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21st Century Supply Chain Management: A Multiple Case Study
Analysis within the UK Aerospace Industry

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Abstract

In recent years, to stimulate the development of Lean Supply Chain Management (SCM) in SMEs, the UK aerospace industry has developed a change programme named “Supply Chains for the 21st century” (SC21). This programme promotes the use of a simple standard improvement framework, which defines performance goals and standardizes the approaches and tools for continuous sustainable improvement. However, its effective impact on Lean SCM and performance measurement systems (PMS) has not been widely covered in the literature. Adopting a qualitative research methodology approach, this study investigates five significant organizations to explore and contribute to knowledge on Lean SCM and PMS challenges related to the adoption of the SC21 programme.

From an academic point of view, the paper highlights the key role of SC21 in accelerating the competitiveness of the aerospace industry by fostering managerial development of supply chain partners. In particular, it highlights the importance of PMS as well as collaboration between supply chain partners for efficient and effective SCM. From a practitioner’s perspective, the SC21 performance award is highlighted as a very successful approach in bridging the gap of differing agendas between supply chain partners. SMEs, with support from their larger supply chain partners, can embrace performance measurement practices to improve their performance. More established SMEs with a headcount of more than 50 employees are capable of developing and documenting strategic plans and more sophisticated PMS.

Keywords: Supply Chain Management, Lean, Performance Measurement, SME, Management Capability

1. Introduction

In recent years, academics and practitioners have recognised particular relevance to SCM in the aerospace industry (Braziotis et al. 2017; Ruiz-Benitez et al. 2018), where emphasis on cost reduction has brought uncertainty to the robustness of delivery schedules. In the aerospace sector prime contractors, usually named “Primes”, play a key role in supply chain management as they are ultimately responsible for the whole project to their client (usually a government agency). They have responsibility for coordinating all of the tiered sub-contractors (usually a large number of SMEs) and they exert high downward pressure on profit margins for SMEs to minimise total cost and enhance quality and customer satisfaction (Spekman and Davis 2016). As a consequence, in this industry SMEs become especially exposed to global competition and they are compelled to achieve world-class standards or risk losing market share (Funo et al. 2011; Quayle, 2003).

To face the increasing global competition, for many years, the aerospace industry has embraced quality management principles, advocating the use of Lean supply chains (Lamming, 1993). Consequently, the lean principles have been adopted within the aerospace organizations (Browning and Heath 2009; Pešalj et al. 2018; Martínez-Jurado and Moyano-Fuentes, 2014; Thomas et al 2016). However, the evidence of externally validated lean supply chain performance is not adequately covered in the literature. There is evidence of self-assessed lean systems within the aerospace sector (Hallam and Keating, 2014). Notwithstanding, the literature recognizes that the successful adoption of lean principles requires a holistic and collaborative strategic vision instead of an adoption focused on specific improvement initiatives (Hines et al. 2004); the investigations about key determinants of lean are still mainly focused on production environment (Martínez-Jurado and Moyano-Fuentes, 2014) Traditionally, the literature suggests Critical Success Factors (CSFs) and Key Performance Indicators (KPIs) supporting performance improvement (Chae, 2009; Suh and Kwon, 2006). Some models are identified for analysing the effects of product variety on performance (Thonemann and Bradley, 2002), as well as addressing issues around performance measurement (Ruiz-Benitez et al. 2018; Haque and James-Moore, 2005; Peters et al 2008). Since 2000s, researchers propose to combine Six Sigma and Lean strategy to favour performance improvement (George, 2002; Timans et al. 2012) and a number of scholars investigated Lean Six Sigma (LSS) also referring to aerospace industry due to

its recognized appropriateness to solve complex cross-functional problems and reduce variations in manufacturing processes (Antony et al., 2012, Thomas et al. 2016).

This approach integrates both lean and Six Sigma approaches to enhance business performance. On one hand, Lean principles support companies in reducing and removing waste, on the other hand, Six Sigma favours the focus on the Critical to Quality (CTQ) issues that affect the quality of products and/or services (Drohomeretski et al. 2014; Assarlind et al 2013; Zhang et al. 2015). A numbers of studies investigate the use of the Define, Measure, Analyse, Improve and Control (DMAIC) cycle as the central driver to the delivery of LSS and its improvement approach is the data-centric process (Pande, Neuman, & Cavanagh, 2014). However, most of them do not show the systematic application of the Lean thinking cycle.

Literature has shown support for six sigma in an SME context (Antony et al. 2008) but there are major challenges implementing six sigma in a low volume SME context. A study of a Spanish SME supporting six sigma with low volumes applied DMAIC principles to the painting task made a bold claim about the opportunities for low volume six sigma in SMEs but was inconclusive (Garrido-Vega et al. (2016). Another study of German SMEs looking at human aspects of sigma in SMEs acknowledges the lack of empirical research in this area (Shokri et al, 2016).

As shown by Thomas et al (2016), “LSS applications are primarily focused on quality improvement where improvements in throughput and overall business improvement are claimed as a result of resolving the Critical to Quality issue at hand”. Moreover, despite the recognized relevance of LSS approach, some scholars highlight the need for further investigations to favour the development of rigorous performance measurement to both establish a strategic baseline and measure improvements (Kumar et al. 2006; Chakravorty and Shah 2012).

Notwithstanding a great deal of studies describes LSS one of the most effective approach for improving quality in both the manufacturing and SMEs (Knapp, 2015; Algassem et al., 2014; Bhat et al., 2014) some studies highlight difficulties in its implementation particular in SMEs. To date small and medium organization studies are mainly focused on the mechanistic issues related to the implementation of the DMAIC methodology. While a more strategic perspectives is recognized useful to manage effective performance improvement it is often neglected (Prashar, 2014; Kaushik et al., 2012; Antony 2012; Wang and Chen, 2012). Some research highlight a number of

barriers to the successful implementation of LSS, particularly in manufacturing SMEs. The most relevant are their resistance to change, organisational culture and the lack of managerial and technical skills (Prashar, 2014; Antony, 2012; Aboelmaged, 2011; Kumar and Antony, 2008). In particular, SMEs suffer from a lack of confidence in using technical and statistical tools required by LSS (Thomas and Barton, 2006).

Since 2000s, literature highlighted the need to embrace a holistic view of performance measurement system, to favour performance improvement in numerous sectors among which aerospace industry (Neely et al 2000). A number of studies investigated PMS as a balanced and dynamic system that is able to support the decision-making process by gathering, elaborating and analysing information in both large and small and medium organization (Garengo et al 2005; Smith and Bititci, 2017). However, few empirical research studies investigate its effective adoption in aerospace organization. A key driver of this has been the concept of the “supply chain for the 21st century” Programme (SC21, 2016), but poor empirical studies investigate its impact on both lean SCM and PMS. In order to fill the above research gaps, this paper investigates the research question:

What are the challenges related to the adoption of the SC21 programme to improve lean supply chains and PMS in the UK aerospace industry?

The paper is structured as follows: after a brief review of the literature regarding lean SCM and performance measurement (Section 2), the research methodology of the paper is presented (Section 3). This is followed by the description and discussion of the case study results (Sections 4 and 5). The final section (Section 6) concludes the paper.

2. Performance measurement and lean SCM

A watershed study relating to performance measurement, the publication “Relevance Lost” by Johnson and Kaplan (1987), argues that organisations should not solely rely on financial metrics as they are effectively lagging indicators. In 1999, a study by Neely (1999) identifies over 3,600 articles published between 1994 and 1996 on performance measurement, coining the phrase “the performance measurement revolution”. To respond to the numerous criticisms to the traditional performance measurement approach, holistic performance frameworks have evolved to promote strategic

alignment, focus on the creation of customer value, process view, etc. Such popular frameworks include the Balanced Scorecard (Kaplan and Norton, 1996) and the European Foundation for Quality Management (EFQM) Excellence Model, also known as the Business Excellence Model (BEM) (Conti, 2007; Dahlgaard et al. 2013; EFQM, 2018) . These frameworks have traditionally been common in larger organisations and not widely adopted by SMEs (Machado et al 2018). The study by Garengo et al. (2005) identifies the reason for the dearth of performance measurement frameworks in SMEs, i.e., the lack of resources and capability plus a perception that they are too bureaucratic and not relevant to the context of an SME. Instead, they find that measurement metrics tend to be limited to operational activities (*ibid*). Some SME research highlights the role of bureaucracy, cultural barriers and governance structure (Heinicke, 2018) in lean adoption and subsequently on how performance measures are used. However, when adopting lean, it is vital for organizations to look externally and find ways of collaborating and coordinating with partners and ensuring that the supply chain is both efficient and responsive to the environmental stimuli (Thakkar et al. 2013).

Plenty of literature on SCM deals with performance measurement metrics such as SCOR (Huan et al., 2004; Dissanayake and Cross,2018).

Even if the key role recognised to lean supply chain management (SCM), a number of organization fail in adopting the effective performance measures and the metrics required to achieve the lean SCM objectives. As Hanson et al. (2011) highlighted the alignment of an organisation's activities with its strategies favour the competitive advantage, and, consequently to effective manage lean supply chains it is necessary to understand and manage the overall company performance. A mainly operational set of measures lacking linkage to Prime Contractors are not enough to face the changing organizational environments caused by globalisation and requiring leaner SCM.

Often companies have not succeeded in maximising their supply chain's potential because their performance measurement goals are not aligned with organisational goals (Gunasekaran et al., 2004; Saleheen et al., 2018)

2.1 Supply Chain for the 21st Century (SC21)

In the last few years, the Trade Association and Regulation Body for the aerospace industry (TARB) has proposed a programme for performance measurement and based on the EFQM (Conti, 2006; EFQM, 2018). It is an alternative to the SCOR model (Huan

et al. 2004), known as “Supply Chains for the 21st Century” (SC21, 2019) and designed to improve competitiveness within the whole supply chain from prime contractor to the SME suppliers. The SC21 programme aspires to be a major step forward in achieving organisational improvement and effectiveness across the aerospace supply chain using the principles of Total Quality Management (TQM). It seeks to address the previous shortfalls of TQM implementations where tools and techniques were given credence whilst lip service was paid to the softer elements such as management commitment, leadership and culture (Powell, 1995). In addition, it seeks to mitigate the challenges faced by SMEs in adopting overarching performance improvement frameworks by stakeholder partnerships across the supply chain (SC21, 2019).

The perception of the supply chain partners, including the trade association which coordinated the SC21 programme with more than 800 participating SMEs, was that quality control systems such as ISO9001 and AS9100 were essential for guaranteeing quality assurance. However, these were effectively compliance and conformance tools rather than facilitating organizational performance improvement. The SC21 programme requires SMEs, and other supply chain partners, to satisfy the independent assessor against four categories, i.e., (1) demonstrating a Continuous Improvement Sustainability Plan (CISP), (2) deployment and scoring of the EFQM framework by the independent assessor, (3) achieving over 90% on the on-time delivery in full KPI and (4) over 98% on the right first time KPI (SC21, 2019). The use of these assessment criteria identifies three categories of award (bronze, silver and gold) as shown in Table 1. Taking part in this programme, some SMEs went beyond the requirement of SC21 and implemented a Balanced Scorecard (BSC) within their organization. The deployment of the SC21 Business Excellence Model within SMEs partially conflicts with the findings of the work by Garengo et al. (2005), as the manufacturing SMEs within the aerospace defence sector are not only measuring performance but also using PMS frameworks.

Requirement for SC21				
Award Level	Improvement Programme	EFQM Score	On-time delivery in full (OTDIF)	Right first time (RFT)
Gold	Plan progressed with regular reviews	Excellence level >500	>99% – 100%	>99.9% – 100%
Silver		Excellence level >400	>95% – <99%	>99.5% – 99.9%
Bronze		Framework deployed	>90% – <95%	>98% – <99.5%

Table 1: SC21 Award Scoring Process (SC21, 2019)

The above literature highlights a dearth of literature discussing the relationship between lean SCM and PMS. The literature has not paid enough attention to the study of softer, non-financial issues as partners work together to co-create customer value. A comprehensive study of 30 LSCM frameworks was conducted by Jasti and Kodali (2015) which highlighted incoherent application to develop LSCM frameworks as well as a lack of studies involving practitioners. For lean SCM to be effective, Jasti and Kodali (2015, p. 1052) recommend that “clients within the supply chain should work together to achieve joint goals”. They attribute the lack of awareness and ineffective implementation processes as the key determinants of failure of organizations in achieving Lean SCM. These gaps support the definition of the above research question.

3. Research Methods

The research adopts a qualitative methodology (Lincoln and Guba, 1985; Yin 2014). A multiple case study approach was chosen to gain a deeper understanding of the lean supply chain management and PMS in organizations adopting SC21. According to Eisenhardt (1989), case study research provides benefits such as novelty, testability and empirical validity. In addition, it “is particularly well-suited to research areas where the theory is deemed inadequate” (ibid, p. 549). Five organizations, belonging to the UK defence aerospace supply chain within the United Kingdom, were selected as case study organizations comprising three SMEs, with SC21 accreditations supplying precision

component parts, one aerospace Prime Contractor and a trade regulatory body. SMEs, especially precision component part suppliers, are included as they are recognized to be a vitally important part of the aerospace supply chain and their study is essential to understand the challenges related to the SC21 programme in the aerospace industry. In order to collect empirical data, fifteen semi-structured interviews were carried out. Each interview took approximately 45 minutes on average and involved employees with different roles (Table 2).

Case Organization	SC21 Accreditation	Position held by interviewees
Trade Association and Regulatory Body (TARB) for SC21	N/A	Managing Director (MD) Senior Project Manager Project Consultant
Prime Contractor – Major contractor to the aerospace industry	N/A	Supply Chain Director
SME1 – Employs 60 people Manufactures precision-engineered component parts	Bronze	Managing Director Operations Manager Quality Manager Production Manager Works Manager Production Engineering Manager
SME2 – Employs 25 people Manufactures precision-engineered component parts	Bronze	Managing Director Works Manager Team Leader
SME3 – Employs 20 people Manufactures precision-engineered component parts	Silver	Managing Director Works Manager (the Works Manager was the expert on SC21 in this organization) Operator

Table 2. Interviewees per Organization and Positions Held

Interviews were audio-recorded and transcribed ad-verbatim. Lincoln and Guba (1985, p. 235) recommend that “a dozen or so interviews, if properly selected, will exhaust most available information; to include as many as twenty will surely reach well beyond the point of redundancy”. The aim was to obtain the views of the strategic decision makers regarding their use of lean SCM and PMS. The interviewees were selected

because of their understanding and expertise of lean and PMS and their involvement in the accreditation of SC21 within their own organization. The interview questions were related to the topics to the extent of the strategic perspective adopted by the SMEs, their PM practices as well as evidence of lean, supply chain management and related challenges to those issues. As recommended by Meredith (1998), to strengthen this empirical analysis, secondary data in the form of the organizations' documents (particularly strategy documents and performance reports), minutes of meetings and public information were also used to support the interviews and to achieve data triangulation as suggested.

Transcribed data were analysed manually following “three concurrent flows of activity: data reduction, data display and conclusion drawing/verification” (Miles and Huberman (1994 p. 10) and paying attention also to the structuring and the de-contextualizing of the data as prescribed by Collis and Hussey (2003). In particular, data were assigned broad initial codes that were refined as research continued. Emergent themes were identified through reviewing field-notes and interview data, and supplementary codes emerged during this subsequent analysis. The emerging themes were further refined as the process continued, thus building the analysis incrementally.

4. Research Findings

The empirical investigation analysed three main key lean SCM themes, i.e., strategic planning, PMS and lean management in an SME context. A summary of the findings is shown in Table 3 and discussed in the next three subsections.

Key Issues			
C a s e S t u d i e s	Strategic Planning	Performance Measurement	Lean Management
Trade Association and Regulatory	<ul style="list-style-type: none"> - Act as accreditation body for SC21 - Devised the SC21 standard - High use of the BEM - Only request operational data from SMEs - Perceived lack strategic planning in SMEs - Has a mentoring and brokering role between SMEs and the Prime Contractors 	<ul style="list-style-type: none"> - Prime Contractors have own performance measurement systems and they audit SMEs - Data collected using multiple visits to SMEs - 40% of supply chain SMEs signed up to the principles of SC21 - TARB provides the supply chain a voice in government. 	<ul style="list-style-type: none"> - Recommend a Continuous Improvement Sustainability Plan (CSIP) - Lean needs to go beyond the factory floor and across the whole business including offices - Recognizing conflicting customer requirements can impede lean principles. - Use of SC21 to reduce multiple site audits to SMEs
Prime Contractor	<ul style="list-style-type: none"> - Formalized strategic plan - AS9100 Quality Standard - 80% of work outsourced - Key issues are globalization and fragmentation of the supply chain 	<ul style="list-style-type: none"> - Prime only require SMEs to provide two KPIs (right first time and on time delivery in full) to comply with the SC21 standard. 	<ul style="list-style-type: none"> - Not about getting the badge - Sharing of resources by SMEs and Primes beneficial for lean - The use of SC21 can minimise No. of site visits - Recognize importance of SMEs - Need to recognize how Prime can be more supportive
SME1	<ul style="list-style-type: none"> - Formalized plan (three years strategy document) - Departmental plans - Strategy Map - AS9100 Quality Standard - SC21 Bronze award 	<ul style="list-style-type: none"> - Exceeds SC21 requirement with the implementation of a Balanced Scorecard and strategy map comprising 16 KPIs to monitor and facilitate improvement. - National Vocational Qualification (NVQ) level 5 Leadership Training - Formalized HR documents including appraisals, job descriptions and training records. - Need to develop further embed capability - Employ external consultant to serve as HR specialist 	<ul style="list-style-type: none"> - CSIP in place - Lean training - Gain resource from Primes
SME2	<ul style="list-style-type: none"> - Simple business plan (formalized in excel) - five-year forecast - AS9100 Quality Standard - SC21 Silver award 	<ul style="list-style-type: none"> - Approx. four operational KPIs including the two SC21 KPIs and their targets - Works manager drives improvement and section managers have ownership of their KPIs 	<ul style="list-style-type: none"> - CSIP in place - Believe continuous improvement is vital for survival - Lean training - Gain resource from Primes - Increase on time delivery in full and quality KPIs

SME3	<ul style="list-style-type: none"> - No business plan - Very reactive managerial approach - Lack of strategic focus - ISO9001 Quality Standard 	<ul style="list-style-type: none"> - Minimum requirement of on time delivery in full and quality KPI - View quality systems such as ISO 9001 and SC21 as a badge to satisfy customers. Works mgr has ownership of KPIs 	<ul style="list-style-type: none"> - CSIP in place - CI driven by works manager. - Limited lean workshops Gain resource from Primes
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Table 3 - Summary of Case Study Findings

4.1 Strategic Planning

The aim of the SC21 initiative is to improve the competitiveness of the aerospace industry by raising the performance of its supply chains (SC21, 2019). The Prime contractor stated that 80% of the components within their products were outsourced and the organization relied heavily on SMEs to satisfy this demand. This meant that a longer term “partnering relationship” would be appropriate and SMEs’ sustainability was recognized as vital for both the contractor and the SMEs. The Trade Association and Regulatory Body provided a mentoring and brokering role between SMEs and the prime contractors in their role as the accreditation body for SC21. To be eligible for accreditation, there was no requirement for the SMEs to have a formalized strategy. When asked about the percentage of SMEs that have a strategic plan, the TARB responded:

“ummm... we don’t ask for that information from them, but generally the SMEs will have some sort of rough business plan, which they will then consider their strategic plan”. (Project Manager, TARB)

Instead, they were scored against the Business Excellence Model framework as well as their delivery performance to the prime contractor in terms of time and quality.

The three SMEs were accredited to SC21 and had differing levels of formalized strategic planning and performance measurement systems. SME1 had a three-year strategy document aligned to a balanced scorecard which was tailored to the SME context. Its strategic intent was to grow the business by 50% in three years whilst maintaining gross profit margins.

“It’s a fit for purpose document, suitable for an SME...we have a balance scorecard, and we also have a golden thread, so the objectives of the business are communicated internally”

SME2 had a relatively simplistic two-page five-year business plan composed on Excel. The document included a group of performance indicators with their own targets.

“...it’s an excel spreadsheet of about two pages. It’s fairly general; it doesn’t really go into huge amount of detail, but it’s quite a generic document, which again, has specific targets that we hope to meet.”

SME3 had no strategic plan and performance measurement system. It was very reactive in its planning having lost a major part of their order book due to an off-shoring decision by one of the Primes.

“Not really, because at the moment, due to our turnover being down, caused by one customer moving a big lump of manufacturing to China, we’re desperately trying to find work to fill that void”. “...if I was totally honest, and between you and me and the gatepost, my next strategic plan is to retire! (laughs)”

5.2 Performance Measurement

Within the aerospace industry, performance measurement took a growing relevance pulled by the very stringent quality standards. Prime contractors and their supply chain companies are often required to be accredited to AS9100. Such quality standards are applicable to the aerospace, defence and space industries but they are quite burdensome for SMEs. This happens because, as well as possessing all of the quality management attributes of ISO9001, they also require organizations to document their project, risk and configuration management procedures (AS9100, 2015). The SMEs in the case studies had been AS9100 accredited for several years, which was deemed a threshold requirement to trade with the prime contractors. It has been recognized for some time that the standard was a “curate’s egg”, good in terms of compliance but not so good in terms of bureaucracy and performance improvement. This shortfall often required Primes to visit SMEs and encourage them to work to their own bespoke standards with the possibility of SMEs subjected to several visits from Primes. The supplementary SC21 standard goes beyond compliance and looks for evidence of continuous improvement and, consequently, it implies a more holistic approach to performance measurement and management.

According to the prime contractor, over 40% of its supply chain was registered with the SC21 programme. The SC21 initiative had a conceptual agreement with the Primes and it also aimed to minimize their site visits to SMEs which, although useful, were not in the spirit of lean as they could result in parallel reporting systems and increased bureaucracy for the SMEs. The SC21 award aims to give Primes a level of confidence in their supply chain so that site visits become unnecessary. In order to be awarded the SC21 standard an SME needs to demonstrate excellent PMS. Particular attention is given to the two criteria over a rolling twelve-month period: on time delivery in full (OTDIF) and right first time (RFT). In order to be awarded the bronze standard the SMEs need to achieve over 90% OTDIF and over 98% RFT. For the silver award, it is 95% and 99.5% respectively plus a score of greater than 400 points on the BEM framework. Two of the investigated SMEs (i.e., SME2 and SME3) monitored these KPIs and little else other than some rudimentary operational KPIs relating to cycle time and financial control. Nevertheless, they found this level of performance measurement beneficial to their organisation.

“I would say that it’s very, very valuable to the company in terms of we know what we’re doing, we know where we are, we know where we’re going, etc. etc....So to coin a phrase the other day, when I knew I was in the shit, but I knew exactly how deep! I’ve got to document that!” (Works Manager SME2)

SME1 went much further and developed a Balanced Scorecard including a strategy map aligned to their business strategy and twenty strategic KPIs belonging to the four BSC perspectives.

“I think this is really a decision which our Managing Director took...he was introduced to it by a customer, and I think our Managing Director looked at it and thought ‘Well you know this could possibly give us an edge over a competitor and make us efficient in the meantime’. So I think that was his thinking behind it anyway” (Works Manager, SME1).

However, it was apparent that all managers and owners of SMEs had limited capability with respect to lean and performance measurement techniques. This required prime

contractors to assist them in building capability. Throughout this capability building exercise, it became apparent that Prime could also learn lessons from SMEs through collaboration (Kourti, 2017; Kache and Seuring, 2014).

As the prime contractor becomes more dependent on the SMEs to realize their own strategies, the relationship evolves from an adversarial approach to a lean collaborative approach where costs can be removed from the supply chain in a mutually beneficial way. Prime contractors recognize that late delivery or quality issues are not always the fault of the SME.

“Typically, when you peel that lid back and find out what the root cause is, probably about 50% of the time isn’t with the supplier, it’s actually something that the customer. They haven’t got the spec in time or the specification is not clear.” (Prime, Supply Chain Director)

As a consequence, during the SC21 process prime contractors offer their own resources and capabilities to assist SMEs to become more effective. This may take the form of benchmarking, training workshops or the secondment of staff to assist in the process. All of the investigated SMEs interviewed had benefitted from the assistance of their Prime Contractor.

Moreover, SMEs highlighted the need for investment in training and development to improve the capability of their staff in developing self-sustainability and creativity. The findings reveal that many employees, including managers, have been employed by their respective SME straight from school and lack formal management qualifications. Consequently, they have learned knowledge only directly “on the job” within the culture of their organization. This means that SMEs rely heavily on the Prime Contractor to provide resource and know how to facilitate knowledge exchange. SME1 has gone further in bridging the knowledge gap by proactively investing in management development by sponsoring NVQ level 5 management qualifications that are gained via on-the-job learning equivalent to a master’s degree level (Jenkins et al. 2003) for their key staff and lean training to all staff. SME1 also employed a human resources consultant to develop a robust appraisal system, which would include the

identification of training needs and the facilitation of a possible succession planning strategy. The appraisal training actions were embedded within its Improvement Sustainability Plan.

5.3 Lean Management

The SC21 philosophy is based on lean principles. To promote this approach, the TARB requires SC21 accredited SMEs to maintain a continuous improvement sustainability plan (CSIP) and they supply templates for SMEs to use. According to our findings, however, lean has been adopted on the factory floor but less so in the office or business environment.

It is important to note that engineering is continually evolving and white-collar roles such as design, estimating, scheduling as well as finance and administration make up a significant composition of the workforce of an SME. When considering the extent of white-collar roles within SMEs, the project manager and the managing director (MD) of the trade association made important observations.

“I think I’ve seen a lot of people with lean programmes, and lean practices and a great sort of information boards, that are completely up to date around the factory and so on...but you walk around the offices and it completely changes... I have seen very few truly lean organisations”. (Managing Director, TARB)

All case study SMEs had received support from their respective “Primes” to establish lean principles on the shop floor such as Kaizen, 5S and the “7 Wastes” improvement initiatives. However, there was an acknowledgement that all staff would benefit from training and development. SME 1 has been proactive and adopted and encouraged employee participation via internal and external lean training programmes.

“Training is key to achieving the goals... we need to get more training; broaden the horizons, more knowledge, pick up new ideas. I think it’s very easy to become stale (Managing Director, SME1)”

He also added that as well as training, ownership and accountability were of paramount importance in improving performance as it facilitates change within the organisation.

“Aah, it’s improved significantly through ownership, that’s a big factor. It’s improved yes; ownership allows many things to change, rather than a single person driving changes at the top of the business.” (Managing Director, SME1).

6. Discussion

The above findings reveal the paramount importance of collaboration between the companies belonging to the Aerospace Defence Security in ensuring SC21 success. Prior to the implementation of the SC21 framework, the use of quality management standards such as ISO9001 and AS9100 were the main references, but there were insufficient for facilitating a closer cooperation between the supply chain partners. Additional vendor rated factory visits by prime contractors aimed at developing closer cooperation had an unintended consequence of adding duplication and bureaucracy which is what scholars cautioned against (McAdam, 2000; Garengo and Biazzo, 2013;). Moreover, within the aerospace manufacturing sector, despite practicing lean, JIT, quality management and performance improvement, lean SCM were not effectively fulfilled. There were relevant implementation issues such as the lack of coordination between supply chain partners, which was highlighted by the prime contractor as their responsibility. This supports the findings of Jasti and Kodali (2016) who argue that joint goals are vital for effective lean SCM. All of the stakeholders believed that SC21 provided the necessary joined up thinking in terms of removing the duplication of multiple site visits from SMEs who had several prime contractors as customers. In addition, having a common purpose of mutual benefit enabled prime contractors to release human capital to build capability and know-how in the participating SMEs. Another larger SME invested in formal management training programmes, which would promote empowerment to release potential to new ideas and innovation. These initiatives partly addressed some of the resource capability and concerns highlighted in the literature by implementing PMS (Smith and Bititci 2017; Garengo et al. 2005). The collaboration with external partners for the accreditation processes has been highlighted in the literature as vital in dealing with the complexities of different agendas and incentives amongst the partners (Anantaram and Guenes, 2004). The trade association

has been credited with being an effective lobbying partner for the entire supply chain by providing a single voice to governments.

Even though the literature highlights the need to make lean management ubiquitous in a factory context (Hines et al. 2004), this research shows that it was notably absent within the offices of those factories, as highlighted by two of the senior members of the trade association who run the SC21 improvement programme. In fact, the literature on lean offices is limited with respect to empirical studies, which is surprising given that many allied roles such as estimating, production engineering and design are vital supporting processes for operational capability. Empowerment and ownership from an SME management perspective were identified as challenges for further embedding lean principles and high maturity in PMS (Smith and Bititci 2017).

The importance of senior management commitment is widely documented within the PMS literature (Garengo and Bititci 2007; Bourne, 2005), but it seems that, too often, lip service is paid to the concept. Notwithstanding that BEM frameworks score leadership highly for SMEs that have achieved either bronze or silver award, their absence of formalized business strategies is noticeable. The SC21 framework does not stipulate the presence of a strategic document even though it is only several sides of paper. The rationale for SMEs not having a strategy is a combination of the bureaucratic concerns highlighted by McAdam (2000), but also a dependency on repeat work from existing customers. With the spread of global competitive pressures across the supply chain, SMEs are beginning to lose substantial contracts to lower cost international suppliers, which makes strategic planning more important. Most of the SMEs are managed by the founder, or family members, and their workforce has often been employed at the SME since leaving school or has joined from another SME. This reinforces the problem of lack of effective use of performance measurement information and effective training of the SME workforce identified by the literature (Garengo et al. 2005; O'Regan et al. 2010). In the investigated companies, the lean principles have often been imported into the SMEs from the primes, and it has been very encouraging and could be regarded as a success for SC21. However, SMEs' focus, hitherto, has been on operational issues and strategy simply extends to increasing turnover by a pre-defined percentage on last year. More could be done with respect to

upskilling the senior management of the SMEs for improving strategic planning and PMS.

7. Conclusion

This study has made several contributions to knowledge with respect to SCM and performance measurement within a SME aerospace precision engineering context. The first is that it has provided rich empirical evidence of a coherent LSCM framework known as SC21 which works collaboratively with prime contractors, a regulatory trade association and more than 800 participating SMEs. Such a framework addresses some of the challenges highlighted in the literature regarding the need for more coherent LSCM frameworks and for supply chain partners to have joint goals. The SC21 framework not only provides several levels of award including bronze, silver and gold, it facilitates knowledge sharing between the prime contractor and the SMEs within the supply chain. SC21 has been a successful approach in bridging the gap of differing agendas between supply chain partners to enable them to pursue joint goals in a post-global financial crisis landscape for mutual gain with the support of the trade association.

The second contribution to knowledge was the rich empirical evidence of performance measurement frameworks such as the Business Excellence model and the balanced scorecard being adopted and utilised by SMEs which contradicts some of the literature that SMEs lack both resources and capability and find them bureaucratic.

All the SME case studies had mature quality management compliance systems in place which gave them a greater understanding of improvement than most SMEs. However, two of the SMEs were quite reactive and reliant on the SC21 trade association for templates to monitor their performance. The third SME was different in that it proactively developed a formalised strategy, adopted a balanced scorecard and invested in management and staff development to improve its competitive position.

7.1 Research limitations

The main limitation of this study is the number of SMEs involved in the empirical research. Although five cases were appropriate for a study, there are more than 850 SMEs are participating in the SC21 programme. A greater number of case studies could enable generalisable claims to be made but the paper makes a valid contribution. In

addition to increasing the number of cases in subsequent studies, further research could involve analysing SC21 accredited organizations that have adopted design for six sigma and LSS tools.

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Appendix 1

Interview Category Summary

SME Interview Category	Broad Interview Questions	Literature
Strategy	<ul style="list-style-type: none"> • Does your organisation have a strategic plan documented? • How did you first come across performance measurement frameworks? • Do internal/external stakeholders influence your choice of key performance indicators? 	Mc Adam (2000) Gunasekaran et al (2004) Garengo et al. (2005) Kumar (2006)
Performance Measurement	<ul style="list-style-type: none"> • Do you have any historical quality management systems in place? • Do you have a single measurement framework? Why? Why not? • What was your motivation for implementing a performance measurement framework? 	Garengo et al (2005); Kaplan and Norton (1996) Huan et al, (2004) Manville (2007)
Lean & Lean Supply Chain	<ul style="list-style-type: none"> • What is the process that you follow in complying with SC21? • Do you need additional resource or a dedicated member of staff to maintain it? • How does the concept of Lean relate to performance measurement/management framework(s)? 	Anantaram and Guenes (2004) Chakravorty and Shah (2012) Pande et al. (2014); Assarlind et al (2013); Bhat et al (2014);
Supply Chain & SC21 Implementation	<ul style="list-style-type: none"> • How many of your suppliers are either signed up to SC21 or are considering it? • How does your organisation influence supplier performance? • How does your performance measurement relate to your supply chain? 	Lamming (1993) Gunasekaran et al (2004) Thakkar et al (2013); Jasti and Kodali (2015)
Improvement	<ul style="list-style-type: none"> • How important is continuous improvement for your business? • What changes have been necessary to achieve performance improvement? • How do employees in your organisation perceive improvements? 	Hines et al (2004); Jenkins et al (2004) Chae (2009) Su and Kwon (2006)