MODELING MANAGEMENT IN LEAN PRODUCTION ENVIRONMENTS: A STUDY OF ITALIAN SMES

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ABSTRACT

This study investigates the management behaviors associated with successful processes of lean transformation applying regression and non-parametric statistical analysis to an original dataset coming from field research on 26 processes of lean transformation in North Italian small and medium manufacturing enterprises. We test if a repertoire of lean management behaviors drawn from the literature captures the essence of management in lean production environments, and find that these behaviors actually correlate with the degree of advancement of the lean transformation process.

Keywords: lean thinking, management behaviors, dynamic capabilities, routines, competencies

INTRODUCTION

Since the groundbreaking work of the International Motor Vehicle Program at MIT (Womack, Jones & Roos, 1990), the understanding of the determinants of the superior performance of companies adopting the Toyota Production System (TPS) has progressively changed. Initially the focus was on the idea that superior performance was driven by the application of one or few lean tools such as kan-ban, 5S, cell manufacturing or TPM. Then, the attention shifted to the idea that it is the integrated adoption of such tools into a system that makes the difference, as well as the associated human resource practices (Spear & Bowen, 1990; MacDuffie, 1995; Shah & Ward, 2003). At the same time, it became clear that, on the one hand the principles of lean thinking underlying the tools were more important than the tools themselves, and that those underlying principles were to be applied not only in manufacturing, but across the organization and across organizations (Womack & Jones, 1996; 2005). The ability to apply those principles and to consistently manage by them over time has been interpreted as a core and dynamic capability of a firm and the possible foundation of sustained competitive advantage (Fujimoto, 1999; Anand et al., 2009). More recently, increasing attention has been given to the role of management in lean environments and, more specifically, to the characteristics of the management system that support lean transformations (Shook, 2008; Rother, 2009), and to the competencies, leadership traits and behaviors of managers in lean environments (Liker, 2004; Liker & Hoseus, 2008; Womack, 2011).

While some studies have described the management systems of "lean firms" like Toyota (Liker, 2004), Danaher (Koenigsaecker, 2009), Harley Davidson (Oosterwal, 2011), Wiremold (Emiliani, 2007), Alcoa (Spear, 2009) and others, there has been little specific theorizing and large scale empirical investigation of what are the management behaviors, competencies and leadership traits that drive lean transformation processes and how they refer to the outstanding literature about lean production, strategic management, organization and leadership. Put differently, while by now we can recognize firms that have successfully realized lean transformations from how their processes

operate and drive results, it remains unclear what do managers do in lean environments and how this allows to align a firm's purpose, processes and people.

This study wishes to fill this research gap and contribute to the "lean thinking" literature and debate providing: a) a repertoire of lean management behaviors that can be used as a reference for lean scholars and practitioners; b) a set of empirical tests, based on field research and first-hand, firm-level data collection, to assess if and to what extent the behaviors usually assumed and maintained as associated with lean production are actually practiced by the managers of firms engaged in lean transformation processes.

In order to do that, we build on the existing research about what do managers do in lean environments and apply regression and non-parametric statistical analysis on an original data set from 26 processes of lean transformation in North Italian small and medium manufacturing enterprises (SMEs) to identify the management behaviors that characterize firms undergoing lean transformations as well as the distinctive management behaviors that differentiate the firms at advanced stages in the lean transformation process. We test what characteristics, after controlling for size, type of firm, and duration of lean efforts are positively and significantly correlated with the degree of advancement of the lean transformation process. More specifically, this study wishes to test if: a) any of the management behaviors reported in the lean management literature are systematically associated with lean transformations; b) the diffusion and intensity of these management behaviors positively co-vary with the stage of advancement of lean transformation processes; and c) any of these management behaviors differentiate firms that are at more advanced stages of their lean transformation processes.

RESEARCH CONSTRUCTS, VARIABLES AND MEASURES

Since the aim of this study is to map lean management behaviors onto the stage of advancement of lean system implementation, we designed the research methods accordingly.

Dependent Variable: the Degree of Advancement in the Lean Transformation Process

Our dependent variable is the Degree of advancement in the lean transformation process. We follow Shah and Ward's (2007) integrated definition of lean production as an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer and internal variability that manages variability in supply, processing time and demand (Hopp & Spearman, 2004; de Treville & Antonakis, 2006). Similarly, we build on the outstanding empirical evidence about the integrated nature of lean (MacDuffie, 1995; Hackman & Wageman, 1995; Flynn et al., 1995; Imai, 1997; Samson & Terziovski, 1999, McKone et. al., 1999; McKone et al., 2001; Fullerton & McWatters, 2001; Cua et al., 2001; Challis et al., 2002; Kaynak, 2003; Fullerton et al., 2003; Shah & Ward, 2003; Nahm et al., 2004; Bou & Beltran, 2005; De Menezes & Wood, 2006; Colombo, Dalmastro & Rabbiosi, 2007; De Menezes et al. 2010) to construct our measure.

We measure the Degree of advancement in the lean transformation process as the mean value of the scores deriving from an on-site assessment conducted by a separate sub-teams or researchers on a set of 30 lean management systems characteristics. The details about the measure, items and scaling are reported in Table 1.

TABLE 1. DEGREE OF ADVANCEMENT IN THE LEAN TRANSFORMATION PROCESS: LIST OF ON-SITE ("GEMBA WALK") ASSESSMENT PARAMETERS

1. Lean in strategic planning	16. Defects detection and prevention (Pokayoke)
2. Lean Strategy deployment	17. Stopping production policy (Andon)
3. Change attitude	18. 5S
4. Management Commitment	19. TPM
5. Management style	20. Setup Reduction
6. Workforce Competence & Training	21. Material Storage
7. Workforce Empowerment and Responsibility	22. Material Contaners
8. Workforce Rewards & Recognition	23. Supplier Pull
9. Pull System	24. Lean Supply Chains
10. Level Schedule	25. Product development
11. Continuous flow	26. Kaizen
12. Takt time	27. Problem Solving
13. Plant Layout	28. Visual management
14. Shop floor layout	29. Standardized Work
15. Man-machine separation	30. Safety

* Each item may range from 1 (low LA) to 5 (high LA). The specific scaling and corresponding descriptions are available upon request.

The 30 parameters of the assessment summarize the tools, routines, artifacts and practices that typically characterize a lean management system and are derived from the above reviewed literature. They are geared towards evaluating the degree of advancement in the lean transformation process regarding the various observable components of lean management systems. The 30 parameters are clustered into eight summary dimensions: *Lean in strategy, Management commitment to lean, Lean people management, Lean tools, Material management, Supplier management, Innovation management* and *Continuous improvement tools*. The 30 parameters may range from 1 (low degree of advancement) to 5 (high degree of advancement). As described below, for some of our analysis we ranked the firms in the sample on the basis of their overall degree of advancement in their lean transformation process.

Our measure (LA) follows:

$$\textit{Degree of advancement in the lean transformation process (LA)} = \frac{\sum_{i}^{n} V_i}{n} \qquad (1)$$

where LA is the degree of advancement in the lean transformation process, V_i is the value of advancement of lean item i, and n is the number of items. LA may range from 1 (low degree of lean advancement) to 5 (high degree of lean advancement).

Independent Variable: Lean Management Behaviors

Our independent variable is the degree of adoption of lean management behaviors. In order to define and measure it, we refer to the above reviewed increasing body of research about the behavioral component of lean management systems (Shook, 2008; Rother, 2009; Womack, 2011). More specifically, we focused and built on the repertoire of lean management behaviors pioneered by Womack (2008a, 2008b, 2009, 2011) and the Lean Enterprise Institute, elaborating, operationalizing and complementing these behaviors with others drawn from other lean management and lean leadership-related works (Ohno, 1988; Liker, 2004, Rother, 2009, Liker & Hoseus, 2008; Sato, 2008). Besides, apart from the management behaviors and leadership traits - like "go and see", "ask why", "show respect" - highlighted by studies on the Toyota Way (Liker, 2004; Liker & Meier, 2006, 2007; Liker & Hoseus, 2008), we also drew upon other similar works (Emiliani, 2003 & 2008; Lakshman, 2006; Koenigsaecker, 2009; Bicheno & Holweg, 2009), upon the few existing analytical quantitative studies conducted to date on the topic (Found, Van Dun & Fei, 2009; Van Dun, Hicks &Wilderom, 2010), and other relevant management literature.

As above mentioned, Womack lists a set of "lean management" behaviors contrasting them with "modern management" behaviors. Elaborating on Womack's framework, we consider the following set of lean management behaviors: 1) Organizational horizontality; 2) Managerial responsibility; 3) Process-based evaluation; 4) Iterative planning; 5) Managerial versatility; 6) Gemba-based managerial development; 7) Fact-based decision making; 8) Scientific method-based problem solving; 9) Standards development; 10) De-hierarchization; 11) Managerial reflexivity; 12) Teaching; 13) Open-mindedness; 14) Challenge.

Furthermore, in order to offer a more fine grained analytical scheme and build a robust measure of the presence and intensity of lean management behaviors, we articulated Womack's framework developing, for each lean management behavior in the list, a scale able to capture the diverse degree of application of the original lean management behaviors. Indeed, the original lean management behaviors included in the set defined by Womack simply contrasted opposed extreme behaviors. Using that framework would oblige us to classify the real, observed management behaviors as belonging either to the modern or to the lean management approach, losing important information and neglecting significant variation in management behaviors. Based on previous research (Camuffo & Volpato, 1995; Camuffo & Micelli, 1997; Camuffo & Gerli, 2007), our direct knowledge of the lean transformation processes going on in several Italian firms and a preliminary thematic analysis of some of the interviews conducted for the study, we came to conclude that most of the real management behaviors observed in lean firms could not be simply categorized as "modern" versus "lean", but required a more fine grained scaling since they could often be considered as intermediate between the two opposites. This is the reason why we articulated some of the considered managerial behaviors into a sub set of specific behaviors which better capture and measure if and to what extent the real, observed behaviors adhere to the "lean management" approach. The subsets of specific behaviors were developed according to the "Just noticeable differences scales" (JNDS) approach, whose adoption in social sciences, and in particular in economics and psychology has been widely acknowledged (Spencer & Spencer, 1993; Stevens & Stone, 1959; Luce, 1956). The considered set of lean management behaviors as well as their articulation into subsets of behaviors and the corresponding scales are summarized in the Appendix.

In order to compute the frequency of occurrence of each lean management behavior we used the following measure:

$$F_{i,j} = \frac{\sum_{n} CB_{i,n} W_{i,n}}{\sum_{n} PB_{i,n}} \qquad (2)$$

with:

$F_{i,j}$: Frequency of management behavior *i* detected in the firm *j*;
$CB_{i,n}$: Coded Behaviors: number of times that the action *n* associated to the behavior *i* was detected in the interview conducted in the firm *j*;
$W_{i,n}$: Weight associated to the action *n* (from -1 to +1 according to the consistency to a modern management approach or to a lean management approach) associated to management behavior *i*;
$PB_{i,n}$: Potential Behaviors: the maximum number of weighted actions associated to the behavior *i* detectable in the interview conducted in the firm *j;*
i : Analyzed behaviors (from 1 to 14);
n : Actions (sub-set of behaviors) associated to each behavior (from 2 to 5 according to the articulation of each lean management behavior into sub-behaviors deriving from the repertoire in Appendix).

As a consequence, our measure for the overall presence of lean management behaviors (LMB) in each of the sampled firms follows:

$$\textit{Lean management behaviors in firm j } (LMB_j) = \sum_{i}^{n} F_i \qquad (3)$$

where LMB is the degree of presence of lean management behaviors, F_i is the weighted frequency of lean management behavior i, and n is the number of management behaviors.

DATA AND METHOD

In order to address the above identified research questions, we conducted an empirical study of a sample of North Italian small and medium enterprises, already engaged, though at different stages, in lean transformation processes. These firms were selected with the aid of lean experts and local employer associations, according to the following criteria: a) they were companies that had experienced positive financial performance in the 2006-2010 period; b) they were companies that, in the same period, had made a significant commitment to the adoption of a lean system. Applying the lean thinking principles (Womack & Jones, 1996) and the Toyota Way philosophy of "go and see, ask why and show respect" (Liker, 2004) to our research approach, we decided not to use secondary data or survey based research methods but instead opted for field research and constructed an original data set built on company visits and interviews with managers. We opted for direct observation of the "gembas" and behavioral/organizational event interviews as data sources for our research (see below for details) because, consistently with the "lean philosophy" we were more interested in the "theory in use" by the managers of the analyzed firms than their "espoused theory" (Argyris & Schoen, 1978).

Our sample was made up of 26 firms. They can be considered a representative sample of the small population of Italian SMEs actively pursuing and successfully engaged in lean transformation processes, although their stage of advancement in the lean transformation process varies. More specifically, these can be considered as a representative sample of the "best lean SMEs in Italy".

Approximately 42% of the firms in the sample started their lean journey more than 5 years ago, while 19% of them started it only in the last two years. These firms belong to many industrial sectors, such as mechanics (42%), furniture (14%), electronics (8%), packaging (8%), motor vehicles (4%), domotics (4%), child equipment (4%), wine (4%), laundry-home care (4%), plastics (4%), industrial gases (4%). Sizewise, about 65% of them has revenues between 10 to 50 Mln. euros, 31% more than 50 Mln. euros, and the remaining 4% less than 10 Mln euros. 69% of the firms in the sample has between 50 and 250 employees, while 27% has more than 250 employees and only 4% has less than 10 employees. Finally, approximately 35% of the firms in the sample are part of a larger multinational group.

With regard to the assessment of the degree of advancement in the lean transformation process (the study dependent variable), each company assessment was conducted by a separate sub-team of researchers through an extensive "Gemba walk" in the main production plant, R&D and engineering and purchasing and supply chain management facilities, talking with managers, engineers and workers and observing the facilities, technologies, operations, and artifacts.

The detection of lean management behaviors was conducted through interviews by a different subset of researchers. The interviewees were the kaizen promotion office chief or top lean agent (in some cases, namely for the smallest firms, these coincided with the owner or managing director of the firm). These features of the research design (separate sub teams of researchers, different

methods and respondents) were aimed at preventing problems of endogeneity and avoid single respondent bias (Podsakoff et al., 2003; Mackenzie et al., 2011).

The interview protocol used by the team of interviewers included a standardized, five-section interview. Section 1 of the interview investigates the motivation and start of the lean journey of the company and is aimed at describing the initial implementation of lean management in the firm; some of this information was then used as control variables in the statistical analysis. Section 2 of the interview explores the process of lean implementation investigating the first implemented lean tool. Section 3 of the interview investigates the first significant results obtained thanks to the implementation of lean thinking. Section 4 of the interview entails the narration of 2 or 3 specific events - during the lean transformation process - in which the firm obtained other significant results through the implementation of lean tools. Section 5 of the interview entails the narration of one specific event – during the lean transformation process - in which some significant difficulties were found in implementing a lean tool.

This interview protocol largely draws upon the critical incident interview technique (Flanagan, 1954), where the attention of the interviewer is focused on gathering information on specific and real cases and events experienced by the interviewee and not on the interviewee's opinions and general evaluations. The critical incident technique and its further developments, such as the behavioral event interview (McClelland, 1998; Boyatzis, 1998) or the storytelling technique (Martin, 1982; Boje, 1991a, 1991b), have been widely adopted to structure qualitative data analysis in order to get rich and detailed information on the context, behaviors, and strategies adopted to achieve particular outcomes (Chell, 2004; Campion et al., 2011; Ekaterini, 2011) and their potential has been recognized not only about their capability to detect and measure individual competencies but also in the process of analysis of organizational competencies by eliciting tacit knowledge (Ambrosini & Bowman, 2001). For this reason, this interview technique represents an efficient substitute for direct observation of real events. Since the aim of our research is to understand the management behaviors characterizing the analyzed firms, we adapted this interview technique by focusing: a) on significant events specifically related to lean implementation and happened during the lean transformation process; b) on the management behaviors emerging at large from the events narrated during the interview, independent on the manager/actor performing those behaviors.

We also adapted the coding technique of the interviews as described below. A research subteam, different from the one conducting the "gemba walk" and assessing the degree of advancement of the lean transformation process, conducted one interview to each of the 26 Kaizen Promotion Office Chiefs of the firms of our sample. Each interview lasted approximately 1.5 hours. All the interviews were entirely tape-recorded and typewritten for the subsequent coding.

Subsequently, each interview was analyzed with the purpose of detecting the presence of the previously defined lean management behaviors. The interview coding took place counting and weighting the frequency of occurrence of the lean management behaviors included in the repertoire. More specifically, we counted the number of time each specific lean management behavior occurred in each event narrated by the interviewee. Then, using the scaling reported in the Appendix, we built an index which weighted negatively (i.e. "-1") the presence of behaviors associated to a modern management approach and positively (i.e. "+1") the presence of behaviors associated to a pure lean management approach. Intermediate behaviors were weighted in between -/+1. Finally we transformed this index on a scale from -100 to 100.

In the analysis of this data, we apply a variety of statistical methods. First of all, we calculated the average weighted frequency distribution of the lean management behaviors for the firms included in the sample. This frequency distribution allows to appreciate what management behaviors

characterize the analyzed sample of lean transformation processes and provides a sort of baseline to model lean management at least in Italian SMEs. Second, we applied multiple regression analysis to test if and to what extent the presence and intensity of the above observed lean management behaviors is associated with the degree of advancement of the lean transformation process. We checked the existence of this relationship controlling for such variables as size (revenues), the duration of the lean journey (years) and the inclusion of the firm in multinational groups. Finally, we identified the management behaviors that differentiate the firms at most advanced stages in the lean transformation processes using non-parametric statistical analysis.

FINDINGS DISCUSSION

The first research question is: what are the management behaviors associated to lean transformation processes? Table 2, that reports the sample averages and standard deviations for the frequency distribution of the lean management behaviors, provides some empirical evidence to answer it.

The most frequent behavior expressed while implementing lean processes appears to be the *Fact based decision making* (33.08%), that is the capability to make decisions at the point of value creation, by converting observable facts into actions. The second most frequent behavior is *Iterative planning* (25%), which is the capability to make and revise plans frequently, not simply according to a top-down perspective, but following circular feedback loops, consistently with the Plan-Do-Check-Act approach. The third most frequent managerial behavior is *Standards development* (23.72%), which is the capability of line managers, with the aid of specialists, to incorporate workers knowledge about how to do work into rules that formalize the current best practice, represent the norm to detect abnormalities and constitute the baseline for improvement. Other very frequent behaviors are *Scientific method based problem solving* (21.15%) and *Managerial reflexivity* (20.19%).

Also the other behaviors have, overall, a lower average frequency. This seems to confirm that Womack's (2011) model well captures lean management, beyond the anecdotal evidence offered by the existing literature and studies. It is interesting to note that one of the behaviors ("Challenge") presents a negative average frequency, i.e. that, on average, the managers of the firms in our sample expressed this behavior according to a "modern management" approach rather than a "lean management" approach. In other words, throughout the interviews, it appears that, in the analyzed firms, managers tend to define (too) challenging goals, according to a top-down perspective, negotiate with subordinates difficult and at times non realistic targets, push actions and try to directly drive results, instead of facilitating the self-definition of targets in terms of future states in coherence with the strategy implementation and with the value for the customer.

The second research question is: given the set of management behaviors that characterize firms engaged in lean transformation processes, are these directly and significantly associated with the degree of advancement of lean transformation processes? Put differently, does the diffusion and intensity of the above identified management behaviors positively and significantly co-vary with the degree of advancement of the lean transformation processes? Testing the above relationship would allow to validate the repertoire of lean management behaviors originally defined by Womack (2011) and go beyond the anecdotal evidence provided so far by existing studies. For this reason, we applied multiple regression analysis investigating the impact of the diffusion and intensity of lean management behaviors on the degree of advancement of the lean transformation process.

TABLE 2. DESCRIPTIVE STATISTICS AND CORRELATIONS. N=26.

	Mean	Std.Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Fact based decision making	33.08	24.77	1	.085	.595**	.286	.073	-.017	.119	.235	.293	.217	-.095	.414*	.332	.081	.155	.485*	.203	-.123	.031
Iterative planning	25.00	33.41	.085	1	.319	.289	.429*	.020	.373	.128	.358	.285	.392*	.424*	.234	-.064	.471*	.595**	.495*	.020	.351
Standards development	23.72	28.56	.595**	.319	1	.155	.189	.181	.445*	.471*	.692**	.484*	.264	.594**	.317	-.231	.691**	.733**	.517**	.198	.528**
Scientific method based problem solving	21.15	31.54	.286	.289	.155	1	.007	-.015	.105	-.073	-.152	-.157	.061	.198	.046	.103	.123	.293	.004	-.104	-.082
Managerial reflexivity	20.19	24.04	.073	.429*	.189	.007	1	-.169	.317	.339	.222	.337	.358	.393*	.172	.023	.169	.483*	.332	-.023	.208
Managerial versatility	19.23	48.19	-.017	.020	.181	-.015	-.169	1	-.081	-.204	.338	.217	.059	-.067	.142	.168	.406*	.302	.405*	.213	.397*
Gemba based managerial development	17.42	20.31	.119	.373	.445*	.105	.317	-.081	1	.309	.377	.095	.472*	.410*	.248	-.222	.375	.498**	.235	-.094	.398*
Managerial responsibility	17.31	33.80	.235	.128	.471*	-.073	.339	-.204	.309	1	.323	.236	.174	.306	.155	-.224	.383	.406*	.389*	.225	.286
Organizational horizontality	16.83	14.06	.293	.358	.692**	-.152	.222	.338	.377	.323	1	.682**	.307	.581**	.364	.070	.622**	.735**	.365	.028	.656**
De-hierarchization	15.38	26.92	.217	.285	.484*	-.157	.337	.217	.095	.236	.682**	1	.024	.461*	.221	.088	.567**	.566**	.252	-.115	.358
Teaching	15.38	30.98	-.095	.392*	.264	.061	.358	.059	.472*	.174	.307	.024	1	.556**	.267	-.199	.335	.503**	.456*	.248	.241
Process-based evaluation	10.58	33.38	.414*	.424*	.594**	.198	.393*	-.067	.410*	.306	.581**	.461*	.556**	1	.442*	.164	.473*	.803**	.388	.072	.320
Open-mindedness	10.26	27.38	.332	.234	.317	.046	.172	.142	.248	.155	.364	.221	.267	.442*	1	.058	.212	.552**	.255	.121	.235
Challenge	-5.77	37.54	.081	-.064	-.231	.103	.023	.168	-.222	-.224	.070	.088	-.199	.164	.058	1	-.046	.173	-.117	-.427*	.075
Lean advancement (LA)	2.41	.47	.155	.471*	.691**	.123	.169	.406*	.375	.383	.622**	.567**	.335	.473*	.212	-.046	1	.702**	.645**	.236	.678**
Lean management behaviors (LMB)	239.76	205.68	.485*	.595**	.733**	.293	.483*	.302	.498**	.406*	.735**	.566**	.503**	.803**	.552**	.173	.702**	1	.612**	.050	.561**
Size	2.27	.53	.203	.495*	.517**	.004	.332	.405*	.235	.389*	.365	.252	.456*	.388	.255	-.117	.645**	.612**	1	.553**	.562**
Group	.35	.49	-.123	.020	.198	-.104	-.023	.213	-.094	.225	.028	-.115	.248	.072	.121	-.427*	.236	.050	.553**	1	.285
Years	3.96	2.71	.031	.351	.528**	-.082	.208	.397*	.398*	.286	.656**	.358	.241	.320	.235	.075	.678**	.561**	.562**	.285	1
Pearson Correlation: *p<.05; p**<.01																					

Given the research design, the nature of the data and the research methods, we do not have problems of endogeneity. In fact, the data for the dependent and independent variables are time lagged, collected by different researchers with different methods and research protocol and form different sources.

The correlation matrix (Table 2) suggests that a relationship between LA, which represents – as explained in the method section – the value of our measure of lean advancement, and LMB, which represents – as explained in the method section – the value of our measure of overall presence of Lean management behaviors (LMB), may exist. In fact, the Pearson's correlation coefficient between LA and LMB is positive (0.702) and significant. At the same time, however, it is necessary to control for the impact of other variables that may also affect the degree of advancement of the lean transformation process, such as the size of the firm (which may positively affect the degree of advancement of the lean transformation because of scale economies of larger investment in lean infrastructures), the fact that the firm belongs or not to a multinational group (which may positively affect the degree of advancement of the lean transformation because faster and easier learning come from the implantation of the headquarters, existing lean management system), and the duration of the lean transformation process (which obviously should positively affect the degree of advancement of the lean transformation because of learning effects).

With regard to the firm size, we used revenues as a proxy, classifying the sampled firms into three classes (less than 10 Mln. euro; from 10 to 50 Mln. euro; more than 50 Mln. euros). With regard to the belonging to a larger group, we used a dummy variable as a proxy, that takes value 0 if the firm is autonomous or 1 if it is financially controlled by a larger group. With regard to the duration of the lean journey, we used as a proxy the number of years since the start of the journey.We ran two ordinary least squares (OLS) models, reported in Table 3.

TABLE 3. OLS RESULTS. DEGREE OF LEAN ADVANCEMENT IN THE LEAN TRANSFORMATION PROCESS (LA) AS DEPENDENT VARIABLE. N=26.

	Model 1	Model 2
	Std. Beta (sig.)	Std. Beta (sig.)
LMB		0.368
		(0.076)
Size	0.476	0.232
	(0.021)	(0.314)
Group	-0.158	-0.009
	(0.353)	(0.960)
Years	0.456	0.345
	(0.012)	(0.055)
Adjusted R^2	0.522	0.571

Both the models consider LA as dependent variable. Model 1 shows that our control variables have the hypothesized positive effect on the degree of advancement of the lean transformation process, with the exception of the control variable Group, that has no effect (Size has a regression coefficient beta = 0.476; p=0.021, and the duration of the lean journey has a regression coefficient beta = 0.456; p=0.012). In Model 2 we included the independent variable LMB that positively and significantly impacts the degree of advancement of the lean transformation process (beta = 0.368;

p=0.076). In this second model, the size effect vanishes while the regression coefficient of the duration of the lean journey remains positive and significant (beta = 0.345; p=0.055).

Once established what are the most widespread lean management behaviors and their overall positive and significant effect on the degree of advancement of the lean transformation process, it may be interesting to know which of those behaviors work as differentiators. The third research question then follows: does any of the lean management behaviors differentiate firms that are at more advanced stages of their lean transformation processes? For this reason, we investigated which of the analyzed lean management behaviors are more diffused in the firms at a more advanced stage of lean transformation. In order to do this, we built on and adapted competency modeling techniques (Boyatzis, 1998; Camuffo & Gerli, 2007; Campion et al., 2011) to identify the management behaviors that differentiate the firms at most advanced stages in the lean transformation processes. We divided our sample into two sub-samples (one of "advanced" and another of "followers") according to their total lean score LA (derived from the assessment). Since the sample average for LA was 2.45, we partitioned the sample into two sub-samples: "advanced" lean firms with above average total lean score (n=13); "followers" lean firms with below average total lean score (n=13). We then compared the frequency distributions of the lean management behaviors of the two sub-samples and tested the null hypothesis that the frequency of the lean management behaviors for the "advanced" group is larger than the frequency of the lean management behaviors for the "followers" group. Since no assumption can be made about the distribution of the population of the two samples, we used non-parametric statistical analysis (Mann-Whitney U test). As a result, we identified the set of lean management behaviors that distinguish the most advanced firms from the others. The statistical analysis is reported in Table 4.

TABLE 4. LEAN MANAGEMENT DISTINCTIVE BEHAVIORS

	Frequency %		Mann Whitney U Test	
Lean behaviors	Freq. Advanced	Freq. Followers	Z values [a]	Distinctive
Fact based decision making	32.31	33.85	0.08	
Iterative planning	34.62	15.38	1.27	
Standards development	37.18	10.26	2.85***	✔
Scientific method based problem solving	26.92	15.38	1.1	
Managerial reflexivity	23.08	17.31	0.33	
Managerial versatility	38.46	0.00	1.99**	✔
Gemba based managerial development	23.05	11.78	1.01	
Managerial responsibility	23.08	11.54	1.17	
Organizational horizontality	21.63	12.02	1.69**	✔
De-hierarchization	23.08	7.69	1.36*	✔
Teaching	30.77	0.00	2.52***	✔
Process-based evaluation	25.00	-3.85	2.30***	✔
Open-mindedness	15.38	5.13	1.18	
Challenge	-7.69	-3.85	0.45	

[a] Z values for Mann-Whitney U Test, one tailed: *p<.10; **p<.05; ***p<.01

Our results show that there are six behaviors that distinguish those firms that are more advanced in their lean journey. These are: *Standards development*, *Managerial versatility*, *Organizational horizontality*, *De-hierarchization*, *Teaching* and *Process-based evaluation*.

According to these results, the managers of the most advanced firms seem to be particularly focused on the development of standards, to have wider responsibilities and extended assignments, to act more responsibly, to pay more attention to the horizontal flow of value along the whole supply chain, to evaluate performance based on the state of the organizational processes rather than on their outcomes, and to conceive their role as that of a teacher.

IMPLICATIONS AND FUTURE RESEARCH DIRECTIONS

This study fills a research gap constituted by the fact that, while there is agreement in defining lean production as an integrated socio-technical system and the link between operations management and human resource management practices has been empirically established, the role of management behaviors in lean systems has been comparatively underestimated and underinvestigated, leading to the widespread observed distortion that many firms undertake lean transformations thinking that it is a technical matter or a question of tools. This misunderstanding often leads to the wrong idea that lean thinking can be applied without questioning the way in which managers (especially top managers) behave, and that results will come from lean transformations independent on the way managers lead and on the social impact of their decisions. In addition, it overcomes one major limitation of outstanding studies about lean management, that is their being grounded on anecdotal evidence, case studies, deduction but little large scale, in-depth, rigorous research. Moreover, it provides a set of empirical tests, based on field research, quantitative analysis and first-hand, firm-level data collection, to assess if and to what extent the management behaviors usually assumed and maintained as associated with lean production are actually practiced by the managers of firms engaged in lean transformation processes. From this standpoint, the key findings are: a) there is a repertoire of management behaviors, largely drawn upon Womack's and the Lean Enterprise Institute work but complemented with other work, that well capture the essence of management in lean production environments; b) these behaviors are valid, in the sense that their diffusion and intensity within an organization, actually correlate with the degree of advancement of the lean transformation process; c) some of these behaviors are associated with more advanced lean implementations.

The managerial implications of this study are straightforward. It provides some directions about how to undertake and sustain lean transformation processes underlining: a) the importance of management behaviors beyond tools and technical infrastructure; b) the need to train managers in order to align their behaviors to the lean environment; c) the need to focus on different sets of behaviors depending on the stage of maturity of the lean transformation; d) the existence of size effects and scale economies that may render the investment for a lean journey prohibitive for a small firm; and e) the fact that the time horizon for lean transformation is long and, hence, long term commitment is a requirement.

This study is characterized by several limitations that future research will have to overcome. Multiple, cross-industry and cross country studies will be necessary to further validate the set of management behaviors associate with successful lean transformations. Also, further studies will have to investigate the interactions between management behaviors and the other elements of lean management systems. Our sample size is small. Larger scale studies are necessary to be normative and provide more robust guidance to lean practitioners. Besides, more control variable should be added to the analysis, including industry, technology and the amount of investment in lean infrastructure (consultants, size of the kaizen promotion office, training, etc.)

Finally, longitudinal analysis would allow to establish what really drives strategic heterogeneity and cross-firm differences with regard lean transformations, as well as variation in cross-firm performance.

APPENDIX

Repertoire of Lean Management Behaviors and Coding Scales

1) Organizational horizontality
0. Strong focus on the vertical functions and departments in the organization, as mechanisms of optimization and control.
1. Strong focus on the horizontal flow of value inside the organization.
2. Strong focus on the horizontal flow of value inside the organization and towards customers or suppliers (but not both of them).
3. Strong focus on the horizontal flow of value across many organizations, from raw materials to the end customer, about one or few value streams.
4. Strong focus on the horizontal flow of value across many organizations, from raw materials to the end customer.

2) Managerial responsibility (pull-based authority)
0. Clear grants of managerial authority by leaders of organizational units (vertical delegation).
1. Clear grants of managerial responsibility from managers at the next higher level, particularly to solve cross-functional, horizontal problems within vertical organizations (like Toyota) granting vertical authority.

3) Process-based evaluation
0. Line managers judged on end-of-the-period results for their span of control, increasingly financial.
1. Line managers judged on the state of their process, with few feedback loops.
2. Line managers judged on the state of their process, with rapid feedback loops with next-level management. "If the process is right the results will be right."

4) Iterative planning
0. Planning and direction from the top down: "Managers make decisions" with a compliance focus: "Make the plan or explain the variances."
1. Iterative planning (PDCA) used by the managers without strong involvement of others.
2. Planning & direction in circular feed-back loops, with bosses asking questions: "What do you think our problem is?" "What do you think the potential solutions (countermeasures) are?" "What countermeasure do you think we should select?" "Who must do what when to test (PDCA) the countermeasure?" "Planning is invaluable but plans rapidly become worthless, so why explain variances rather than proposing new countermeasures?".

5) Managerial versatility
0. Generalist managers, rotated frequently with weak process knowledge.
1. Line managers on extended assignments, with deep process knowledge.

6) Gemba based managerial development
0. Managers are not developed formally (just "sink or swim") or are developed externally (e.g., management schools, consulting firms).
1. All managers developed through in-company gemba learning without repetitive A3 analysis.
2. All managers developed through in-company gemba learning via repetitive A3 analysis in dialogue with superiors throughout their careers.

7) Fact based decision making
0. Decisions made by managers far from the point of value creation, by analyzing data.
1. Decisions made at the point of value creation, by converting data into facts. ("Go see, ask why, show respect").

8) Scientific method based problem solving
0. Problem solving and improvement conducted by staffs, often through programs.
1. Problem solving and improvement conducted by line managers taking responsibility when necessary for cross-function teams, with staffs reserved for unique technical problems.

9) Standards development
0. Standardization of activities conducted by staffs, often with little gemba interaction and little auditing.
1. Standardization of activities conducted by line managers in collaboration with work teams, with no or infrequent auditing.
2. Standardization of activities conducted by line managers in collaboration with work teams, with frequent auditing.

10) De-hierarchization (supportiveness)
0. The ratio of direct supervision to value creating labor is minimized, to maximize efficiency.
1. The ratio of direct supervision to value creating labor is set to fully and quickly support the needs of direct labor, to maximize efficiency and effectiveness.

11) Managerial reflexivity
0. "Go fast" as a general mandate: "Jump to solutions" (with the consequence of going slow through the complete cycle of product & process development, launch & fulfillment).
1. "Go slow" as a general mandate: "Start with the problem" and pursue many potential counter-measures in parallel (with higher costs & more time at the beginning, followed by lower costs, less time & happier customers and employees at the end).

12) Teaching
0. Business Schools or external instructors or HR training teach specific routines and solutions assuming they will be contextualized and adapted.
1. Managers act as teachers/instructors and use lean tools (processes underlying standard work, A3, TWI, VSM, etc.) as katas to change, train and/or make flexible people's mindsets.

13) Open-mindedness
0. Managers use routines, formulas, algorithms to calculate the optimal solutions to unknown problems. They tend to stick in an implementation mode replicating what they know.
1. Managers use and practice diverse katas (processes underlying standard work, A3, TWI, VSM, etc.) to gather the information necessary to learn how to solve problems.

14) Challenge
0. Managers set high expectations, negotiate ambitious objectives and commensurate resources, push actions and check results.
1. Managers facilitate the self-definition of target conditions/future states on the basis of strategy deployment and customer value.

REFERENCES

Ambrosini, V. & Bowman, C. (2001). Tacit knowledge: Some suggestions for operationalization. *Journal of Management Studies*, 38: 811–829.

Anand, G., Ward, P., Tatikonda, M., & Schilling, D. (2009). Dynamic capabilities through continuous improvement infrastructure. *Journal of Operations Management*, 27: 444-461.

Argyris, C., Schoen, D. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison-Wesley Publishing Company.

Bicheno, J., & Holweg, M. (2009). *The Lean toolbox. The essential guide to lean transformation*. Buckingham: PICSIE Books.

Boje, D. M. (1991a). The storytelling organization: a study of story performance in an office supply firm. *Administrative Science Quarterly*, 36: 106-26.

Boje, D. M. (1991b). Consulting and change in storytelling organization. *Journal of Organizational Change Management*, 4(3): 7-17.

Bou, J.C., & Beltran, I. (2005). Total quality management, high-commitment human resource strategy and firm performance: an empirical study. *Total Quality Management* 16 (1): 71–86.

Boyatzis, R. (1998). *Transforming qualitative information*. Thousand Oaks: Sage Publications.

Campion, M. A., Fink, A. A., Ruggeberg, B. J., Carr, L., Phillips, G. M. & Odman, R. B. (2011). Doing competencies well: best practices in competency modeling. *Personnel Psychology*, 64: 225–262.

Camuffo, A. & Gerli, F. (2007). Competent production supervisors, *Industrial Relations*, 46(4).

Camuffo, A. & Volpato, G. (1995). The labor relations heritage and lean manufacturing at FIAT, *The International Journal of Human Resource Management*, 6(4).

Camuffo, A. & Micelli S. (1997). Spain, France and Italy: Mediterranean Lean Production. In T. A. Kochan, R. D. Lansbury, J.P. MacDuffie (eds.), *After lean production: evolving employment practices in the world auto industry*, Itacha: Cornell University Press.

Challis, D., Samson, D., & Lawson, B. (2002). Integrated manufacturing, employee and business performance: australian and new zealand evidence. *International Journal Of Production Research*, 40(8): 1941–1964.

Chell, E. (2004). Critical incident technique. In C. Cassell, G. Symon (Eds.), *Essential guide to qualitative methods in organizational research*: 45-62. Thousand Oaks: SAGE Publications.

Colombo, M. G., Delmastro, M., & Rabbiosi, L. (2007). High Performance Work Practices, decentralization, and profitability: evidence from panel data, *Industrial and Corporate Change*, 16(6):1037-1067.

Cua, K. O., Mckone, K. E., & Schroeder, R. G. (2001). Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. *Journal of Operations Management*, 19 (2): 675-694.

De Menezes, L.M., Wood, S. & Gelade, G. (2010). The integration of human resource and operation management practices and its link with performance: a longitudinal latent class study. *Operations Management Journal*, 18(7).

De Menezes, L.M., & Wood, S. (2006). The reality of flexible work systems in Britain. *International Journal Of Human Resource Management*, 17 (2): 106–138.

De Treville, S., & Antonakis, J. (2006). Could lean production job design be intrinsically motivating? Contextual, configural, and levels-of-analysis issues. *Journal Of Operations Management*, 24(2): 99-123.

Ekaterini G. (2011). A qualitative approach to middle managers' competences. *Management Research Review*, 34(5):553 – 575

Emiliani, M. L. (2003). Linking leaders' beliefs to their behaviors and competencies. *Management Decision*, 41(9): 893-910.

Emiliani, B. (2007), *Better Thinking, Better Results. Case Study and Analysis of an Enterprise-Wide Lean Transformation*, Wethersfield: CLBM.

Emiliani, M. L. (2008). *Practical lean leadership: A strategic leadership guide for executives*, Wethersfield: CLBM.

Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin*, 51: 327-335.

Flynn, B. B., Sakakibara, S., & Schroeder, R. G. (1995). Relationship between JIT And TQM: Practices and performance. *Academy of Management Journal*, 38 (5): 1325-1360.

Found, P. A., Van Dun, D. H., & Fei, F. (2009). *Leadership skills at different levels within a Lean organization*. Paper presented at the 20th Annual Production and Operations Management Society Conference, Orlando, May, 1-4.

Fujimoto, T. (1999). *The evolution of a manufacturing system at Toyota*. New York: Oxford University Press.

Fullerton, R. R., & McWatters, C. S. (2001). The production performance benefits from JIT implementation. *Journal of Operations Management*, 19: 81-96.

Fullerton, R.R., McWatters, C.S., Fawson, C. (2003). An examination of the relationship between JIT and financial performance. *Journal of Operations Management*, 21 (4): 383–404.

Hackman, J. R., & Wageman, R. (1995). Total Quality Management: Empirical, conceptual, and practical issues. *Administrative Science Quarterly*, 40 (2): 309-342.

Hopp, J.H. & Spearman, M.L. (2004), To pull or not to pull: What is the question? *Manufacturing & Service Operations Management*, 6(2), pp. 133–148.

Kaynak, H. (2003). The relationship between total quality management practices and their effects on firm performance. *Journal of Operations Management*, 21(4): 405–435.

Koenigsaecker, G. (2009). *Leading the lean enterprise transformation*, New York: Productivity Press.

Imai, M. (1997). *Gemba Kaizen: A Commonsense Low-Cost Approach to Management*. New York: McGraw-Hill.

Lakshman, C. (2006). A theory of leadership for quality: Lessons from TQM for leadership theory, *Total Quality Management and Business Excellence*, 17(1): 41-60.

Liker, J.K. (2004). *The Toyota Way: 14 management principles from the world's greatest manufacturer*. New York: McGraw-Hill.

Liker J.K., & Hoseus M. (2008). *Toyota Culture. The heart and soul of the Toyota Way*, New York: McGraw-Hill.

Liker J.K., & Meier D.P. (2007). *Toyota talent: Developing your people the Toyota Way*. New York: McGraw-Hill.

Liker, J. K., & Meier, D. (2006). *The Toyota Way fieldbook: A practical guide for implementing Toyota's 4P's.* New York: McGraw-Hill.

Luce, R. D. (1956). Semiorder and a theory of utility discrimination. *Econometrica*, 24(2): 178-191.

Macduffie, J.P. (1995). Human resource bundles and manufacturing performance: organizational logic and flexible production systems in the world auto industry, *Industrial and Labor Relations Review*, 48 (2): 196-218.

Mackenzie S.B., Podsakoff, P. M., Podsakoff, N. P. (2011). Construct measurement and validation procedures. In MIS and Behavioral Research: Integrating New And Existing Techniques. *Mis Quarterly*, Research Commentary.

Martin, J. (1982). Stories and scripts in organizational settings. In Hastorf, A. H. & Isen, A. M. (Eds), *Cognitive Social Psychology*: 255-305. New York: Elsevier.

McClelland, D. C. (1998). Identifying competencies with behavioral event interviews, *Psychological Science*, 9(5), 331-339.

Mckone, K. E., Schroeder, R. G., & Cua, K. O. (2001). The impact of total productive maintenance on manufacturing performance. *Journal of Operations Management*, 19 (1): 39-58.

Mckone, K.E., Schroeder, R. G., & Cua, K. O. (1999). Total Productive Maintenance: A contextual view. *Journal of Operations Management*, 17 (2): 123-144.

Nahm, A., Vonderembse, M.A., Koufteros, X. (2004). The impact of organizational culture on time-based manufacturing and performance. *Decision Sciences*, 35 (4): 579–607

Ohno, T. (1988). *Toyota Production System: Beyond large scale production*. Cambridge MA: Productivity Press.

Oosterwald, D.P. (2011). *The Lean Machine. How Harley-Davidson Drove Top-Line Growth and Profitability with Revolutionary Lean Product Development*, New York: AMCACOM.

Podsakoff, P.M., Mackenzie, S.M., Podsakoff, N.P., & Lee, J. (2003). The mismeasure of man(agement) and its implications for leadership research. *Leadership Quarterly*, 14: 615-656.

Rother, M. (2009). *Toyota Kata: Managing people for improvement, adaptiveness and superior results.* New York: McGraw Hill.

Samson, D., & Terziovski, M. (1999). The relationship between Total Quality Management practices and operational performance. *Journal of Operations Management*, 17 (5): 393-409.

Sato, M. (2008). *The Toyota Leaders. An Executive Guide*, New York: Vertical.

Shah R., & Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, 25: 785–805.

Shah, R., & Ward, P.T. (2003). Lean Manufacturing: Context, practice bundles, and performance. *Journal of Operations Management*, 21 (2): 129–150.

Shook J. (2008). *Managing to learn: Using the A3 management process to solve problems, gain agreement, mentor, and lead*. Cambridge: The Lean Enterprise Institute.

Spear, S., & Bowen, H.K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review*, 77 (9): 97–106.

Spear, S. (2009). *The High-Velocity Edge. How Market Leaders Leverage Operational Excellence To Beat Competition*, New York: McGraw-Hill.

Spencer, L. M. Jr., & Spencer, S. M. (1993). *Competence at work: Models for superior performance*. New York: John Wiley And Sons.

Stevens, S. & Stone, G. (1959). Ratio scale, category scale, and JND scale. *Journal of Experimental Psychology*, 57(2): 91-95.

Van Dun, D. H., Hicks, J. N., & Wilderom, C. P. M. (2010). *What are the values and behaviors of effective lean leaders?* Paper presented at the Annual Academy of Management Conference, Montréal, August, 6-10.

Womack J.P., & Jones, D.T. (1996). *Lean Thinking. Banish waste and create wealth in your corporation*. New York: Simon and Schuster.

Womack J.P., & Jones D.T. (2005). *Lean Solutions: How companies and customers can create value and wealth together*. New York: The Free Press.

Womack J.P., Jones D.T., & Roos D. (1990). *The machine that changed the world*, New York: MacMillan Press.

Womack, J. (2008a). *From Modern Management to Lean Management*. Presentation given at the LEA Lean Transformation Summit, London (www.lean.org/common/display/?o=785)

Womack, J. (2008b). *Modern Management versus Lean Management*. http://www.leanuk.org/downloads/jim/jim_eletter_200809.pdf

Womack, J. (2009). *Lean Management*. Presentation given at the Lean Enterprise Institute webinar, October 13th (http://www.lean.org/events/womack_on_lean_mng.html)

Womack, J. (2011). *Gemba walks*. Cambridge: Lean Enterprise Institute.