

# Performance management practices in lean manufacturing organizations: a systematic review of research evidence

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## ABSTRACT

This paper provides the first systematic look into the existing research on performance management (PM) practices employed in lean manufacturing organisations (LMOs). It adopts a systematic review method to examine the evidence generated in the period 2004 – 2015 and uses a comprehensive PM framework to synthesise the findings. The results suggest that PM practices that have the most prominent role in LMOs are those that, firstly, are located closest to front-line actions and, secondly, explicitly address operational realities. This calls into question the primacy of accounting-driven controls in LMOs, suggesting that operational controls may be more effective than top-down accounting-based PM practices. The results also confirm the bias towards operational-level issues but suggest that LMOs may integrate the operational and the strategic levels by using PM practices that drive organisational learning through employee involvement and engagement.

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## 1. Introduction

Over the past two decades, both lean manufacturing and performance management (PM) have grown from niche concepts to major themes within operations management (OM). Lean manufacturing has evolved into a vast area and become a subject in its own right (Womack and Jones 1996; Holweg 2007; Negro, Filho, and Marodin 2016). Likewise, PM has progressed from a critique of one-sided methods for evaluating organisational performance (Kaplan and Norton 1992) to a holistic approach to executing strategy and managing organisations (Bititci, Suwignjo, and Carrie 2001; McAdam, Bititci, and Galbraith 2017; Micheli and Mura 2017; Pavlov et al. 2017) and supply chains (Maestrini et al. 2017).

However, research in these domains has for the most part remained within separate conversations, and the growing overlap between them has not been systematically examined. For example, recent reviews of lean manufacturing conducted in the OM literature (e.g. Bhamu and Sangwan 2014) focused on developing general models of lean production, leaving the discussion of PM largely neglected. This lack of inquiry into how PM functions in the lean environment seems an important oversight, especially considering that the need to understand how lean manufacturing organisations (LMO) manage performance has been growing more urgent. In fact, the link between lean manufacturing and superior performance has been a recurring theme in many major recent studies of LMOs (Shah and Ward 2003, 2007; Holweg 2007; Negro, Filho, and Marodin 2016).

The first attempts to bring these two domains together originate primarily in the management control systems (MCS)

literature with its emphasis on ‘lean accounting’ (Kennedy and Brewer 2005). This work has focused on understanding the contingency factors shaping the design and effects of MCS in LMOs, the importance of a particular configuration of control systems (Kennedy and Widener 2008; Fullerton, Kennedy, and Widener 2013) and the ‘balances and complementarities’ (Kristensen and Israelsen 2014, 45) involved in the simultaneous functioning of multiple control systems. Focusing on the implementation of lean manufacturing initiatives, the work of MCS scholars has identified three ways in which performance can be managed: output control, related to the use of financial and non-financial performance measures; behavioural control, enacted through rules and standard operating procedures; and social control, related to training, visualisation, peer pressure and employee empowerment. The use of accounting practices underpinning these controls was seen as particularly significant (Kennedy and Widener 2008; Fullerton, Kennedy, and Widener 2014).

Despite these contributions, neither of the above literature domains has provided a comprehensive overview of PM in LMOs. As a result, our understanding of the way these organisations manage performance is incomplete and two major issues remain.

Firstly, the existing work remains largely silent about *how* PM systems in LMOs produce an effect on performance. In the MCS literature, Kristensen and Israelsen (2014) approximate this effect statistically, but stop short of identifying the actual mechanisms underlying the effect of control systems on performance. In the OM literature, Pavlov and Bourne (2011) make a step towards explaining this, but do so only conceptually. Empirically, however, we still do not know how PM contributes to the success of LMOs.

Secondly, and perhaps more fundamentally, we do not have a clear understanding of *what* LMOs actually do to manage performance. In other words, we do not know how managers in these organisations use PM systems and to what extent their practices adequately reflect the requirements of a comprehensive PM system (cf. Bititci et al. 2011). Responding to this challenge is made more difficult by the concept of lean as spanning the operational and the strategic levels (Hines, Holweg, and Rich 2004) and consequently requiring that a meaningful discussion of PM practices should bridge these levels and be holistic as well as exhaustive. Most prior research, however, focused on the operational level of LMOs, leaving unexamined the practices that relate management control and PM to the formulation and implementation of strategy. More strategic aspects of PM (De Toni and Tonchia 1996; Shah and Ward 2003; Towill 2007) were sometimes overlooked and the discussion of managing performance in LMOs often took a narrow and technical focus.

These major considerations led us to review the documented evidence of practices employed by LMOs to manage performance. We drew a comprehensive picture of current knowledge, and critically evaluated it against a holistic PM framework. The formal review question guiding this process was: ‘What are the documented PM practices employed by LMOs?’ This formulation allowed us to address the two issues identified above, as it was both explicitly focused on the way LMOs manage performance and sufficiently broad to capture the full range of practices, from operational to strategic (Hines, Holweg, and Rich 2004; Micheli and Manzoni 2010). More specifically, the objectives of this study were:

- extract from the existing research the documented practices used by LMOs to manage performance;
- analyse the extracted practices through the lens of a holistic PM framework;
- present a structured and comprehensive picture of the current state of knowledge of PM in LMOs;
- determine the existing patterns explaining the advances in this area and identify the most promising implications for research and practice.

The rest of the paper reflects these objectives and is structured as follows. The next section describes the procedures of the review of literature that we followed and presents the holistic PM framework used for extracting and interpreting the evidence. The following section presents our findings organised by the elements of the PM framework. The discussion evaluates the findings and identifies two major patterns as well as a number of smaller trends discovered in the literature. It also proposes several promising avenues for further work. We end with a brief conclusion restating the answer to the research question and explaining the value of the paper for the study of PM in LMOs.

## 2. Methods

In order to establish the pool of PM practices employed in LMOs, we conducted a systematic literature review that is based on Tranfield, Denyer, and Smart’s (2003) early work and consistent with the guidelines for systematic literature reviews in the OM field recommended by this journal (Thomé, Scavarda, and Scavarda 2016). Systematic reviews of evidence are the

fundamental tool of evidence-based management, and their contribution to advancing the field is based on the fact that ‘a synthesis of evidence from multiple studies is better than evidence from a single study’ (Briner, Denyer, and Rousseau 2009, 24). This is because single studies always provide partial insights, and thus distilling the most relevant implications for future research and practice requires an understanding of the collective body of evidence (Briner, Denyer, and Rousseau 2009). As such, systematic reviews have served as the foundation for advancing knowledge in many fields (Rousseau, Manning, and Denyer 2008). Achieving this, however, requires a fairly sophisticated procedure for conducting a review (Tranfield, Denyer, and Smart 2003; Thomé, Scavarda, and Scavarda 2016), which begins with a brief scoping study of the field and then takes the researcher through a protocol (Moher et al. 2009) for identifying, screening, determining the eligibility and deciding on the inclusion of the studies that form the evidence base for subsequent synthesis. Our implementation of this flow is summarised in Figure 1 and described below.

### 2.1. Identification and screening of records

We derived a set of keywords that corresponded to the core concepts in our research question. The concept of the LMO presented the greatest difficulty, as it refers to a complex phenomenon that does not have an agreed-upon definition (Shah and Ward 2007). Therefore, in order to capture the full range of practices employed in organisations that can be described as ‘lean’, we used Hines, Holweg, and Rich’s (2004) framework to drive the choice of appropriate keywords. This framework provides a comprehensive view of the lean environment in organisations, as it explicitly incorporates Womack and Jones’ (1996) lean principles and bridges the strategic and the operational levels by relating ‘strategic value propositions’ to operations. This framework is presented in Figure 2.

Before making the final decision, we considered a number of other conceptual, empirical, and historical accounts of ‘lean’, e.g. Krafcik’s (1988) conceptualisation of lean production systems, Womack and Jones’ (1990, 1996) work, Holweg’s (2007) historical analysis, as well as the contributions of De Toni and Tonchia (1996), Spear and Bowen (1999), and Shah and Ward (2003). However, in terms of providing a structure for the selection of keywords, none of these models offered the balance between comprehensiveness and specificity afforded by Hines et al.’s work.

Our selection of keywords for the concept of PM reflected the contemporary view of PM as, first, both operational and strategic in scope and, second, as explicitly encompassing performance measurement as a key element of PM (Micheli and Manzoni 2010). As the conversation in this area takes place not only in the OM but also in the MCS literature, we also needed to ensure that the insights from the MCS research are included in our evidence base.

Recent work in the MCS literature, however, notes that the term ‘performance management’ is used in this domain to address ‘the same issues and concerns’ (Otley 2003, 316) that traditionally drove the broad field of MCS. Adopting the term ‘performance management’, therefore, allows us to draw on both literature domains and capture the evidence generated by both OM and MCS scholars. Moreover, its wide scope is, again, consistent with our aim of capturing both operational and strategic PM practices

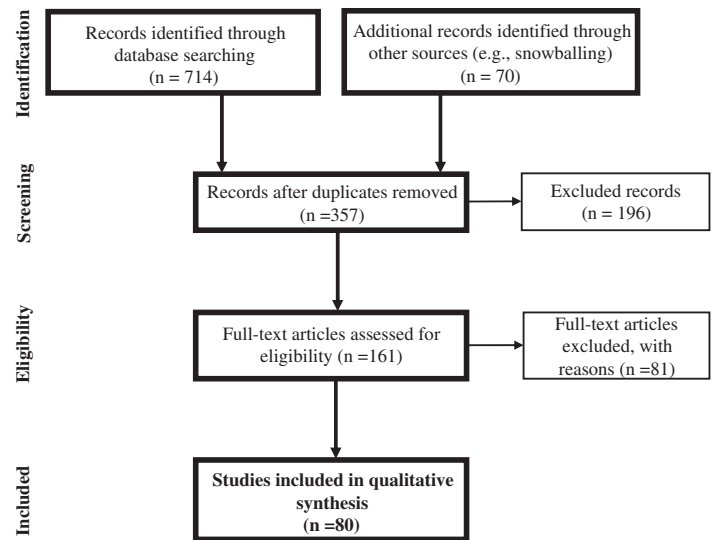


Figure 1. The systematic review protocol (adapted from Moher et al. 2009).

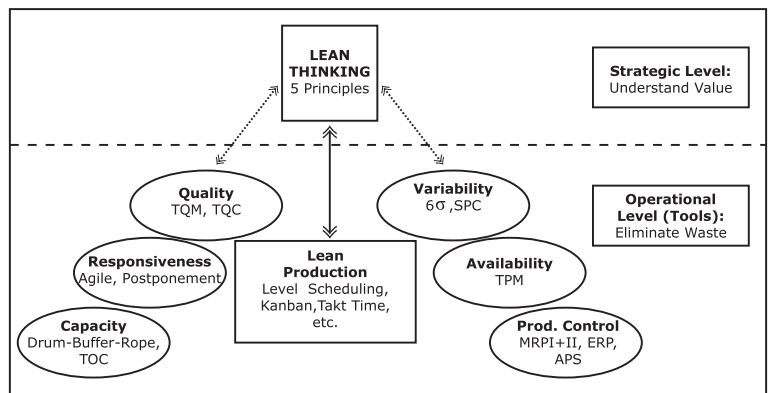


Figure 2. The framework used to define the full spectrum of practices investigated in the study (adapted from Hines, Holweg, and Rich 2004).

Table 1. The keywords employed in the systematic search.

Category	Keywords	Rationale
Lean (strategic level)	<i>lean; lean principl*; implement*</i>	Captures Hines, Holweg, and Rich's (2004) strategic dimension of lean
Lean (operational level)	<i>lean prod*; lean pract*; lean manufact*; Toyota Production System; value str*; Total Quality Management; Just in Time; Six Sigma; Total Preventive Maintenance; Theory of Constraint*; Drum-Buffer-Rope; agil*; VSM; JIT; TQM; TPM; TOC; ERP; MRP; TPS</i>	Captures Hines, Holweg, and Rich's (2004) operational dimension of lean
Performance management	<i>strateg*; strategy implement*; performance; performance meas*; performance assess*</i>	Reflects the view of PM as both operational and strategic in scope, and explicitly encompasses performance measurement as a key element (Micheli and Manzoni 2010)

used in LMOs. The summary of employed keywords is shown in Table 1.

*Business Source Complete (EBSCO)* was chosen as the database that provided the greatest coverage and the largest number of full-text materials. We also performed a search in a different database (*ABI Inform Complete-ProQuest*) as a secondary check.

Various keyword combinations were entered into the default search field of *EBSCO*, which performs the search in the title, abstract, and subject terms of the source. A broad trial based on the combination of terms 'Lean' AND 'Strategy' as well as 'Lean'

AND 'Performance' joined up by the 'OR' operator was done first, yielding 714 results. Separately these combinations produced 379 and 473 results, respectively. These basic search strings were then expanded and refined using the multiple keywords listed above.

Searches limited exclusively to electronic databases, however, have been shown to omit up to 70% of relevant evidence base, making the so-called 'snowballing' technique and the use of personal knowledge and contacts indispensable (Greenhalgh and Peacock 2005). Therefore, we used the reference sections of the obtained sources to perform the 'snowballing' procedure (Duff

1996) and asked a consultation panel of scholars in the field to evaluate the final evidence base for omissions. The panel included experts in PM and OM (Associate Professor and Professor, UK; Assistant Professor, Italy) as well as in lean accounting (Assistant Professor and Professor, Italy). This step generated 70 additional records.

The individual searches were cross-checked against each other in order to avoid duplicates. After all combinations were executed, the procedure yielded 357 unique records.

## 2.2. Eligibility and inclusion of records

The search was limited to peer-reviewed scholarly papers written in English. In order to focus on recent developments but still be able to identify trends, we included materials published from 01 January 2004 to 31 December 2015. This timeframe allowed us to trace the development of the field since the publication of Hines, Holweg, and Rich's (2004) seminal conceptualisation of lean, which shifted attention to the meaning of lean as an organisational phenomenon and introduced a coherent framework that made formal studies of LMOs possible. The full text of studies that passed this stage (161 in total) was read, and the studies were subjected to a second, three-part selection filter. First, as our inquiry focused on lean manufacturing rather than the application of lean philosophy in general, only studies in the manufacturing sector were included. Second, the studies that were not relevant to the research question – i.e. not discussing PM practices – were excluded. Third, since the aim of our research was to identify the existing practices used by LMOs, studies that employed only mathematical illustrations, engineering modelling, and simulations were excluded. Finally, the studies were assessed for quality, where only the papers indexed in the Thomson Reuters *ISI 2014 Journal Citation Report* (Thomson Reuters 2014) were included. Bibliographic research has recognised the Thomson Reuters ISI database as the 'most prestigious source of [research assessment measures], ... the benchmark against which other general databases ... are compared', and a coveted indication of journal quality (Chang, Maasoumi, and McAleer 2016, 51). As such, it has been used in systematic reviews in different fields (Dahlander and Gann 2010; Bossle et al. 2016) as the database that 'includes the most prominent journals in a field' (Dahlander and Gann 2010, 700). Overall, 80 papers passed all stages of the protocol and formed the evidence base.

A structured extraction procedure was created, which made it possible to capture the key elements of each study, ranging from the authors' names and the year of publication to the PM practices examined in the study.

## 2.3. The analytical lens used to synthesise and interpret the findings

The nature of management as a field of knowledge often favours qualitative approaches to synthesising the evidence extracted through systematic reviews (Thomé, Scavarda, and Scavarda 2016). Thus, in this paper, we employed Ferreira and Otley's (2009) holistic *Performance Management Systems Framework* (2009) as the conceptual foundation for coding and synthesising the findings. This framework is shown in Figure 3.

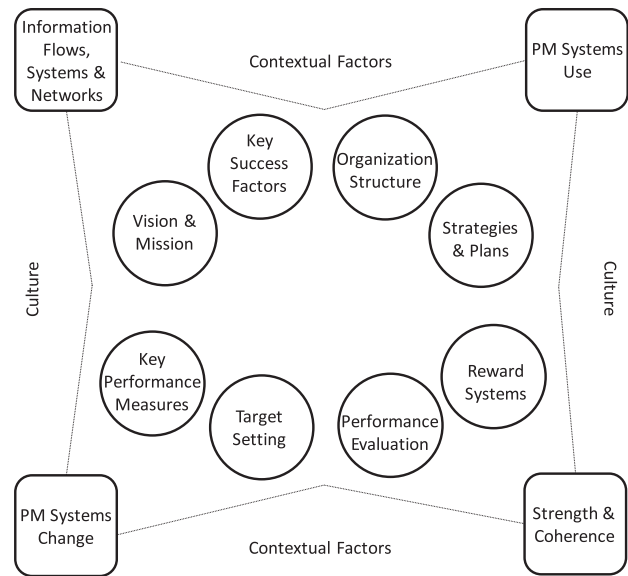


Figure 3. The framework used to code and synthesise the findings (adapted from Ferreira and Otley 2009).

We consider this framework to be the most appropriate for our analysis for a number of reasons. First, it addresses multiple elements of PM and is therefore suitable for analysing the full range of PM practices in LMOs. Second, unlike other frameworks (e.g. Broadbent and Laughlin 2009), it provides specific guidance for categorising practices. Third, it was designed to function not only as a conceptual framework, but as a comprehensive checklist whose focus is 'to provide a descriptive tool that may be used to amass evidence upon which further analysis can be based' (Ferreira and Otley 2009, 266). Finally, it is consistent with both our definition of PM and with Hines, Holweg, and Rich's (2004) framework we used for the operationalisation of the LMO concept, with the latter's emphasis on the connection between the strategic and the operational levels.

The specific procedure employed at this stage was as follows. The first author manually coded the extracted practices into the a priori categories of Ferreira and Otley's (2009) framework. The second author then checked the codes against the original data and made changes when needed. Throughout this process, the assignment of extracted practices into codes was also iteratively checked against the definitions of Ferreira and Otley's (2009) categories, thus ensuring the fidelity of the findings with both the original data and with the categories of the analytical framework. After that, the structure of the findings was discussed and agreed upon between the authors. Overall, this strengthened the validity of the results presented.

The next section presents the descriptive findings followed by the thematic findings organised by the elements of Ferreira and Otley's (2009) framework.

## 3. Findings

### 3.1. Descriptive findings

The descriptive analysis of the 80 sources revealed that 84% of papers were published in OM journals, with five journals providing the basic space for the development of the conversation on



PM in LMOs. The remaining sources came from the Accounting, General Management, Economics, Innovation, and HR Management domains (see Figure 4).

The evidence base included 69 empirical studies and 11 non-empirical studies which included conceptual papers and literature reviews (see Appendix 1). The empirical papers were case-based ( $N = 38$ ), experimental ( $N = 2$ ) and survey-based ( $N = 20$ ) or relied on secondary data ( $N = 9$ ). The empirical strength of the reviewed evidence base was underpinned by 3633 surveyed responses, 11,169 empirical observations studied through secondary data analysis, 82 cases and 2 experiments.

### 3.2. Thematic findings

The presentation of thematic findings is based on Ferreira and Otley's (2009) framework that describes the PM system itself, the mechanisms enabling its functioning, and the external influences (see Figure 3). The PM system consists of four elements that are concerned with setting the strategic direction for the firm and establishing the appropriate capabilities and structure to support it (*Vision and Mission, Key Success Factors, Organization Structure, and Strategies and Plans*) and four elements that are focused on operationalising the vision and strategy (*Key Performance Measures, Target Setting, Performance Evaluation, and Reward Systems*). The four enabling mechanisms include the *Information Flows, Systems and Networks, PM Systems Use, PM Systems Change*, and the *Overall Strength and Coherence* of PM systems. Finally, the system may be influenced by the context and culture. The review of findings in this section follows this structure, and the full list of the results can be found in Appendix 2.

#### 3.2.1. Practices within strategic elements of PM systems

Perhaps surprisingly, the review of PM practices in LMOs provided limited evidence of specific actions used for setting and communicating core organisational values and strategies within these organisations. Only 15 papers offered some discussion of the way strategies were generated and communicated. Moreover, these sources usually provided a very narrow view of strategy, using it simply for introducing arguments that

subsequently focused on operational-level practices. This is interesting because the development of a lean philosophy in the organisation (Alagaraja and Egan 2013) is often the central element guiding the implementation of lean; and yet, the analysed literature did not provide any evidence of practices formalising the high-level vision and strategies.

The only direct discussion of the process of generating, communicating and implementing strategy was provided by Alagaraja and Egan (2013), yet even their work examined the value of human resources and was thus functionally focused. Other studies simply highlighted the strategic value of cross-functional collaboration (Netland, Schloetzer, and Ferdows 2015) and emphasised the importance of securing support of multiple executives to ensure the alignment between lean initiatives and broader environmental and social sustainability goals (Longoni and Cagliano 2015).

The discussion of the organisational structure and the key success factors supporting strategic work within LMOs provided a more extensive set of practices for managing performance. For example, Holweg (2007) examined organisational structure in light of a complex nexus of learning activities, and Shah and Ward (2007) emphasised the relationships between people, processes, and external elements. Subsequently, Gollan et al. (2014) showed that these activities were often facilitated by the use of small teams in organising production. Moreover, strong attention seemed to be paid to the role of individuals. Although lean represents a group-level intervention (De Treville and Antonakis 2006), it often requires a high degree of employee empowerment. Empowerment in turn promotes flexible and organic structures (Jayaram, Das, and Nicolae 2010; Alagaraja and Egan 2013) through a high degree of decentralisation and task autonomy often described as a sense of shop floor ownership (e.g. Moyano-Fuentes and Sacristan-Diaz 2012). The viability of such structures, however, depends on practices ensuring communication across organisational levels, for example, using a suggestions box to collect ideas from multiple levels of hierarchy (Gollan et al. 2014).

Finally, an analysis of the key success factors – i.e. the activities, attributes, competencies and capabilities recognised as critical for the successful pursuit of the organisation's vision (Ferreira and Otley 2009) – revealed four bundles of practices:

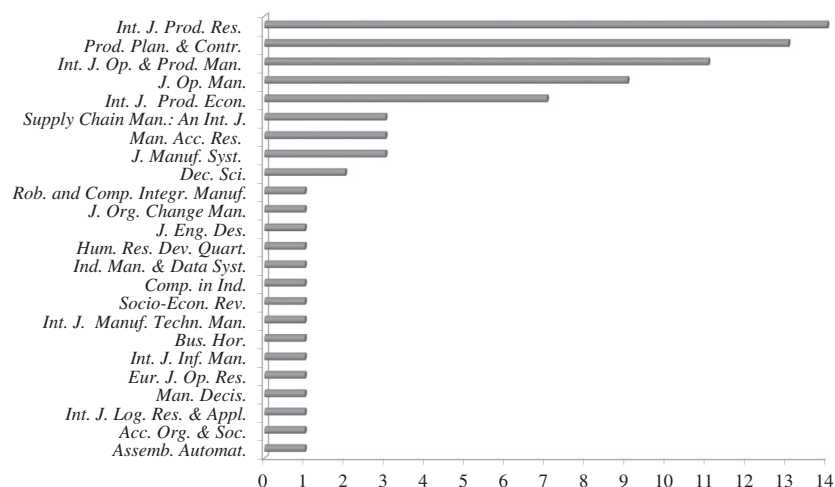


Figure 4. Distribution of sources by the journal.

organisational learning, elimination of waste, customer focus, and, for certain kinds of LMOs, the combination of lean and agile features.

Organisational learning processes (Holweg 2007), mainly characterised by various forms of individual 'deutero-learning' (learning 'how to learn') (Hines, Holweg, and Rich 2004; Lander and Liker 2007; Towill 2007), have been recognised as important antecedents of success in LMOs. This is tightly linked with the notion of 'commitment', as deutero-learning requires a number of supporting practices, such as employees' active involvement in and contribution to an atmosphere of collaboration and improvement (Doolen and Hacker 2005; Towill 2007; Scherrer-Rathje, Boyle, and Deflorin 2009; Moyano-Fuentes and Sacristan-Díaz 2012; Panizzolo et al. 2012; Alagaraja and Egan 2013; Lyons et al. 2013; Bhamu and Sangwan 2014; Marin-Garcia and Bonavia 2015). Making tactical and strategic goals transparent and giving employees autonomy for making decisions that promote lean thinking are also practices that support organisational learning and that have been shown to contribute to long-term sustainability (Scherrer-Rathje, Boyle, and Deflorin 2009). Extending this thinking, Gollan et al. (2014) note that training and upskilling promote functional flexibility that in turn mitigates business risks and fosters resilience.

Waste elimination practices have similarly been shown to stimulate and enhance organisational decision-making (Lyons et al. 2013). Specific practices here included the use of Six Sigma and quality systems for preventing defects as well as more tactical actions, such as working to reduce process set-up and introducing visual management (Haque and James-Moore 2004; Kumar et al. 2006; Lyons et al. 2013).

The customer-centred view of lean also emphasises the practice of involving customers in separating value-adding and waste-producing activities, thus helping to identify the sources of competitive advantage for the firm (Adamides et al. 2008; Jeffers 2010; Parry, Mills, and Turner 2010; Chavez et al. 2015). Jayaram, Vickery, and Droge (2008) highlighted the practice of comprehensive assessment of product design and manufacturing characteristics with respect to the customer's requirements. However, all the previous evidence concerning customer involvement was focused mostly on improving demand forecasting (Shah and Ward 2007) and the corresponding optimisation of production processes (Doolen and Hacker 2005; Jayaram, Vickery, and Droge 2008).

Finally, the literature revealed that LMOs often employ practices that combine lean and agile characteristics in order to respond more effectively to fast-changing environments (Qi, Boyer, and Zhao 2009; Qi, Zhao, and Sheu 2011). Narasimhan, Swink, and Kim (2006) point out that, although lean and agile practices may coexist, leanness seems to be a pre-requisite for agility. Setting optimal priorities for the lean/agile combination is then one of the key success factors for LMOs. In supply chain management, Soni and Kodali (2012) highlighted the practice of 'leagile' (lean and agile), which aims to ensure both responsiveness and cost efficiency through effective management of collaboration, logistics, marketing, and strategy.

Overall, although the review of the strategic elements of PM systems yielded a number of documented practices used in LMOs, the identified set displayed a strong emphasis on operational considerations.

### 3.2.2. Practices within operational elements of PM systems

If the review of PM practices within the strategic elements of PM systems revealed an operational bias of research on LMOs, the analysis of the operational elements made this even more evident. The discussion of performance measurement in particular reflected a heavy focus on operational issues and revealed several interesting themes. First, LMOs often tailor standard measures to their production needs. Second, the use of performance measurement is less prominent in supply chain management, whereas the organisation's general operations represent the major domain of use. Finally, LMOs use performance measures extensively also to support value stream mapping, both within the organisation and in supply chains. A summary of performance measures extracted from the reviewed sources is presented in Tables 2 and 3. Slack et al.'s (2009) performance objectives were used to organise the list of measures. This is consistent with the reviewed literature (e.g. Belekoukias, Garza-Reyes, and Kumar 2014; Drohomerski et al. 2014).

Target setting, which follows the development of performance measures, then becomes especially relevant for LMOs with their 'pull' orientation. Panizzolo et al. (2012) show that synchronised scheduling of levelled production based on pull principles improves the effectiveness of operational processes. This is supported by Towill (2007) and Jayaram, Das, and Nicolae (2010) who highlight the importance of operational guidance and show that lean practices must be carefully calibrated to avoid detrimental effects on performance. Likewise, Shah and Ward (2007) define ten operational variables, show the synergistic interrelations between them, and explain how and why the pursuit of their goals and targets may depend on them. This is echoed by Lander and Liker's (2007) concept of a 'toolkit', Saurin, Marodin, and Ribeiro's (2011) framework for assessing lean production in manufacturing cells, and Bozarth et al.'s (2009) discussion of the application of lean in supply chains. Most of this discussion, however, also remains very operational in scope.

It is worth noting that many practices relevant for target setting emerge from the discussion of value stream maps (VSM) as a tool for providing the scheduling of resources (Serrano, Ochoa, and De Castro 2008). Their use is related to structured analysis, where the VSM defines the targets for process planning and identifies resource capacity and the related sales and budgeting activity (Towill 2007). Similarly, VSM can be used for scenario analysis and target identification within LMOs (Abdulmalek and Rajgopal 2007; Lasa, de Castro, and Laburu 2009) and across supply chains (Taylor 2009; Wee and Wu 2009).

Performance evaluation and reward practices are the final operational elements of the PM system in the sense that they aim to align behaviour with strategy (Ferreira and Otley 2009). The reviewed set of papers highlighted a revealing tension between the use of operational and accounting controls within LMOs. For example, Browning and Heath (2009) noted that evaluating the performance of an LMO depends on the holistic concept of value provision, which is a result of a complex process rather than a simple execution of tasks in a prescriptive way. Extending this insight, Bhasin (2012) showed that the benefits gained from lean implementation are not always obvious because there is no direct connection between financial and non-financial measures. Likewise, Fullerton and Wempe (2009) demonstrated that the effect of lean practices on financial performance is positively

Table 2. Performance measures employed by LMOs within the organisation.

Domain of use	Non-financial indicators	Financial indicators
General operations	<ul style="list-style-type: none"> <li>• <i>Quality</i>: ease to service product; defects per unit; reduction of defects through automation; service quality; quality rating; quality of new product development projects; scrap and rework; quality conformance; first time yield</li> <li>• <i>Flexibility</i>: time to develop/time to market for new products; range of products; machine change over time; time to change schedule; responsiveness; new product development lead time; anticipating future changes index; new market and technology index; volume flexibility; product mix flexibility; release material JIT</li> <li>• <i>Dependability</i>: delivery on due date (ship on time); % of orders delivered late; average lateness of orders; schedule adherence; quoted customer lead time; JIT delivery from suppliers; customer query; JIT delivery to customers</li> <li>• <i>Speed</i>: Order entry to shipment; frequency of delivery; cycle time; throughput time; manufacturing cycle time reduction; lead time; average customer lead time</li> <li>• <i>Other</i>: Customer satisfaction; retention of employees; quality of professional development; quality of leadership development; health and safety; employees perception survey index; OEE (overall equipment efficiency); process capability index; depth of strategic planning</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Cost</i>: production full cost; labour cost; raw material cost; operating expenses; variable cost against budget; cost per operation hour; manufacturing cost; quality cost; cost of activities (ABC rationale); cost reduction; labour productivity, space productivity; inventory-related measures (stock turnover, inventory turnover); inventory turnover weighted by industry</li> <li>• <i>Other</i>: ROI; growth of market share; growth of sales; profit margin on sales; EBIT/sales; earning per share; current ratio; profit after intertexts and tax; % of sales for new products; net profit; ROA; ROE; break-even</li> </ul>
As part of VSM	<ul style="list-style-type: none"> <li>• <i>Flexibility</i>: response time variability; batch size; transfer lot size</li> <li>• <i>Speed</i>: set-up time; processing time; moving time; takt time; delivery speed</li> <li>• <i>Other</i>: daily production per terminal; productivity capacity; non productivity capacity; available capacity; production output per man; manpower</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Cost</i>: conversion cost; value stream cost; in-process inventory</li> <li>• <i>Other</i>: revenue; value stream gross profit; value stream ROS</li> </ul>

Table 3. Performance measures employed by LMOs in supply chains.

Domain of use	Non-financial indicators	Financial indicators
General operations	<ul style="list-style-type: none"> <li>• <i>Quality</i>: quality performance</li> <li>• <i>Flexibility</i>: new product development time; new product introduction time; customer heterogeneity; demand variability; short product life-cycle; customer responsiveness; number of products; number of active parts; % of low volume batch production</li> <li>• <i>Dependability</i>: delivery reliability; supplier delivery unreliability; schedule attainment; manufacturing scheduling</li> <li>• <i>Speed</i>: delivery speed; manufacturing lead time; supplier lead time</li> <li>• <i>Other</i>: plant-level customer satisfaction</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Cost</i>: % of purchase imported; unit cost manufacturing; business waste</li> <li>• <i>Other</i>: cash-to-cash cycle</li> </ul>
As part of VSM	<ul style="list-style-type: none"> <li>• <i>Quality</i>: quality performance; scrap and rework; customer complaints</li> <li>• <i>Dependability</i>: build to schedule; on time delivery; perfect order fulfilment</li> <li>• <i>Speed</i>: first time throughput; available time; takt time; cycle time; working time; delivery lead time; delivery frequency; manufacturing throughput time; manufacturing process time; set-up time; order fulfilment cycle time</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Cost</i>: inventory rotation index</li> </ul>

mediated by non-financial manufacturing performance measures. Finally, the absence of the relationship between operational efficiencies and financial ratios was also noted by Klingenberg et al. (2013). Thus, traditional accounting measures cascaded from the top may on their own be sufficient for LMOs because their benefits are not always clear.

Addressing this limitation, Ifandoudas and Chapman (2009) proposed a shift to *throughput accounting*, which better captures the combined effect of process optimisation (from the Theory of Constraints viewpoint) and the identification of key resources (from the Resource-Based View viewpoint) to secure competitive advantage. Similarly, performance evaluation practices grounded in value stream costing systems may offer a bridge between the operational and financial evaluation of performance in LMOs (Parry and Turner 2006; Rivera and Chen 2007; Li et al. 2012; Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo 2013; Belekoukias, Garza-Reyes, and Kumar 2014; Fullerton, Kennedy, and Widener 2014). Similarly, Chiarini and Vagnoni (2015) noted that cost deployment could in fact be integrated with traditional cost accounting systems, such as Activity-Based Costing, thus maintaining the link between lean initiatives and financial performance.

Difficulties with integrating the wider benefits of lean into accounting-based performance evaluation systems were also evident in inventory management (Meade, Kumar, and Houshyar 2006; Demeter and Matyusz 2011; Eroglu and Hofer 2011; Isaksson and Seifert 2014) and in supply chains (Taylor 2009; Yang, Hong, and Modi 2011). However, organisation-wide lean performance evaluation practices are emerging. These include the development and review of lean-focused performance reports and the introduction of bottom-up performance reporting structures (e.g. Netland, Schloetzer, and Ferdows 2015).

The reviewed literature did not provide any specific practices related to the use of reward systems in LMOs, other than a general observation that in the context of lean manufacturing, team-level rewards were preferable to individual-level reward (Gollan et al. 2014) and that non-financial rewards were particularly valuable (Netland, Schloetzer, and Ferdows 2015). What did seem to be relevant, however, was a strong focus on the concept of employee commitment (Towill 2007; Scherrer-Rathje, Boyle, and Deflorin 2009; Moyano-Fuentes and Sacristan-Diaz 2012; Panizzolo et al. 2012; Alagaraja and Egan 2013; Lyons et al. 2013) to generate a lean mindset. Similarly, Alagaraja and Egan (2013) found that the use of employee engagement surveys and efforts to gain buy-in from informal leaders provided alternative ways for increasing motivation in LMOs.

### 3.2.3. Enabling mechanisms of PM systems

The research into the way performance information is structured, integrated, and controlled in the organisation has described a wide spectrum of practices employed within LMOs and in their supply chains (Cagliano, Caniato, and Spina 2006; Adamides et al. 2008; So and Sun 2010). Some of the practices resulted from the application of Womack and Jones' (1996) fundamental principles to information management. In particular, Hicks (2007) argued that feedback and feed-forward activities that support decision-making processes could be enhanced to improve organisational performance.

Integrated IT solutions (Cottyn et al. 2011; Chiarini and Vagnoni 2015) and particularly ERP systems (Powell 2013; Powell, Riezebos, and Strandhagen 2013; Powell, Alfnes, et al. 2013; Ghobakhloo and Hong 2014) connect different areas of operations, support the alignment of strategy with operations, and provide real time information, enabling the optimisation of the flow of materials and lead times. Specific practices involved in the implementation of lean information management include information visualisation, performance indicators for demonstrating the impact of information management, horizontal decision-making procedures, and the reliance on lean experts for co-ordinating the delivery of information management initiatives (Bevilacqua, Ciarapica, and Paciarotti 2015). The analysis also revealed the fundamental role of VSM in information management. Alagaraja and Egan (2013) and Seth and Gupta (2005) recognised VSM as a useful tool for providing visual representation of key activities within a web of cross-departmental interconnections and improving the flow of information when transactional and communication breakdowns occur.

The literature provided very little information regarding the overall approach to the use of PM systems in LMOs. Li et al. (2012), Wee and Wu (2009), Parry and Turner (2006) and Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo (2013) turned to VSM as a means for managing performance. Similarly, Ifandoudas and Chapman (2009) suggested an alternative look at performance measurement based on the theory of constraints. However, most of the arguments in these contributions remained very operational and focused on the type of information such approaches could provide and how they could provide it, rather than on how managers in LMOs actually used performance information to make decisions and control the organisation.

Likewise, the reviewed set of sources provided little evidence of specific practices employed by LMOs for updating their PM systems. Even in systemic views on measuring performance (e.g. Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo (2013) and Parry and Turner's (2006) conceptualisation of VSM), primary attention was paid to the mechanics of such approaches rather than to the question of how PM systems could continuously maintain fit with the changing requirements of the organisation and its environment. The only mention of PM practices that might be used to update an LMO's approach to managing performance was made by Kennedy and Widener (2008), who suggested relying on lean accounting principles to break away from standard cost allocation; introducing social control practices, such as employee empowerment and peer pressure; and strengthening behavioural control practices, such as standard operating procedures.

Finally, despite containing substantial information about PM practices, none of the 80 sources provided evidence of specific practices aimed at ensuring the strength and coherence of PM systems in LMOs. Tillema and van der Steen (2015) warn that lean production may challenge the existing understanding of management control and lead to tensions within LMOs, but do not suggest any practices other than a general recommendation to foster organisational learning. The only evidence of practices for maintaining the overall strength and coherence was provided by Alagaraja and Egan (2013) with respect to the use of VSMs. Nonetheless, even their discussion falls short of explaining how the use of VSMs is linked back to the overall strategy in a way that is coherent with organisational values, vision and mission.



Overall, the current understanding of what LMOs do to manage the mechanisms enabling the functioning of their PM systems appears limited. Most of the existing practices seem to be focused on the relatively technical aspects of managing performance information rather than on integrating multiple aspects of PM systems.

### 3.2.4. External influences on PM systems

The analysis closes with the discussion of context and culture as the external influences affecting the use of PM systems. Here it is important to highlight the distinction between the effects of context and culture on lean production practices themselves, which has been extensively covered in the literature (see e.g. Losonci et al. 2017), and such effects on PM practices (Ferreira and Otley's 2009) which are instead the focus of this study.

The analysis of the 80 sources provided very little information about the way PM practices in LMOs are influenced by size and industry – the main contextual factors (cf. Hines, Holweg, and Rich 2004). The available evidence was largely limited to the effect of size on measuring inventory turnover (Demeter and Matyusz 2011; Eroglu and Hofer 2011). There was no significant discussion of the effects of industry on PM practices, other than Langstrand and Elg's (2012) broader observation that technological change may hinder the development of alternative reward and incentive systems.

A culture supporting performance improvement efforts, however, was seen as important both on the individual (Alagaraja and Egan 2013) and on the organisational (Moyano-Fuentes and Sacristan-Diaz 2012) levels. On the individual level, it is fostered by practices such as continuous experimentation (Towill 2007) as well as employee involvement and empowerment (Panizzolo et al. 2012). On the organisational level, the culture of performance improvement affects the use of incentive systems (Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbos 2013; Parry, Mills, and Turner 2010) which in turn help embed it more deeply within the organisation (Gollan et al. 2014).

## 4. Managing performance in LMOs: discussion and implications

### 4.1. Patterns in current research

The review of research into PM practices in LMOs, as identified through the systematic review procedures and coded into elements of the Performance Management Systems framework (Ferreira and Otley 2009), produced an elaborate picture of the current state of knowledge in this area. As is often the case with literature reviews (e.g. Samuel, Found, and William 2014; Negrao, Filho, and Marodin 2016), our analysis suggests a number of insights highlighting different aspects of the studied phenomenon. These insights fall into two patterns in the existing research, each of which has a number of important implications for both scholars and practitioners. This section identifies these patterns and structures the remaining discussion around them.

#### 4.1.1. Accounting control versus operations control

Our analysis reveals a number of organisational coordination and control mechanisms that underlie the design and implementation of PM in LMOs. In general, in considering the control

of employees' behaviour, existing research seems to suggest two approaches to managing performance: one related to accounting practices and the other focused on performing the job task. More specifically, the former concerns the effect that accounting rules and systems have on the achievement of organisational objectives. Such controls only depend on accounting practices that guide the employees' behaviour (e.g. Fullerton, Kennedy, and Widener 2014). However, the findings highlighted a tension between the accounting- and the operations-based controls (see Section 3.2.2), suggesting that the rationale underlying accounting-driven control systems may need to be interpreted within the broader picture of managing lean operations. This in turn means that relying primarily on performance information from accounting systems may be a limited way to understand the actual benefits of 'lean'.

For example, Browning and Heath (2009) found that accounting information alone was not sufficient to guide employees' behaviour effectively. Rather, what actually matters is how these tasks lead people to interact to each other, generating value for the organisation. Thus, the effect of accounting-based controls on performance might be mediated by the process configuration (e.g. JIT, production levelling, visual controls, quality improvement, TPM) supported by general management practices, such as training, employee involvement and engagement and cross-functional arrangements.

The extent to which the behaviour of people in LMOs is driven by accounting-based control practices can be questioned by other findings of our study. For example, Parry and Turner (2006) see the process underpinning VSM design as the primary driver of a whole range of behaviours. The evidence thus suggests that PM practices in LMOs enact management control in ways that go beyond the use of accounting tools. For example, Chiarini and Vagnoni (2015) highlight the critical role of process configuration in shaping employees' behaviour. Similarly, other studies note that full information about the way processes are performed by people cannot be adequately captured by accounting-based control practices, which limits the usefulness of such practices for driving the necessary behaviour (see, for example, Klingenberg et al.'s (2013) critical analysis of the relationship between operational processes efficiency and the use of financial ratios). These contributions suggest that the information provided by accounting-based control practices may be not fully adequate for meeting the task of managing performance holistically.

Taken together, these contributions partially counter Kennedy and Widener's (2008), Fullerton, Kennedy, and Widener's (2013) and Kristensen and Israelsen's (2014) emphasis on accounting control and provide a more sophisticated and a more operations-centred view of how PM is structured and used in LMOs. In other words, our findings suggest that PM practices that have the most prominent relevance in an LMO may be those that are located closest to the actions on the shop floor and that explicitly address operational realities. If this is true, it calls into question the primacy of centrally driven and accounting-based PM tools. Moreover, it suggests that relying on the somewhat abstract notions of 'alignment' (Kaplan and Norton 2006) and 'cascading' (Bourne et al. 2002) which underpin many accounting-based approaches may be less helpful in ensuring effective control in LMOs than using PM practices that address continuously changing production needs more directly.

Finally, it is interesting that the development of conceptual work on PM in lean likewise seems to be led by research in operations management. For example, Kennedy and Widener's (2008) framework, which has been particularly influential in the MCS literature, addresses the connection between what they call a 'lean strategic initiative' (Kennedy and Widener 2008; Fullerton, Kennedy, and Widener 2013) and its related effects on organisational controls. However, the need for understanding this relationship was highlighted earlier by OM scholars (e.g. Lander and Liker 2007), and in fact Shah and Ward's (2003, 2007) work has remained the foundation for most of the research on management control to date. Similarly, Kristensen and Israelsen's (2014) notion of 'balances and complementarities' required for effective management control echoes some of the earlier contributions made to the OM literature (see, for example, the discussion of target setting and performance evaluation practices in Section 3.2.2). Thus, comparing the work on managing performance in LMOs across the OM and MCS domains, it is possible to trace a 'lock-in effect', whereby the advances made in OM and a focus on the operations-centred control become the basis for management control frameworks employed in the MCS research.

#### 4.1.2. A persisting focus on the operational level

The observations presented in the preceding section may also help explain another theme suggested by our findings. In reviewing the documented practices employed by LMOs to manage organisational performance, we saw a clear and persistent focus on the operational level and a lack of evidence that helps explain how these organisations are managed in an integrated, comprehensive way. Shop floor issues commanded the attention of most of the studies of PM in LMOs (Samuel, Found, and William 2014). This is interesting and somewhat surprising, considering that the theoretical foundations in all of the fields that contributed to our study emphasise a holistic approach. For example, lean is seen as an organisation-wide philosophy (Hines, Holweg, and Rich 2004; Fullerton, Kennedy, and Widener 2014). Likewise, modern work in PM (e.g. Micheli and Manzoni 2010) and MCS (Ferreira and Otley 2009) emphasises an end-to-end integrative approach to managing performance. However, despite designing our review to capture this breadth of thinking, the existing research into PM practices used by LMOs still demonstrates a heavy bias towards operational issues.

This is true of PM practices across both strategic and operational elements of PM systems, as well as many of the enabling mechanisms. In all of these areas, PM practices essentially focus on ensuring and maintaining the effectiveness of the production process by optimising available organisational resources, technical as well as human. In fact, most of the extracted practices fit neatly onto what Hines, Holweg, and Rich (2004) call the 'operational level'. Remarkably, even the practices surfaced within the strategic elements of PM systems (see Section 3.2.1) revealed an emphasis on operational considerations rather than on supporting strategy formulation and opportunity seeking. For example, encouraging learning was often seen as simply a means of developing operational expertise, and even the concept of 'vision' was translated into 'efficient production delivery process' (Towill 2007, 3625), which does not quite reflect its meaning within a more holistic approach to PM (Ferreira and Otley 2009).

The dominance of such practices has meant that the conversation about the role played by PM in LMOs could not move away from its focus on the operational issues, thus echoing Kennedy and Widener's (2008) critique of management control and PM as overly focused on the operational level of analysis. Likewise, evaluating the practices within the enabling mechanisms of PM systems (Section 3.2.3), it is possible to say that, while some 'managerial emphasis' (Ferreira and Otley 2009) has been put on formal and informal mechanisms that directly involve managers in various aspects of PM, this cannot yet be considered sufficient for a holistic view of the organisation-wide process of managing performance in LMOs. Furthermore, although this analysis produced some evidence of the use of various tools for utilising performance information about lean operations, little attention has been paid to how such tools may indeed facilitate high-level decision-making and control.

Nonetheless, the picture is of course not static, and our findings do provide some clues for what might become the basis for integrated PM in LMOs in the future. As the analysis demonstrated, PM practices that actively encourage learning, such as employee involvement (Alagaraja and Egan 2013; Marin-Garcia and Bonavia 2015), employee empowerment (Scherrer-Rathje, Boyle, and Deflorin 2009) and collaborative design (Jayaram, Vickery, and Droge 2008), integrate the diverse aspects of managing performance into the organisational capabilities of the LMOs. Many of these are supported by an organisation-wide culture of performance improvement. Alagaraja and Egan (2013) in particular show how the link between the strategic and operational levels can be established. Learning-oriented practices can also support strategy implementation, for example through an active encouragement of employees' contributions to the process of executing a strategy (Panizzolo et al. 2012).

The evidence of PM practices that connect the strategic and the operational levels is thus beginning to emerge, and it is possible to speculate that the approach to managing performance in LMOs could be becoming strategic in scope. Moreover, the emphasis on PM practices that encourage organisational learning may suggest a particular mechanism for integrating the operational and the strategic levels. Rather than imposing a framework-led PM system and driving alignment, LMOs seem to connect operations with the overall strategy through bottom-up engagement and participation. If this is true, it may also help to explain the lack of practices explicitly focusing on the integrated, 'big picture' PM.

## 4.2. Implications for research and practice

The two patterns described above – the insight into the relationship between accounting-centred and operations-centred views of control and the enduring focus on the operational level – have several important implications for both research and practice. This section presents both sets of implications organised by the patterns identified in the findings.

### 4.2.1. Implications for research

**4.2.1.1 Accounting control versus operations control.** Our results suggest that examining the relative impact of operations-based and accounting-based PM practices in LMOs is one of the

most promising avenues for further research. There is already some work in this area (e.g. Abernethy and Lillis 1995; Chenhall 1997; Sousa and Voss 2008). However, these contributions fall short of understanding how accounting- and operations-based PM practices interact and produce an impact on performance. Future work in this area can examine whether the logic of designing optimal production processes can indeed outweigh the logic of rules and economic incentives and ask questions such as 'Does the configuration of production processes moderate the effect of accounting systems on performance in LMOs?' or 'What are the relative effects of accounting-based and operations-based PM practices on performance?'

Also, further research can examine the extent to which accounting systems and production processes can be complementary. The debate about the relevance of financial measures in facilitating decision-making in production is familiar to scholars both in MCS and in OM (Hudson, Lean, and Smart 2001; Ketokivi and Heikkilä 2003; Chenhall and Langfield-Smith 2007). However, exploring *how* different PM practices support the design and execution of lean production may represent a valuable development of this line of research. Tools such as value stream costing and throughput accounting (Ifandoudas and Chapman 2009; Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo 2013) may offer the first steps in this direction, and potential research questions might include 'How does the use of value stream costing affect decision-making in LMOs?' or 'What drives the adoption of throughput accounting in LMOs?'

Similarly, one of the natural next steps is to examine how PM practices are implemented and whether they have an effect on performance. Recent work in this journal has provided substantial steps in this direction (e.g. Negrao, Filho, and Marodin 2016), and future research can continue building the current state of the art in the subject. Scholars may focus on the current challenges such as international issues (Bozarth et al. 2009) or environmental and social performance (Chavez et al. 2015) and ask questions such as 'What is the effect of customer involvement in value identification on social performance of LMOs?' or 'What are the determinants of the use of flexible organisational structures in LMOs in different countries?'

Finally, the study also suggests that integrating PM practices into IT infrastructure (Powell 2013; Ghobakhloo and Hong 2014), may play an important role in supporting lean operations. This calls for more detailed investigation into the way operational and financial information may be integrated in these systems. Researchers can ask: 'Do ERP systems privilege the use of accounting information in LMOs?' or simply 'How do managers use ERP systems to manage lean operations?'

**4.2.1.2. A persisting focus on the operational level.** Here, the enduring emphasis on the operational level of analysis revealed by this study presents an opportunity to explore how LMOs integrate the operational and the strategic level considerations. Our analysis suggests a useful direction for this line of inquiry by noting the ability of learning-oriented PM practices to create connections across different levels of the organisation. For example, this work may include examining how this process evolves throughout different phases of implementation of lean (Bhamu and Sangwan 2014). Specific questions may focus on individual practices and ask, for example, 'Does decision-making

autonomy facilitate the development of a lean mindset?' Alternatively, researchers can ask broader questions such as 'How do organizational lean capabilities emerge throughout the process of implementing lean initiatives?'

Similarly, the notion of 'organizational learning' (Crossan, Lane, and White 1999; Visser 2007; Wilson, Goodman, and Cronin 2007) can represent a fruitful theoretical foundation for future research. The findings of our study document empirical support for the conceptual links in Hines, Holweg, and Rich's (2004) original framework, which were in fact conceived as learning-based. The evidence systematised in our study, however, suggests that it might be beneficial to shift the focus of analysis from the organisation as a 'learning entity' to people engagement as the most immediate mechanism through which learning can develop. This direction would generate plenty of relevant research questions focusing for example on the way in which specific PM practices (e.g. VSM, Six Sigma, or visual display of information) affect the nature and intensity of employee engagement in LMOs.

From a PM viewpoint, the discussion above means that it would be useful to study how managers actually use PM practices and related performance measures in LMOs. If managing performance in lean is deeply contextual and practice-related, we need to understand how managers use the various control systems, how these systems interact and, above all, how managers ensure the continuous engagement and participation of the workforce in PM practices. In this sense, the identified gap in understanding how cultural issues affect the use of PM systems and practices suggests a critical avenue for future work, which will complement the existing studies of the effects of culture on lean production itself (Bortolotti, Boscarri, and Danese 2015; Losonci et al. 2017). Relevant research questions may take the form of 'How do managers in LMOs establish and secure cross-functional support for PM programmes?' or 'How does organisational culture affect the implementation of PM systems in LMOs?'

Finally, recent technological disruptions in the manufacturing industry (often referred to by practitioners as 'Industry 4.0') may provide new empirical grounds for studying PM in the changed operations paradigms. PM practices may be crucial in this change (Nudurupati, Tebboune, and Hardman 2015). The identified lack of evidence regarding the effects of contextual factors on PM practices suggests that research examining the environment of LMOs may generate many interesting research questions. For example, researchers may ask 'Is the effect of individual PM practices on LMOs performance moderated by environmental turbulence?' and, more generally, examine the interplay between strategic and operational aspects of managing performance in LMOs in new environmental conditions.

## 4.2.2. Implications for practice

**4.2.2.1. Accounting control versus operations control.** First, the results of this study reaffirm the importance of operations-based PM practices in LMOs. Therefore, practitioners seeking direct control of performance in these organisations would be served well by prioritising operations-focused PM practices over accounting-based ones. While accounting systems may usefully highlight the financial aspects of operations, it is the operations-based measures and controls that inform action and affect performance in the most direct way.



Second, considering that accounting-driven PM practices remain an inalienable part of managing an organisation, managers engaged in lean production will benefit from leading the conversation about the effect of lean operations on accounting information and demonstrating the beneficial effects of lean on financial performance. This is particularly important where the discussion of alternative costing systems is involved. A practical way of initiating this conversation would be performing value stream costing (e.g. actual costs, overhead tracked by cycle time), which would provide common ground for the operations-based and accounting-based view of PM and facilitate a more integrative view of performance.

Third, the reviewed evidence suggests that accounting measures do not always capture the benefits of lean implementation accurately, and managers embarking on lean initiatives may be put off by the possible short-term drop in financial performance. Therefore, at the early stages of lean implementations, organisations will benefit from involving lean experts and dedicated lean implementation teams who may help managers and executives understand how operational and financial information is integrated and appreciate the long-term benefits of lean. As lean implementation progresses and the IT systems capturing and integrating the appropriate performance information are developed, the reliance on dedicated lean experts will be lessened.

Finally, the systematic review has shown that LMOs adapt their performance measures to suit their context, and this practice needs to continue. However, the analysis also showed that updating these measures in order to maintain fit provides an opportunity to engage in learning-oriented PM practices. Practically speaking, this means that the regular revision of performance measures should not be seen as a simple operational necessity, but rather as an opportunity to stimulate debate about the drivers of performance. Engaging people in this debate generates learning that bridges the operational and the strategic levels and builds the organisation's lean capability.

**4.2.2.2. A persisting focus on the operational level.** The identified emphasis on operational considerations also suggests several implications. First, our study has confirmed that involving employees, customers and suppliers in the implementation of lean initiatives is an important practice for managing performance. Broad stakeholder involvement leads to engagement that in turn helps to create an organisation-wide lean mindset. More specific PM practices for achieving this include increasing and delegating responsibilities and authority, both formally and informally.

Second, building on the point above, the HR function in LMOs should actively promote bottom-up involvements into the most critical decision areas. HR managers have a range of practices they can deploy to this effect, e.g. establishing a lean-focused performance reporting structure, designing performance appraisals that encourage representation of different functions, or sharing performance information for specific purposes.

Third, maximising the learning PM practices provide may be facilitated by institutionalised activities that capture, codify and share best and worse practices. LMOs can do this by relying on IT systems and using visual management tools. Institutionalising this process would allow managers to exploit organisation-wide knowledge for decision-making and guide more informed

discussions across organisational levels by offering opportunities for people to learn and improve their task performance.

Finally, this study produced a systematised list of researched and documented practices that LMOs use to manage performance (see Appendix 2). Although this list is limited to the PM practices that have been studied and reported in research and although a particular organisation may not need all of them, practitioners of lean will find this list a useful reference point for an organised set of PM practices that the field has amassed and that they can use for their operational needs.

## 5. Conclusions

This paper responded to the lack of systematic understanding of the research at the intersection of lean manufacturing and PM, coupled with the need to understand how LMOs manage performance. To this end, we conducted a systematic review of literature (Tranfield, Denyer, and Smart 2003). Foundational aspects of both PM (Ferreira and Otley 2009) and lean (Hines, Holweg, and Rich 2004) were brought together to strengthen the accuracy and consistency of findings. We identified the documented practices currently employed by LMOs for managing performance, examined them through a comprehensive analytical lens, and presented a structured and comprehensive picture of the current state of knowledge of PM in LMOs. This is important for a number of reasons. First, this paper provided the first systematic look into the overlap between PM and lean manufacturing. Second, the findings identified a number of patterns, namely, the limitations of accounting-based framework-driven control in LMOs, the leading role of OM research in advancing the knowledge of PM in lean, the enduring gap between the operational and the strategic levels, and the potential of learning-based PM practices to close this gap. Finally, the systematic review helped establish promising directions for research and distilled a set of learning points for improving the practice of managing performance in LMOs.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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## Appendix 1. The sources forming the evidence base

Author(s)	Method and sample*	Aims
Abdulmalek and Rajgopal (2007)	Case-based ( $n = 1$ )	Exploring value stream map uses in a process sector firm to understand the potential dynamic gained from implementing lean tools
Adamides et al. (2008)	Case-based ( $n = 1$ )	Exploring how an ICT solution (the CO-Lean) can act as a catalyst in the development of lean supply networks by fostering a collaborative manufacturing strategy development
Agarwal, Shankar, and Tiwari (2006)	Case-based ( $n = 1$ )	Testing the effects of a framework aimed at modelling performance of lean, agile and leagile (lean + agile) supply chains
Alagaraja and Egan (2013)	Case-based ( $n = 1$ )	Understanding the contribution and relevance of human resource development for the implementation of lean strategies
Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbos (2013)	Conceptual/Literature-based	Demonstrating the validity and convenience of the value stream costing technique with respect to the traditional cost accounting
Belekoukias, Garza-Reyes, and Kumar (2014)	Survey ( $n = 140$ )	Validating the actual effect of lean practices (e.g. JIT, VSM; TPM; kaizen automation) on operational performance
Bevilacqua, Ciarapica, and Paciarotti (2015)	Case-based ( $n = 1$ )	Application of lean thinking to the field of information management
Bhamu and Sangwan (2014)	Conceptual/Literature-based	Reviewing literature on lean manufacturing: scopes, objectives, techniques, methodologies and tools
Bhasin (2012)	Multiple methods: Survey ( $n = 68$ ); Case-based ( $n = 7$ )	Assessing the financial and operational performance dimensions of large-size lean organisations
Bortolotti, Boscarri, and Danese (2015)	Secondary data ( $n = 317$ )	Testing the effects of organisational culture and soft practices on lean implementation
Bozarth et al. (2009)	Survey ( $n = 209$ )	Investigating the impact of supply chain complexity on organisational performance
Browning and Heath (2009)	Case-based ( $n = 1$ )	Exploring lean production effects on production costs
Cabral, Grilo, and Cruz-Machado (2012)	Case-based ( $n = 1$ )	Providing a decision-making model to choose the most appropriate practices for defining KPIs of lean, agile, resilient and green (LARG) supply chains
Cagliano, Caniato, and Spina (2006)	Secondary data ( $n = 297$ )	Investigating how lean supply chain strategies are linked with internal operations strategies
Chavez et al. (2015)	Survey ( $n = 228$ )	Testing the effects of technological changes on supplier partnership and customer relationship and on internal lean practices and performance
Chen, Chen, and Cox (2012)	Case-based ( $n = 1$ )	Analysing value stream map implementation to automate the collection, processing and distribution of operational performance information
Chiarini and Vagnoni (2015)	Case-based ( $n = 1$ )	Illustrating the performance measurement, strategic and operations management aspects of lean and WCM
Cottyn et al. (2011)	Case-based ( $n = 1$ )	Exploring the use of IT solutions to align strategy and operations
De Treville and Antonakis (2006)	Conceptual/Literature-based	Examining the relationships between job characteristics and motivational outcomes in lean production
Demeter and Matyusz (2011)	Secondary data ( $n = 711$ )	Understanding how lean organisations can improve their inventory turnover performance through lean practices
Doolen and Hacker (2005)	Survey ( $n = 13$ )	Understanding the main effects of lean implementation on performance
Drohomeretski et al. (2014)	Survey ( $n = 88$ )	Exploring differences and complementarities in the production decision areas of lean organisations
Eroglu and Hofer (2011)	Secondary data ( $n = 1600$ )	Understanding the impact of lean inventory practices on the firm's financial performance
Moyano-Fuentes and Sacristan-Diaz (2012)	Conceptual/Literature-based	Systematising and interpreting the development of the concept of 'lean production'
Fullerton and Wempe (2009)	Survey ( $n = 121$ )	Examining how the use of non-financial manufacturing performance measures impacts financial performance
Fullerton, Kennedy, and Widener (2013)	Survey ( $n = 244$ )	Testing the effect of accounting and control practices as facilitators of lean implementation
Fullerton, Kennedy, and Widener (2014)	Survey ( $n = 244$ )	Testing the contribution of management accounting practices on the performance of lean organisations
Ghobakhloo and Hong (2014)	Survey ( $n = 231$ )	Testing the joint effect of lean practices and IT investments on the performance of lean organisations
Gollan et al. (2014)	Case-based ( $n = 1$ )	Exploring the effects of HR practices in the implementation of lean production
Hallgren and Olhager (2009)	Secondary data ( $n = 211$ )	Testing the impact of lean and agile arrangements on organisational performance
Haque and James-Moore (2004)	Case-based ( $n = 2$ )	Describing the application of lean principles in new product introduction
Hicks (2007)	Conceptual/Literature-based	Exploring the application of lean thinking to information management and the consequent beneficial effects on performance
Hines, Holweg, and Rich (2004)	Conceptual/Literature-based	Conceptualisation of the lean manufacturing organisation
Holweg (2007)	Conceptual/Literature-based	Historical account of the evolution of the concept of lean production
Ifandoudas and Chapman (2009)	Case-based ( $n = 1$ )	Identification of the steps for becoming an agile manufacturer
Isaksson and Seifert (2014)	Secondary data ( $n = 4324$ )	Testing the effects of lean inventory practices on financial performance
Jayaram, Vickery, and Droge (2008)	Survey ( $n = 57$ )	Examining the strategic effects of lean design and manufacturing and the related effects of supplier relationship building
Jayaram, Das, and Nicolae (2010)	Secondary data ( $n = 1700$ )	Examining the effect of lean practices on organisational performance
Jeffers (2010)	Survey ( $n = 64$ )	Examining the competitiveness and sustainability in lean organisations in relation with the use of IT infrastructure
Kennedy and Widener (2008)	Case-based ( $n = 1$ )	Developing a control framework for lean organisations
Klingenberg et al. (2013)	Secondary data ( $n = 1700$ )	Testing whether financial ratios are suitable indicators to determine the effects of production innovation – including lean manufacturing – on firm performance
Krishnamurthy and Yauch (2007)	Case-based ( $n = 1$ )	Conceptualising leagile (lean + agile)
Kristensen and Israelsen (2014)	Case-based ( $n = 1$ )	Exploring the balanced and complementary effects of control practices on firm's performance
Kumar et al. (2006)	Case-based ( $n = 1$ )	Assessing the impact of a Lean Six Sigma framework on operational performance

(Continued)



## Appendix 2. (Continued).

Author(s)	Method and sample*	Aims
Lander and Liker (2007)	Case-based ( $n = 1$ )	Exploring the Toyota production system as a set of principles to manage the whole organisation beyond its application as a toolkit
Langstrand and Elg (2012)	Case-based ( $n = 1$ )	Exploring the resistance of non-human (physical) actors and its effect on strategic alignment during a lean implementation initiative
Lasa, de Castro, and Laburu (2009)	Case-based ( $n = 6$ )	Exploring value stream map uses for re-designing and planning the production process
Li et al. (2012)	Experiment ( $n = 1$ )	Assessing the relative impact of different management accounting systems in evaluating performance in lean manufacturing
Longoni and Cagliano (2015)	Case-based ( $n = 10$ )	Exploring the role of cross-functional executive and employee involvement in the execution of lean strategies
Lyons et al. (2013)	Multiple methods: Survey ( $n = 62$ ); Case-based ( $n = 5$ )	Investigating the alignment of production, integration of suppliers, creative involvement of the workforce and reduction of waste as drivers of performance
Marin-Garcia and Bonavia (2015)	Survey ( $n = 101$ )	Assessing the effect of employee involvement on performance
Martinez-Jurado and Moyano-Fuentes (2014)	Case-based ( $n = 1$ )	Exploring the key determinants of adopting lean production and the related effects on the firm's performance
Meade, Kumar, and Houshyar (2006)	Experiment ( $n = 1$ )	Investigating the magnitude and duration of negative effects of lean manufacturing implementation on profits
Narasimhan, Swink, and Kim (2006)	Survey ( $n = 281$ )	Determining whether lean and agile forms occur with any degree of regularity in manufacturing plants; defining their effects on performance
Netland, Schloetzer, and Ferdows (2015)	Multiple methods: Survey ( $n = 36$ ); Interviews with organisational representatives	Testing the effect of managerial control practices on the lean implementation
Panizzolo et al. (2012)	Case-based ( $n = 1$ )	Exploring how lean production is implemented in a small organisation
Parry, Mills, and Turner (2010)	Case-based ( $n = 1$ )	Applying core competence theory for developing an effective lean implementation methodology
Parry and Turner (2006)	Case-based ( $n = 3$ )	Exploring how visual tools help facilitate performance measurement and communication in different processes
Powell (2013)	Conceptual/Literature-based	Reviewing the role played by ERP systems in lean production
Powell, Alfnes, et al. (2013)	Case-based ( $n = 1$ )	Exploring the performance benefits of a joint implementation of lean production and ERP systems
Powell, Riezebos, and Strandhagen (2013)	Case-based ( $n = 4$ )	Assessing the benefits of ERP systems for process improvement
Qi, Boyer, and Zhao (2009)	Survey ( $n = 604$ )	Investigating on the effect of different supply chain strategies (lean, agile and leagile) on performance
Qi, Zhao, and Sheu (2011)	Survey ( $n = 604$ )	Investigating the relationship between competitive strategy and supply chain strategy with respect to the role of environmental uncertainty
Rivera and Chen (2007)	Conceptual/Literature-based	Elaboration of a Cost-Time Profile (CTP) analysis for measuring performance improvement in lean implementation initiatives
Samuel, Found, and William (2014)	Conceptual/Literature-based	Mapping the evolution of the concept of lean thinking in both practice and research
Saurin, Marodin, and Ribeiro (2011)	Case-based ( $n = 1$ )	Developing a framework for assessing lean implementation and performance in manufacturing cells
Scherrer-Rathje, Boyle, and Deflorin (2009)	Case-based ( $n = 1$ )	Identifying criteria and conditions for success and failure of lean initiatives
Serrano, Ochoa, and De Castro (2008)	Case-based ( $n = 6$ )	Investigating the role of the value stream maps in re-designing production systems
Seth and Gupta (2005)	Case-based ( $n = 1$ )	Exploring the usefulness of value stream maps for achieving productivity improvement
Shah and Ward (2007)	Survey ( $n = 343$ )	Operationalisation of the phenomenon of lean production through the identification of specific operational practices
Soni and Kodali (2012)	Survey ( $n = 185$ )	Testing reliability and validity of the lean, agile and leagile constructs for supply chain strategies
So and Sun (2010)	Survey ( $n = 558$ )	Testing the effect of supplier integration practices on the long-term adoption of lean manufacturing
Taylor (2009)	Case-based ( $n = 1$ )	Investigating the use of value stream mapping for improving the performance of global supply chains
Tillema and van der Steen (2015)	Case-based ( $n = 4$ )	Exploring the tensions between different types of control during the process of lean implementation
Towill (2007)	Conceptual/Literature-based	Conceptualising the phenomenon of Toyota Production System and its usefulness for application in lean production
Vidal (2007)	Case-based ( $n = 6$ )	Exploring the effects of employee empowerment during lean implementation
Vinodh, Kumar, and Vimal (2014)	Case-based ( $n = 1$ )	Developing a framework for integrating lean tools within six sigma methodology
Wee and Wu (2009)	Case-based ( $n = 1$ )	Using value stream mapping to explore how product quality and cost are affected by lean supply chain
Worley and Doolen (2006)	Case-based ( $n = 1$ )	Investigating the role of managerial support in lean implementation initiatives
Yang, Hong, and Modi (2011)	Secondary data ( $n = 309$ )	Investigating the impact of environmental management practices on environmental and financial performance of lean organisations

\*Classified by the authors to highlight empirical work (large-scale surveys and secondary data analysis and small-scale case work and experiments) and non-empirical work.

## Appendix 2. PM practices organised by the elements of Ferreira and Otley's (2009) framework

Element	Definition	Practices for managing performance in LMOs
<i>Vision and mission</i>	The organisation's purpose and commitment to meeting stakeholder expectations	–
<i>Key success factors</i>	Essential elements for a successful pursuit of the organisation's objectives	<p><i>Organizational learning:</i></p> <p>Employees' involvement (Doolen and Hacker 2005; Towill 2007; Scherrer-Rathje, Boyle, and Deflorin 2009; Moyano-Fuentes and Sacristan-Diaz 2012; Panizzolo et al. 2012; Alagaraja and Egan 2013; Lyons et al. 2013; Bhamu and Sangwan 2014; Marin-Garcia and Bonavia 2015)</p> <p>Integrating supplier-, customer-, and internally-focused practices (Shah and Ward 2007)</p> <p>Making organisational goals transparent (Scherrer-Rathje, Boyle, and Deflorin 2009)</p> <p>Providing decision-making autonomy to employees (Scherrer-Rathje, Boyle, and Deflorin 2009)</p> <p>Providing training and upskilling (Gollan et al. 2014)</p> <p>Top management communication and support (Worley and Doolen 2006; Martinez-Jurado and Moyano-Fuentes 2014; Marin-Garcia and Bonavia 2015)</p> <p>Building relationships with supply chain partners (Jayaram, Vickery, and Droge 2008; Chavez et al. 2015)</p> <p><i>Waste elimination:</i></p> <p>Promoting the use of Six Sigma tools (Kumar et al. 2006)</p> <p>Reducing process set-up; using 5S and TPM practices; using visual displays to support standard operating procedures; using quality systems to prevent defects (Haque and James-Moore 2004; Lyons et al. 2013)</p> <p><i>Customer-centric practices:</i></p> <p>Involving customers in value identification (Adamides et al. 2008; Jeffers 2010; Parry, Mills, and Turner 2010; Chavez et al. 2015)</p> <p>Comprehensive assessment of product design and manufacturing (Jayaram, Vickery, and Droge 2008)</p> <p>Improving demand forecasting (Shah and Ward 2007)</p> <p>Improving production processes (Doolen and Hacker 2005; Jayaram, Vickery, and Droge 2008)</p> <p><i>Combining lean and agile principles:</i></p> <p>Combining and sequencing lean and agile principles (Narasimhan, Swink, and Kim 2006; Hallgren and Olhager 2009)</p> <p>Building a 'leagile' capability (Soni and Kodali 2012)</p>
<i>Organization structure</i>	Formal definition and configuration of roles and tasks	<p>Designing organisational structure to facilitate learning (Hines, Holweg, and Rich 2004; Holweg 2007)</p> <p>Integrating people, processes, and external elements (Shah and Ward 2007)</p> <p>Using small teams for organising production (Gollan et al. 2014)</p> <p>Separating production-focused and market-focused parts of operations (Krishnamurthy and Yauch 2007)</p> <p>Establishing flexible and organic structures based on employee empowerment (Jayaram, Das, and Nicolae 2010; Moyano-Fuentes and Sacristan-Diaz 2012; Alagaraja and Egan 2013)</p> <p>Promoting communication across level of hierarchy (Gollan et al. 2014)</p> <p>Providing both formal and informal leadership commitment to implementing lean strategy (Alagaraja and Egan 2013)</p> <p>Maintaining an ongoing dialogue about the implementation process (Alagaraja and Egan 2013)</p> <p>Using process mapping to link strategy with operations (Alagaraja and Egan 2013)</p> <p>Setting up cross-functional teams to support strategy implementation (Alagaraja and Egan 2013; Netland, Schloetzer, and Ferdows 2015)</p> <p>Securing cross-functional support for integrating lean into broader organisational goals (Longoni and Cagliano 2015)</p>
<i>Strategies and plans</i>	Generation, adaptation, and communications of strategies and plans throughout the organisation	<p>Tailoring standard measures to specific production needs and using measures to support value stream mapping (see Tables 2 and 3 for more detail)</p> <p>Using 'pull' principles to synchronise scheduling of levelled production and calibrate lean practices (Towill 2007; Jayaram, Das, and Nicolae 2010; Panizzolo et al. 2012)</p> <p>Identifying specific elements in lean production that can be linked to goals and targets (Lander and Liker 2007; Shah and Ward 2007; Bozarth et al. 2009; Saurin, Marodin, and Ribeiro 2011)</p> <p>Using value stream maps for setting targets for resource scheduling, process planning, sales, and budgeting (Abdulmalek and Rajgopal 2007; Towill 2007; Serrano, Ochoa, and De Castro 2008; Wee and Wu 2009)</p> <p>Using value stream maps for scenario analysis and target identification (Abdulmalek and Rajgopal 2007; Lasa, de Castro, and Laburu 2009; Taylor 2009)</p>
<i>Key performance measures</i>	Financial and non-financial measures of performance for key objectives	<p>Using internal auditing systems for benchmarking internal production sites (Chiarini and Vagnoni 2015)</p> <p>Exercising caution in applying accounting-based methods of performance evaluation (Fullerton and Wempe 2009; Bhasin 2012; Klingenberg et al. 2013)</p> <p>Integrating cost deployment with traditional accounting systems (Chiarini and Vagnoni 2015)</p> <p>Employing throughput accounting principles (Ifandoudas and Chapman 2009)</p> <p>Relying on value stream costing principles (Parry and Turner 2006; Li et al. 2012; Belekoukias, Garza-Reyes, and Kumar 2014; Fullerton, Kennedy, and Widener 2014)</p> <p>Value stream costing at assembly (Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo 2013)</p> <p>Cost-Time Profile (Rivera and Chen 2007)</p> <p>Inventory tracking (Meade, Kumar, and Houshyar 2006; Demeter and Matyusz 2011; Eroglu and Hofer 2011; Isaksson and Seifert 2014)</p>
<i>Target setting</i>	Rationale and methods for setting performance targets	<p>Lean-focused performance reporting structure (Netland, Schloetzer, and Ferdows 2015)</p> <p>Using reward systems to promote commitment (Towill 2007; Scherrer-Rathje, Boyle, and Deflorin 2009; Moyano-Fuentes and Sacristan-Diaz 2012; Panizzolo et al. 2012; Alagaraja and Egan 2013; Lyons et al. 2013)</p> <p>Using employee engagement surveys and gaining buy-in from informal leaders as alternatives to reward systems (Alagaraja and Egan 2013)</p>
<i>Performance evaluation</i>	Evaluation of individual, team and organisational performance	
<i>Reward systems</i>	Financial and non-financial rewards for meeting performance targets and penalties for failing to do so	

(Continued)

## Appendix 2. (Continued).

Element	Definition	Practices for managing performance in LMOs
<i>Information flows, systems and networks</i>	Feedback and feed-forward mechanisms that support performance management	Using information for both feedback and feedforward effects (Hicks 2007) Employing integrated IT solutions and ERP systems internally and within supply chains (Cagliano, Caniato, and Spina 2006; Parry and Turner 2006; Adamides et al. 2008; Jeffers 2010; So and Sun 2010; Cottyn et al. 2011; Powell 2013; Powell, Riezebos, and Strandhagen 2013; Powell, Alfnes, et al. 2013; Ghobakhloo and Hong 2014; Chiarini and Vagnoni 2015) Information visualisation, performance indicators, horizontal decision-making procedures, and lean experts (Bevilacqua, Ciarpica, and Paciarotti 2015) Using value stream maps for visualising and communicating information flows (Seth and Gupta 2005; Alagaraja and Egan 2013)
<i>Performance management systems use</i>	Use of performance information for various control purposes	Using value stream maps (Parry and Turner 2006; Wee and Wu 2009; Li et al. 2012; Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo 2013) Using throughput accounting principles (Ifandoudas and Chapman 2009)
<i>Performance management systems change</i>	Ability to change the structure and operation of controls in response to organisational changes	Eliminating standard costs, discontinuing cost allocation, introducing social control practices (e.g. employee empowerment and peer pressure) and behavioural control practices (e.g. standard operating procedures) (Kennedy and Widener 2008)
<i>Strength and coherence</i>	Integration amongst different kinds of controls; alignment with key objectives	–
<i>Contextual factors and culture</i>	External influences and cultural factors which impact performance management	Encouraging continuous experimentation to promote a culture of performance improvement (Towill 2007) Employee involvement and empowerment (Panizzolo et al. 2012) Using incentive systems to foster a culture of performance improvement (Parry, Mills, and Turner 2010; Arbulo-Lopez, Fortuny-Santos, and Cuatrecasas-Arbo 2013)

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