 4 appears near here

RQ3 – *Does the perceived importance of linking LSS to manufacturing strategy variables make any significant impact on perceived importance of technical CSFs of LSS?*

It was revealed that amongst linking LSS to the manufacturer's strategy ingredients, the perceived importance of primary strategic objectives makes significant impact *(Sig value <0.01)* on perceived importance of appropriate project selection, infra- structured team building and LSS methodology. It was also evident that the perceived importance of aligning stretched goals to major manufacturing strategy makes significant impact *(Sig value <0.01)* on perceived importance of LSS training and teamwork in LSS projects. The perceived importance of data availability makes significant impact *(Sigma value <0.01)* on perceived importance of teamwork, appropriate project selection and LSS methodology. No other significant impact was found from perceived importance of alignment of project selection to major manufacturing strategy on perceived importance of any technical CFS of LSS (*Sig value>0.01)* amongst respondents. The result was summarised in table 5. This means that in order to develop technical CSFs collectively in any LSS project, managers should prioritise the changing of people's perception about importance of primary strategic manufacturing objectives, alignment of strategic goals to major manufacturing strategy, and availability of data and information about major manufacturing strategy.

Table 5 appears near here

RQ4 – *Does the perceived importance of customer-focus variables make any significant impact on perceived importance of technical CSFs of LSS?*

The Kruskal-Wallis test suggested that amongst customer-focus ingredients, only the perceived importance of customised operations amongst people makes significant impact *(Sig value <0.01)* on perceived importance of teamwork as a technical CSFs of LSS (table 6). No other significant impact was found from perceived importance of method of VOC collection, being obsess with customer need, customer involvement in strategic decision making and delighting

the existing customers amongst respondents on perceived importance of any technical CFS of LSS *(Sig value>0.01)*. This means that changing the people's perception towards importance of customised operations should be in the priority for the whole organisation to develop better teamwork and reduce the failure rate to implement LSS in the departments.

Table 6 appears near here

5.Discussion and research implications

Longitudinal studies exist about critical factors in success of LSS in manufacturing (Singh et al., 2021; Laureani and Antony, 2018; Patil et al, 2017; Kalashnikov et al, 2017; De Jesus, 2016; Kavcic and Gusnik, 2016; Knapp, 2015; Lam et al, 2015), importance of investment in human resources in LSS (Shokri et al, 2016; De Jesus et al, 2016; Knapp, 2015); and Dorohomereski et al, 2014), and distinguishing between CRFs and critical failure or success factors (Sunders et al, 2018). Nevertheless, no study took a causal relationship approach to have a focused investigation on the impact of perceived importance of CRF on perceived importance of technical CSFs in manufacturing setting. This study about people's perception is a contribution of our study to the existing knwoledge.

Following previous studies by scholars about a pivotal role of CRFs for any LSS project success (Shokri et al, 2016; Prashar, 2014; and Antony, 2014), we decided to extend on their studies in a perceived LSS manufacturing environment. Further to that and in respond to studies conducted by Abu Bakar (2015) and Albliwi et al (2014), we intended to investigate the existing impact of the perceived ingredients of CRFs on technical perceived LSS success factors in UK manufacturing sector. In order to fulfil this analysis, we conducted survey analysis for four OEM sites in the UK with LSS implementation experiences to have more comprehensive review of the phenomena. We decided to investigate the relationship between perceived importance of every single ingredient of CRFs on perceived importance of technical CSFs that need resources and investment to fulfil successful LSS project. This was to guarantee more effective establishment of readiness culture for any LSS implementation success.

Our finding bridges studies that acknowledged the leadership style as a CRF (Singh et al., 2021; Sreedharan et al., 2016) with those studies with identifying the project selection as a key technical CSF (Laureani and Antony, 2018) by investigating the inter-relationship between perceived importance of both factors. Our finding also bridges studies that considered visible involvement of managers (Antony, 2014) as a crucial CRFs and infrastructure team building and methodology as key technical CSFs (Singh et al., 2021; Laureani and Antony, 2018; Patil

et al, 2017; De Jesus, 2016) by investigating the inter-relationship between perceived importance of both factors. Our finding spans studies about data availability and stretched goal setting (Singh et al., 2021; Sreedharan et a., 2016; Ang et al., 2015; Knapp, 2015; Antony, 2014) as key CRFs with studies that highlighted training, strategic project selection, infra-structure team building and methodologies as major technical CSFs (Laureani and Antony, 2018; Patil et al, 2017; De Jesus, 2016) by investigating the inter-relationship between perceived importance of both factors. Similarly, our finding spans studies about customer focus as part of CRFs (Singh et al., 2021); Sreedharan et al., 2016; Knapp, 2015; and Antony, 2014) and those studies (De Jesus, 2016) that presented teamwork as major technical CSFs by investigating the inter-relationship between perceived importance of both factors.

With the best of our knowledge, our study fills the research gap in investigating the inter-relationship of perceived CRFs or soft readiness factors of LSS and perceived technical or hard CSFs of implementing LSS in manufacturing firms as part of a critical empirical research study. Our finding was complementary to previous studies (Singh et al., 2021; Laureani and Antony, 2018; Patil et al, 2017; De Jesus, 2016; Shokri, 2016; Abu Bakar, 2015; Antony, 2014; and Albliwi, 2014) that highlighted the importance of analysing CRFs and their influence on LSS success.

The result of our hypothesis testing also responded to previous studies conducted by Sunder et al. (2018), Abu Bakar (2015) and Antony (2014) who acknowledged the necessity of investigating inert-relationship between perceived importance of CRFs and technical CSFs amongst practitioners. Our empirical research highlighted a need for scholars and practitioners in relation to identifying the influence of human resource and cultural factors sustain success of LSS projects.

6.Conclusion, future studies and managerial implications

It was concluded that the impact of four critical CRFs recommended by the literature on the technical CSFs of LSS implementation wasn't conclusive for a manufacturer organisation with some failures in their LSS journey. This means that depending on what technical CSF was investigated, there were various ingredients of CRFs that had significant impact on those technical success measures. It was also evident that the number of impactful ingredients of CRFs on technical CSFs wasn't comprehensive and there were only few critical measures that need to be prioritised by managers or champions of LSS projects to facilitate a successful LSS project completion. This means that in order to reduce the technical failure of LSS projects in manufacturing firms, managers should give priority to changing the perception of their people

towards importance of leadership style, management visibility, identifying primary strategic objectives and alignment of stretched goals to them, data availability and customised operations. It was also concluded that the number of technical CSFs that would be affected by these ingredients of CRFs are also not comprehensive depending upon each individual CRF. This means in order to develop an effective technical CSF for reducing the rate of failure and increasing the success of the LSS project, particular ingredients of CRFs need to be prioritised by champions. Nevertheless, it was clearly obvious from the result that to have a sustainable LSS project success, all technical CSFs are required collectively and therefore collective approach of perception changes towards ingredients of CRFs is also required.

This study demonstrates a significant managerial issue in LSS manufacturers with technical failure experience and limited understanding of compelling role of the perception of their own employees and managers towards importance of CRFs for any LSS project success. As the result of this study, managers, process owners or LSS champions in any manufacturing firms can have both proactive and reactive approach to success of their LSS projects. Proactively, managers or champions will require to establish cultural readiness by focusing more or prioritising some specific measures for a quicker and more effective readiness for a LSS initiative. Reactively and in the event of experiencing significant failure rates of LSS projects, these managers or champions need to re-investigate their cultural readiness. They need to concentrate more on those ingredients that have higher impact on technical CSFs to develop their staff and managers before investing and allocating resources to the project as part of critical pathway to success.

Despite the greater deal of comprehensiveness in analysing the impact between CRFs and technical CSFs of LSS project as part of diagnosing stage of action research, we identified the CRFs and technical CSFs objectively and through intensive critical literature review. Therefore, we acknowledge the possibility of common method bias as limitation of this study. We suggest similar studies in other countries to compare results and also further studies with possible subjective identification of factors and multi case study analysis covering different manufacturing fields as future studies. This will have more meaningful result in terms of generalisability and continuation of this study to conduct action research. This may also be followed up by other research studies looking at differences amongst each manufacturing firm within these multiple case studies.

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Table 1 – Selected ingratiates of cultural CRFs and technical CSFs for LSS with references

Cultural Readiness Factors		
Factors	**Ingredients**	**Supportive reference**
1.Leadership	1.1.leadership style, 1.2.the presence of leaders, 1.3.support and direction led by leaders, 1.4.the leader's communication with employees, 1.5.empowerment	Singh et al., (2021); Sreedharan et al (2016); Knapp (2015) and Antony (2014)
2.Management commitment and resources	2.1.long term management commitment to quality, 2.2.allocate sufficient time to achieve quality, 2.3.managers' understanding of LSS benefits, 2.4.involving employees to strategic decision making by managers, 2.5.visible involvement of managers in progress of projects, 2.6.setting challenging goals	Singh et al., (2021); Sreedharan et al (216); Haffar (2016); Knapp (2015) and Antony (2014)
3.Linking LSS to manufacturing strategy	3.1.Importance of strategic primary manufacturing objectives, 3.2. Importance of strategic secondary manufacturing objectives, 3.3.alignment of project selection, 3.4.goal setting and data collection to strategic manufacturing objectives, 3.5.startegic project selection	Singh et al., (2021); Sreedharan et al (2016); Ang et al (2015); Knapp (2015); Antony (2014); and Sousa (2003)
4.Customer focus	4.1.being obsessed with customer needs, 4.2. customer centric, 4.3.customer involvement in decision making, 4.4.customised operations and production, 4.5.customer delighting	Singh et al., (2021); Sreedharan et al (216); Knapp (2015) and Antony (2014)
LSS technical CSFs		
Factors	**Ingredients**	**Supportive reference**
1.Training	1.1.LSS training (LSST), 1.2.Training willingness (TW)	Singh et al., (2021); Laureani and Antony, 2018; Patil et al, 2017; De Jesus, 2016
2.Strategic project selection	Project selection (PSel)	Singh et al., (2021); Laureani and Antony, 2018; Patil et al, 2017; De Jesus, 2016
3.Infra-structure team building	3.1.Team building (TB), 3.2.Teamwork	Singh et al., (2021); Laureani and Antony, 2018; Patil et al, 2017; De Jesus, 2016
4.LSS methodology	Methodology	Singh et al., (2021); Laureani and Antony, 2018; Patil et al, 2017; De Jesus, 2016

Table 2 – Primary strategic manufacturing objectives from respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low Price	9	6.3	6.6	6.6
	Design flexibility	3	2.1	2.2	8.8
	Volume flexibility	8	5.6	5.8	14.6
	Broad product line	3	2.1	2.2	16.8
	Consistent quality	27	18.8	19.7	36.5
	High performance product	38	26.4	27.7	64.2
	Deliver speed	1	.7	.7	65.0
	On-time delivery	25	17.4	18.2	83.2
	After sales service	1	.7	.7	83.9
	Waste reduction	2	1.4	1.5	85.4
	Quality perfection	13	9.0	9.5	94.9
	Standardisation	1	.7	.7	95.6
	Customisation	3	2.1	2.2	97.8
	Other	3	2.1	2.2	100.0
	Total	137	95.1	100.0	
Missing	System	7	4.9		
Total		144	100.0		

Table 3- Differences in perception towards types of leadership style and impact on perception towards technical CSFs importance

	LSST	TW	PSel	TB	Teamwork	Methodology
Chi-Square	8.097	9.429	14.459	7.629	10.131	4.859
Df	3	3	3	3	3	3
Asymp. Sig.	.044	.024	.002	.054	.017	.182

a. Kruskal Wallis Test

b. Grouping Variable: Leadership style

Table 4- Differences in perception towards visible manager's involvement and impact on perception towards technical CSFs importance

	LSST	TW	PSel	TB	Teamwork	Methodology
Chi-Square	4.829	4.650	4.591	10.794	4.872	10.435
df	1	1	1	1	1	1
Asymp. Sig.	.028	.031	.032	.001	.027	.001

a. Kruskal Wallis Test

b. Grouping Variable: MI (Management Involvement)

Table 5- Differences in perception towards linking LSS to manufacturing strategy and impact on perception towards technical CSFs importance

Test Statistics a,b						
a. Kruskal Wallis Test, b. Grouping Variable: **Primary Strategy**	LSST	TW	PSel	TB	Teamwork	Methodology
Chi-Square	13.358	26.252	33.531	29.062	22.230	28.145
Df	13	13	13	13	13	13
Asymp. Sig.	*.421*	*.016*	*.001*	*.006*	*.052*	*.009*
a. Kruskal Wallis Test, b. Grouping Variable: **Setting stretched goals**	LSST	TW	PSel	TB	Teamwork	Methodology
Chi-Square	7.251	3.093	2.272	.671	6.964	2.089
Df	1	1	1	1	1	1
Asymp. Sig.	*.007*	*.079*	*.132*	*.413*	*.008*	*.148*
a. Kruskal Wallis Test, b. Grouping Variable: DA **Data availability**	LSST	TW	PSel	TB	Teamwork	Methodology
Chi-Square	6.373	7.202	8.776	6.108	6.397	7.387
Df	1	1	1	1	1	1
Asymp. Sig.	*.012*	*.007*	*.003*	*.013*	*.011*	*.007*

Table 6- Differences in perception towards being customer focus and impact on perception towards technical CSFs importance

	LSST	TW	PSel	TB	Teamwork	Methodology
Chi-Square	3.192	1.419	3.216	3.344	6.768	3.216
Df	1	1	1	1	1	1
Asymp. Sig.	.074	.234	.073	.067	.009	.073

a. Kruskal Wallis Test

b. Grouping Variable: Customised Operation (CO)

Responses to the reviewers' comments

The reviews have raised some very helpful issues with our paper and provided insightful comment. We are really grateful for the reviewers' constructive comments. As a consequence, we have made changes to the paper in association to your comments. The following sections refer to each specific review point in turn, explaining where and how we have amended the paper. We think the paper is now a much stronger piece and we hope it deals with the reviewer's comments in a satisfactory manner. We deal with each reviewer's comments in turn.

Reviewer 1

Comments	Response/ amendments
An interesting paper	*Thank you ; we appreciate your comments as overall.*
This documents a preliminary study on cultural readiness and LSS using a multiple embedded case study. This makes it original although the topic is well written about.	*Thank you for your comment.*
A good breadth of literature is explored.	*Thank you for your comment*
Four manufacturing cases were used appropriately.	*Thank you for your comment*
The results are clearly laid out.	*Thank you for your comment*
This will be useful for managers when considering finance.	*Thank you for your comment*
Good well written	*Thank you for your comment*

Reviewer 2

Comments	Response/ amendments
The research is a good effort (coverage of background information is thorough) to illustrate the impact of CRFs on LSS success factors	*Thank you for your comment*
The literature review needs to be much more concise. A visual display would help to show a few exemplar/landmark studies (and basic findings) about how the CRFs impact the technical factors of LSS. In the present paper the CRFs and the technical factors appear in isolation	*Thank you for the comment. We appreciate this comment raised by the reviewer. However, it was actually our intension to identify the direct relationship between CRFs and technical CSFs of LSS as a missing jigsaw in the relevant research field. Nevertheless, we took this comment on board and created a visual diagram to reflect more*

	general role of readiness factors in LSS success supported by some references. This will support this study and also reflects the originality of this work looking at it from different perspective (perceived role of ingredients of some top CRFs on technical CSFs) Please, refer to the first paragraph of page 5 and figure 1.
The author(s) are perhaps confusing between research question and research hypothesis. I was expecting a clear research question and research objective in the Introduction section itself to start with.	*Thank you for the comment. We appreciate this comment and took it on board. We have added the research question (embedded to aim) and objectives of our study. Please, refer to the last paragraph of page 2 and first paragraph of page 3.*
In the research design section, we find that the sample is businesses in UK. Is this a way to distinguish your work in the knowledge base? Is there any reason to believe that CRFs in UK are different?	*Thank you for the comment. We took this comment on board and added a few lines for clarification. We focused only on the UK market due to previous study-supported statement of lack of universality of CRFs country-wise. Please, refer to the last paragraph in page 10.*
The use of Kruskal Wallis test in not explained properly. The author fails to present the rationale of using non-parametric tests. Do the existing studies (Haffar et al) have failed to address the problem because of normality assumption? There should be a comparative statement.	*Thank you for the comment. We appreciate reviewer's comment. However, we have already explained the reasons behind selecting this type of non-parametric analysis that include limited sample size, ordinal type of data and no consideration of normal distribution due to sample size that are all supported by the literature (Haffar et al, 2016; and Field, 2013). However, we made a better clarification in the main body. Please, refer to the last paragraph of page 11.*
Please provide an explanation for why the select factors were chosen for study and not others.	*Thank you for the comment. We appreciate this comment. We have already explained in the first paragraph of page 9 that we identified these factors objectively and through intensive critical review of the relevant literature sources. However, we also mentioned this as a limitation of this study in the last paragraph of our paper in page 17.*
Please be sure to acknowledge that common method bias is a limitation.	*Thank you for the comment. We acknowledged this as a limitation of our study in conclusion. Please, refer to the last paragraph of the paper in page 17.*
Findings are not surprising, nor novel compared to the existing knowledge base. The authors need to do better to identify how the extensive (and perhaps over specified) model offers new information	*Thank you for your comment. We appreciate your comment. We believe this is a novel study as it looks at the impact of perceived importance of CRFs on perceived importance of technical CSFs. However, we agree that this needs to be clarified further. Hence, we*

	added more information about the contribution of our study in the existing knwoledge. Please, refer to the first paragraph under section 5 in page 15.
In the Discussion section, please ensure that you more clearly describe how this study adds to what is already known in the literature.	*Thank you for your comment. We took this comment on board and added one more paragraph at the beginning of the discussion. Please, refer to the first paragraph under section 5 in page 15.*
The discussion may be enriched with a comparison of the present results (of UK firms) to results of firms in other areas	*Thank you for the comments. We appreciate this comment. However, since this was a preliminary study in four manufacturing sites in the UK, we didn't have opportunity of comparison with similar studies in other countries. However, this has already been reflected as the limitation and suggestion for future study in the conclusion. Please, refer to the last paragraph of conclusion in page 17.*
Overall, writing style is problematic in several ways. For example, in page 11 the question presented to assess the "leaders' presence" is confusing and wrong framing of sentence.	*Thank you for the comment. We took this comment on board and modified this sentence. Please, refer to the first paragraph in page 11. We have also run this paper through one more proof reading.*
Section 2, all the CRFs should be numbered and presented properly.	*Thank you for the comment. We appreciate the reviewer's comment. However, we believe we have already presented the CRF in figure 2 and have also listed CRFs and their ingredients in table 1. However, we took reviewer's comments on board and numbered the CRFs ingredients in table 1.*
There are numerous typos throughout. A close proofing prior to next submission will be helpful.	*Thank you for the comment. Although we had already asked for a professional proof reading before amendments, we have done another set of proof reading and to the best of our knowledge this paper should be an improved version in terms of typos.*