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An instrument for assessing lean service adoption

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Abstract

Purpose – The purpose of this paper is to develop and empirically validate an instrument containing operational measures of lean service. The instrument is intended for use by both researchers and practitioners.

Design/methodology/approach – The instrument was developed and validated in an iterative process between theoretical and empirical insights. Drawing on a wide selection of frequently cited papers on lean service, a preliminary list of items was generated. These items were then vetted through four steps in order to achieve high validity. Empirical refinement and validation included workshops and semi-structured interviews with expert practitioners, as well as testing the instrument's ability to discriminate between high and low adoption of lean and portray changes during lean service adoption.

Findings – The instrument contains 34 items that assess enablers of lean adoption, lean practices, and operational performance. Empirical validation suggested the instrument was able to discriminate between high and low adoption of lean service, as well as portray changes over time during lean adoption.

Practical implications – Practicing managers will be able to use the instrument in order to track progress during lean service adoption, thereby identifying and acting upon deviations from planned progress.

Originality/value – The paper represents the first comprehensive attempt to develop an instrument for assessing lean service adoption. Through this instrument, operational definitions of lean service will allow researchers to measure the level of lean service adoption, and using this information, to develop knowledge of for instance the contingencies to lean service adoption, the problems and pitfalls in lean service adoption and the feasibility of transferring practices to various service settings.

Keywords Performance measurement, Lean production, Assessment instrument, Lean service, Service industries

Paper type Research paper

1. Introduction

Although the interest among service organizations in adopting lean practices is large and increasing, research on lean services is still in its infancy. Early contributors, such as Bowen and Youngdahl (1998) argued for the applicability of lean practices in service industries. Then followed a number of conceptual contributions concerning which modifications may be necessary in order to translate lean from its manufacturing origins to service operations (Åhlström, 2004). There are also a number of case reports from service organizations that have, allegedly, successfully adopted lean practices, particularly in healthcare (Ballé and Régnier, 2007; Bushell and Shelest, 2002; Lodge and Bamford, 2008; Proudlove *et al.*, 2008). Systematic and rigorous empirical research is, however, scarce. One reason for this, is the lack of conceptual clarification and attendant definition of operational measures (Pilkington and Fitzgerald, 2006, pp. 1265-1266).

In practice, making the transition towards a lean service organization is a long-term and large-scale endeavor. One important aspect of such an endeavor is to track the

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progress being made (Allway and Corbett, 2002). Considering the amount of investments required, there is also a need for evaluating the effects of interventions aimed at adopting lean services. Traditional financial measures are often used to evaluate the success of process improvement initiatives such as lean services. Unfortunately, traditional financial measures are ill-equipped to portray the effects of process improvements and may even deter process improvements (Schonberger, 2008; Swank, 2003). A lean service assessment instrument can complement traditional financial measures and act as an early warning system signaling whether the adoption of lean service is progressing as planned or not (Bayou and De Korvin, 2008).

An extensive literature review revealed four previous papers focusing on operational measures of lean service. Sánchez and Pérez (2004) tested to what extent lean service indicators were used in balanced scorecards in Spanish service firms but did not attempt to assess lean service adoption. The remaining three papers by Apte and Goh (2004), Cuatrecasas (2004) and Kollberg *et al.* (2007) develop or use instruments for assessing the level of lean service adoption but focus only on the outcomes from adopting lean, such as lead time reduction or inventory turnover rate, and do not attempt to assess the level of adoption of lean principles, such as employee involvement, incremental improvement activities and usage of pull. In other words, these instruments do not fully cover all the dimensions of lean service.

Against this background this paper contributes to the emerging field of research on lean service by developing and qualitatively validating an instrument for assessing the level of lean service adoption. The rationale is that the research on lean services would greatly benefit from a definition of operational measures (Pilkington and Fitzgerald, 2006, pp. 1265-1266), to help advance our understanding of the contingencies and limitations to adopting lean in service organizations. But the instrument is also intended for use by managers in service organizations, who are interested in understanding how the adoption of lean service is progressing.

The paper is structured as follows. We start by reviewing literature on assessing lean adoption. Out of this review, we develop a number of desirable characteristics for a measurement instrument, against which existing lean service assessment instruments are compared. We then go on to describe how the instrument was developed and validated in close connection with a Western European company in the process of adopting lean in its service sites. After this we describe the actual assessment instrument, which was based on the previously developed characteristics and an emergent consensus definition of lean services. The paper ends with a discussion, conclusions and suggestions for further work.

2. Characteristics of lean adoption assessment instruments

As a starting point for developing an instrument to assess lean service adoption, a literature review was conducted. The literature review was intentionally broad. We used the terms "lean" and "leanness" interchangeably together with four keywords related to measurement: "assess", "measure", "evaluate" and "audit". Starting with the list of papers generated by the keyword searches, we scanned the title, abstract and keywords for their fit with the literature review's focus. The list of papers to be reviewed was thus arrived at by manually including and excluding papers based on the scope of the study. Note particularly that papers exploring the effect of the adoption

of lean on the performance management system were excluded if they did not address the issue of assessing the level of lean adoption.

The literature review yielded just over 30 papers, of which only four dealt with service operations. The instruments assessing lean in manufacturing were all reviewed with an eye towards using them in services. As they were focused on manufacturing processes, they were deemed, in their entirety, not to be suitable for use in assessing lean adoption in services. However, aspects of the instruments may nevertheless be useful as input in designing an instrument for assessing lean service adoption.

A key intention of the literature review was to develop an understanding of different choices in designing an instrument for assessing lean service adoption. To this end, we could draw on the more established research on lean in manufacturing operations. Instruments for assessing the adoption of lean in manufacturing have been around since the mid-1990s. To illustrate the different choices made in designing instruments, Table I contains a selection of papers on assessing lean in manufacturing, derived from the literature review. The selection criterion for inclusion in the table was the number of citations the paper had in Google Scholar. As our intention was to develop a managerially relevant assessment instrument, we used Google Scholar to obtain a broader impact measure.

The identified papers were read with the aim of categorizing the instrument developed and/or used. The existing instruments were often based on underlying lean principles that were often very similar, as can be seen from the third column in Table I, which details what the instruments measure and the corresponding type of items. The instruments also differed in how lean principles were measured, as can be seen in the fourth column of Table I. While some assess the adoption of lean principles by Likert-type scales ranging from no adoption to complete adoption, others choose to operationalise the lean principles by assessing the use of lean practices linked to those principles. This led to the instruments varying both in terms of the type of items used, but also in terms of how they were measured. Third, the instruments had various intended users, as the fifth column in Table I shows. Many of the instruments had a primary research-aim, they were developed for use by other researchers in order to study the process of lean adoption, but there were also instruments that were intended for self-assessments by practitioners. Finally, there was a large variation in if and how these instruments had been validated, as column six of Table I illustrates.

2.1 What was measured – type of items

In the reviewed literature, three main types of items could be identified. The first type of items focus on enablers of lean adoption, the second focus on the extent of use of lean practices, and the third on operational performance:

(1) *Enablers* often include management commitment, training for employees and time and resource allocation (Shah and Ward, 2007; Soriano-Meier and Forrester, 2002). These types of items stress the importance of achieving behavioral and even cultural change for the adoption of lean to be sustainable (Bhasin, 2011; Boyer, 1996; Nightingale and Mize, 2002).

(2) *Lean practices* focus on the way of working that is seen as consistent with lean principles. Examples of these type of items can be usage of processes mapping (Gurumurthy and Kodali, 2009; Singh *et al.*, 2010; Wan and Chen, 2009; Vinodh and Chintha, 2011), if tasks are standardized (Doolen and Hacker, 2005;

Table I.
An overview of instruments for assessing lean manufacturing adoption

Author	Instrument	What is measured – type of items	Measurement of items	Intended user	Validation	Target industry
Boyer (1996)	Managerial commitment to lean production model	Quality leadership, group problem solving, training, worker empowerment	Seven-point Likert-type scale. 1 – strongly disagree; 4 – neither agree nor disagree; 7 – strongly agree. And for worker empowerment 1 – no emphasis; 4 – moderate emphasis; 7 – extreme emphasis	Researchers	Pre-test followed by mail survey with 202 responses. Scales previously validated in other studies	Metalworking industry
Karlsson and Åhlström (1996)	Determinants of lean production assessment model	Elimination of waste, continuous improvement, zero defects, just-in-time, pull instead of push, multifunctional teams, decentralized responsibilities, integrated functions, vertical information systems	Movement is assessed, the desired direction of the indicator, if moving in a lean direction. For some items 3-7 maturity levels are defined	Researchers, but possible to use for self assessment	No	Mechanical and electronic office equipment industry
Panizzolo (1998)	Lean production best practices in excellent firms model	Process and equipment, manufacturing planning and control, human resources, product design, supplier relationships, customer relationships	Structured interviews. Perceptual questions measured on five-point Likert-type scale	Researchers. Intention is for use as a instrument to explore other research questions	Used in a multiple case study of 27 international firms	Italian finished goods producers (high concentration of metalworking manufacturing, but also clothing, etc.)
Sánchez and Pérez (2001)	Integrated check-list tool	Elimination of zero-value activities, continuous improvement, multifunctional teams, JIT production and delivery, integration of suppliers, flexible information system	No actual measurement of the items in study. Goal is to see use and usefulness of these indicators. Measurement was use/not use, and on five-point Likert-type scale the usefulness (1 – not important, 5 – very important)	The study tests the actual use by practitioners of these lean indicators	Tested degree of applicability by mail survey including 41 companies. 60 percent of lean indicators were used by more than half of the surveyed companies	Automotive and machinery industries

(*continued*)

Table I.

Author	Instrument	What is measured – type of items	Measurement of items	Intended user	Validation	Target industry
Goodson (2002)	Rapid plant assessment (RPA)	Customer satisfaction, safety, environment, cleanliness and order, visual management system, scheduling system, use of space, movement of materials, and product line flow, levels of inventory and WIP, teamwork and motivation, condition and maintenance of equipment and instruments, management of complexity and variability, supply chain integration, commitment to quality	Six scale levels with scores for each: poor (1), below average (3), average (5), above average (7), excellent (9), best in class (11). In addition there is a questionnaire with 20 yes-or-no questions	Group of experts taking a plant tour	No. Used by the author and his co-workers and students	Manufacturing plants (but claims to have been used in both manufacturing and service industries)
Nightingale and Mize (2002)	Lean enterprise self-assessment tool (LESAT)	Lean transformation/leadership: enterprise strategic planning, adopt lean paradigm, focus on the value stream, develop lean structure and behavior, create and refine transformation plan, implement lean initiatives, focus on continuous improvement; life-cycle processes: business acquisition and program management, requirements definition, develop product and process, manage supply chain, produce product, distribute and service product; enabling infrastructure processes: lean organizational enablers, lean process enablers	Specific capability levels have been developed for each indicator based on maturity matrices with generic definitions of maturity levels	Assessment done by the company, analysis to be done by consultant	Testing of the instrument in ten US aerospace organizations	Aerospace industry

(*continued*)

Table I.

Author	Instrument	What is measured – type of items	Measurement of items	Intended user	Validation	Target industry
Soriano-Meier and Forrester (2002)	Managerial commitment to lean, leanness and performance model	Degree of adoption of lean principles (elimination of waste, continuous improvement, zero defects, just-in-time deliveries, pull of raw materials, multifunctional teams, decentralisation, integration of functions, vertical information systems), degree of commitment to lean programme (quality leadership, problem-solving teams, training, empowerment)	Seven-point Likert-type scale. 1 – no adoption; 4 – partial adoption; 7 – total adoption	Researchers	Survey of 33 firms	UK ceramics tableware industry
Doolen and Hacker (2005)	Instrument for assessing range and level of implementation of lean practices	Manufacturing equipment and processes, shop floor management, new product development, supplier management, customer relations, workforce management	Five-point Likert-type scale on how often a practice is used (always, most of the time, some of the time, rarely, never). Average score and std dev for all six impact areas	Researchers	Review of items by six researchers, four lean experts, and two survey development experts in the USA, Europe and South America, followed by survey of 13 companies	Electronics manufacturers
Li *et al.* (2005)	Instrument for SCM practices, delivery dependability, and time-to-market (lean is one of the groups of SCM practices included in the instrument)	Internal lean practices (reduction of setup time, continuous quality improvement program, "pull" production system, shorter lead-times from suppliers, streamlining ordering, receiving and other paperwork from suppliers)	Five-point scale	Researcher	Pre-pilot study with review of items by six academicians and three practitioners. Pilot study with inter-rater reliability etc by purchasing/ production managers. Empirical validation 196 survey respondents, senior managers in manufacturing companies	Manufacturing supply chains (furniture and fixtures, rubber and plastics, fabricated metal products, industrial and commercial machinery, electronic and other electric equipment, transportation equipment)
Shah and Ward (2007)	Instrument for measuring variability reducing lean practices and underlying factors	Supplier related: supplier feedback, JIT delivery, developing suppliers; customer related: involved customers; internally related: pull, flow, low setup, controlled processes, productive maintenance, involved employees	Five-point Likert-type scale on the implementation of each lean practice. 1 – no implementation; 2 – little implementation; 3 – some implementation; 4 – extensive implementation; 5 – complete implementation	Researchers	Interviews with ten practitioners, pre-test with 16 experts. Pilot study with 63 comp. Large-scale study with 295 manufacturing firms implementing lean production	Manufacturing firms (SIC 20-39)

Nightingale and Mize, 2002; Singh *et al.*, 2010; Wan and Chen, 2009) and if visual signals are used (Mejabi, 2003; Sawhney and Chason, 2005; Wan and Chen, 2009).

(3) *Performance* refers to items measuring operational performance and are similar to financial performance measures in that they focus on the results of lean adoption, for example, increased productivity (Mejabi, 2003; Searcy, 2009), lead time reduction (Ahmad *et al.*, 2004; Panizzolo, 1998) or inventory turnover rate (Bayou and De Korvin, 2008; Sánchez and Pérez, 2001; Taj, 2008). There are indications that the utilization of operational performance measures positively mediate in the relationship between lean practices and financial performance (Fullerton and Wempe, 2009).

We argue that an instrument for assessing lean service adoption should include all three types of items, to fully reflect the adoption. Enablers give a good view of the supporting structure for lean. The importance of the supporting structure for successful adoption has increasingly been held up as critical (Hines and Lethbridge, 2008; Radnor, 2010). However, enablers do not answer the question of whether there have been any real process improvements or whether these have actually led to any improved performance results. The importance of assessing the use of lean practices should be seen against the background of the fact that lean adoption is a long and complex process and that some performance items may even point in the wrong direction at first even if the company is in fact becoming "leaner" (Karlsson and Åhlström, 1996). Assessing the use of lean practices is thus important, since it can take some time for these practices to lead to improved performance. Performance-oriented measures, finally, are of course important to include. There are reasons to argue that a process is not becoming "leaner" if it does not display an improvement in important key performance indicators (Wan and Chen, 2008).

2.2 Measurement of items

The items were measured in three different ways:

(1) Some instruments use Likert-type scales where items range from "no adoption" to "complete adoption" in five or seven steps (Sakakibara *et al.*, 1993; Shah and Ward, 2007; Soriano-Meier and Forrester, 2002).

(2) Other instruments attempt to relate the company's level of adoption to something else, i.e. benchmarking against the industry leader or an ideal industry standard (Bayou and De Korvin, 2008; Comm and Mathaisel, 2000; Srinivasaraghavan and Allada, 2006).

(3) Maturity levels are particularly used by practitioner-oriented instruments, such as rapid plant assessment (RPA) (Goodson, 2002) or lean level self-assessment instrument, LESAT (Nightingale and Mize, 2002). The exact nature of these maturity levels differs. Some, such as RPA, use only words such as "poor", "below average", "average", "excellent" and "best in class" to describe each maturity level. Others, such as LESAT, use generic definitions of each level describing to what extent a lean practice has been adopted.

Likert-type scales have the obvious advantage in research terms in that it permits the usage of parametric statistical methods for analysis (Hair *et al.*, 1998). However, at this

stage of the practice and research on lean services, Likert-type scales do have disadvantages. The main disadvantage is linked to the conceptual confusion surrounding lean services (Shah and Ward, 2007), with the existence of a multitude of interpretations of the term "lean" (Papadopoulos *et al.*, 2011). This makes it likely to be difficult for a respondent, especially if lean adoption has just begun, to imagine what "complete adoption" of a lean principle entails. Not having any reference point for one end of the Likert-type scale makes it extremely difficult to choose the appropriate level in between "no adoption" and "complete adoption". Benchmarking poses some practical problems as it may be difficult to obtain information from competitors and the outcome relies heavily on the quality of the information obtained (Srinivasaraghavan and Allada, 2006). Maturity levels, finally, can be difficult to describe, especially if the organization is just starting to adopt lean. In the beginning it may not be possible to imagine what the perfect situation would look like, or what the steps leading towards that ideal state look like. This can however be solved or at least partially solved by using general definitions of each level as a base (Nightingale and Mize, 2002). This means that it is not necessary to imagine what the ideal state would look like in the specific organizational setting and on the specific parameter. It is this approach we chose in designing our instrument, as it was seen as most promising given our dual aim of developing an instrument that could be used both by researchers and by practitioners.

2.3 Intended user

The intended user of the reviewed instrument also differs. Many of the instruments are based on assessments done by researchers who then give feedback to the company as input in the company's effort to adopt lean (Bayou and De Korvin, 2008; Soriano-Meier and Forrester, 2002; Srinivasaraghavan and Allada, 2006; Wan and Chen, 2008). The instruments and the statistical analysis however, are too complex and time consuming to be suited for managerial use. The other possibility is to develop an instrument to help companies carry out an assessment themselves. Examples are the lean determinants developed by Karlsson and Åhlström (1996) and LESAT (Nightingale and Mize, 2002) developed in the airline industry. While answering a questionnaire and getting feedback on the results may prompt reflection in the respondent, self assessments are more useful for individual companies (Caffyn, 1999; Karapetrovic and Willborn, 2001). Considering our aim is to develop an instrument which can be used both by researchers and by practitioners, we therefore propose an instrument designed to permit self-assessments.

2.4 Validation

Finally, to what extent the instruments have been validated varies. Some have not specifically been validated, but have been used by the researcher with claimed good results (Goodson, 2002). Other instruments have gone through an extensive development and validation process including pre-test, pilot study and large-scale survey (Shah and Ward, 2007). The actual validation has been performed in quantitative ways through surveys and statistical analysis (Boyer, 1996; Li *et al.*, 2005; Shah and Ward, 2007) and in qualitative ways in case studies (Nightingale and Mize, 2002; Panizzolo, 1998).

3. Existing instruments for evaluating lean service adoption

As mentioned before, we identified only four previous papers related to assessing lean service adoption. In Table II, we have mapped the characteristics of these four

	Type of items	Measurement of items	Intended user	Validation
Apte and Goh (2004)	Performance: cycle time, productivity and quality	Measurement of lead time, productivity and quality	Permits self-assessment	Uses data from a previous study (Apte and Goh, 2004) of the insurance claims process at one of the largest property and casualty company in the USA as an example
Cuatrecasas (2004)	Performance: cycle time, inventory and productivity	Measurement of lead time, productivity and stock	Permits self-assessment	Metrics are used to evaluate changes during lean adoption in one case study of a hotel check-out service
Kollberg *et al.* (2007)	Performance: lead time	Measuring lead time between specific points in the process	Permits self-assessment	No explicit validation was conducted, but the measure has been in use since 2004. The authors studied six local development teams over time and concluded that the flow model has the potential of measuring changes towards lean thinking in several aspects
Sánchez and Pérez (2004)	Practices: elimination of zero-value activities, continuous improvement, multifunctional teams, JIT delivery, suppliers involvement, flexible information system few performance items: WIP and inventory	No scales for assessing items were developed	No ready-to-use instrument developed	Tested degree of usage of indicators by mail survey. 108 companies in service industry. Nine out of 29 indicators of lean indicators were used by more than half of the surveyed companies

Table II.
Evaluation of instruments assessing lean service adoption

instruments against the characteristics extracted from the literature on assessment instruments. The instruments are described below.

Kollberg *et al.* (2007) used what they called the "flow model" which measures lead times and their improvement in health care. The flow model was not developed specifically for measuring lean, but rather as a way for the Swedish health care to follow up lead times to deal with long waiting times and delays. The flow model focuses on lead-time measures as the final result of lean adoption rather than lean principles. Still, the authors conclude that it is possible to use the model to measure most aspects of the lean principles suggested by Womack and Jones (1996). However, the authors also indicate a need to use other

measurements to assess, for example, policy deployment, respect and participation and continuous improvement as these are not reflected in the flow model.

Cuatrecasas (2004) similarly focuses on operational performance as a way of assessing the adoption, but includes inventory (stock of components or persons waiting) and productivity in addition to cycle time of the whole process. While also using measures related to the operational performance, Apte and Goh (2004) argue that to measure the success in adopting lean principles in information-intensive services the metrics of productivity and quality need to be combined and lead time reduction should replace the traditional inventory metrics.

Three of the four papers thus used only performance items. In contrast, Sánchez and Pérez (2004) focused on an adaptation of measures developed by Karlsson and Åhlström (1996) in manufacturing. The authors cover different dimensions of lean by including indicators of lean practices in the areas of elimination of zero-value activities, continuous improvement, multifunctional teams, JIT delivery, supplier involvement and flexible information system. The aim of their study was, however, not to investigate whether these measures were a good way of assessing the level of lean service adoption, but instead to investigate if Spanish service companies were using these types of measures in balanced scorecards to complement purely financial measures. The conclusion was that very few of the studied service companies used these types of measures, but there was no inquiry into if any of these companies had attempted to adopt lean.

From the review of lean manufacturing assessment instruments, we concluded that an instrument would first of all integrate three types of items: enablers, practices and performance. Second, maturity levels would be used to depict the progression related to lean adoption. Third, to be of long-term use to companies, the instrument should permit self-assessments. Using these characteristics for judging the fit of the four previous papers focusing on assessing lean service, we can conclude that existing literature does have limitations. Three instruments focus on performance items and omit items concerning enablers and lean practices. The fourth paper did not attempt to develop an instrument for assessing lean service adoption.

4. Instrument development and validation process

Having concluded that there is a need for an instrument containing operational measures of lean service for assessing the level of adoption of lean service, we now turn to describing the instrument development and validation process. The instrument was developed in an iterative process between theoretical and empirical insights. The steps in the development and validation process are shown in Figure 1.

In developing the instrument, we chose a case-based methodology. The main reason for this choice was the state-of-the-art of knowledge on the topic (following Voss *et al.*, 2002). As noted, the interest among service organizations in adopting lean practices is large and increasing, but research on lean services is still in its infancy. Particularly, the existing instruments to assess lean service adoption were found to have certain limitations. Finally, as we also had an interest in developing an instrument that was

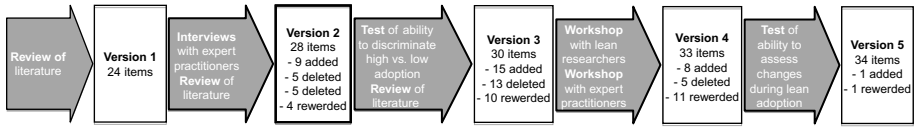

Figure 1.
Steps in the instrument development and validation process

possible for organizations to use themselves, the case study methodology was found to be appropriate, as it would allow us to explore the issue of interest in more depth.

We developed and validated the instrument in close connection with a Western European company well-known for successfully having adopted lean in their manufacturing units, which since a few years back is in the process of adopting lean in their service sites. The service business of the company is characterized by a large number of geographically dispersed service sites with semi-autonomous workers selling, delivering and providing support for an industrial product. At the end of 2011, the number of employees in services totaled approximately 15,000.

In addition to the two researchers, a total of 82 lean practitioners and eight academics were involved in the different steps in development and validation of the instrument. These steps are described in more detail below.

4.1 Steps in development and validation

Step 1: review of literature to form preliminary list of items. Starting from existing literature on lean service, we developed a preliminary list of items for assessing lean service adoption. The details of the literature review are described at length in Section 5 of the paper. Apart from the lean service literature, we also reviewed and used some items from existing instruments measuring lean manufacturing adoption. We further developed maturity level descriptions for each item starting from an adaptation of the generic maturity levels developed by Nightingale and Mize (2002). The items and maturity level descriptions were vetted through four more steps in order to assure high quality in terms of face and content validity.

Step 2: semi-structured interviews and review of literature. The items were first refined using semi-structured interviews with five expert practitioners. These five practitioners had between five and 15 years of experience from lean adoption in our focal company, and were all actively involved in the current initiative to adopt lean in their service sites. Having gained additional insights from the interviews we revisited the relevant literature before creating the second version of the instrument. While the first version of the instrument was very focused on practices, the interviews with expert practitioners at this early stage centered very much around enablers of these lean practices including the need for local expert practitioners and the crucial role of management:

> The local coordinators are key for success. You need to find the right profile, an informal leader, someone who other employees listen to. Then you need to get the manager involved, but on the right level. He has to be interested and ask questions and follow up progress but not take away the mandate from the local coordinator. In other words you need both the right manager and the right coordinator to have a successful lean adoption – Lean expert from headquarters with over ten years experience.

The interviews led us to revisit literature on enablers of lean adoption and reword, add and delete some items and specific maturity level descriptions in the instrument. Change agents was, for example, added as one item, and leadership was split into two new items, one centered around management's understanding of lean, and one focused on the role managers take in the adoption process. When it comes to lean practices items, customer value was deleted and replaced by two new items, one aiming at the understanding of customer value by internal employees, and the other on the actual involvement of customers in the work processes.

Step 3: test of ability to discriminate between high and low adoption and review of literature. The third step was to test the ability of the instrument to discriminate between high and low adoption of lean. To this end, we selected four service sites in France and Benelux. The service sites were selected based on semi-structured interviews with two expert practitioners. The goal was to select two sites in each country, one service site which had just started adopting lean and one service site which had come further in lean adoption according to the focal company's own belief. The service sites were visited over three days, and the researchers spent on average three hours in each service site. We were joined by two company lean experts for these visits. One expert was from the headquarters, and joined the authors for all site visits. In addition, there was one local (business unit) lean expert who was more familiar with the service sites in each particular business unit. The focus during the visits was to see how well the items reflected the differences in lean adoption level between the "just started" sites and the advanced or role model sites. Each site visit was followed by discussions around how the authors and the company lean experts judged the lean adoption level of the service site and how well this was reflected by the measurement items.

Discussions in this step very much focused on practices and performance items. For example, it was felt that the performance items (lead time, inventory, productivity and quality) were not enough to judge the outcome from lean adoption. In essence, the company was aiming for reduced costs and higher customer satisfaction:

> Of course we expect lead time to drop and productivity to go up for example, but what we're really trying to do is provide customers with a service offering that they are more pleased with, at a lower cost than today – Business unit lean expert.

These two items; cost and customer satisfaction, were added to the instrument in this step. Much of the work in the service sites was considered unplanned by employees, whereas we, along with the company lean experts saw demand as fairly predictable. After finding support for this need to make demand more predictable in literature, we added a lean practice item to the instrument that we labeled proactive planning. In this step, we also chose to reword several of the maturity level descriptions. This was done in an effort to strike a balance between specificity and length in maturity level descriptions. Company lean experts advocated maturity level descriptions that were as specific as possible, which tended to make them very long. This led to a re-assessment of the maturity level descriptions and an effort to simplify and shorten them in order to have an acceptable length and level of complexity to allow the instrument to be used for self-assessments. Insights from the site visits and the following discussions with company lean experts, in combination with further insights from literature, thus led to a substantial amount of changes to the items and maturity level descriptions, resulting in a revised instrument which reflected the researchers' and the experts' judgment of the lean adoption level in the different service sites. The third version of the instrument was thus able to distinguish between the sites which had just started and the sites which were perceived as more advanced.

Step 4: workshops with expert practitioners and academics. The revised instrument was further refined through a workshop with eight academics within the field of operations management including researchers with extensive experience from studying lean in services, and one workshop with four expert practitioners. These workshops resulted in some changes to the instrument. There were fewer items deleted in this step and a lot of focus was now on the actual wording of items. This led to several items that were perceived

to measure more than one construct being divided into separate items, thus adding a number of items to the instrument. Standardization, for example, was deleted and replaced by two new items, one focusing on the use of standardized tasks, and the other on the formalization of work standards. Expert practitioners in this step also brought up the need for the company to make actual investments in time and resources in the change effort:

> Some managers just want to do lean on paper, they are not willing to make any investments in it. But if you don't let people sit down and think about how to make the process better, or if you're not willing to make any actual investments in changing the process, you will never become lean. It's as simple as that – Senior manager at headquarters with over 20 years of experience of lean.

We found ample support in literature for this need to invest in time and resources in order for lean adoption to be successful, and thus added an enabler item labeled resources for improvement work.

Step 5: testing the ability of the instrument to assess changes during lean adoption. The fifth and last step in the development and validation of our instrument was to use it for assessing the changes taking place during a period of lean adoption. For this purpose, we focused on seven of the company's European service sites that were adopting lean. The service sites were located across Europe: two in Great Britain, two in France, one in Belgium, one in Germany and one in Austria. Some of the sites had been working with lean for over four years, whereas others were just starting up. During a limited time these workshops received training and intense on-location support by head office resources. There was in essence someone on location at these service sites every week with the aim of following up results, facilitating improvement activities and helping local teams overcoming hurdles. In addition to these general support and control activities, there were on-location training events including value stream mapping, training in using problem solving tools, etc. The approach was thus the same in all seven sites, even if the starting point differed.

The assessment instrument was first used to establish a starting point for each service site. Three months later, the assessment instrument was used again to establish a new level of lean adoption that could be compared to the first. We conducted five to eight semi-structured interviews during one day at each service site with the aim of collecting information on the current status of lean adoption in the service site. The 14 site visits yielded a total of 100 interviews, with 71 individual respondents. Respondents were selected with the aim of gaining a multitude of perspectives on the changes being made in connection with lean adoption. This included shop floor employees and managers, local change agents, as well as representatives from the different departments such as sales and aftersales support. Interviews ranged from between 30 and 90 minutes in length. An expert practitioner and the researchers then filled out the assessment instrument independently. The assessment differed on no more than six items, and in all cases, the difference between the researcher and the expert practitioner was no more than one maturity level. After having filled out the instrument, expert practitioners reported that it was fairly easy to fill out and that it reflected their view of lean adoption in the sites. When asked if there was anything else that they would look for when assessing the level of lean adoption of a service site, expert practitioners did not suggest adding any items. Nevertheless, following these discussions, the researchers decided to split one of the items in the instrument into two as it was deemed to measure more than one construct. This led to one item being

added, and one item being reworded in this final step. No items were deleted in this step.

4.2 Validity of the instrument

We validated the instrument qualitatively in four ways throughout our development process. First, the instrument was put to the test with respect to how well it was able to discriminate between service sites that expert practitioners judged as very immature when it comes to lean adoption and sites that were judged more mature in lean adoption. Second, we tested how well the instrument was able to reflect changes over time during a service site's adoption of lean. Third, we looked at whether practitioners were able to use the instrument, i.e. if they were able to understand the items and maturity levels and if they were able to select what they felt was an appropriate maturity level corresponding to their view of their service operation. Finally, practitioners were asked whether the assessment instrument reflected their view as to what degree lean had been adopted, i.e. were there items missing or items included that do not measure the level of lean adoption. The fact that lean expert practitioners found the items to be usable and reflected their view as to what degree lean had been adopted is a sign of a high level of face validity of our instrument. Further, we argue that content validity is high given the fact that lean expert practitioners and lean service researchers did not suggest adding any items, but reported that the instrument gave a good view of the level of lean adoption, indicating that the instrument covers the dimensions of lean service. The fact that the instrument was able to show development in the level of lean adoption over time and discriminate between high and low adoption suggests that it has high construct validity and indeed measured what was intended to be measured: lean service adoption. A further indication of construct validity is the fact that our items correspond both to an emergent consensus definition of lean service from literature and were also deemed relevant by practitioners.

5. Lean service assessment instrument

The final instrument consisted of 34 items to reflect a comprehensive set of enablers, practices and performance of lean service adoption. An overview of the organization of the lean service assessment instrument is as follows:

Section I – enablers:

A. Employee training, commitment and understanding:

- employee training;
- employee commitment; and
- employee understanding.

B. Management commitment and understanding:

- management commitment; and
- management understanding.

C. Infrastructural elements:

- time for improvement work;
- resources for improvement work;
- change agent; and
- bi-directional information flow.

Section II – lean practices:

A. Customer value:
- identification of customer value; and
- customer involvement.

B. Identify waste:
- value stream mapping.

C. Flow:
- workplace design for flow; and
- connecting the process.

D. Standardize work:
- standardized tasks; and
- formalization of work standards.

E. Level and balance workloads:
- proactive planning.

F. Quality/zero defects:
- built-in quality.

G. Pull:
- pull system.

H. Visualization:
- visual signals;
- visualization of information; and
- visualization of improvements.

I. Multifunctional employees:
- employees measure and follow up work; and
- Multifunctional teams.

J. Continuous improvement:
- employee participation in improvement work;
- focus of improvement work;
- structured problem solving; and
- sustaining improvements.

Section III – performance:

A. Lead time.
B. Inventory.
C. Productivity.
D. Quality.
E. Cost.
F. Customer satisfaction.

The instrument is included in the Appendix.

5.1 Enablers of lean service adoption

Enablers of lean adoption such as management commitment and dedication of time and resources to lean work are given high importance in lean service literature (Delgado *et al.*, 2010; Radnor, 2010). In our instrument, we have included items relating to employees, managers and infrastructural elements.

Employees play a critical role in lean adoption and the training they receive along with their commitment and understanding of the lean adoption effort are commonly stated as important enablers for lean adoption (Ballé and Régnier, 2007; Bowen and Youngdahl, 1998; Rahimnia and Moghadasian, 2010). Therefore, we included items that focus on employee training in lean and improvement work, employee understanding of the lean concept, and employee commitment to the improvement effort.

Managers and their actions can make the difference between a successful and unsuccessful lean adoption effort (Radnor, 2010; Suárez-Barraza and Ramis-Pujol, 2010). We incorporated items designed to assess management commitment and the role played by managers in lean adoption, as well as managerial understanding of the lean concept.

Infrastructural elements are as important for the improvement effort as management commitment. Even with a strong commitment from top management, there is a need to dedicate time and resources to improvement work for any changes to take place (Delgado *et al.*, 2010; Sim and Rogers, 2009). We therefore included two items for assessing time and resources for improvement work, and one item related to change agents. A fourth item used for assessing infrastructural elements relates to bi-directional vertical information flow. As the organization adopts lean it is important to put in place ways for information to be transmitted between hierarchical levels. Some examples are problems and their short-term and long-term solutions as developed by employees and investment decisions from management based on those proposed solutions.

5.2 Lean practices

In order to develop items for assessing the use of lean service practices, we first need to define lean service on the level of what we term "lean principles" and then move on to operationalize those principles in what we call "lean practices".

Defining lean service. A key issue in designing an instrument to assess lean service adoption is how to define lean service. The research on lean service shares the conceptual confusion surrounding the research on lean manufacturing (Pilkington and Fitzgerald, 2006, pp. 1265-1266). There have been numerous attempts over the years to "decode the DNA" (Spear and Bowen, 1999) of TPS and lean. The attendant diversity in conceptualizations of lean has led to confusion around what lean really is and consequently how it can be measured (Shah and Ward, 2007). For this reason, we base our assessment instrument on an "emergent consensus definition" of lean services.

In arriving at our definition of lean services, we used the Scopus database to select the top ten cited papers on lean service, which provided an explicit definition (four of the papers on the top list did not define lean service). Common throughout the ten selected papers, was to see lean service as consisting of a set of principles (compare Womack and Jones, 1996). We follow this view and see lean service as consisting of a set of principles, for improving service delivery.

Out of these ten papers, we thus extracted an emergent consensus definition of lean service principles, through searching for commonalities in definitions, see Table III. Out of the ten papers, we extracted a total of 29 principles that were reduced to ten. First we

Table III. An emergent consensus definition of lean service

	Åhlström (2004)	Apte and Goh (2004)	Ballé and Régnier (2007)	Bowen and Youngdahl (1998)	Kim *et al.* (2006)	Kollberg *et al.* (2007)	Proudlove *et al.* (2008)	Spear (2005)	Swank (2003)	Womack and Jones (2005)
Define value from the customer's perspective		X	X	X	X	X	X			X
Map processes to identify waste	X	X		X	X	X	X			X
Make those actions that create value flow without interruptions		X			X	X	X			X
Standardize work			X						X	
Level and balance workloads		X							X	
Ensure a high level of quality in processes, striving for zero defects	X	X	X							
Ensure that all activities are pulled by the customer in a just-in-time fashion	X	X	X	X	X	X	X			X
Visualize processes and performance results	X								X	
Develop multifunctional employees	X	X	X	X						
Pursue continuous improvement	X	X	X		X	X	X			X

merged principles that were common among different authors. Then we focused our attention on those principles that were used by more than one author. Out of those principles that were excluded, some were on a detailed level describing elimination of waste, such as placing linked processes next to each other and eliminating loop backs (Swank, 2003). However, most significantly, the conceptualization of lean service used by Spear (2005), turned out to be quite different from the others. Hence, although it is the most cited paper and indeed has an interesting approach to lean, it is not included in our definition. It would also be quite hard to operationalize his definition.

In the work of arriving at the emergent consensus definition, a key issue was thus to distinguish between different "levels" of lean: a strategic and an operational (Hines *et al.*, 2004), which we term "principles" and "practices":

- At the strategic level lean is portrayed as a philosophy rather than a collection of tools and practices (Hines *et al.*, 2004). Literature adopting this view of lean, tends to focus on underlying principles which then manifest themselves in a number of practices on a more operational level (Åhlström, 2004).
- Early literature on lean predominantly focused on the visible aspects of lean, at the operational level (Spear and Bowen, 1999). The operational level includes shop floor techniques and tools, or practices.

Moving from an operational to strategic level definition has the benefit of making the definition more generally applicable (Hines *et al.*, 2004). However, the higher the level of abstraction the harder it is to define operational measures. Thus, in extracting a conceptualization of lean we focused on obtaining a definition that was possible to operationalize. One of the effects of this intention was that the principles we extracted from literature were not always mutually exclusive.

Lean practice items. Almost all previously developed instruments for assessing lean adoption in manufacturing include items for assessing the use of lean practices. Often, these are deduced from a basic set of lean principles (Karlsson and Åhlström, 1996; Sánchez and Pérez, 2001; Shah and Ward, 2007), but there are examples of lean practice items organized by organizational levels (Baggaley, 2006), adoption phases (Sawhney and Chason, 2005) and product life-cycle process, from product development to service after sales and re-sales (Nightingale and Mize, 2002). In our instrument, we use 19 items to assess the level of adoption of lean service practices related to the ten lean service principles extracted from previous literature. It is important to note here that the intention was to strike a balance between attempting to capture "all" aspects of lean service and having a parsimonious instrument. For items and maturity levels, see the Appendix.

Customer value is measured using one item related to identifying customer value and one item related to customer involvement. Identifying customer value has to do with the search for which internal activities that add value from a customer perspective (Young and Mcclean, 2008). Customer involvement focuses on to what extent and in what way customers are involved in the development of the business (Bowen and Youngdahl, 1998). This ranges from annual surveys to close cooperation with customers in improvement efforts.

Identification of waste was operationalized as methods for identifying waste. The item we use relates to the use of value stream mapping of processes. Process mapping is given high importance in the lean service literature and has been suggested to help capture tacit knowledge in semi-autonomous service workers (Arlbjørn *et al.*, 2011;

Teehan and Tucker, 2010). By mapping processes, various types of waste are identified, for example, waiting time between activities and unnecessary transports and movements (Esimai, 2005; Towill and Christopher, 2005).

Flow means that the service flows seamlessly from start to finish in the value stream (Piercy and Rich, 2009). This is measured in our assessment instrument using one item related to workplace design for flow, and one related to connecting the different parts of the process. Workplace design in this case does not merely refer to equipment layout (which may be difficult to apply to a service setting), but rather workplace design in the sense of how easily the tools needed for the job such as information, material and information systems can be accessed. Connecting the different parts of the process leads to increased flow in the sense that the service delivery does not stop, or is put on hold, but instead flows through the process all the way to completion.

Standardization focuses on whether there are standardized tasks and whether these standards are formalized (Papadopoulos *et al.*, 2011). The first item concerns the way of working, is there one agreed-upon way of performing tasks, or is everyone free to perform them in the way they see fit? The second item regards the formalization of those work standards.

Leveled and balanced workload was operationalized by an item that focuses on proactive planning in service to achieve leveling and balancing of workloads as far as possible. Services often demand the customer to be present and or to a high extent involved in the "production" of the service (Apte and Goh, 2004; Swank, 2003). It has been suggested that lean is most suitable for standardized and leveled processes (Arlbjørn *et al.*, 2011), but the involvement of the customer can lead to high variation and difficulties in leveling and balancing workloads. Attempting to eliminate or reduce variability has therefore become key in lean service literature (Iannettoni *et al.*, 2011; Laganga, 2011; Setijono *et al.*, 2010). Proactive planning means that the service organization is actively working to smooth demand and create a more leveled and balanced workflow.

Quality/zero defects is assessed through an item that focuses on whether quality is built in or not. The underlying reasoning is to make sure that quality is built-in from the start, resulting in less need for inspections and quality controls (Åhlström, 2004). This means that the responsibility for quality no longer lies with quality inspectors, but rather with the worker that performs the operation in the first place. Assuring quality is built-in means doing it right the first time, and can be done, for example, through the use of poke-yoke solutions (automatic defect-proofing) (Chase and Stewart, 1994).

Pull is here seen as the signal that initiates work to be performed in order to deliver a service. In a lean system, work starts when there is a specific customer demand (Kim *et al.*, 2006; Proudlove *et al.*, 2008). It is open to debate whether it is in fact possible to use the pull principle in services (Radnor, 2010), given that one of the characteristics considered to differentiate goods from services, is that services are produced and consumed simultaneously. The notion of pull in services is, depending on the service, thus different than in manufacturing since the service may require the participation of the customer, and thus it is not possible to perform many activities without a specific customer demand. Nevertheless, services are heterogeneous and differ substantially. There are also processes in service firms which act on material and information, where it is indeed possible to use the pull principle. This is particularly the case if we look internally in a service organization, where each part of the process is seen as the customer of the previous

part, and the supplier of the next part. This notion of internal customer means that it is possible to initiate work based on customer demand in each part of the process, thus avoiding overproduction and inventory build-up. Thus, services are often complex offerings and it is possible to work ahead to build up a safety margin, store excess inventory or avoid using signals for when each activity should start. Our instrument includes one item for assessing the use of pull, with focus on the notion of internal customers and the signal for starting an activity.

Visualization is operationalized by three lean service practice items: use of visual signals, visualization of general information, and visualization of improvements. Visual signals can be used for signaling the arrival of customers, deviations that need immediate attention, or the location of information and other material needed to perform a specific task. Visualization of information has to do with posting performance results and similar general information (Papadopoulos *et al.*, 2011; Swank, 2003; Åhlström, 2004). Finally, visualization of improvements is often done through the use of a visualization board where ongoing and recently finished improvements are displayed for all to see.

Multifunctional employees are central in lean service (Bowen and Youngdahl, 1998; Caldwell *et al.*, 2005; Laureani *et al.*, 2010; Åhlström, 2004). We have operationalized this principle by items that assess two lean practices: one item related to measuring and following up work by employees themselves, and one item related to the use of multifunctional teams. As employees are encouraged to improve the process and the operations they perform, there is an increase in employee involvement and responsibilities. As responsibilities are transferred and employees empowered, employees themselves as opposed to specialists, measure and follow up work. The second item: multifunctional teams, relates to putting together teams of people from all functions that have an involvement in the process or the segment of a process that is in focus for the team's improvement efforts.

Continuous improvement is an integral part of lean service (Kollberg *et al.*, 2007; Liker and Morgan, 2006; Womack and Jones, 2005) and researchers have stressed practices related to problem solving by those who do the work (Staats *et al.*, 2011), and related to sustainability of improvements (Murphree *et al.*, 2011; Sokalski *et al.*, 2010). In the instrument we used four items designed to assess continuous improvements: employee participation in improvement teams, improvement work, structured problem solving, and sustaining improvements. The participation of employees in improvement teams where problems are brought up and systematically solved by the people that actually do the work is the basis of this lean principle. The second item assesses the focus of those improvements. In the beginning of lean adoption the focus of improvements is often on short-term solutions to what can be called "symptoms" of the real problems, whereas more advanced teams focus long-term solutions to root causes of problems. The third item relates to the techniques used by employees in improvement work and includes the use of different problem solving tools. The last item focuses on how improvement gains are sustained over time, and focuses on how you know that you do not slip back to doing things the way they used to be done.

5.3 Performance

As we could see previously, the instruments that exist for assessing lean adoption in services mainly focus on outcomes from lean adoption, i.e. operational performance

in the form of lead times, inventory, productivity and quality. Recent contributions to lean service research also stress the importance of measuring actual performance improvements (Staats *et al.*, 2011). In our instrument, we have included the four types of items from previous lean service assessment instruments, and added two items: cost and customer satisfaction. Service processes are heterogeneous in nature and in for instance a public or a private organization, the definition and measure of operational performance measures such as quality or customer satisfaction will necessarily differ. Based on the general performance measures we have suggested, each organization can, using their own definition of those operational measures, develop items suited to assess the performance of their specific process. The formulation of these items will thus need to be developed specifically in relation to the type of service being assessed.

5.4 Maturity level definitions

We started by developing general definitions of maturity levels based on the generic maturity level descriptions developed by Nightingale and Mize (2002). They developed their instrument based on a capability maturity model format. This format implies determining the most important factors for performance. For each factor, a series of maturity levels are defined, such that progressively greater levels of capability are reflected as the organization "matures" in its performance on that factor. The descriptions of the levels were in our study adapted to suit the purpose and service setting for our instrument. For the resultant maturity level descriptions, see Table IV.

Using these generic descriptions, we went on to develop specific maturity level descriptions for each item in the instrument, see the Appendix.

6. Concluding discussion

We set out in this paper to develop and validate an instrument for assessing the level of adoption of lean in services. The instrument is thus our contribution. Based on the extant literature on assessing lean adoption in manufacturing, we developed a number of desirable characteristics of the instrument. The instrument therefore incorporates items for assessing enablers for lean adoption, lean practices, and performance. To enable self-assessments by practicing managers, the instrument uses specific maturity levels for

	Generic definition of maturity levels
Level 1	No adoption: problems are often explicit and solutions often focus on symptoms instead of causes
Level 2	General awareness: start of searching for proper tools and methods, problem solving is becoming more structured. Informal approach in a few areas with varying degrees of effectiveness
Level 3	Systematic approach: most areas involved, but at varying stages. Experimentation using more and more tools and methods and employees start following-up work using metrics
Level 4	On-going refinement: all areas involved, but at varying stages. Improvement gains are sustained
Level 5	Exceptional, well-defined, innovative approach: all areas are involved at the advanced level. Improvement gains are sustained and challenged systematically. Innovative solutions to common problems, recognized as best practice/role model

Source: Adapted from Nightingale and Mize (2002)

Table IV.
Definition of generic maturity levels

judging the level of lean adoption on each of the included items. The instrument development process included in-depth interviews with expert practitioners and academics. We also conducted two rounds of qualitative validation in a company currently adopting lean service. The instrument was found to be able to discriminate between high and low adoption of lean as well as portray changes during a period of lean adoption.

There is a lack of conceptual clarity in research on lean service which has led to difficulties in defining operational measures. This is unsurprising given that lean service shares its conceptual confusion with lean manufacturing (Pilkington and Fitzgerald, 2006). Bearing in mind that empirical research on lean service is in its infancy, it is important to move it forward by shifting focus from descriptive contributions to developing operational definitions of lean practices, as has happened in the more mature research field of lean manufacturing. This will allow researchers to measure the level of lean adoption, and using this information, to develop knowledge of, for instance, the contingencies to lean service adoption, the problems and pitfalls in adoption and the feasibility of transferring lean practices to various service settings. The importance of defining operational measures of lean service is now greater than ever, as lean service is increasingly being seen as a philosophy rather than as a set of tools and techniques. To this end, we base our instrument on an emergent consensus definition of lean service, based on a review of the ten most cited papers on lean service.

Apart from its academic contribution, a key intention with the assessment instrument is that it should also be useful for practicing managers. This usefulness should be seen against the fact that the practical interest in adopting lean in services is increasing rapidly. However, the challenge in adopting lean is often underestimated. Given the high risk of failure and the substantial investments necessary for such a transformation, there is a case for assessing whether the adoption process is progressing or not, and if so, at what pace. Furthermore, in many service settings, companies have numerous geographically dispersed service sites. This leads to managerial challenges relating to how to overview the progress of lean adoption in the sites and the need for an early warning system indicating deviations from the lean adoption plan in order to focus managerial time and resources in the best way. Traditional financial measures are not suited for portraying such a movement and may even deter process improvements (Schonberger, 2008; Swank, 2003). A lean service assessment instrument complements traditional financial measures, and acts as an early warning system signaling whether the adoption of lean is progressing as planned or not.

In using the assessment instrument, two things are necessary to take into consideration. First is the dynamic nature of lean. An absolutely fundamental characteristic of the lean concept is the focus on continuous improvement, the relentless pursuit of perfection. This means that any lean practice is likely to evolve over time. What is considered an "exceptional, well-defined and innovative approach", to quote our own maturity levels, today is likely to be different tomorrow. Thus, to assess the level of lean adoption, one needs to be aware that maturity levels are likely to need to be updated over time. Furthermore, there is also a need to be sensitive to the fact that principles, practices and tools used for lean service adoption, may develop and change over time. As the field of lean service matures and organizations in various industries gain more experience from adopting lean, there may be a need to update the items included in the instrument. Thus, any assessment instrument needs to be dynamic. We have endeavoured to design the instrument to enable it to be useful over the medium-term, approximately five to ten years,

but it is nevertheless important to be aware that the instrument may need to be iterative, and change over time.

The second thing to take into consideration in using the instrument is the heterogeneous nature of services. Services are not a uniform phenomenon and often cover the largest part of the economic activity in developed countries. Correspondingly, there are several ways of classifying services (Chase, 1978; Maister and Lovelock, 1982; Schmenner, 2004; Silvestro *et al.*, 1992), based on for instance volume, variety, degree of customer contact and degree of customization. These are all dimensions that are likely to affect the operationalization of lean principles. Perhaps most importantly, there is also a key distinction to be made between private and public services (Radnor, 2010). Thus, the type of service is likely to have an impact on how lean is defined and assessed. This will inevitably have an influence on the general applicability of the instrument we developed. In addressing the consideration of the general nature of the instrument, a few things need to be noticed.

First of all, we developed our assessment instrument based on an emergent consensus definition of lean services. Thus, we drew on a wide selection of widely cited definitions of lean, increasing the chances that our definition had a wide coverage. Thus, we believe that the items that aim at assessing the level of adoption of the lean principles may not be much affected by the type of service operation. Second, we based our maturity levels on a general definition, where we borrowed from existing literature on assessing lean in manufacturing. Nevertheless, our development and validation process did take place in one specific service setting. This may serve as a limitation to the instrument. Although the generic definitions of maturity levels can also be expected to hold for different service types, the definition of specific maturity levels may need to differ between different service operations, and the extent of adaptation needed will probably depend on the service type.

In so far as it is necessary to modify dimensions of the assessment instrument, researchers and managers alike can follow the development and validation process described in this paper. The starting point is always the employed definition of lean. As a first step, this definition needs to be broken down into a number of operational practices. Then it is a matter of devising a list of items to measure the enablers, practices and performance. The third step is to define maturity levels for each item, based on the generic definitions described earlier in the paper. The specific maturity level definitions may vary substantially between different types of services, whereas the basic principles and items will probably be more generally useful as will the generic maturity level definitions.

The developing research field on lean services is so far characterized by its highly descriptive nature. Most contributions focus on describing the use of lean practices in various organizational settings, although predominantly in healthcare. A key focus in literature has been to determine the transferability of lean practices, from their origin in manufacturing to services. Most contributions are either single case studies or conceptual discussions. Rigorous empirical studies are scarce. The instrument that we developed and validated in this paper can contribute to further our understanding of lean adoption in services. While the instrument was developed with the aim of being of use for a variety of service operations, validation took place in one service setting. In the future, it would be valuable to test its usefulness in assessing the level of lean adoption in different types of services, ideally over an extended period of time.

In addition to this extended scope of validation of the instrument, we suggest that the instrument can be used in research on contingencies of lean service adoption as

well as in research on barriers and enablers in the process of adopting lean service. By using the instrument as either a sampling frame, selecting polar, or similar, cases, or by tracking changes during a period of lean adoption, researchers can empirically study the "messy and sometimes meandering trajectory" (Papadopoulos *et al.*, 2011, p. 185) of lean service adoption. This will allow researchers to explore questions that remain unanswered in the lean service literature, such as why different service sites develop differently over time when adopting lean service, and what distinguishes sites that have a high level of adoption of lean, from those that have a low level of adoption of lean. Extending the scope from descriptive studies focused on transferability of lean practices from manufacturing to services, to rigorous empirical studies of contingencies and the adoption process will add valuable insights that will further our knowledge in this emerging field.

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Appendix. Lean service assessment instrument

Enablers

Employee training, commitment and understanding. Employee training:

- No training in lean for employees.
- Start of training: some employees trained.
- All employees attended some training in lean, but competence in improvement techniques varies.
- All employees attended training in improvement techniques and the underlying ideas of lean.
- All employees continuously train in different aspects of improvement work and are considered highly competent in improvement work.

Employee commitment:

- No commitment to lean, openly negative towards lean or does not display any commitment.
- Sees lean as a temporary project and is willing to dedicate limited time and energy for improvement work now.
- Expresses support for lean and dedicates time and energy for coming up with improvement ideas, but does not take an active role in problem solving and adoption of new ways of doing work.
- Actively participates in improvement work, comes up with improvement suggestions, sees problems through to long-term solutions and is a driving force for lean adoption.
- Exceptional approach to employee's role in lean. Sees improvement work as an important part of everyday job. Equal focus on new solutions and sustaining previous ones.

Employee understanding:

- Employees cannot explain the lean concept.
- Employees focus on housekeeping aspects of lean when explaining the concept.
- Employees focus on internal efficiency when speaking of lean.
- Employees describe lean in terms of processes and flow.
- Employees are able to describe what the ideal flow would look like and how they work towards that in their everyday work.

Management commitment and understanding. Management commitment:

- No commitment to lean, openly negative towards lean or does not display any commitment.
- Sees lean as a temporary project and is willing to dedicate limited time and resources for improvement work now.
- Expresses support for lean and approves time and resources for improvement work, but does not take an active role in the adoption (sees it mainly as something for employees to do).
- Asks questions in a coaching manner regarding problems and improvement suggestions and is a driving force for lean adoption.
- Exceptional approach to manager's role in lean. Ask questions in a coaching manner that has led to innovative solutions by employees. Equal focus on new solutions and sustaining previous ones.

Management understanding:

- Managers cannot explain the lean concept.
- Managers focus on housekeeping aspects of lean when explaining the concept.
- Managers focus on internal efficiency when speaking of lean.
- Managers describe lean in terms of processes and flow.
- Managers are able to describe what the ideal flow would look like and how they work towards that in their everyday work.

Infrastructural elements. Time for improvement work:

- No time specifically allocated for improvement work.
- Infrequently, some time is allocated for improvement work.
- Frequent improvement meetings or similar in most areas, but teams are at varying stages.
- Frequent improvement meetings or similar in all areas means everyone is involved in improvement work.
- Exceptional approach where improvement work is part of everyday work for all employees.

Resources for improvement work:

- No investments or resource allocation as a result from improvement work.
- Some investments in connection to lean adoption, such as visualization board, etc.
- Some visible investments/resource allocation in most areas as a result from improvement work.
- Several visible investments from improvement work, focused on facilitating individual tasks.
- Visible investments throughout the service site in connection to lean adoption, focused on enhancing customer value and/or process flow.

Change agent:

- No local change agent/expert practitioner.
- Local change agent selected and appointed.
- Change agent has undergone appropriate training in lean.
- Change agent is a driving force for improvement work, works closely with teams and acts as motivator.

- Exceptional approach to the role of change agents. Change agent is considered an expert resource for improvement teams.

Bi-directional vertical information flow:

- No bi-directional vertical information flow. Employees do not have a way of forwarding information to different levels of management, and they rarely get information from management.
- Starting to use methods for forwarding information and issues between employees and different levels of management, but informal approach in a few areas.
- Forwarding of information between employees and different levels of management is done in a systematic way in most areas of the organization.
- Forwarding of information between employees and different levels of management is working well in all areas of the organization, and employees continually receive information and responses. Ongoing refinement of the approach.
- Exceptional approach to bi-directional vertical information flow. Forwarding of information daily from the improvement teams all the way through to the business unit and head office. In the same way, information is continually fed back to improvement teams from different levels of management.

Lean practices

Customer value. Identification of customer value:

- No real effort to understand customer value.
- Start searching for ways to understand customer value, but informal approach at varying levels in different areas of the organization.
- Most areas in the organization are actively discussing what customer value is, and which activities add to that or not.
- Most employees can see and describe what activities are value adding or not for the customer and in their own work they can identify what part of their activities add to customer value and which do not.
- Exceptional, innovative approach to identification of customer value, recognized as best practice. Customer value has been redefined and is constantly challenged. All employees can see what part of their activities add to customer value and which do not.

Customer involvement:

- No direct interaction with customers. Feedback received through, for example, yearly customer satisfaction surveys or complaints.
- Infrequently customers are asked for feedback, but solutions are often *ad hoc* and focusing on symptoms rather than root cause.
- Customers are often asked for feedback, which is used for improvement work.
- Customers are routinely asked for feedback, which is used for improvement work and as inspiration for challenging the processes.
- Exceptional approach to involving customers. Evidence of innovative solutions developed from customer feedback and customers receive information on improvements made.

Identify waste. Value stream mapping:

- No value stream mapping.

- Some processes or sections of processes may be mapped, but with varying quality and/or not always up to date. Non-value adding activities are identified based on recurring internal problems.
- Major repetitive processes have been mapped, but with varying quality and details. Non-value adding activities are identified based on customer perspective.
- Detailed and updated process maps. Process maps are visualized in the workplace and updated more often than once per year.
- Exceptional use of value stream mapping. Process maps are continuously updated and used for continuously challenging activities from a customer perspective.

Flow. Workplace design for flow:

- Work area is disorderly and employees spend a lot of time searching for information and other resources needed to do the job.
- Start searching for a way to organize the workplace, discussions around location of information and resources availability.
- Information and resources have been sorted and organized for easy retrieval.
- Information and resources located based on when and where they are needed in the process in order to facilitate flow.
- Exceptional and innovative location of information and resources for process flow. It is possible to see the most recurring processes by looking at the organization and location of resources and information.

Connecting the process:

- All organizational areas work towards own goals, no process awareness.
- Starting to connect different areas into a value chain, but informal approach. Often some blaming of others when problems occur (delays or quality).
- Most areas of the organization working together to connect cross functional processes. Still some acceptance of time buffers in between areas that are not always transparent, but less blaming of others.
- All areas are working together to connect activities without delays. The operational components of the service are performed one directly after the other and any time buffers are challenged. No blaming between areas.
- Exceptional approach to connecting the process cross-functionally. All areas working together to continuously challenge and improve the process activities based on insights related to customer value and process flow.

Standardization. Standardized tasks:

- No use of standardized tasks.
- Start using standardized tasks in some areas, may not be written down or in forms of simple checklists.
- Use of standardized tasks in some selected areas, starting to become more explicit, detailed and written down.
- Use of standardized tasks in most areas. Starting to follow up if agreed-upon standards are used at all times.
- Exceptional use of standardized tasks in all areas. When deviations (quality, time, etc.) occur, the standard is used as a guide to find the reason (was standard followed?, If yes – improve standard, if no – why? Training needs or other reason? Etc.).

Formalization of work standards:

- No formal work standards.
- Development of work standards has started in some areas. Informal approach and often in forms of checklists.
- Work standards are appearing in most areas. Experimentation to find appropriate format and level of detail.
- Formalized, explicit and detailed work standards exist in most areas.
- Exceptional and innovative use of formal work standards. Standards are continuously challenged and updated.

Level and balance workloads. Proactive planning:

- No proactive planning. Variations in customer arrival time and resources needed are largely unforeseen.
- Starting to analyze variations in customer arrival time and resources needed for different types of service offerings.
- Internal resources are planned based on forecasts of customer arrival times and typical resources (time, physical resources and competence) needed for different types of service offerings.
- Working with early customer contact in order to accurately foresee resources (time, physical resources and competence) needed for each specific job. Internal resources are planned accordingly.
- Innovative, exceptional approach to proactive planning. Using innovative methods for educating and influencing customers in order to reduce process variability.

Quality/zero defects. Built-in quality:

- No notion of built-in quality. Quality control either takes up much time or there is little quality awareness in general.
- Start searching for instruments and methods to assure quality is built-in, but informal approach in few areas.
- Structured approach in some areas using experimentation to find the best way of assuring quality in work without having to control.
- Most areas are actively working to assure built-in quality. Use of poke-yoke solutions and employees control quality themselves before finishing a job.
- Exceptional approach to built-in quality. Work tasks have been specifically designed to assure quality is built-in and very little time is spent on checking quality.

Pull. Pull system:

- No pull system, operations, parts, etc. are performed and/or stored without specific customer need.
- Starting to use pull and create efficient handovers between different parts in the chain, but with varying degrees of effectiveness. Working ahead to have a safety margin is still common.
- Experimentation with signals for when each step should start working to avoid overproduction and other types of waste. Most areas involved, and the notion of internal customer is becoming more and more known.
- Use of pull in all areas and processes, but at varying stages. Each step in the chain is aware of the status of the previous and next step and has a signal for when to start working. Improvement gains are sustained.

- Exceptional approach to using a pull system in service. Continuous challenging of the pull signals used to avoid wastes connected to operations and storage which are not demanded by the customer.

Visualization. Visual signals:

- No use of visual signals.
- Start using visual signals in some areas, signalling, for example, location of different types of resources but to a varying degree and possibly not always up to date.
- Visual signals used to facilitate work in some areas, signalling not only location of resources but also process progress and starting to visualize some deviations.
- Extensive use of visual signals in all areas to draw attention to multiple types of deviations.
- Exceptional and innovative use of visual signals in all processes. It is possible for anyone to see the current situation and any problems or deviations by looking at visual signals in the workplace.

Visualization of information:

- No visualization of general information.
- Some general information visualized in some areas, such as safety instructions, etc. but informal approach.
- Most areas experimenting to find the appropriate way of, and place for, visualizing different types of information.
- Systematic visualization in all areas of the organization of information needed in the right place. Information visualized is diverse and based on need (general company information regarding the performance as well as work and safety instructions in different locations in the workplace).
- Exceptional, innovative visualization of general information, recognized as best practice/role model. Visualized information is diverse (not only safety instructions, but also company performance or critical parts of work standards, for example) and in appropriate place in order for employees to benefit from it.

Visualization of improvements:

- No visualization of improvements.
- Informal approach to visualizing improvements. Some visualization (photos or similar) of improvements have been put up in some areas. Searching for ways of visualizing improvements.
- In most areas, improvements are visualized in central locations. Information is updated and there is experimentation with regards to what to visualize.
- All areas are visualizing improvements in central locations. Information is updated and there is a diversity of information (for example, evidence of root cause analysis, measurement of frequency of different problems, etc.).
- Exceptional and innovative visualization of improvements, recognized as best practice/role model. Diverse information regarding improvements (for example, evidence of root cause analysis, measurement of frequency of different problems, etc.) visualized in a central area of the workplace.

Multifunctional employees. Employees measure and follow up work:

- No following-up of work by employees themselves. Metrics used to evaluate are commonly set by head office and difficult for employees to affect.

- Start searching for methods for following up the work and processes locally, but informal approach in few areas.
- Starting to measure and following up some work by employees themselves, local metrics are starting to appear.
- Measuring and following up work in most processes but at varying stages. Metrics follow up process rather than individual.
- Exceptional approach to following up processes by employees in all areas. Innovative metrics are developed and used by employees to follow up process improvements.

Multifunctional teams:

- No multifunctional teams (teams are often organized by function).
- Informal approach to multifunctional teams in some processes or some parts of a process. General awareness and focus on developing multifunctionality in teams and individuals increasing.
- Most areas are starting to use multifunctional teams. Experimentation with the appropriate level of multifunctionality on individual and team level.
- All employees participate in teams that span functional boundaries and follow parts of the process. These teams contain staff with diverse skills and teams are responsible for several aspects of their part of the process flow.
- Exceptional, innovative use of multifunctional teams spanning functional boundaries. Recognized as best practice/role model. Appropriate level of multifunctionality in individuals and teams for the specific type of service process.

Continuous improvement. Employee participation in improvement work:

- No improvement work by employees.
- Start of improvement work. Informal approach in a few areas, all staff does not participate.
- Most staff participates in improvement work, but at varying levels. Experimentation with time, participants and agenda for improvement work meetings.
- All employees participate in improvement work, but level of activity varies in different areas. Participation is based on knowledge of the process in focus for the meeting.
- Exceptional participation in improvement work in teams. All employees participate actively in improvement work regarding processes that they are part of. Recognized as best practice/role model.

Focus of improvement work:

- Improvement activities are *ad hoc* and there is no clear focus of improvement activities.
- Improvement activities focus on improving the working environment, housekeeping, etc.
- Improvement activities are mainly focused on issues related to the working environment, housekeeping, repair of tools, etc. but in some areas process improvements are starting to appear.
- Issues related to process flow and customer value in improvement work are becoming predominant in all areas.
- Exceptional and innovative improvement work. Recognized as best practice/role model. Continuously improving the entire flow (not just a function) is part of everyday work for all employees.

Structured problem solving:

- Improvement activities are *ad hoc* and not part of a systematic approach. Often focus on symptoms and not real root cause. Problems are solved in "fire fighting" manner.
- Start of systematic improvement work. Searching for the root cause of problems, starting to use problem solving tools.
- Root cause analysis and other problem solving tools are being used routinely. Employees are proficient in problem solving techniques.
- Improvement work as experimentation, where outcome after implemented solution is assessed and adjustments made accordingly.
- Exceptional approach to improvement work. Improvements are made not just by solving apparent problems, but also by challenging the current situation.

Sustaining improvements:

- Earlier improvements are not sustained.
- Increasing awareness of the importance of sustaining earlier improvements. Start searching for proper methods for securing that improvements are sustained over time.
- Most areas have a systematic way of checking whether agreed upon improvements are followed. If they are not followed, reasons are discussed.
- All areas have a way of assuring that agreed upon improvements are sustained over time. If they are not followed, reasons are discussed and there is evidence of changes to work standards or similar based on those discussions.
- Exceptional innovative approach to ensuring that improvements are sustained involving both employees and managers. If improvement is no longer in use, reasons are discussed and if necessary the improvement is updated based on the findings of this analysis.

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