Lean Six Sigma Deployment and Maturity Models: A Critical Review

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For guidance in implementing Lean Six Sigma (LSS), both the academic and the practitioners' literature offer deployment models and models for assessing the implementation's maturity. This paper makes a critical appraisal of the quality and usefulness of a sample of 19 such models. The appraisal follows a set of review criteria developed on the basis of theory. The analyzed models appear disconnected from established theory in organizational development, and the given advice lacks in specificity and operationality. The underlying notion of deployment processes seems an exclusively programmatic view, leaving little room for idiosyncrasy and learning elements. The study signals an important need for scientific insight in the process of implementing approaches such as LSS, and for a more effective translation of established theory in organizational development to forms practitioners can use. The paper also bridges the gap between academic literature on organizational development and practices in the field as codified in practical deployment models, and identifies how the former could have more impact on the latter.

Key words: deployment, diffusion of practices, Lean Six Sigma, maturity, operations improvement, organizational development

INTRODUCTION

Operations improvement manifests itself in various forms, such as total quality management (TQM), business process reengineering, lean manufacturing, business process management, Six Sigma, theory of constraints, and Lean Six Sigma (LSS). This paper focuses on operations improvement following the Six Sigma method (Linderman et al. 2003; Schroeder et al. 2008; Zu, Fredendall, and Douglas 2008; Arumugam, Antony, and Linderman 2014), including recent manifestations that incorporate principles from the lean manufacturing community. This latter amalgamation is generally called LSS in the popular literature (George 2003; Shah, Chandrasekaran, and Linderman 2008).

Adoption of LSS principles and the translation to structures, policy, and action plans create a task for an organization's leadership, namely that of managing the LSS implementation process. This involves the design of the initiative, its day-to-day control, and, when needed, the adjustment of the initiative. This study focuses on the task of adopting LSS, which the authors refer to as LSS deployment. The academic and practitioners' literature on LSS offers a multitude of models for structuring the deployment task, which the authors call deployment models. In addition, this literature offers models for assessing how far an organization has progressed in deploying LSS. The authors refer to these models as maturity models.

Academic literature offers a vast and mature theory on organizational change and development, but specific models for the deployment of LSS are scarce

(see Hilton and Sohal 2012; Kumar, Antony, and Tiwari 2011). Chakravorty (2009) argues that many LSS implementations fail to produce the results LSS can bring, because an adequate LSS deployment model "to guide the implementation" does not exist, and Naslund (2008) observes that the academic literature does not offer a systematic approach to the deployment of LSS.

This study makes a critical appraisal of the quality and usefulness of the LSS deployment and maturity models offered in the practitioners' and the academic literature. Such models are widely used, and they appear in management course books and LSS practitioner publications. Therefore, these models can have a great impact on the deployment of LSS in organizations. This makes a critical assessment important for the field. For the academic community, a review of applied manifestations of organizational change and development theory reveals how the academic body of knowledge is transferred to the field. Questions that are of interest include: How useful and understandable are the prescriptions for managers and practitioners? How complete are these models? To what extent are these models in line with theory in the field of organizational change and development? What is the level of agreement between these models? How well is the advice embodied in LSS deployment and maturity models based on a solid evidence base or theory? And, finally, how can these models be improved?

To answer these questions, the authors designed a review protocol where deployment and maturity models in the literature are assessed based on criteria in four categories: operational requirements, the comprehensiveness of the organizational scope, the presence and detail of an underlying organizational development paradigm, and the strength of the theoretical grounding. In the next section, the authors define the theoretical framework of their study and present the review protocol. Their research sample consists of 19 deployment and maturity models, which were reviewed following their protocol. Next they present the within- and cross-case findings and results. In the final section, the authors discuss the implications of the results, draw conclusions, and define implications for future research.

THEORY AND METHODS

Lean, Six Sigma, and Lean Six Sigma

Lean and Six Sigma have emerged as separate streams of thought for operations improvement. Lean emerged in practice and started being codified when authors such as Womack and Jones (2003) and Spear and Bowen (1999) tried to articulate its principles (Holweg 2007). In the recent literature, lean is usually understood as a coherent system of practices focused on the elimination of waste by concurrently reducing supplier, customer, and internal variability (Shah and Ward 2007). The practices of lean pertain to just-in-time production, quality management, preventive maintenance, and human resources management (Shah and Ward 2003; Bortolotti et al. 2015).

Six Sigma was developed by Motorola in the 1980s. The authors adopt the definition of Linderman et al. (2003): "Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer-defined defect rates." This systematic method is the define, measure, analyze, improve, and control (DMAIC) structure (De Mast and Lokkerbol 2012). In recent years, the lean and Six Sigma methodologies are applied and studied as one (Shah, Chandrasekaran, and Linderman 2008). Six Sigma, lean, and LSS build on a tradition of operations improvement with earlier manifestations, such as continuous improvement and TQM (Zu, Fredendall, and Douglas 2008; Schroeder et al. 2008). Deployment was also studied in these earlier frameworks, as in Wu and Chen (2006) and Leonard, McAdam, and Reid (2002).

Academic research on the deployment of LSS focuses on the deployment of LSS as a program (a collection of LSS projects) and the execution of LSS projects (Arumugam, Antony, and Linderman 2014). These studies aim to identify the critical success factors of LSS deployment. Empirical as well as case studies have been conducted to find these factors for LSS deployment by, among others, Coronado and Antony (2002) and Brun (2011). Arumugam, Antony, and Linderman (2014)

conducted a meta-study on LSS deployment and summarize nine critical success factors for LSS deployments. These are: 1) management commitment and support for projects, training, and prioritization of projects; 2) involvement of improvement specialists in projects; 3) structured approaches to project execution; 4) customer focus in project objectives; 5) usage of tools and techniques; 6) the link of LSS to business strategy; 7) a focus on metrics; 8) the link of LSS to human resource management; and 9) data-based decision making.

Organizational Development Theory

Since the implementation of LSS is a transformation or development of the organization, the authors' framework for reviewing deployment and maturity models is based on the theory of organizational development (OD). Poole and Van de Ven (2004) define OD as "a difference in form, quality, or state over time in an organizational entity." Studies on the OD process find their roots in the early work of Lewin (1947) and developed through three phases (Seo et al. 2004). In the third and latest generation of research, the notions of organizational learning and perceiving change as a process gained wide attention (Senge et al. 1994; Pettigrew, Woodman, and Cameron 2001). The authors focus on this process research approach.

Van de Ven and Poole (1995) propose that OD processes are driven by four essentially different mechanisms (or combinations thereof). The mechanisms differ in whether they assume a prescriptive or a constructive change process, and in whether they assume a single or multiple actors in the change process. The first mechanism is the life-cycle model, which sees change as driven by a given agenda, program, or principles (prescriptive). To the contrary, the teleological model, which is the second mechanism, sees change as driven by a learning process in which agents use trial-and-error to discover what works and what does not (constructive). Also, the third model, dialectical or conflictive change (Van de Ven and Sun 2011), sees change as constructed. In dialectical change, however, the learning process involves multiple actors, each with his or her own perceptions, logic, and interpretations, and learning occurs when multiple views are synthesized or reconciled. The evolutionary model, finally, also involves multiple actors. These actors have a variety of plans, but they do not engage in a process of dialectical learning by synthesis and reconciliation. Rather, they compete for scarce resources such as time and budget, where some plans prevail and others are abandoned.

During the OD process, change leaders must make decisions that involve trade-offs. Such decisions are called dualities. They result in tensions and have played an important role in OD-process research (Cameron and Quinn 1999; Seo, Putnam, and Bartunek 2004). The theory on these trade-off situations is also included in the authors' review protocol. In their summarizing work on change processes, Beer and Nohria (2000) identify six dualities:

1. The *purpose* duality is about whether OD should aim at economic value maximization, or rather at the development of competences of the organization and its employees.
2. The *leadership* duality distinguishes between top-down leadership versus bottom-up participation in OD processes.
3. The *focus* duality entails whether the subject of change involves mostly formal structures and systems such as procedures, hierarchy, and governance structures, or whether OD focuses on changing the culture.
4. The *planning* duality distinguishes OD initiatives that proceed in a planned and programmatic fashion from initiatives that are left to emerge and evolve.
5. The *motivation* duality is about the importance of financial incentives, early or later in the change cycle, to reinforce the goals of the change initiative.
6. The *consultants'* duality is the trade-off between the involvement of many or few consultants and the role they play.

Study Design and Sample of Deployment and Maturity Models

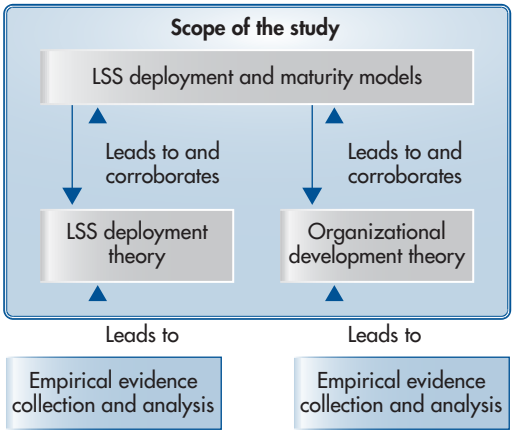
The research questions concern the quality and usefulness of deployment and maturity models offered to practitioners. To answer these questions, the authors

review a selection of models on a number of criteria, which are explained next. The review assesses how well the offered models are grounded in and reflect LSS deployment and OD theory. These OD and LSS deployment theories in their turn are grounded in empirical evidence by the normal process of scientific research, but this linkage is beyond the scope of the authors' study (see Figure 1).

The authors have searched various sources to identify LSS deployment and maturity models for inclusion in their review.

- Academic publications: The authors systematically searched for LSS deployment and maturity models in 150 journals that the Scimago Journal and Country Ranking (SJR) categorizes as management science and operations research journals (Scimago Lab 2015). The authors searched for "lean" and "Six Sigma" in combination with "deployment," "roadmap," or "maturity" in each of the 150 journal databases. This resulted in LSS deployment and maturity models from the following journals: *International Journal of Quality and Reliability Management, International Journal of Production Research, Journal of Manufacturing Technology Management*, and *Total Quality Management and Business Excellence*.
- Practitioner publications: A similar search in publications and online platforms aimed at practitioners, using the same key words, resulted in the inclusion of LSS maturity and deployment models from the following sources: *The Quality Management Forum* (ASQ), *Quality Progress* (ASQ), and *iSixSigma.com*.
- Textbooks and course materials: Many books have been written on lean, Six Sigma, and LSS. The authors performed desk research for books and publicly available course materials in LSS deployment and maturity. The search protocol consisted of searches for "lean" and "Six Sigma" in combination with "deployment," "roadmap," or "maturity" through internet search engines and online book libraries. The search resulted in deployment and maturity models varying in form from research papers to slide-show presentations and teaching materials. After a first round of reviewing, the authors dropped seven models that obtained a 0 percent score for three or four (out of four) review categories (categories are elaborated in Table 1 and explained later), as the authors consider such models not sufficiently developed to allow a meaningful review. Table 2 presents the resulting sample of 19 deployment and maturity models, which they take to be a fair representation of the available guidance for LSS practitioners.

Figure 1 Conceptual model and scope of the research



Review Protocol

Next, the authors present their review methodology for the selected deployment and maturity models. The review protocol is based on design principles for deployment and maturity models (Becker, Knackstedt, and Pöppelbuß 2009; Röglinger, Pöppelbuß, and Becker 2012). Their review model is built around four categories: 1) the operational requirements they believe must be met for a model to be useful; 2) the organizational scope of the model; 3) the OD paradigm underlying the model; and 4) the strength of the model's theoretical grounding. These categories are refined in 11 review criteria (see Table 1).

The objective of the authors' review protocol is twofold. First, they aim to assess the usefulness of deployment and maturity models. They do this by a quantitative review of the comprehensiveness of the reviewed deployment and maturity models. This assessment quantifies

Table 1 LSS deployment and maturity model review criteria

Category Review criteria
1. Operational requirements Research Question (RQ) 1: "How useable is the deployment and maturity model for the target group?"
A. The function of the deployment or maturity model.
B. The stated goal or claimed effect of applying Lean Six Sigma according to the model.
C. The intended target group or target user of the model.
D. The level of the operationalization of the model.
E. The limitations for applying the model.
2. Organizational scope RQ2: "How comprehensive is the deployment and maturity model in covering organizational development?"
A. The width of organizational scope: Organizational dimensions that the model addresses.
B. The depth of organizational scope: The start and end point of deployment process coverage by the model.
3. Organizational development paradigm RQ3: "How are concepts and theory in the OD literature reflected in the deployment and maturity models?"
A. The four process theories of OD by Poole and Van de Ven (2004) addressed by the model.
B. The six dualities in OD processes by Beer and Nohria (2000) addressed by the model.
4. Strength of theoretical grounding RQ4: "How strong is the scientific support for the deployment and maturity model offered by its authors?"
A. The other deployment or maturity models or theories that are integrated into the model.
B. The LSS deployment theory or organizational development theory that is integrated into the model.

what proportion of the issues defined by their review criteria is addressed by each of the reviewed models. For each of the 11 detailed criteria in Table 1, each model's coverage was scored as 0 (not addressed) or 1 (addressed), and these scores were aggregated into a coverage percentage for each of the four review categories in Table 1. For example, model No. 4 is scored as 1, 0, 1, 1, and 0 for the five criteria 1A through 1E in category 1 (operational requirements), and this results in a coverage percentage of 60 percent for category 1.

Second, the authors aim to assess the quality of deployment and maturity models. Where the quantitative analysis reviews *whether* the review criteria are addressed, this qualitative analysis reviews *how* the topics defined by the authors' criteria are addressed. They do this by reviewing what substantiation or interpretation the models in the sample give to each of the 11 review criteria. This allows an assessment of the agreement between deployment and maturity models about their substantiation, and a comparison of the LSS deployment and maturity models with theory on LSS and OD. Next, the authors discuss the review criteria in more detail.

Operational Requirements

The review criteria 1A through 1E concern basic information that is required for a deployment or maturity model to be useful for a user, that is, whether the model defines its purpose and target user, whether limitations to its applicability are specified, and whether the given guidance is tangible and operational. By rating on a two-point scale (0 or 1) whether the criteria 1A through 1E are covered, the authors evaluate whether a model is precise and specific enough to be used easily without substantial resourcefulness of the user. For criteria 1A, 1B, and 1C, a 0 or 1 means the item is addressed in a model. For criterion 1D (the level of operationalization), a model is scored as 1 if at least two out of the following three criteria are met satisfactorily:

1. Are steps and levels in the deployment or maturity tangibly delineated? An example of a tangible demarcation between two successive levels is: "10 percent of the employees are LSS Green Belt trained."
2. Do models go beyond stating *what* to achieve, and tangibly specify *how* to achieve it?

Table 2 Within-case results of the 19 reviewed deployment and maturity models, and per-category coverage percentages

Deployment or maturity model title	Category	Operational requirements	Organizational scope	OD paradigm	Theoretical grounding	Average coverage
A conceptual model for the successful deployment of Lean Six Sigma (Hilton and Sohal 2012)	Academic publications	40%	63%	60%	100%	**66%**
Six Sigma implementation for SMEs – A roadmap to manage and sustain the change (Kumar, Antony, and Tiwari 2011)	Academic publications	60%	88%	40%	100%	**72%**
Applying Lean Six Sigma in a small engineering company, a model for change (Thomas, Barton, and Chuke-Okafor 2008)	Academic publications	80%	50%	40%	50%	**55%**
A framework for effective Six Sigma implementation (Jones, Parast, and Adams 2010)	Academic publications	60%	50%	30%	100%	**60%**
Combining Lean and Six Sigma for optimal results (Cudney et al. 2006)	Academic publications	60%	50%	40%	50%	**50%**
Does your deployment measure up? Presenting a maturity model for Lean Six Sigma (Watson-Hemphill and Bradley 2012)	Practitioner publications	60%	100%	60%	0%	**55%**
Progress report: Learn something about your Six Sigma program's maturity (He 2009)	Practitioner publications	60%	100%	60%	50%	**68%**
Are you ready? How to conduct a maturity assessment (Choudhury 2016)	Practitioner publications	60%	75%	20%	0%	**39%**
Maturity model describes stages of Six Sigma evolution (Raje 2016)	Practitioner publications	80%	75%	30%	0%	**46%**
Successful Six Sigma deployment (Phadnis 2016)	Practitioner publications	20%	38%	30%	0%	**22%**
Eight steps to a successful Lean Six Sigma implementation (Lokesh 2016)	Practitioner publications	20%	25%	20%	0%	**16%**
Assessing process maturity to make Lean Six Sigma more effective; the CMMI[1] capability maturity model (Hung 2005)	Practitioner publications	20%	38%	50%	50%	**39%**
Basic LSS maturity model (Lean Management Institute 2016)	Practitioner publications	0%	38%	30%	0%	**17%**
Fail to consider these areas in a Lean Six Sigma project and risk failure (Toppazzini 2013)	Books and course materials	20%	63%	40%	50%	**43%**
Successfully implementing Lean Six Sigma: The Lean Six Sigma deployment roadmap (Gardner 2013)	Books and course materials	40%	63%	40%	0%	**36%**
Deployment timeline (Pyzdek 2003)	Books and course materials	80%	63%	50%	0%	**48%**
Deploying Lean Six Sigma in service organizations (George 2003)	Books and course materials	40%	63%	40%	0%	**36%**
Lean Six Sigma audit worksheets (Cole 2011)	Books and course materials	0%	63%	40%	0%	**26%**
LESAT[2]: The lean enterprise self-assessment tool (Nightingale 2005)	Books and course materials	80%	100%	60%	0%	**60%**
Average coverage		**46%**	**63%**	**41%**	**29%**	**45%**

[1]Capability Maturity Model Integration.
[2]Lean Enterprise Self-Assessment Tool.

3. Do the models provide specific indicators for establishing the effect of deployment actions?

For criterion 1E (the limitations for applying the model), the authors score whether a model specifies contingency factors for applying the model, such as environmental uncertainty, organizational size, and industry sector (Damanpour 1996).

The Organizational Scope

The review criteria 2A and 2B review how comprehensively the deployment and maturity models cover organizational dimensions. The width of the organizational scope (criterion 2A) assesses how many domains of organizational activity are integrated or covered. The authors rate the models on the basis of the 7S model by Waterman, Peters, and Phillips (1980). The seven dimensions are strategy, systems, style, staff, skill, structure, and shared values. For each of these dimensions, models obtain a score of 1 (covered) or 0.

The depth of the organizational scope (criterion 2B) addresses whether models define the point of departure for deployment (the prerequisites that should be met) and the end point of deployment (when the deployment roadmap is completed and LSS implementation is achieved). The model is rated 1 if both points are defined and 0 otherwise. The seven binary ratings of 2A and the binary rating of 2B are added up and divided by 8 to arrive at the category coverage percentage.

The Organizational Development Paradigm

The review criteria 3A and 3B reflect to what extent and how the deployment and maturity models are grounded in OD theory. Criterion 3A assesses which of the four change mechanisms of Van De Ven and Poole (1995) play a role in a deployment or maturity model: the life-cycle mechanism, the teleological mechanism, dialectical change, and evolutionary change. Deployment and maturity models are scored 1 or 0 for each of these four mechanisms depending on whether the authors could find elements based on each of these four mechanisms.

The six dualities of OD processes by Beer and Nohria (2000) are reviewed in criterion 3B. When the existence of the trade-off is either explicitly recognized or implicitly recognized by promoting only one of the two sides of the duality, a score of 1 is given. When both sides of the duality are promoted and the trade-off is therefore not recognized, a score of 0 is given. The scores for 3A and 3B are summed up and divided by 10. This results in the total review category coverage percentages.

The Strength of Theoretical Grounding

The review criteria 4A and 4B assess the strength of the theoretical support offered for a deployment or maturity model. Criterion 4a scores whether a model refers to other LSS deployment and maturity models in the practitioners' or academic literature (score of 1) or not (score of 0). Criterion 4B scores whether a reviewed model is grounded explicitly by its authors in OD or LSS theory (score of 1) or not (score of 0). The results of the two review criteria are added up and divided by 2 to generate the review category coverage percentages, as presented in Table 2.

RESULTS AND FINDINGS

The presentation of the results and findings is structured according to the four review categories: operational requirements, organizational scope, organizational paradigm, and theoretical grounding. The authors first present a summary of the within-case analysis in Table 2 (the extensive within-case analyses are available upon request). Then they present the results of the cross-case analysis, which highlights the most interesting findings on the similarities and differences between deployment and maturity models. Subsequent sections discuss the descriptive statistics, findings, and results.

The average coverage percentages express the comprehensiveness of each deployment and maturity model. None of the 19 reviewed models has an average score higher than 72 percent. The models offered in the academic literature have a substantially better

coverage than models in practitioners' publications and in books and course materials (61 percent for academic publications versus 38 percent for practitioner publications and 41 percent for books and course materials). This is almost entirely due to the better scores of academic publications on the fourth category (theoretical grounding). Note that these scores give a favorable view of the comprehensiveness of deployment and maturity models in practitioners' publications and course materials, since the seven models excluded in the first review round for scoring 0 percent on three or four categories were all from these domains. The authors turn now to the cross-case analysis, structured by the four review categories.

Operational Requirements

This first review category rates how comprehensively the models address basic operational requirements (the authors' criteria 1A through 1E), such as specifying their purpose and target group, offering guidance in a tangible and operational form, and addressing limitations to their applicability. Table 3 shows that models score poorly on average. Most models only state their function (criterion 1A: 74 percent), and they specify the goal or claimed effect of implementing LSS (1B: 58 percent). The function of deployment models is typically described as to benchmark a deployment initiative, to identify performance gaps, to pinpoint the next steps, and to communicate progress. The function of maturity models is typically described as to provide a "… detailed, step-by-step, quantitative scoring to diagnose the current state [of the deployment]" (Choudhury 2016). The stated goals or claimed effects of LSS deployment are mostly linked to monetary benefits, improved customer satisfaction, improved process performance, and motivated employees.

The majority of deployment and maturity models do not identify their target users (1C) and do not address limitations to their applicability (1E). When defined, the target users are identified as business leaders, actors taking part in the LSS initiative (Green Belts, Black Belts, champions, deployment leaders), and scholars. Almost none of the models discuss limitations and contingency factors for their applicability. For example, the models do not discuss to what extent the application should be adjusted to the size of the organization or in what circumstances the models should not be applied.

Deployment and maturity models score rather low (53 percent on average) on whether the guidance that is offered is tangible and operationalized (criterion 1D). Attempts at operationalization are done by sequences of steps that prescribe what should be accomplished. Examples of such steps are: "create top management commitment" (Nightingale 2005), "LSS project metrics should be linked to strategic metrics" (Raje 2016), and "continuous improvement should be fully integrated into the culture" (Watson-Hemphill and Bradley 2012). Many models are limited to stating what results should be achieved, but fail to offer guidance on how the user should go about pursuing these results.

The authors observe that deployment and maturity models generally fall short in basic operational requirements such as defining their target group, pointing out limitations to their applicability, and offering guidance to users in a form that is specific enough to be operational. This finding suggests that such models, although perhaps useful for a novice user looking to obtain an overview of themes in deploying LSS, are likely to fall short in guiding users through the actual process.

Table 3 Results of the six operational requirement criteria review.

Operational requirements:	1A: Function	1B: Goal or effect	1C: Target group	1D: Operationalization	1E: Limitations	Average coverage
Academic publications	100%	60%	40%	80%	20%	**60%**
Practitioner publications	63%	63%	38%	38%	0%	**40%**
Books and course materials	67%	50%	50%	50%	0%	**43%**
Average coverage	**74%**	**58%**	**42%**	**53%**	**5%**	

Organizational Scope

This analysis answers the question: "How comprehensive is the deployment and maturity model in covering organizational development?" Horizontal width (criterion 2A) assesses how many domains of organizational activity are addressed by a deployment or maturity model. Table 4 shows that most deployment and maturity models address strategy, systems, style, staff, and skills, while structure and shared values are less covered domains. The vertical depth (2B) of a model assesses the model's range from its stated begin point to its end point. Most models define their scope by specifying their begin and end points.

Although the strategy dimension ($2A^1$) is covered by most deployment and maturity models, a qualitative evaluation of the offered guidance reveals that only scant strategic direction is offered for the users. One strategic idea, generally promoted, is that of cost reduction through LSS projects and revenue improvement by satisfying customers. Some models give ambitious but unsubstantiated targets such as "eventually LSS projects will yield 20 times return on investment ratio" (Watson-Hemphill and Bradley 2012). Besides achieving monetary goals, models typically state that LSS deployment should contribute to realizing the business strategy already adopted by an organization by aligning the program and projects with it. To achieve this, deployment and maturity models prescribe that project metrics should be traceable to key strategic metrics in corporate dashboards. Also, this line of strategic advice is limited to sketching the general idea, but few of the models give operational guidance or a substantiation of the made claims.

The systems dimension ($2A^2$) is best covered by deployment and maturity models. Systems, procedures, and processes that should be altered include the organization's training system, which should develop the capability to deliver LSS courses internally. Further, the organization's resource planning processes should be augmented to integrate the planning of LSS activities. Financial accounting reporting systems should integrate reports on the impact of LSS deployment. Also, the principles of LSS should be integrated in an organization's systems and procedures. For example, procedures for product and process design should evolve to better involve customers and stakeholders, and decision procedures should be improved by adding data about the root causes of problems and key performance metrics. In line with the authors' earlier findings, most models are limited to describing what should be achieved, but fail to offer guidance for how to effectuate that.

Deployment and maturity models typically interpret leadership style ($2A^3$) as top management committing to the initiative and line management driving LSS deployment. Advice about leadership style is typically along the lines that "…CEO and senior management team own it [LSS deployment], support it, and drive it" (Kumar, Antony, and Tiwari 2011). This is generally operationalized in four pieces of advice:

1. Management is educated in the principles of LSS, for example: "Leaders invest two days of their own time in learning more about Lean Six Sigma and their role" (Kumar, Antony, and Tiwari 2011).
2. Management approves the LSS initiative, sets the goals and scope, and links them to the mission and vision of the organization.
3. Management monitors aggregated LSS deployment results versus the plan and takes corrective action.

Table 4 Results of the eight organizational scope criteria review.

Organizational scope:	$2A^1$: Strategy	$2A^2$: Systems	$2A^3$: Style	$2A^4$: Staff	$2A^5$: Skills	$2A^6$: Structure	$2A^7$: Shared values	2B: Vertical depth	Average coverage
Academic publications	40%	100%	80%	80%	100%	0%	60%	20%	**60%**
Practitioner publications	63%	88%	63%	75%	63%	25%	38%	75%	**61%**
Books and course materials	83%	83%	67%	83%	83%	67%	17%	67%	**69%**
Average coverage	**63%**	**89%**	**68%**	**79%**	**79%**	**32%**	**37%**	**58%**	

4. Management undertakes follow-up communication and action on LSS issues with both direct reports and other organizational members.

As for the staff dimension (2A[4]), most deployment and maturity models emphasize the empowerment and motivation of employees to participate in the deployment of LSS. For example, Lokesh (2016) advises to "… train team members to be powerful change agents that share the organization's vision." Information processes should enable the empowerment of employees by frequent communication about the improvement initiatives. Also, there must be policies for the development of current and future business leaders in Black Belt, Master Black Belt, and champion roles.

Generally, deployment and maturity models suggest that contributions to improvement initiatives should be recognized in the employee reward system for employees. Skills (2A[5]) refer to the mastery of LSS tools and principles. Three commonly addressed skills are: 1) the ability to understand and respond to customer requirements at every level in the company; 2) the ability to manage value streams by establishing appropriate process ownership; and 3) competencies in LSS project management (coaching, project selection, and planning), fact-based problem solving, and the DMAIC structure and tools.

The structure (2A[6]) and shared values (2A[7]) domains are the least covered. Structure is interpreted as a reorganization of functional hierarchy into product- or process-based value streams. Shared values are generally substantiated in terms of "… LSS should be in the DNA of the organization and is a way of life" (Lean Management Institute 2016). In more detail, the involvement and empowerment of employees should be based on "relationships based on mutual trust" and "open and timely communications" (Nightingale 2005). Most models promote a mindset for continuous improvement and a mentality of zero defects. The result should be an organizationwide focus on customer demands and attention to customer satisfaction. Almost all models promote that the use of data should lead to more fact-based decision making.

The vertical depth (2B) refers to the range in the implementation process that is covered by a deployment or maturity model. The range starts with a begin point, defined by prerequisites that should be met before implementation can start. Generally, models do not give strong prerequisites, and, thus, the begin point could be very early in the process of developing the organization. The end point defines the terms that are fulfilled when the implementation is considered completed. It is generally described as "…continuous improvement is fully integrated in the culture, and linking continuous improvement to performance planning for employees is no longer needed" or "there is a broad understanding of customer requirements at every level in the company, and key decisions are made with the perspective of how it will help the customer" (Watson-Hemphill and Bradley 2012).

The authors find that the scope of deployment and maturity models, both horizontally (range of organizational domains) and vertically (range in the implementation process), is comprehensive.

Organizational Development Paradigm

The third review category answers the research question: "How are concepts and theory in the OD literature reflected in the deployment and maturity models?" Review criterion 3A analyzes whether deployment and maturity models embody some or all of the four change mechanisms of Poole and Van de Ven (2004). Table 5 shows that the life-cycle mechanism is dominant, which sees change as driven by a given program, prescribed by step-by-step models and plans. Although a few models contain isolated traces of a teleological or evolutionary view on change, in general there appears no awareness of the alternative mechanisms by which change can be driven. It is somewhat surprising that almost no traces are found of the teleological mechanism (3A[2]). This mechanism of change is similar to adaptive or trial-and-error learning (Argote and Miron-Spektor 2011; Levinthal and March 1981). Teleological change occurs when deployment does not proceed by following the steps of a prescribed program, but instead by trying out ideas, evaluating their outcomes, and modifying their actions based on the results. It is likely that implementing LSS cannot be driven entirely by following the steps in a given program, but instead

Table 5 Results of the 10 OD paradigm criteria review.

Organizational development paradigm:	3A[1]: Life cycle theory	3A[2]: Teleological theory	3A[3]: Dialectical theory	3A[4]: Evolutionary theory	3B[1]: Purpose duality	3B[2]: Leadership duality	3B[3]: Focus duality	3B[4]: Planning duality	3B[5]: Motivation duality	3B[6]: Consultants duality	Average coverage
Academic publications	60%	20%	0%	40%	20%	60%	60%	20%	100%	40%	**42%**
Practitioner publications	100%	0%	0%	0%	38%	13%	38%	88%	50%	50%	**38%**
Books and course materials	83%	33%	0%	0%	67%	67%	33%	33%	67%	67%	**45%**
Average coverage	**84%**	**16%**	**0%**	**11%**	**42%**	**42%**	**42%**	**53%**	**68%**	**53%**	

involves some trial-and-error learning to adjust it to the specifics of an organization. This is recognized in the literature on the adoption of best practices (for example, Ansari, Fiss, and Zajac 2010; Bresman 2013). The underrepresentation of teleological change mechanisms in LSS deployment models is surprising because the mechanism of trial-and-error learning resonates so well with the plan-do-check-act and DMAIC principles that are at the core of LSS. Also, dialectical change mechanisms ($3A^3$) and evolutionary change mechanisms ($3A^4$) are largely absent in deployment and maturity models.

Where the view of deployment and maturity models on change mechanisms is one-sided, there is also no awareness of trade-offs that the management of change involves. Mostly, deployment and maturity models implicitly promote one side of the duality. Some choices in deploying change imply incompatibilities and strains with other choices, and the most common of these are summarized in the six dualities by Beer and Nohria (2000). Leaders of change have to deal with these inherent strains, for example, by making a clear choice for one or the other extreme of the duality, by focusing on one pole of the duality first and on the second later, or by finding a way to reconcile seemingly incompatible modes. In the deployment and maturity models the authors reviewed, there is an almost complete unawareness of such inherent strains. Options on both ends of the dualities are sometimes explained, but in a fragmentary and rather gratuitous manner that does not acknowledge the underlying trade-offs and incompatibilities. There is no guidance for making trade-offs or for dealing with the inherent strains in other ways. For the purpose duality ($3B^1$), the polar goals of economic value (monetary benefits) versus organizational learning are generally acknowledged, but without awareness that these ambitions imply incompatibilities to some extent. Also, for the leadership duality ($3B^2$), both poles of the duality, top-down and bottom-up leadership, are generally described and elaborated. In the deployment and maturity models, top-down leadership is reflected in the emphasis on the creation of a leadership vision for the deployment and the advice that the deployment be led by executive steering committees. The other pole, bottom-up participation, is reflected in the bottom-up selection of LSS projects and emphasis on the empowerment of employees. There is, however, no recognition of or advice about the inherent tensions between these top-down and bottom-up modes.

The reviewed deployment and maturity models are equally ambiguous and gratuitous about the focus of change (whether change efforts should concentrate on organizational structures or on culture), the planning duality (whether the implementation should be managed as a planned or an emergent initiative), the motivation duality (what and when extrinsic incentives should be used), and the consultants' duality (whether the implementation should be performed by a larger number of expert consultants, or whether it should be supported by fewer consultants who facilitate organizational learning and change).

The authors' review of deployment and maturity models makes it clear that they do not incorporate important concepts from the OD literature. In particular, there is no awareness that change processes are

driven by different types of mechanisms, and, instead, all reviewed models appear to adopt a life-cycle notion inadvertently. Also, there seems to be no awareness of tensions and incompatibilities implied by choices that deployment leaders could make, and instead, options are presented and explained without any recognition of their consequences or guidance in dealing with the strains they are likely to bring about.

Theoretical Grounding

The last review category focuses on the question: "How strong is the scientific support for the deployment and maturity models offered by its authors?" The review assesses the integration with other deployment and maturity models and theory on OD and LSS. Table 6 shows that the underpinning of deployment and maturity models consists predominantly of references to other deployment and maturity models.

References to other models (4A) are, for example, Baldrige criteria, guidelines for quality systems from Motorola and other companies, or previous quality improvement initiatives such as TQM. Few deployment and maturity models discuss LSS or OD theory (4B). When discussed, models refer to critical success factors for LSS deployment and literature on maturity and self-assessment models for TQM. Rather than grounding their models in theory, deployment and maturity models mostly cite experiences of consultants as support. A few examples include: "Having been a part of hundreds of deployments, we have seen some common themes emerge" (Watson-Hemphill and Bradley 2012), or "This model has been built out of the experience of working with dozens of leading Six Sigma companies, executive advisory boards, and luminaries in the field" (Raje 2016). The authors conclude that deployment and maturity models offer little evidence of a strong grounding in theory or science. This is problematic because claims about effects of the prescriptions remain unsubstantiated.

DISCUSSION AND CONCLUSIONS

This paper assesses the quality and usefulness of deployment and maturity models for LSS as they are generally offered in the practitioners' and academic literature. Given the very large scale on which LSS is adopted by organizations, and the substantial efforts invested in implementing the system, effective guidance in the deployment effort is important. The authors found, however, that the state of currently available models for deployment and maturity assessment is unsatisfactory. The guidance offered is sketchy, outlining in general terms what should be achieved but falling short in offering specific, operational advice on how to get there. Limitations and contingency factors for applying a model are not specified. Moreover, the underpinning of deployment and maturity models is unsatisfactory. They do not incorporate theory on OD, such as insight into the various mechanisms by which organizational development proceeds and theory on trade-offs in designing and managing the implementation effort. Instead, it is unclear on what knowledge base or theoretical field the advice in deployment and maturity models is built. In general, the models themselves do not cite literature to support their claims or underpin their assumptions and approach. The authors' assessment of the quality and usefulness of advice for deploying LSS, therefore, is not positive, and the study marks a clear need for deployment support of a more useful and better grounded nature.

Table 6 Results of the three theoretical grounding criteria review.

Theoretical grounding	4A: Reference to other models	4B : Reference to OD/LSS theory	Average coverage
Academic publications	100%	60%	**80%**
Practitioner publications	25%	0%	**13%**
Books and course materials	17%	0%	**8%**
Average coverage	**42%**	**16%**	

A salient characteristic of all studied models is that they embody a programmatic view on implementation processes, where the deployment effort is driven by a plan or program. This is the life-cycle mechanism of change. The desired end state of implementation is not something the organization needs to discover or that is open to adjustment; rather, it is a given, fixed, and generic blueprint. There is no notion that implementation processes may be idiosyncratic and difficult to chart from the beginning. Instead, deployment models offer generic step-by-step programs in which implementation tasks are organized in a linear sequence. Some deployment models portray the implementation as a cultural transformation. On closer examination, however, this appears to boil down to an indoctrination model of change (Ouchi 1979), where implementing LSS is a matter of convincing people to adopt its principles. The stages in such implementation models are defined by successive degrees of penetration, from small pilot initiatives in the beginning driven by "early believers" and "initial visionaries," to organization-wide acceptance and institutionalization ("buy-in") in the end. Actors who have reservations or different views are framed as "resistors to change."

The portrayal of LSS implementation in the studied deployment and maturity models is that of a copy-and-paste exercise, where a generic and given end state is implemented in the organization in programmatic and linear fashion. In view of theory in the field of OD, this portrayal of LSS deployment appears rather one-sided. First, deployment and maturity models should better integrate constructive mechanisms of organizational development, such as the teleological mechanism (adaptive learning) and the dialectical mechanism. The authors acknowledge that substantial parts of implementing LSS consist of copying practices and principles from elsewhere. But when practices such as LSS are adopted by an organization, they are bound to hit on misfits, such as technical, cultural, or political misfits (Ansari, Fiss, and Zajac 2010). Consequently, organizations need to adjust practices such that these misfits are overcome (Bresman 2013). Therefore, implementations differ in the degree of fidelity to the original practice and the extensiveness of the deployment in the organization (Ansari, Fiss, and Zajac 2010). These adjustments require constructive learning processes, such as adaptive and dialectical learning, to be part of the implementation effort.

Second, this one-sided view on implementation processes is also apparent in the failure to acknowledge typical trade-offs in managing such efforts. The six dualities of Beer and Nohria (2000) show that implementation processes come in many varieties, but this variety is not reflected in the studied models. The OD literature generally describes organizational transformations as idiosyncratic processes that are difficult to chart from the start (Tushman and Romanelli 1985). Tushman, Newman, and Romanelli (1986), for example, emphasize the idiosyncratic and unpredictable nature of such processes, and observed that "…organizations do not evolve through a standard set of stages." The blueprints and generic step-by-step programs given in deployment and maturity models should at least be put into perspective, and users should be made aware that the implementation is likely to be much more involved and less predictable than the programmatic models convey.

For the academic literature, this study marks a clear disconnect between theory in the field of OD and the practice of LSS implementation. The authors believe the OD literature has much to offer to improve deployment support for LSS. OD theorists could help in improving deployment models to better integrate constructive learning mechanisms needed to adjust LSS to one's organization. Also, implementation support for practitioners could be improved by offering guidance in dealing with the idiosyncratic nature of such processes, which makes them difficult to plan.

For managers responsible for implementing LSS, the study implies that they should not overly rely on the available deployment and maturity models, which simply lack in maturity. The sketchy nature of the offered guidance and poor integration of important insights on OD processes suggest that practitioners should expect to rely more on their own resourcefulness and inventiveness. Also, they should anticipate that the deployment of LSS is less predictable and more difficult to control than the programmatic and generic models suggest.

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