SCIREA Journal of Economics
ISSN: 2995-3863
http://www.scirea.org/journal/Economics
June 10, 2024
Volume 9, Issue 2, April 2024
https://doi.org/10.54647/economics790459

A Lean longevity matrix steering an organization's journey towards higher levels of maturity

Sanjay Bhasin [1], Alessandro Laureani [2]

[1] University of Buckingham, United Kingdom

[2] Independent Lean Six Sigma Scholar, Ireland

Email: Sanjay.bhasin@buckingham.ac.uk (Sanjay Bhasin), alaureani@hotmail.com (Alessandro Laureani)

Abstract

Purpose: The overriding objective of this investigation is creating and deploying a new Lean longevity matrix, to enable organisations to reliably gauge the juncture of leanness achieved, steps necessary to move towards the next level and where dedicated resources are necessary. This was achieved by presenting and piloting a new maturity matrix addressing limitations of the existing ones. Methodology: The methodology consisted of a literature review coupled with 15 Case Studies representing 15 disparate UK manufacturing organizations. This incorporated integrating primary data capture through structured interviews from a statistically representative sample. Findings An all-embracing matrix was developed facilitating improved Lean implementation records whilst steering organizations towards higher Lean maturity levels. These aims are attained by incorporating the necessary assurance and appropriate prioritization by distinguishing areas necessitating dedicated resources safeguarding sustainability of the initiative preventing backsliding. Practical implications Extensive metrics were incorporated scrutinising the prevailing culture and change management systems. By permitting a self-assessment eradicating the bureaucracy accompanying matrixes it permits a reliable determination of juncture an organization has

attained. Feedback steers a possible course of action navigating the organization towards the next phase. Originality: The matrix tackles an existing void found in most Lean maturity matrices, specifically addressing two aspects: firstly, establishing whether an organization has adopted Lean as a philosophy and, secondly, distinctively deducing the Lean phase attained. Subsequently, informing an organisation regards steps facilitating it to move to a higher maturity level preventing regression.

Keywords: Lean, matrices, maturity, audits, metrics, journey, manufacturing.

Introduction

Camp (2013), Loyd *et al*. (2020) and Loh *et al*. (2019) acknowledge organizational strategies struggle to be implemented in their entirety. This research acknowledges most Lean transformations are approached from a tactical rather than a strategic angle, neglecting wider holistic considerations (Elnadi and Shehab, 2021). Wilson (2015) suggests Lean endures complex transformational changes obligating cultural transformation. The term "Lean" dates to John Krafcik, who, in 1988, studied as an undergraduate at the MIT under the guidance of Jim Womack. Nonetheless, it is the NIST's (2003) proposition that resonates with this research. Lean is "*a systematic approach to identify and eliminate waste through continuous improvement; flowing the product at the pull of the customer in pursuit of perfection*" (NIST, 2003, p.1). Policy makers have tentatively utilized the concepts forwarded by the likes of Henderson and Soares et al., (2021) and Kobayashi (1996).

Matrices are an important management practice, albeit not well-studied within scholarly literature. Existing Lean matrices struggle to gauge an organization's juncture and consequently remain unclear regards steps necessary to secure the next Lean juncture. Mann (2014) reiterates that "*80% of the effort in Lean implementation is expended on changing leaders' practices and behaviours, and ultimately their mindset*" (p.26). This matrix enables an organisation to reliably assess the level of Leanness it has achieved on its journey. This should aid improved implementation rates. Fifteen organizations were used as case studies. Whilst none achieved the ultimate phase reflecting Lean is treated as an ideology, its contribution to the academic and practitioner fields was ratified.

1.1 Theoretical contribution

It will transpire how this research resonates with systems theory, as the organization is perceived as a network encompassing various components (subsystems) obliged to function harmoniously. Consequently, full attention needs to be paid to the interdependencies and interconnections. The maturity matrix holistically considers the entire system. This research accepts the restrictions of systems theory as it is not inherently a prescriptive theory and does not advocate tools and techniques for leaders specifically within a Lean organization (Jackson, 2019). The research acknowledges that systems theory does not fully consider the vital and predominant links necessary for higher levels of Lean maturity (Nath et al., 2016).

2.0 Objectives

The existing matrix offerings fail to determine an accurate state of Lean: the operational aspects of Lean secure disproportionate emphasis, while the sustainability and ideological facets do not gain appropriate acknowledgement. Similarly, the causal relationship between a Lean matrix and an organization's Lean journey remains distorted. This research aims to achieve the following objectives:

i. Develop and evaluate a maturity matrix tackling the more common issues with other similar Lean maturity matrices
ii. Assess whether the matrix permits greater collaboration, enabling a self-assessment process where necessary reflecting a tool which is unassuming and free of officialdom
iii. Evaluate whether the matrix identifies that Lean encompasses a distinct multifaceted philosophy by facilitating these complex constituent components to be meritoriously evaluated.

3.0 Literature Review

The review concentrated on four databases spanning 1988 to 2024 and these included ABI/INFORM Global, Emerald Library, EBSCO Business Source Premier and Google Scholar. Management journals were incorporated. An extensive review and synthesis of the Lean literature, its principles, values, and ideology were deliberated, approximating a "systematic" approach. This initially involved scanning 600 articles from 46 different journals; 455 were selected, eliminating 145 using strict search criteria; namely:

- Articles spanning 1988 to 2024
- Focused on peer-reviewed books and articles

- Geographical location was determined inconsequential
- Systematic reviews and editorials included
- Assorted methodologies allowed
- Management journals were consulted to ascertain industry sectors
- Non-peer-evaluated literature was ignored
- Research concentrated on manufacturing to bolster generalizability
- Search criteria were "Lean" or "C.I." against "audits," "maturity," "matrix," "journey," "indices," "metrics", "measures", "leanness", "gauge", "juncture" and "measurement"

The content analysis approach (Mayring, 2004) was chosen for this investigation since it employed effectively within literature reviews in the sphere of operations management.

3.1 *Existing matrices scrutinized*

Numerous Lean maturity matrices are analysed. Some studies suggested measures judging Lean to be synonymous with a matrix assessment of Lean (Nikneshan et al., 2023; Atkinson, 2010; Schonberger, 2008). Lean measures cannot be viewed similarly to a comprehensive matrix assessment (Schonberger, 1996; Soares et al., 2021). Many failed to develop a practical system for reliably measuring the Leanness of a manufacturing firm (Cochrane, 2017). Drew *et al*. (2016) state few genuine "best" or "perfect" methods exist as some focus on the qualitative approach (Goodson, 2002; Shah and Ward, 2007), whilst others employ different indices, building a quantitative assessment with a variety of incomplete components (Haskin, 2010; Liker, 2004; Singh *et al*., 2010). Paterson (2015) and Loyd *et al*. (2020) endorse a mixed methodology. Frequently, separate stages of Lean are identified without capturing the inherent complexities of the journey (Baggaley, 2006; Cousins *et al*., 2008; Scala et al., 2023, 2005; Nath and Agrawal, 2020).

The QCDMMS measures (Bicheno and Holweg, 2009) accentuate an organization's continuous improvement journey without appreciating the intricacies of the implementation phases, while Goldratt (1990) emphasizes the supply chain without exploring the links with higher maturity. An abundance of literature endeavours to gauge the success of Lean through groups of metrics (Amir et al., 2016; Patel and Patel, 2021; Vimal and Vinodh, 2013; Vinodh and Chintha, 2011), incorporating an inherent bias and focus on possible financial advantages (Baggaley, 2006; Bou-Lluser *et al*., 2005; Shetty *et al*., 2010; Tekez and Taşdeviren, 2020). An entire system perspective is frequently not appraised, and when undertaken, it depicts specific sector concentration (Ritterbeck, 2007) on explicit sections of the value chain

(Vaishnavi and Suresh, 2020), hence disregarding the multidimensional aspects of Lean (Doolen and Hacker, 2005; Gurumurthy and Kodali, 2010). Others deliberate on the notion of Lean and its gains (Cousins *et al*., 2008; Husby, 2007), with only a few defining Leanness. Bayou and De Korvin (2008) propose that Leanness is a matter of relativeness without exploring Lean implementation as a fragmentary journey.

The DTI's (2021) seven measures alongside the LESAT matrix offer a broader viewpoint without fully acknowledging change and cultural implications. This applies to Goodson (2002) and Shah and Ward (2007), while Lee (2008) attempts to integrate external suppliers and Henderson and Larco (2003) incorporate marketing and promotion. The EFQM Excellence model is employed as an organization-wide management framework through associations amongst the results and the enablers. The statistical evidence of the model's causal relationships is restricted as it analyses segregated relationships (Bou-Lluser *et al*., 2005). Goodson's Rapid Plant Assessment (RPA) allows few individuals to establish a factory's Leanness simply through visual gauges and deliberations with employees. Its simplicity fails to consider the change process and employee contribution, as metrics are appraised remotely with limited corroboration probing existing associations amongst the groupings.

Schonberger (1996) recognizes the value of customers, employee participation and the relevance of training and marketing, alongside benchmarking other companies. But the importance of Lean as a never-ending journey and employee influence are underrated, failing to explore the principles and methodology of managing change. Kobayashi's (1996) "20 keys" accentuate 20 of the world's best manufacturing improvement tactics, though the metrics do not delve sufficiently into the impact of employees. They allow benchmark evaluations between organizations, considering Lean as a business initiative and emphasizing the factory floor-level improvements. The Lean evaluations of Goodson (2002) and Shah and Ward (2007) overlook the importance and relevance of organizational development and design, while Henderson and Larco (2003), Lee (2008), Mann (2005) and Shah and Ward (2007) underestimate culture's role in Lean's success. Lee (2008) fittingly focuses expansively on nine key parts of manufacturing, neglecting the actual bearing of the climate, culture, and management of change whilst not promoting how Lean needs to be treated as a business initiative. Henderson and Larco (2003) highlight employee collaboration and change management via the "continuous pursuit of perfection" and focus on Six Sigma though neglect the role of sustainability. The literature implies that most Lean failures (Mann, 2005; Patel and Patel, 2021) result from several factors, although culture and change management

remain constant. Lee (2008) singles out the role of quality but then selects four questions accentuating the statistical process charts necessitating greater context. Shah and Ward (2007) comprehend the multi-faceted nature and interdependencies inherent in Lean journeys, with 10 factors deemed operationally necessary, including supplier and customer participation. It would be incorrect for an organization to interpret any one of the components as a system, failing to gauge the real value of Lean.

Mann's (2005) matrix specifies eight categories of process and behaviour in a review spanning five integrated levels ("1" = "pre-implementation" and "5" = "sustainable system"), permitting a valuable self-assessment to be undertaken though performance levels are not recorded and cultural and change factors are not fully considered.

The Shingo Prize (2023) is regarded as flexible and relevant to manufacturing, service, and non-profit organizations, being applicable at various levels, including sites, entire plants, or the complete organization. The overall assessment process can be extraordinarily protracted, incorporating six phases and incurring high costs. Critics of the Shingo Prize assert that an investment made in a Shingo prize winner since 2001 would reap a return of -0.75% (Graban, 2020), reiterating that a multitude of factors contribute to the performance levels of an organization.

Lee (2008) and the Business Excellence Model dilute Lean's commercial relevance, while Henderson and Larco (2003), Mann (2005), Pakdil and Leonard (2013) and Shah and Ward (2007) neglect the structural requirements alongside key cultural and leadership traits. The DTI's (2021) seven measures are endorsed by the Industry Forum of the Society of Motor Manufacturers and Traders (SMMT) within the context of quality, cost, and delivery (QCD). These intend to facilitate continuous improvement aiding better customer relations and feedback whilst scrutinizing the levels of effectiveness through the compilation of a development plan focusing attention on areas and indices enabling greater levels of productivity. The QCD permits quicker responses and comparable numeric judgements at the departmental or organizational level. Bicheno's (2009) focuses on crucial measures of Lean, embracing lead time, customer satisfaction, schedule attainment and inventory turns. Goldratt's (1990) proposal for supply chain effectiveness also incorporates throughput dollar days and inventory dollar days. Furthermore, QCDMMS – an acronym for a collection of indices that numerous companies have adopted while implementing Lean (Henderson and Larco, 2003), namely quality, cost, delivery performance, morale, management, and safety – is a commendable instrument to assist productivity but cannot reliably assess an

organization's Lean maturity. LESAT, developed as a joint initiative between the Massachusetts Institute of Technology (MIT) and the Warwick Manufacturing Group (University of Warwick), does attempt to provide a holistic recognition of leadership's role alongside the varied processes providing value (Azadeh *et al*., 2015; Mann, 2014). Whilst identifying the cultural aspects and the need to incorporate lean ideologies, it fails to explore the interrelationships.

3.2 All-inclusive literature review influencing possible constituent matrix components

Nickneshan et al., (2023) imply that a Lean transformation is a process that organizations adopt progressively through a planned programme aiming to secure competitive capability. Azadeh (2015), Bicheno *et al*. (2009), Holweg *et al*. (2018), Mann (2014) and Zirar *et al*. (2020) suggest Lean permits organizations to improve the ability of their employees using a range of tools dependent on the process scrutinized. When an organization accomplishes enhanced waste reduction, it should move to advanced Lean maturity (Scale et al., 2023; Elnadi and Shehab 2021). Pakdil and Leonard (2017) and Vinodh and Vimal (2012) insist that the fundamental objective of Lean is to explore customer value by reducing internal waste. Vaishnavi and Suresh (2020) reiterate that Lean operates more effectively around value perceived by customers and the usage of resources at the organization's disposal. Liker and Franz (2011) confirm that fewer than 5% of all lean initiatives proceed to achieve the predicted results. Overlooked in many Lean matrices is leadership which incorporates an arrangement of leadership competencies, practices, and behaviours to execute and use a Lean system effectively (Narayanamurthy and Gurumurthy, 2018; Paterson *et al*., 2015; Perera and Perera, 2019; Toledo *et al*., 2018).

Mann (2014) and Nikneshan et al., (2023) insist that a vision facilitates the change required. Collaboration and coaching should be incorporated (Bhasin and Found, 2020). Holweg and Maylor (2018) emphasize the technical features of effective performance management and information sharing. Liker (2004) reinforces the long-term commitment necessary from leadership. Empirical studies solely concentrating on Lean leadership are scarce (Atkinson, 2010; Azadeh *et al*., 2015; Camp, 2013; Gopalakrishnan and Anand, 2016; Holweg and Maylor, 2018; Loh *et al*., 2019; Pakdil and Leonard, 2013). The inferences whilst focusing on leadership (Mann, 2014) steer us to the role of commitment and communication (Piercy and Rich, 2015). A consensus view promotes the idea that Lean leaders need to be supportive,

effective delegators and successful at motivating staff. Ohno (1988), Samuel (2010) and Vimal and Vinodh (2012) endorse that employees drive Lean success and the "respect for people" pillar of Lean. Lean leadership should enable all of this (Nath and Agrawal, 2020; Singh *et al*., 2010; Soares et al., 2021).

Table I provides a summary from the literature identifying the key ingredients necessary for Lean. This formed a major consideration regards aspects to consider for the Lean matrix devised.

Table I – Literature highlighting the key ingredients necessary for Lean

Lean requirement	Identified within percentage of articles	Indicative literature acknowledged
Clear grasp of strategic vision and goals	65	▪Emiliani (1998); Essex et al., (2016); Nickneshan et al., (2023); Patel and Patel (2021)
Top management commitment	54	▪ Bhasin (2011); Holweg and Maylor (2018); Antony *et al*. (2022); Fullerton and Wempe (2009)
Leadership	24	▪Bayou and De Korvin (2008); Mann (2014); Anthony and Anthony (2022); Bhasin and Found (2020)
Excellent project management	14	▪ Cochrane (2017); Drew *et al*. (2016); Jasti *et al*. (2020); Soares et al., (2021)
Lean as a commercial venture	9	▪ Camp (2013); Mann (2014); Haskin (2010); Holweg and Maylor (2018); Zirar *et al*. (2020)
Lean transcending boundaries	23	▪ Dimancescu *et al*. (1997); Patel and Patel (2021); Ohno (1988); Tekez and Taşdeviren (2020); Wilson (2015)
Organizational structural change	27	▪ Emiliani (1998); Jasti (2020); Drew et al., (2016); Liker (2004); Loh *et al*. (2019)
Deterring of backsliding	19	▪Patel and Patel (2021); Essex et al., (2016); Wilson (2015); Elnadi and Shehab (2021); Wong *et al*. (2014)
Communication plan	29	▪ Lee (2008); Liker and Franz (2011); Ohno (1988); Perera and Perera (2019); Shah and Ward (2007)
Suitable tools deployed	79	▪ Gunasekaran et al., (2017); Croom et al., (2016); Bhasin and Found (2020); Soures et al., (2021); Jasti *et al*. (2020); Loh *et al*. (2019)
Suitable IT installed	18	▪ Loh et al., (2019); Loyd et al., (2020); Anthony and Anthony (2022); Essex et al., (2016)
Customer focus	82	▪ Loh *et al*. (2019); Pakdil and Leonard (2017); Perera and

		Perera (2019); Nikneshan et al., (2023); Zirar *et al*. (2020)
Respect for people and C.I.	88	▪ Bicheno and Holweg (2009); Pakdil and Leonard (2017); Antony et al., 2019); Wilson (2015)
Levelized production – Heijunka	32	▪ Wong et al., (2014); Samuel *et al*. (2015); Tekez and Tasdeviren (2020); Piercy and Rich (2015)
Process management	29	▪Bicheno and Holweg (2009); Jasti *et al*. (2020); Toledo et al., (2018); Tekes and Tasdeviren (2020)
Lean accounting	12	▪Neely *et al*. (2005); Singh *et al*. (2010); Torbjorn (2016); Nath and Agrawal (2020);
A remarkable implementation team	24	▪ Baggaley (2006); Loh *et al*. (2019); Zirar et al., (2020); ▪ Antony *et al*. (2022); Gopalakrishnan and Anand (2016); Zirar *et al*. (2020)
Training and education	78	▪Elnadi and Shehab (2021); Samuel (2010); Zirar et al., (2020); Wilson (2015); Tekez and Taşdeviren (2020)
Motivated staff	78	▪Camp (2013); Nath and Agrawal (2020); Cochrane (2017); Bhasin (2011); Patel and Patel (2021)
Standardization	34	▪Azadeh et al, (2015); Croom et al., (2016); Wilson (2015); Loh *et al*. (2019); Wong *et al*. (2014)
Realistic timescales	16	▪Bhasin and Found (2020); Gunasekaran et al., (2017); Essex et al., (2016); Perera and Perera (2019)
Continued evaluation of Lean's progress	22	▪Atkinson (2010); Jackson (2019); Drew *et al*. (2016); Loh *et al*. (2019); Patel and Patel (2021); Tekez and Taşdeviren (2020); Wincel (2013)
Financial capability to undertake Lean	39	▪Neely *et al*. (2005); Singh *et al*. (2010); Graben (2020); Antony *et al*. (2019); Schonberger (2008)
Lean champion(s) appointed	26	▪Baggaley (2006); Gopalakrishnan and Anand (2016); Jasti *et al*. (2020); Patel and Patel (2021); Zirar *et al*. (2020)
Lean as a philosophy and not a strategy	24	▪Bhasin (2011); Jasti et al., (2020); Paterson (2015); Perera and Perera (2019); Wilson (2015)
Long-term journey	78	▪Patel and Patel (2021); Pakdil and Leonard (2017); Andrea and Emidia (2017); Bhasin and Found (2020)
Performance evaluation of Lean's impact	34	▪ Narayanamurthy and Gurumurthy (2018); Cousins et al., (2017); Paterson (2015); Zirar *et al*. (2020)
Right calibre of gurus	28	▪ Antony *et al*. (2022); Azadeh *et al*. (2015); Croom et al., (2016); Gunasekaren et al., (2017)
Middle management buy-in	69	▪ Bicheno and Holweg (2009); Andrea and Emidia (2017); Jasti (2020); Mann (2014)
A conducive culture		▪ Camp (2013); Wilson (2015); Loh *et al*. (2019); Nath and

	91	Agrawal (2020); Pakdil and Leonard (2017); Wilson (2015)

Lean integrates a commercial perspective with the overriding goal of accomplishing a flourishing and buoyant organization (Bhasin and Found, 2020; Soares et al., 2021; Piercy and Rich, 2015). Gopalakrishnan and Anand (2016) promote the application of Lean as a whole-system approach. Amir *et al*. (2016) and Andrea and Emidia (2017) suggest that Lean's success necessitates organizations and practitioners to embrace its ideology whilst distinguishing its philosophy from the practices and tools, like Six Sigma, used to sustain this ideology. Ohno (1988) and subsequent Lean exponents such as Shah and Ward (2007) and Womack and Jones (2005) provide a reminder that an organization needs to determine its own ways of refining the Lean tools within the context that best serves it. The Toyota Way provides a framework for the Toyota culture, permitting the Toyota Production System (TPS) to function fruitfully (Vaishnavi and Suresh, 2020). Emiliani (1998), Fullerton and Wempe (2009) and Liker (2004) infer that Lean should encourage employees to evolve the existing processes continuously.

Debating Lean's commercial potential, Azadeh *et al*. (2015), Neely et al. (2005), Pakdil and Leonard (2013) and Torbjørn (2016) echo that it needs to demonstrate its business potential, despite practitioners struggling to grasp this. Dimancescu *et al*. (1997) initially make progress by referencing Lean's operational impact, but the level of scrutiny was limited. The return that an organization secures from its Lean endeavours is difficult to decipher through conventional accounting methods. The subsequent work by Bond (1999) and Wade (1997), alongside the concentrated explorations undertaken by Kaplan and Norton (1992, 1993, 2001, 2005), further refines this concept and partly manages to evaluate the impact of Lean. Fullerton and Wempe (2009), Holweg and Maylor (2018) and Elnadi and Shehab (2021) specify the inherent bias within the literature whereby Lean is seen as a manufacturing notion instead of a whole-system approach. Piercy and Rich (2015) recap that Lean operates effortlessly when the different internal components work in harmony. Bicheno and Holweg (2009) and Maltz *et al*. (2003) emphasize the need to apply Lean to the entire value chain.

An abundance of literature promotes the application of separate tools (Nath and Agrawal, 2020; Paterson, 2015; Nikneshan et al., 2023). Pertinent tools should be applied at correct times under appropriate conditions in the context of the interdependencies of the organization's value chain (Bicheno and Holweg, 2009). The literature proposing supplier development when discussing the entire value chain is scant (Bicheno and Holweg, 2009;

Vimal and Vinodh, 2012). This should form part of an organization's Lean objectives alongside a desire to reduce the supplier base (Tekez and Taşdeviren, 2020; Vinodh and Vimal, 2012). It supports an organization's scheduling and planning (Doolen and Hacker, 2005; Patel and Patel, 2021). To integrate this into the cultural perspective, an organization must manage and execute its relationships with suppliers collaboratively minimising hostilities often encountered (Anthony and Anthony, 2022).

As reflected in Figure 1, the literature reveals a common thread of culture and change as hindrances (Antony *et al*., 2019; Drew et al., 2016); Mann, 2014; Wong *et al*., 2014). An organization's culture forms the resolutions, ideologies, customs, and perceptible artefacts of its staff members as well as their behaviours (Jasti *et al*., 2020; Wilson, 2015). To accomplish organizational change, there is a definite need to alter the behavioural patterns (Scala et al., 2023; Pakdil and Leonard, 2017; Perera and Perera, 2019; Schonberger, 2008; Vimal and Vinodh, 2013). Practitioners erroneously attempt to emulate a formula that was effective in another organization (Camp, 2013; Drew *et al*., 2016).

The change strategy adopted must be equally effective as the culture (Vaishnavi and Suresh, 2020). Bhasin and Found (2020) promote the need to generate and connect a vision of an all-embracing wide-ranging plan. The employees must both grasp and relate to this plan (Ohno, 1988).

Gopalakrishnan and Anand (2016) emphasise the need to adopt and execute a suitable performance system. The literature exposes reservations concerning Lean (Cooney, 2002). One theme implies that some market conditions may favour different manufacturing approaches. Equally, from a people perspective, Gill (2003) suggests that Lean can pose additional stress intensities exhibited by employee attrition and non-attendance, often as a direct consequence of accidents. This premise implies that operating under Lean conditions can exert additional pressure on managers. Neely *et al*. (2005) and Scala et al., (2023) advocate the need to adopt suitable and informative performance metrics.

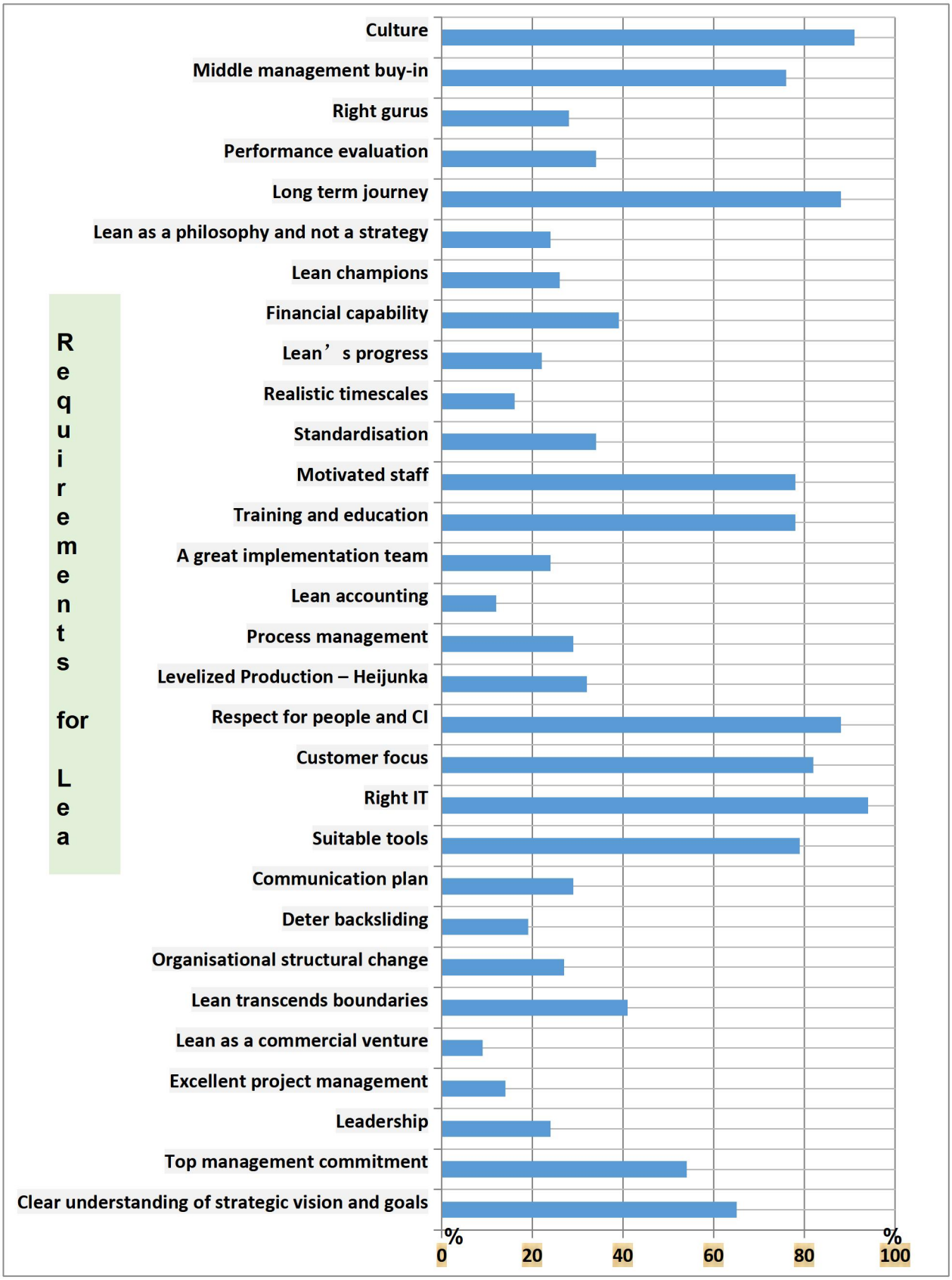

Figure 1 – Percentage of the total reflecting a requirement for Lean to be successful

Frequently, organizations opt for non-specific metrics that reveal little (Antony et al., 2019). Soares et al., (2021) emphasize the importance of selecting metrics reflecting the varied levels of an organization. Wan and Frank (2008) warn that Lean benefits can be difficult to compute. This matrix considers intangible assets, which are often neglected. It was vital to encapsulate the concept of value adding, which practitioners can be guilty of overlooking (Vaishnavi and Suresh, 2020).

4.0 An all-inclusive Lean assessment

This matrix principles grasp that organizations are unique, presenting distinctive struggles and boundaries (Elnadi and Shehab, 2021; Schonberger, 2008; Wilson, 2015). Literature implies levels of Lean implementation differ. Drew *et al*. (2016) proposes five phases, Harbour (2001) describes four phases and Motley (2004) opts for six levels. Ten separate categories (dimensions) of distinct metrics are deployed. The author's extensive experience of operating as a Lean champion and C.I. lead of large national organizations within different sectors was used alongside deductions from the literature, empirical evidence, and experience of Lean implementations. Common themes emerged:

- The literature highlights visual management inducing this suite of metrics. We operate in a health and safety-conscious world. The pilot validated the amalgamation of these metrics.
- The operational aspects steering the need to use the right tools at correct intervals implied by literature are persistently undertaken erroneously, triggering a separate suite of indices.
- Relevant aspects focusing on the flow, processes and design of quality formed another dimension.
- An initial attempt was made to combine the "continuous improvement" and "change" metrics. The pilot study undertaken within Royal Doulton Plc revealed that the causal factors can be quite diverse, necessitating the separation of these groups. The literature endorses this approach.
- Culture and the transformation strategy adopted were separated into distinctive suites of metrics, with culture forming two autonomous sections.
- The literature asserts that a common error is backsliding, whereby progress is not sustained, which steered another grouping.

- Lean has a business rationale. It was astounding to discover the lack of accountability within the organizations trying to assess and capture the impact of this substantial investment. This prompted another suite of metrics.
- Despite most organizations supposedly supporting the view that Lean needs to be regarded as a philosophy or ideology, there was often a lack of evidence to support this. This prompted a suite of indices.

5.0 Methodology

5.1 Case Studies

Case Studies were chosen since they permit an in-depth anlayisis of often difficult phenomenon whilst awarding a holistic understanding of the organisation (Voss, Johnson and Godsell, 2016). In this research it was felt undue attention was not required regards sampling or to control variables whilst permitting real-world research (Saunders, Lewis and Thornhill, 2016, p. 184). Furthermore, evidence can be analysed from a positivistic or a phenomenological perspective. A close affiliation with Robson's (2016) definition was found; that a "*Case Study is a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real-life context using multiple sources of evidence*" (page 52). A stratification system was adopted in terms of closeness, size, and the phase of Lean that each organization had accomplished whilst ensuring the representation of varied manufacturing sub-sectors.

Yin (2009) utilises two dimensions - a single case or multiple case design. A multiple case study allowed comparisons between cases awarding repeatibility of the research (Voss, Johnson and Godsell, 2016) whilst contributing to the generalisation of the findings. Process steps guided by Yin (2018, p. 58) were adopted.

- Selection of the cases.
- Design the evidence protocol.
- Conduct the case studies.
- Write-up the case studies.
- Draw cross-case conclusions.
- Modify theory enabling policy implications.
- Writing of the report.

Literature implies larger organizations embrace Lean to an enhanced level (Bhasin, 2011), which meant considering a multitude of factors. Access was secured to fifteen diverse manufacturing UK organizations as case studies Stake (1995) and Yin (2018) identified at least six sources of Case Study evidence which were explored within each organisation:

- Documents (documental evidence necessary was supplied by either the CEO or the Production Director)
- Archival material (secured from respective directors)
- Interviews; (structured interview schedules were undertaken with at least 12 people. These included:
  - CEO or Production Director
  - A Lean champion or Head of the Lean initiative
  - Five team leaders representing various sections
  - Five operatives representing the team leaders' areas (to try and secure validation)
- Direct observation as access was permitted
- Participant-observation as I was permitted to sit in key meetings to seek clarification, and
- Physical artefacts which included CEDAC boards and layout modifications undertaken.

These are reflected in Tables II and III. To safeguard greater reliability, small, medium, and large organisations reflecting various sectors were chosen – Table II.

Table II Organisations selected by sector

Organisations chosen by Size	
Small	i. Solutions Engineering ii. Tonge and Taylor Limited iii. Trentex Engineering Limited iv. Uniwire v. Britalco Engineering Limited
Medium	i. Excel (Electronics) ii. Roballo iii. Simrad

	iv.	Copper and Optic Limited
Large	i.	Ricardo
	ii.	Robert Bosch
	iii.	Leoni wiring
	iv.	Kab seating
	v.	Jaquar Cars
	vi.	Royal Doulton

To achieve a better all-inclusive deduction, every effort was exerted to guarantee various sectors are represented as depicted in Table III

Table III – Organizations split by sector

Organizations by manufacturing sub-sectors represented		
Electronic	**Components**	**Automotive**
Tonge and Taylor Limited	Uniwire	Ricardo
Excel (Electronics)	Britalco Engineering Limited	Kab seating
Roballo	Trentex Engineering Limited	Jaquar Cars
Solutions Engineering	Copper and Optic Limited	Leoni wiring
Robert Bosch	Simrad	
	Royal Doulton	

5.2 Case Study quality considerations

Quality considerations are vital in research (Patton, 2015). This rigor was integrated prior to, during, and after undertaking the case study research. The investigation adopted a multi-perspective stance, safeguarding validity, reliability, and triangulation. Construct validity, internal validity, external validity and reliability (Karlsson, 2016) were fully acknowledged within this research. Reliability according to Karlsson (2016) denotes that "*had the same research, in the same conditions, been undertaken by other researchers, they would have come to the same conclusions*." 'Reliability has become the most important criterion in many research communities' (Karlsson, 2016, p. 31). Construct validity, infers, that the accurate measures are used (Karlsson, 2016). To safeguard reliability, a reliable sample of individuals were required to complete the maturity matrix determining the organization's Lean maturity. Triangulation suggests authenticating data, findings, results and outcomes by employing more than one data collection technique whilst comparing data and findings from multiple sources (Flick, 2018). Triangulation was achieved by comparing findings of different personnel from

each organisation. As a validating exercise, a balanced scorecard, clarified below, was developed, and deployed to scrutinize the findings further. The overarching statistical analysis was undertaken with the aid of SPSS software, incorporating parametrical and non-parametrical examinations.

6.0 Recommended seven phases of Lean

The pilot conducted within Royal Doulton PLC reinforced a Lean implementation comprises various phases. The literature dictates that most organizations fail to reach the pinnacle stage; this remains aspirational. Table III clarifies the seven junctures decided upon after considerable deliberation with the relevant symbolic characteristics for each. The authors noticed the seven phases of the Lean journey are not mutually exclusive. Instead, they may coexist in an organization. Nevertheless, the matrix provides an overall baseline for the organization. The time taken and signposts inevitably differ between organizations owing to unique internal and external mitigating factors. These are governed by the prevailing constructs, magnitude of the organization, its level of commitment, its scope of internal skills, its financial readiness and the age of the company concerned coupled with the product groupings and lines, amidst other factors.

Table III – Lean stages clarified

Phases of a Lean journey	
Seven junctures	**Symbolic features depicted within the organization**
1. Initiation	• No enactment has occurred • The benefits are generally understood but not actioned • No structural aspects have been implemented; no whole choices have been executed • Few execution tactics may have been articulated • A Sensei or Lean advocate/champion has already been located or placed • The overall decision makers alongside the senior management teams consider the Lean journey in concurrence with the unions
2. Developmental	• The execution of the Lean plan has commenced

	• Pilot area(s) selected with evidence of some work starting • No indication of broadening the execution to remaining or other areas • Evidence of isolated tools in place with no successive assurance obvious • Relevance of culture is not fully acknowledged • Some execution plans may have been devised with little detail • Interdependencies with other areas are not considered
3. Mechanistic	• Initial pilot area is making reasonable progress; benefits are encouraged • Isolated tools are entrenched, though largely within manufacturing/operational • Tools are employed haphazardly without acknowledging interdependencies • Relevance and impact of culture are not appreciated • Internal advocates of Lean are promoting its spread internally alone
4. Enhanced	• Pilot has verified great success and is being promoted widely • Evidence of cascading the lessons learnt and Lean principles to other prominent areas internally • Predominantly a manufacturing / operational emphasis exists • Decent evidence of a lessons learnt culture; some structure to plans to spread the application of Lean • Definite recognition of how Lean can assist greater productivity levels • Acknowledgement that the culture needs to address organizational routines; some concrete evidence that this is being accomplished
5. Holistic	• The diffusion of the Lean principles is hitting initial targets and progressing • Large parts of the internal organization have been assimilated • Suppliers are integrated with evidence of amalgamation of the entire value chain • A certain acknowledgement on how Lean supports greater productivity and is being encouraged tactically • The recognition and evidence culture and organizational systems require modification

	• Organizational and cultural advances still require some work
6. Pioneering	• Evidence that Lean principles are accepted and pursued internally • Decent advancement to assimilate the Lean ideas within the entire value chain • Many cultural and organizational change aspects have been incorporated in readiness for additional work • Lean ideology has been entrenched as an overriding strategy • Suppliers are supported to accept the Lean principles with evidence of them accepting the ideology • Lean systems have been ingrained within the subsidiary aspects of the organization, namely logistics, HR, finance, and marketing
7. Philosophical	• Lean techniques, prevailing culture and organizational structures coupled with the Lean ideology are applied to the entire value chain • Evidence that the organization appreciates the amalgamation of value streams and the interdependencies • Lean is seen to be the principle of everyday working, pursuing continuous improvement • Lean principles are developed and ingrained as part of the vision • Lean principles are developed and ingrained as part of the mission • Suppliers are viewed as part of the entire team and not as antagonists • Lean is consistently revealing and producing commercial benefits

6.1 Scoring system for the matrix

A Likert scale was used to gauge attitudes and behaviours with the aid of answer choices ranging between two extremes. Spector (1992) suggests that, unlike a simple "yes/no" question, this permits researchers to unearth grades of opinion. Consequently, the matrix provides scores for the two extreme responses:

- 0 = No observance of or obedience to the principles summarized for each metric
- 6 = Complete obedience to the principles charted within the metric

*(*** "0" was chosen as the pilot showed that some facets are not in place; awarding a "1" can seem confusing. Opted for "6" on a "0" to "6" scale enabled a sufficient range to be used.)*

This facility permitted the matrix to provide an interim score reflecting which side of the continuum the organization represented against each metric. Table IV provides an indicative example of the following:

- Two of the groupings and
- Two indicative metrics for each group of the matrix devised

Table IV – Summary of the indicative matrix

Overall visual organization	**Score**
Health and safety 0 = Totally unsafe; numerous dangers can be located; no compliance with guidelines 6 = Totally safe; no hazards and comprehensive adherence to guidelines	
Complete organization 0 = Random and no classifications for markings or to locate any tools 6 = Just compulsory objects easily obtainable; strong motifs for tools	
Score = / 54 (as in total 9 metrics were used)	
Manufacturing, overall flow and procedures	**Score**
Continuous flow 0 = Meagre or no flow arrangements with no recognized batch proportions 6 = Forward-thinking flow and reduced batches	
Certification of procedures 0 = No procedures apparent and when in place they are wholly not consistent 6 = Procedures are clear and totally consistent	
Score = / 78 (as in total 13 metrics were used)	

The maximum score available was 648 points (100%), representing 108 metrics. This was achievable if an organization secured a "6" for each metric. The matrix scores were split amongst the categories as follows:

i. Overall visual organization (9 metrics) - 54 points

ii. Manufacturing, overall flow and procedures (13 metrics) - 78 points

iii. Quality embedded in the product (15 metrics) - 90 points

iv. Continuous improvement (11 metrics) - 66 points

v. Change approach (13 metrics) - 78 points

vi. Supporting and maintaining the Lean journey (8 metrics) - 48 points

vii. Culture related to the procedures (13 metrics) - 78 points

viii. Culture aspects focused upon the employees (8 metrics) - 48 points

ix. Lean perceived as a business initiative (10 metrics) - 60 points

x. Lean philosophy (8 metrics) - 48 points

The total score (648 from 108 metrics) represents 100%. The category split was as follows:

- Initiation - between 0 and 15% (0–97 points)
- Developmental - more than 15% (98 +)
- Mechanistic - more than 30% (195+)
- Enhanced - more than 45% (292+)
- Holistic - more than 60% (389 +)
- Pioneering - more than 75% (487+)
- Philosophical - more than 90% (584+)

In summary, we could encounter a scenario in which an organization scores 350 points. This parallels to an "Enhanced" stage, awarding the organization three probable courses of direction:

i. It makes headway towards the next stage by addressing the areas that the matrix identified,

ii. It decides to remain stagnated at its present level or

iii. It fades and either settles at a lower phase or its Lean journey begins to fizzle out.

7.0 Balanced scorecard judging performance

To uphold the validity and credibility of the findings from a practitioner and academic perspective, it was decided to devise and deploy an extensive scorecard (Table V) across the 15 organizations to decipher any themes or associations. The intention was to gauge reliably Lean's impact on the organizations.

7.1 Scorecard Rationale

In discussions with the Lean sponsors of the 15 Case Studies (often Production Directors or the CEOs themselves) evidently a huge concern centred upon the failed attempts to gauge the impact their Lean initiatives had made. This steered the authors towards the compilation of a scorecard. The authors considered when crafting a business strategy, we must be able to acknowledge the intangibles and award them considerable emphasis alongside the financial goals. This initially involved analysing the five elements (Maltz *et al*., 2003) coupled with the principles and thoughts of other proponents (Bond, 1999; Dimancescu *et al*., 1997; Kaplan and Norton, 1992, 1993, 2005; Wade, 1997). Maltz *et al*. (2003) advocate five categories, adding the "future" to Kaplan and Norton's conventional dimensions. This methodology was pursued since sustaining a Lean initiative was regarded an important ingredient of the matrix. Care was taken to acknowledge the importance of establishing cause-and-effect relationships; if improved operational performance fails to instigate financial performance, this indicates that the chain of cause and effect has not been established correctly and needs revision. The five categories adopted and deployed by the DMP framework (Maltz *et al*., 2003) are:

- Financial
- Customer-led indices
- Process
- People and
- Parameters looking at the organization's prospects.

In using the Maltz framework, 33 metrics across five categories were implemented as reflected in Table V. These metrics emerged from discussions with the organisations alongside a review of the existing measures individual organisations were employing. These 33 metrics permitted valid comparisons of the impact Lean had made within each organisation. To undertake the analysis safeguarding consistency, the average figure obtained for each of the five categories ("finance," "customer," "process," "people" and "future") was used for

comparison purposes, providing better holistic positioning against each category as individual metrics can skew results.

Table V – Performance scorecard used

Financial	**Process**
Profit	NPD lead times
Asset usage	Total material costs
Stock turnover	Raw material inventory
Return on capital employed	Total cycle time
Current liquidity ratio	Time to market for new products
Customer/market	Fault levels
Percentage of the total market	Costs of quality
Customer approval index	Production adaptability
Retaining the customer base	Overall manufacturing costs
Quality of service provided	Total productivity
Delivery rates	Inventory levels
Flexibility of service customers receive	**Future**
People	Quality of strategic planning
Staff perception survey	Capability to accommodate future changes
H&S spent on each employee	Pioneering market development
Labour attrition rates	Pioneering product development
Retaining skilled employees	New technology progress
Training prospects	Percentage of revenue from new products

7.2 Scorecard analysis aiding the validation

The scorecard analysis established that five organizations clearly presented superior results, necessitating further scrutiny; the most significant correlations were for the following metrics:

- Continuous improvement ($r = 0.75$; $p \leq 0.001$)
- Supporting and maintaining the Lean Journey ($r = 0.80$; $p \leq 0.0001$)
- Cultural aspects in relation to the employees ($r = 0.74$; $p \leq 0.0001$)

- Lean perceived as a business initiative ($r = 0.78$; $p \leq 0.0001$)
- Lean philosophy ($r = 0.77$; $p \leq 0.0001$)
- Change approach ($r = 0.69$; $p = \leq 0.002$)

Whilst this acted as a corroborating exercise, it verified the importance of the crucial constituents often found within organizations that have fully embraced Lean as an ideology, namely:

- A continuous improvement ethos
- Sustainability formulating a requirement to deter backsliding
- A culture of valuing employees
- Acknowledging and pursuing the business benefits of Lean
- Viewing Lean as an overarching ideology and not another strategy
- A change strategy that relentlessly drives Lean.

Nonetheless, revealingly, despite the literature advocating the importance of the technical tools for Lean to succeed, the correlation coefficients were not significant for the following categories:

- Manufacturing, overall flow and procedures - 0.35 $p \leq 0.0001$
- Culture relating to procedures - 0.39 $p \leq 0.0001$
- Quality embedded in the product - 0.39 $p \leq 0.0001$
- Overall visual management - 0.43 $p \leq 0.0001$

8.0 Discussion, implications, and contribution of the research

The research has introduced a new Lean longevity matrix and has assessed it in 15 different organizations: the matrix permitted greater collaboration, enabled a self-assessment process, facilitating constituents' evaluation, hence meeting the original research objectives.

This matrix also indicates that Leanness must not be viewed narrowly as a collection of tools, techniques, and practices. Instead, it should be viewed from an entire system approach, transcending the frontiers of the shopfloor. This assists in determining the genuine Lean juncture an organization has accomplished alongside reliable pointers navigating the organization towards the next juncture. A matrix should also help to answer the question of

whether the organization has transformed sufficiently to accept the Lean principles whilst promoting a conducive culture.

The rationale and the objective of any matrix's results must be pursued for the right reasons. Striving to achieve results for the sole purpose of winning the prize can result in the long-term structural and sustainability factors not being appropriately embedded. This research reveals that, when undertaken incorrectly, instead of aiding the organization, it could represent a substantial risk. The core ethos of any matrix should be its ability to analyse the prevailing processes whilst identifying opportunities to save costs and reduce the lead time. Organizations complain about having to make a significant resource commitment involving external experts. This matrix provides an efficient self-assessment tool. This research clarifies numerous key recommendations that would prove useful to both Lean practitioners and the world of academia.

8.1 Practical and practitioner contribution

The authors discovered that the seven phases of the lean journey are not necessarily mutually exclusive and can coexist in an organization. However, the matrix could provide an overall baseline for the organization. Nonetheless, Leanness should not be viewed narrowly as a collection of tools, techniques, and practices. In fact, it needs to encapsulate an entire systems approach, surpassing the limits of the shopfloor. This assists in defining the honest juncture of Lean that an organization has accomplished alongside unswerving indicators steering the organization towards the next juncture.

It was evident that a definitive requirement exists to undertake an assessment periodically, investigating an organization's Lean status. This permits an evaluation of whether the metrics continue to reinforce the organization's standards and values, acknowledging the dynamic structure of Lean. When assumed responsibly and correctly, the matrix assists in cultivating a consistent rhythm. This encourages managers to react in predictable ways with assigned responsibilities in line with the principles of the Lean ideology. The feedback from the sample organizations suggested that this enables better standardization levels, steering the formulation of a desired culture.

Furthermore, to permit greater collaboration, matrix assessments should be unassuming and free of officialdom. This matrix demonstrated additional practical advantages; namely, one unit's assessment score could be based on the appraisal undertaken by the leader of the next level in the organization. This reinforces that many of the best practices such as greater

collaboration, coordination, deducing overall value and the better flow are achieved. Where impractical, a mixed model of assessors helps to preserve the trustworthiness and legitimacy. This awards the matrix greater credibility and confidence in its findings. Senior managers can ensure that a collective understanding of the assessments is retained. The sample organizations showed that, in large sub-units, a core group of managers from other areas can be assisted by internal managers. To grasp an organization's Lean journey fully, adjudication should happen against a wide-ranging spectrum of metrics encompassing product development, supplier selection, product costing and employee training and development whilst considering collaboration with customers and the value chain. Scrutinizing the varied dimensions is strongly proposed as a single average could erroneously induce inappropriate action. To achieve the best results, this research implies that metrics should clearly inform an organization, referencing the juncture accomplished. This highlights any slippage and should accompany a development plan facilitating the attainment of higher levels of maturity. Another interesting deduction from feedback of the CEOs from the 15 case organizations was a preference towards a radar screen profile to be utilised as a useful visual devise.

8.2 Theoretical contribution

Practitioners and academics need to fully comprehend that an organization's Lean journey is unique which feedback implied this matrix skilfully accommodates. The assessment needs to be tailored, ensuring that advice is shared transparently with the organization regarding its present Lean status and its evolution since the inception of its Lean journey. Furthermore, as an ideology, Lean incorporates a distinct multifaceted philosophy requiring a high degree of effort when implemented appropriately. This matrix safeguards that these complex constituent components are meritoriously integrated for evaluation. A significant barrier within the literature concerns the inability of many organizations to capture the benefits that Lean prompts. The benefit realization aspects which often appears in the Lean literature is frequently considered problematic to integrate. Consequently, this matrix assists in clarifying the concept for respective organizations in a harmonious fashion. In line with the literature, any matrix must embrace metrics focusing on indicative barriers specified within the literature, assisting organizations to gauge whether the prevailing conditions are conducive for Lean to flourish. Likewise, the literature is often unclear regarding how a matrix helps an organization to steer towards the next juncture as clear with this matrix.

The tangible outcomes of this matrix should emphasize and guide the organization's efforts towards specific aspects requiring further energy. This leads the organization towards greater

Lean maturity. The literature substantiates that this deters backsliding as it continues to form one of the prominent barriers. The research describes how a matrix must always be treated as another Lean tool to reap its full benefits. The matrix is a perfect example of promoting the importance of involving employees which provides that catalyst required to enthuse people about Lean and encourage greater cooperation. The sample organizations endorsed this, which enabled an astute swing from KPI numbers to numeric process data. This research reinforces that achieving Lean maturity is a gradual process with the emphasise placed upon self-improvement. Most of the Lean maturity models incorporate five levels or stages unlike the seven integrated within this model. This awards greater detail and a level of observation equipping the organisation to recognise which areas may necessitate further interventions. There also exists a considerable transferability value of this matrix since it can be applied to any manufacturing organisation or specific departments if the respective organisations which to narrow their focus.

9.0 Limitations of the research

A superior extent of validity and reliability was achieved than would have been possible with a single methodological approach as the matrix was piloted in 15 disparate organizations. This investigation concentrated on manufacturing as the tool choice, overall objectives and hindrances alongside the predominant cultures differ noticeably between sectors. Every effort was made to ensure that reliable data were obtained from the participant organizations. They were clearly instructed that, when responding to the performance measures, only the impact that their respective Lean journeys had made was pertinent, and they were guided towards adjusting for the naturally expected growth rates since this research was exclusively focused on Lean's sway. The 15 organizations also completed structured interview questionnaires that complemented the individual case studies within each organization. This helped to facilitate a wider examination.

9.1 Future research

Replication of this investigation within services, as it accounts for one in five workers within the UK is a definite opportunity. It would prove advantageous to ascertain whether similarities exist regarding the obstacles realized, the dominant culture's impact and the change management arrangements. This approach could provide an improved awareness of the relevant factors to deliberate when employing performance measurement alongside the

sustainability evaluations between sectors. An element of pragmatism is acknowledged. Lean critics state that smaller organizations involved in contract manufacturing encounter experiences whereby certain Lean practices, such as cellular manufacturing, prove challenging. A small organization with distinct categories of customers and a fluctuating schedule can struggle to guarantee the consistency required to set up cells.

10.0 Conclusions

The literature reinforces the idea that matrices assist organization to adopt Lean. When thorough, they are correctly viewed as decisive computing sticks. However, when badly undertaken, they are next to hopeless. As integrated within this matrix the role of any measuring tool of this nature, should challenge the organization whilst accurately gauging the true performance levels from a holistic perspective. It should determine whether an organization's culture, sustainability mechanisms and the prevailing leadership view Lean as a journey fully embracing Lean's fundamental ideological principles. It was imperative always to acknowledge the holistic nature of Lean. This was pursued as many Lean initiatives fail owing to their focus on only a few components.

This matrix incorporates a quantitative and a qualitative approach which aligned itself to a balanced scorecard validating exercise. The matrix recommends assessing both the practical inputs with the transformational methodology coupled with the cultural constituents obligatory for Lean. To achieve the full benefits, a matrix should be adopted as part of an expedition informing the organization regards its implementation journey. It should reveal whether Lean is leading towards enhanced performance levels. A matrix should enable an organization to gauge its Lean implementation correctly in a disciplined manner, generating business gains. Lean operations may necessitate noteworthy monetary investments at the forefront, inducing a perception of it being costly; as the inventory decreases, it leads to higher costs of goods sold. A conventional absorption accounting system, with its short-term focus, can misinform decision makers. Successful Lean implementations specify that a change from traditional standard cost accounting practices is essential. It also needs to be acknowledged that Lean practices cannot deliver a compelling competitive edge in all operational practices. Benefits realisation remains a difficult area within the field of Lean. Consequently, we discover many organisations, in their pursuit to gauge performance. utilising varied KPIs, OKRs (objectives and key results), or other countless goal/objective-

driven metrics. However, these metrics often encounter difficulties when trying to apply qualitative data. It is here that a reliable and less problematic tool such as a maturity matrix can demonstrate to be an unbelievably valuable device.

References

[1] Amir, A., Ky, L., and Bhaskaran G. (2016), "Lean and US manufacturing industry: popularity of practices and implementation barriers", *International Journal of Productivity and Performance Management*, Vol. 65, pp.875-897.

[2] Andrea, C. and Emidia, V. (2017), "Strategies for modern operations management: answers from European manufacturing companies", *Benchmarking: An International Journal*, Vol. 24, pp.123-148.

[3] Antony, J., Sunder, M.V., Laux, C. and Cudney, E. (2019), "Lean Six Sigma sustainability", *The Ten Commandments of Lean Six Sigma*, London.

[4] Anthony, S.G. and Antony, J. (2022), "Frameworks and Maturity Models for Delivering Change", Lean Six Sigma in Higher Education Institutions, Emerald Publishing Limited, Leeds, pp. 75-96.

[5] Atkinson, P. (2010), "Lean is a cultural issue", *Management Services*, Vol. 54, pp.35-44.

[6] Azadeh, A., Zarrin, M., Abdollahi, M., Noury, S. and Farahmand, S. (2015), "Leanness assessment and optimization by fuzzy cognitive map and multivariate analysis", *Expert Systems with Applications*, Vol. 42, pp.6050-6064.

[7] Baggaley, B. (2006), "Using strategic performance measures to accelerate Lean performance", *Cost Management*, Vol. 20, pp.36-45.

[8] Bayou, M. and De Korvin, A. (2008), "Measuring the Leanness of manufacturing systems – a case study of Ford Motor Company and General Motors", *Journal of Engineering Technology and Management*, Vol. 25, pp.287-304.

[9] Bhasin, S. (2011), "Measuring the Leanness of an organization", *International Journal of Lean Six Sigma*, Vol. 2, pp.55-74.

[10] Bhasin, S. and Found, P. (2020), "Sustaining the Lean ideology", *Management Decision*, Vol. 3, pp.124-149.

[11] Bicheno, J. and Holweg, M. (2009), *The Lean Toolbox*, Picsie, Buckingham.

[12] Bond, T. (1999), “The role of performance measurement in continuous improvement”, *International Journal of Operations and Production Management*, Vol. 19, pp.1318-1334.

[13] Bou-Llusar, J., Escrig-Tena, A., Roca-Puig, V. and Beltran-Martin, I. (2005), “To what extent do enablers explain results in the EFQM Excellence Model?”, *International Journal of Quality and Reliability Management*, Vol. 22, pp.337-353.

[14] Camp, R. (2013), *Sustainable Lean*, Productivity Press, New York.

[15] Cochrane, A. (2017), “Lean matrix”, available at: http://www.Lean-matrix.com/matrices/Lean-culture-matrix/ (accessed 30 January 2023).

[16] Cooney, R (2002). “Is 'lean' a universal production system?” *International Journal of Operations and Production Management*, Vol. 22, pp. 1130 - 1147.

[17] Cousins, P., Lawson, B. and Squire, B. (2008), “Performance measurement in strategic buyer–supplier relationships”, *International Journal of Operations & Production Management*, Vol. 34, pp.238-258.

[18] Croom, S., Svetina, M. and Betts, A. (2016), “Does customer or competitor performance drive operations prioritisation?”, *Production Planning & Control*, Vol. 12, pp.2-16.

[19] Dimancescu, D., Hines, P. and Rich, N. (1997), *The Lean Enterprise*, Amazon, New York.

[20] Doolen, T. and Hacker, M. (2005), “A review of Lean assessment in organizations: an exploratory study of Lean practices by electronics manufacturers”, *Journal of Manufacturing Systems*, Vol. 24, pp.55-67.

[21] Drew, J., McCallum, B. and Roggenhofer, S. (2016), *Journey to Lean: Making Operational Change Stick*, Springer, London.

[22] DTI (2021), “Seven measures”, available at: http://www.kcts.co.uk/resourceassets/Measures-of-performance-in-Lean.pdf (accessed 15 April 2023).

[23] Elnadi, M. and Shehab, E. (2021), "Product-service system leanness assessment model: study of a UK manufacturing company", International Journal of Lean Six Sigma, Vol. 12 No. 5, pp. 1046-1072.

[24] Emiliani, M.L. (1998), “Lean behaviours”, *Management Decision*, Vol. 36, pp.615-631.

[25] Essex, A., Subramanian, N. and Gunasekaran, A. (2016), "The relationship between supply chain manager capabilities and performance: empirical evidence", *Production Planning & Control*, Vol. 27, pp.198-211.

[26] Feld, W.M. (2001), *Lean Manufacturing Tools, Techniques and How To Use Them*, St. Lucie Press, Alexandria.

[27] Flick, U. (2018a) *Doing Triangulation and Mixed Methods*. London: SAGE.

[28] Fullerton, R. and Wempe, W. (2009), "Lean manufacturing", *International Journal of Operations and Production Managemen*t, Vol. 29, pp.214-240.

[29] Gill C., (2003) "Worker Job stress effects of JIT / Lean production: Design and operating policies," EPSRC Funded Research Project, Cambridge, Cambridge University.

[30] Goldratt, E. (1990), *The Theory of Constraints*, North River Press, New York.

[31] Goodson, R.G. (2002), "Read a plant – fast", *Harvard Business Review*, Vol. 23, pp.105-113.

[32] Gopalakrishnan, N. and Anand, G. (2016), "Leanness assessment: a literature review", *International Journal of Operations & Production Management*, Vol. 36, pp.1115-1160.

[33] Graben, M. (2020), "Excellence model", available at: http://www.evolvingexcellence.com (accessed 19 March 2020).

[34] Gunasekaran, A., Subramanian, N. and Rahman, S. (2017), "Improving supply chain performance through management capabilities", *Production, Planning and Control*, Vol. 12, pp.473-477.

[35] Gurumurthy, A. and Kodali, R. (2010), "Application of benchmarking for assessing Lean manufacturing", *Benchmarking*, Vol. 16, pp.274-291.

[36] Harbour, R. (2001), "It's not easy being Lean", *Automotive Industries*, Vol. 11, pp.5-18.

[37] Haskin, D. (2010), "Allocating internal matrix costs in a Lean environment", *Internal Matrixing*, Vol. 25, pp.25-32.

[38] Henderson, B. and Larco, J. (2003), *Lean Transformation*, Oaklea Press, New York.

[39] Holweg, M. and Maylor, H. (2018), "Lean leadership in major projects: from predict and provide to predict and prevent", *International Journal of Operations & Production Management*, Vol. 38, pp.1368-1386.

[40] Husby, P. (2007), “Becoming Lean”, *Material Handling Management*, Vol. 62, pp.42-51.

[41] Jackson, M. (2019), *Critical Systems Thinking and the Management of Complexity*, Wiley, Chichester.

[42] Jasti, N.V.K., Kota, S. and Kale, S.R. (2020), “Development of a framework for Lean enterprise”, *Measuring Business Excellence*, Vol. 24, pp.431-459.

[43] Karlsson, C. (2016) ‘Research in operations management’, in Karlsson, C. (ed.). *Research Methods for Operations Management*. London: Routledge, pp. 7-45.

[44] Kaplan, R. and Norton, D. (1992), “The Balanced Scorecard – measures that drive performance”, *Harvard Business Review*, Vol. 70, pp.71-80.

[45] Kaplan, R. and Norton, D.P. (1993), “Putting the Balanced Scorecard to work”, *Harvard Business Review*, Vol. 71, pp.134-142.

[46] Kaplan, R. and Norton, D.P. (2001), “Transforming the Balanced Scorecard from performance management to strategic management: part 1”, *Strategic Management*, Vol. 15, pp.87-105.

[47] Kaplan, R. and Norton, D.P. (2005), “The office of strategic management”, *Strategic Finance*, Vol. 87, pp.56-60.

[48] Kobayashi, I. (1996), *20 Keys to Workplace Improvement*, Productivity Press, New York.

[49] Krafcik, J. (1988), “Triumph of the Lean production system”, *Sloan Management Review*, Vol. 41, pp.41-52.

[50] Lee, Q. (2008), “Lean in hard times”, available at: http://www.strategosinc.com (accessed 23 December 2022).

[51] Liker, J.K. (2004), *The Toyota Way – 14 Management Principles from the World’s Greatest Manufacturer*, McGraw-Hill, New York.

[52] Liker, J. and Franz, J. (2011), *The Toyota Way to Continuous Improvement*, McGraw Hill, New York.

[53] Loh, K.L., Mohd Yusof, S. and Lau, D.H.C. (2019), “Blue ocean leadership in Lean sustainability”, *International Journal of Lean Six Sigma*, Vol. 10, pp.275-294.

[54] Loyd, N., Harris, G., Gholston, S. and Berkowitz, D. (2020), “Development of a Lean assessment tool and measuring the effect of culture from employee perception”, *Journal of Manufacturing Technology Management*, Vol. 31, pp.1439-1456.

[55] Maltz, A., Shenhar, A. and Reilly, R. (2003), “Beyond the Balanced Scorecard: refining the search for organizational success measures”, *Long Range Planning*, Vol. 36, pp.187-204.

[56] Mann, D. (2005), *Creating a Lean Culture*, Productivity Press, New York.

[57] Mann, D. (2014), *Creating a Lean Culture: Tools to Sustain Lean Conversions*, CRC Press, New York.

[58] Mayring, P., (2004), Qualitative content analysis. A companion to qualitative research, Vol 1, pp.159-176.

[59] Motley, W. (2004), “Lean thinking redefines O&M practices”, *Power*, Vol. 148, pp.72-76.

[60] Narayanamurthy, G. and Gurumurthy, A. (2018), “Is the hospital lean? A mathematical model for assessing the implementation of Lean thinking in healthcare institutions”, *Operations Research for Health Care*, Vol. 18, pp.84-98.

[61] Nath, V. and Agrawal, R. (2020), “Agility and Lean practices as antecedents of supply chain social sustainability”, *International Journal of Operations & Production Management*, Vol. 40, pp.123-154.

[62] Neely, A., Gregory, M. and Platts, K. (2005), “Performance measurement system design”, *International Journal of Operations and Production Management*, Vol. 25, pp.1228-1263.

[63] Nightingale, D. (2005), “LESAT tool”, available at: https://ocw.mit.edu/courses/aeronautics-and-astronautics/lesat.pdf (accessed 4 July 2022).

[64] Nikneshan, P., Shahin, A. and Davazdahemami, H. (2023), "Proposing a framework for analyzing the effect of lean and agile innovation on lean and agile supply chain", International Journal of Quality & Reliability Management, Vol. 14, pp. 221-245

[65] NIST (2003), “Lean principles”, available at: http://www.mhc – nec-com/whitepapers (accessed 21 December 2022).

[66] Ohno, T. (1988), *Toyota Production System – Beyond Large-Scale Production*, Productivity Press, New York.

[67] Patton, M.Q. (2015) *Qualitative Research & Evaluation Methods: Integrating Theory and Practice*. Thousand Oaks: SAGE Publications Inc.

[68] Pakdil, F. and Leonard, K.M. (2013), “Criteria for a Lean organization: development of a Lean assessment tool”, *International Journal of Production Research*, Vol. 12, pp.24-39.

[69] Pakdil, F. and Leonard, K.M. (2017), “Implementing and sustaining Lean processes: the dilemma of societal culture effects”, *International Journal of Production Research*, Vol. 55, pp.700-717.

[70] Patel, A.S. and Patel, K.M. (2021), “Critical review of literature on Lean Six Sigma methodology”, *International Journal of Lean Six Sigma*, Vol. 3, pp.231-254.

[71] Paterson, J. (2015), *Lean Matrixing: Driving Added Value and Efficiency in Internal Matrix*, Wiley, New York.

[72] Perera, S. and Perera, C. (2019), “Performance measurement system for a Lean manufacturing setting”, *Measuring Business Excellence*, Vol. 23, pp.240-252.

[73] Piercy, N. and Rich, N. (2015), “The relationship between Lean operations and sustainable operations”, *International Journal of Operations & Production Management*, Vol. 35, pp.282-315.

[74] Robson C., (2016), “Real World Research” Oxford, Blackwell,

[75] Ritterbeck, R. (2007), “The impact of the Matrix score”, *Quality*, Vol. 46, pp.3-15.

[76] Samuel, D., Found, P. and Williams, S. (2015), “How did the publication of the book *The Machine that Changes the World* change management thinking?”, *International Journal of Operations and Production Research*, Vol. 35, pp.84-106.

[77] Samuel, K. (2010), “Integrated Lean TQM model for sustainable development”, *TQM Journal*, Vol. 22, pp.583-599.

[78] Saunders, M., Lewis, P., and Thornhill, A. (2016) *Research methods for business students*. Harlow: Pearson Education Limited.

[79] Scala, N.M., Liu, M., Alves, T.d.C.L., Schiavone, V. and Hawkins, D. (2023), "The gold standard: developing a maturity model to assess collaborative scheduling", Engineering, Construction and Architectural Management, Vol. 30 No. 4, pp. 1636-1656.

[80] Schonberger, R. (1996), *World Class Manufacturing*, Free Press, New York.

[81] Schonberger, R. (2008), “Lean performance management”, *Cost Accountant*, Vol. 22, pp.5-18.

[82] Shah, R. and Ward, P. (2007), “Defining and developing measures of Lean production”,

Journal of Operations Management, Vol. 25, pp.785-811.

[83] Shetty, S., Componation, P., Glolston, S. and Utley, D. (2010), "Assessing the extent of Lean implementation in an organization", *IIE Annual Conference Proceedings*, Norcross, pp.1-6.

[84] Shingo Prize (2023), "Shingo Prize guidelines", available at http://www.shingoprize.org/ (accessed 12 January 2023).

[85] Singh, B., Garg, S. and Sharma, S. (2010), "Development of index for measuring Leanness", *Measuring Business Excellence*, Vol. 14, pp.46-59.

[86] Soares, G.P., Tortorella, G., Bouzon, M. and Tavana, M. (2021), "A fuzzy maturity-based method for lean supply chain management assessment", International Journal of Lean Six Sigma, Vol. 12 No. 5, pp. 1017-1045.

[87] Spear, S. (2004), "Learning to Lead at Toyota", *Harvard Business Review*, Vol. 82, pp.78-87.

[88] Spector, P.E. (1992), *Summated Rating Scale Construction: An Introduction*, Sage, CA.

[89] Stake R. (1995). "The Art of Case Research", CA., Thousand Oaks;

[90] Tekez, E.K. and Taşdeviren, G. (2020), "Measuring the influence values of Lean criteria on Leanness", *Journal of Manufacturing Technology Management*, Vol. 31, pp.1391-1416.

[91] Toledo, J., Valio, R., Gonzalez, D., Lizarelli, F. and Pelegrino, R. (2018), "Lean production system development through leadership practices", *Management Decision*, Vol. 3, pp.167-196.

[92] Torbjørn, H. (2016), "Critical success factors for implementing Lean production: the effect of contingencies", *International Journal of Production Research*, Vol. 54, pp.2433-2448.

[93] Vaishnavi, V. and Suresh, M. (2020), "Modelling of readiness factors for the implementation of Lean Six Sigma in healthcare organizations", International Journal of Lean Six Sigma, Vol. 11 No. 4, pp. 597-633.

[94] Van Assen, M.F. (2018), "Exploring the impact of higher management's leadership styles on Lean management", *Total Quality Management & Business Excellence*, Vol. 29. pp.1312-1341.

[95] Vimal, K. and Vinodh, S. (2012), "Leanness evaluation using IF–THEN rules", *International Journal of Advanced Manufacturing Technology*, Vol. 63, pp.407-413.

[96] Vimal, K.E.K. and Vinodh, S. (2013), "Application of artificial neural network for fuzzy logic-based leanness assessment", *Journal of Manufacturing Technology Management*, Vol. 24, pp.274-292.

[97] Vinodh, S. and Chintha, S.K. (2011), "Leanness assessment using multi-grade fuzzy approach", *International Journal of Production Research*, Vol. 49, pp.431-445.

[98] Vinodh, S. and Vimal, K.E.K. (2012), "Thirty criteria-based leanness assessment using fuzzy logic approach", *International Journal of Advanced Manufacturing Technology*, Vol. 60, pp.1185-1195.

[99] Voss, C., Johnson, M. and Godsell, J. (2016) 'Case Research', in Karlsson, C. (ed.). *Research Methods for Operations Management*. London: Routledge, pp. 165-197.

[100] Wade, D. (1997), Measuring performance with a Balanced Scorecard", *Managers Handbook*, Vol. 2, pp.6-17.

[101] Wan, H.D. and Frank, C.F. (2008), "A Leanness measure of manufacturing systems for quantifying impacts of Lean initiatives", *International Journal of Production Research*, Vol. 46, pp.6567-6584.

[102] Wilson, L. (2015), *How to Implement Lean Manufacturing*, McGraw-Hill, New York.

[103] Womack, J. and Jones, D. (2005), *Lean Solutions*, Simon and Schuster, London.

[104] Wong, W.P., Ignatius, J. and Soh, K.L. (2014), "What is the Leanness level of your organization in Lean transformation implementation? An integrated Lean index using ANP approach", *Production Planning & Control*, Vol. 25, pp.273-287.

[105] Yin, R.K. (2018) *Case Study Research and Applications*. Los Angeles: SAGE Publications Inc.

[106] Zirar, A., Trusson, C. and Choudhary, A. (2020), "Towards a high-performance HR bundle process for lean service operations", *International Journal of Quality & Reliability Management*, Vol. 38, pp.25-45.