The Change in Communication Patterns in Teams Implementing Lean

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Abstract

Team dynamics in companies implementing the Lean production paradigm are not clearly understood, and overlooked as success factors for the implementation of such systems. In this paper it is argued that the parameters describing communication networks change dramatically as a number of teams embark on a Lean transformation. This exploratory paper presents data from multiple sites that show that indeed, business units succeeding in their implementation of Lean undergo a drastic transformation in their teams' communication patterns, and this change is more pronounced in more successful cases. Conclusions from the exploratory phase of the study suggest that in order to support successful implementations of Lean, management need to facilitate the changes in team network dynamics that are associated with rapid evolution towards a Lean enterprise.

1. Introduction

Lean is a system of tools, techniques and philosophies that seek to eliminate waste or non-value added from the production value stream. It can be argued that the "Lean" method for the production of goods and services is the current benchmark for efficient production systems.

Companies of all sectors have tried or are trying to implement different versions of the so called "Japanese System" under different monikers depending on the area of application, such as Lean Manufacturing, Lean Services [1], Lean Healthcare [2], Lean Software Development [3] or more generally, Lean Six Sigma.

Despite the popularity of the overall Lean concept, it is clear at this point in time that many implementations of the system have been much less than successful, with confirmed acclaims in a clear minority.

The failure to obtain the purported benefits from Lean has been ascribed to cultural reasons, deficiencies in managerial knowledge, and others. The fact is, we still do not understand completely what makes some implementations successful and others a failure [4].

In fact, most literature on Lean has been focused on describing practices are associated with Lean [5], or the obstacles found for its implementation [6], but when it comes to explore whether there are underlying phenomena that makes the system work in a sustainable way, the best the literature has to offer is pinning the reasons on to some fuzzy "cultural change" [7] that cannot be clearly described but seems to be very difficult to accomplish (and even more difficult to measure). Furthermore, some believe that the right cultural conditions for Lean success can only be fully realized in Japan or if being more lenient, in East Asia [8]. This, however, is contradicted by some successful Lean examples all over the World, such as in transplants of some Japanese automakers such as Toyota.

A contemporaneous study [9] looked into team leaders' social capital using network analysis. This paper further explores the idea of applying social network analysis to Lean implementations by measuring the change in communication network parameters for teams at several industrial facilities implementing Lean from scratch.

In the remainder of the paper, section 2 reviews relevant literature and puts forward the hypotheses to be tested. Section 3 explains the methodology for empirical test of hypotheses and section 4 contains results of the tests, while section 5 includes conclusions and limitations of the study and ideas for future research.

2. Literature review and research questions

The "Japanese" or "Lean" production paradigm, is also known as Lean Manufacturing, Lean Production or Toyota Production System, and originated at Toyota Motor Corporation in Japan after World War II as a manufacturing system based on a set of principles established by the founding Toyoda family and other contributors such as Taiichi Ohno [10] and Shigeo Shingo [11].

There are two pillars of the system:

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1. Jidoka (Japanese word meaning "autonomation" or "zero defect")
2. Just in Time Production

These main concepts are supported by lower level constructs such as continuous improvement (Kaizen), work standardization, work load leveling, waste detection and elimination, and others [12].

The understanding of the system in the Western Hemisphere was in the first couple of decades after its inception in the 1950's very fractional and the system was only assimilated to some of its most visible tools or techniques, such as the Kanban system for inventory management or the concept of Just in Time [13], many times misunderstood.

Interest in the system rose when given the oil price crisis in the 1970's the US automotive industry, pressed to increase efficiencies, observed that Toyota was able to manufacture cars with better fuel mileage, an order of magnitude better quality and at much lower cost than US based companies, even after discounting the effects of different exchange rates and other comparative advantages [12, 14].

Research on the Japanese system was spearheaded and made hugely popular by MIT's International Motor Vehicle Program, which in the early 1990's produced the book "The Machine that Changed the World" [12] comparing automakers in Japan, USA and Europe and was avidly read by operations and production managers in the West. The authors popularized the term "Lean Manufacturing" to describe a production system with highly interdependent subsystems of techniques that reduces or eliminates all waste from the production process, thus generating a "Lean" operation [15].

The system recognizes as its two main conceptual pillars the idea of Just in Time (producing only what is needed, in the amount needed and at the time is needed) and Jidoka, or production line autonomy to avoid passing defective product downstream. A multitude of other tools and techniques, or "practice bundles" [5] support the two main pillars, some of the best known being the kanban system for inventory management, the idea of Single Minute Exchange of Dies (SMED) which reduces setup times, the use of quality circles, creative suggestion systems, standardized work, visual controls, "5S" (standardized housekeeping), and a multitude other techniques.

Although the Lean system has manufacturing roots, many of its core ideas such as elimination of waste, leveling of work load, continuous improvement, constant feedback, etc, have been also successfully applied to different sectors such as industrial new product development [16], services [1], healthcare [2] and software development, where there is a fully fledged new software development paradigm based on Lean [3].

Success in the implementation of Lean is variable, both within Japan, in Japanese subsidiaries located in the Western Hemisphere (called "transplants") [14] and in originally Western firms that tried to implement the system [17].

Of course, factors for the success of Lean implementations have been the focus of some academic research, and the factors found are in general of macro level relating to age of the plant prior to the implementation, unionization, top management support and others [5, 6] .

In order to explain what, if any, deep changes occur within a company that undergoes a Lean transformation this study explores clues from practice and the literature that indicate that part of a sustainable Lean transformation is related to changes in work team dynamics. In particular, to the way workers within those Lean teams and management communicate.

Many of the Lean tools and concepts require not only the development of specific hard skills such as basic assembly tool usage or new management tools such as value stream mapping, standardized work documents or visual controls [18, 19].

As opposed to this mechanistic, toolkit-based view of Lean, we argue that full benefits from Lean cannot be realized if there is not a radical change in the way workers and managers share information about the process, changing their communication and collaboration patterns. This seems logical if one explores how really the tools associated with Lean work, but there has been next to none in terms of research trying to confirm it. This paper partially fills that void.

For instance, the Lean concept of Genchi Genbutsu (go and see by yourself) [20] can be reductionistically explained as asking managers to spend more time in the shop floor watching the process instead of relying on reports, but it is only completely fruitful if those observations are fed back to different worker teams, and if those teams in turn communicate with each other to make sure that what the manager observed is discussed, analyzed and implemented comprehensively, timely and correctly, all of which implies the development of a certain set of communication patterns.

Similarly, the idea of root cause discovery, [21] critically important in the Lean paradigm, cannot in real life be executed if workers do not ask questions whose answers many times involve other teams or sectors, who will need to actively collaborate with the focal team members in order to find and solve the real cause for a process glitch.

These and other hints the author observed in his many years of working on Lean implementations unequivocally signal that as companies successfully go Lean there is a concomitant change in communication patterns all across the company that are a necessary condition for the system to work in a successful and sustainable way. In unsuccessful cases thought, the author has observed that in all cases, obstacles impeding free communication are evident and detrimental to Lean implementation.

Measuring those changes in communication patterns can be a potent indicator of the degree of Lean accomplishment at the shop floor that could complement other hard metrics such as the popular OEE (Overall Equipment Efficiency) [22] and also shed light on the kind of core sustained changes that are critical to a successful Lean transformation.

The overarching research question for this paper is: *Do communication patterns change in teams as the company becomes leaner?* Specifically, it is contended that changes can be expected in communication patterns:

- among workers
- among different work teams
- between workers and management

Given that communication patterns in teams are indicators of other important team dynamics characteristics such as the fit between task and problem solving process [23] and eventually to team outcomes, investigating whether and how communication patterns change as teams become leaner may open a window into the more intimate reasons for Lean success. A secondary but not less important research question is then: *Are some communication patterns associated with success in implementing Lean?*

These research questions are explored in this paper in anticipation of a bigger study, with preliminary data from a mid-size industrial company that has been undergoing a Lean transformation during the last few years and using metrics derived from Social Network Analysis (SNA) methods.

When researchers have tried to measure the degree of "leanness", few if any of those measures relate to human resources. For instance one study [24] includes employee involvement as only 1 out of 10 different dimensions of Lean accomplishment.

Despite the relative lack of research on the human relationship aspect of Lean success, we can read some hints from the academic literature that point to the building of communication networks as an important factor for success.

For instance, it has been observed that successful implementations create a learning network between the company and its suppliers [25] and Lean companies very actively seek external information [26].

Lean companies increase the level of communication with key suppliers, even providing engineering support and trying to actively improve the suppliers' processes to make them as Lean as they are in the focal company [27]. It would be logical to expect that the same level of external support to suppliers could be perhaps replicated in the internal support among workers ("Team Members" in the Toyota jargon) and management.

Some studies observed that human resources management is a significant issue to achieve Lean success [28] and create a "Lean culture"[7]. We also know that a rigid hierarchical organization design is bad for Lean success since it exacerbates the separation among functions or departments [29] and that Lean and agile performers develop their human resources more intensively than less lean companies [30]. Lean corporations have been found to have a more collaborative and integrative culture [31] where workers are closer to management than in non-lean companies [32].

These studies looked at the aggregate company level, but although it has been noted that cooperative work and teamwork performance associate with Lean performance [33] only one study to date could be found looking at network traits of teams in Lean [9] but none evaluating how network characteristics change in time along the Lean transformation and how this change is associated with implementation success.

3. Exploratory hypotheses

To think about how the lean organizational structure and the different concepts they enact may affect communication and collaboration patterns, first let's have a look at the typical manpower arrangement at a Lean plant.

Typically, the structure of the production line is composed of working teams with about 5 workers or "team members" supervised by a Team Leader that can also work the line and whose main purpose is enforcing the concept of Jidoka (not letting defects pass downstream) and training and coaching workers, among other functions. Every 2 to 5 teams there is a higher level supervisor called Group Leader and depending on the organization there may be several other managerial levels all the way up to plant manager or the equivalent position [27].

We assume that as companies become leaner, their evolution towards leanness can be observed by measuring the degree to which the different techniques associated with the Lean paradigm have been implemented.

The intensity to which teams communicate internally, with other teams or with management can be observed by examining network-related characteristics of the teams' communication networks where managers, team members or the teams themselves are the actors of the network and there is a link between two actors when there is a communication instance between them.

The mathematics of graphs allow measuring different traits of these communication networks such as in or out degree, network density, centrality and other metrics that are relate to and characterize the unique communication interactions in a given team or group of teams.

Results from network-based studies have shed light on important issues such as which actors are more important for knowledge diffusion [34] or what kind of communication patterns are associated with quality or productivity [35].

For the case of communication among different teams, the intensity (here frequency) of communication is captured by the degree centrality [36] of a team in the inter-team network where teams are the network actors and there is a link between teams when members of two different teams communicate. The out degree of a given team captures communications initiated by that team rather than incoming to the same.

In the case of intra-team, or member to member communication, intensity of communication is related to the team network density [36], represented by the average number of communication instances between actors in a given period of time. Mathematically, network density is the ratio between the number of links observed in the network and the maximum possible number of links given the size of the network. In the case of valued networks, where every link has a non integer value, density is basically the average link value. The links have a value of zero when there has been no communication between those two actors and "n" where those two actors have communicated "n" times during the specified period of time, here one week.

In the case of communication between workers and management, we can imagine a multimodal (specifically two-mode) network where actors belong to either of two different kinds of modes. The first mode is the teams and the second mode is individual managers. Communication intensity between teams and managers is captured by the average degree between actors of the two modes, i.e. the average number of communication instances between a team and any managers. For instance if in a four worker team with workers A, B, C, D worker A has had no communication with a manager in a week, his/her degree centrality would be zero. If worker B has communicated two times, his/her degree centrality would be two, and if workers C and D have each communicated four times with managers in the week, their degree centrality would be 4 each time. The most central workers in this example are C and D and the least central or important member is A. The team's degree centralization would be (0+2+4+4)/4 = 2.5.

Several are the characteristics of the Lean paradigm that would potentially change communication patterns among workers and between workers and management when compared to non-Lean equivalents.

First, team leaders must actively check with the upstream team and negotiate with them incoming quality standards that allow the team leader to accept or reject processing work that has been sent to them below agreed quality, besides confirming and if necessary giving feedback about defects passed from the upstream process. This is part of the core concept of Jidoka, or not passing defects downstream.

In the same way, team leaders must check downstream for the impact of his team's work on their internal customers and on the final product. This requires communication spanning the boundaries of the team differently from what may happen within a "classic" pre-lean system where the only feedback, if any is given primarily by the team's direct supervisor.

We can then expect that in a Lean organization given the kind of feedback that team leaders are expected to give and request, teams will communicate more with other teams and the following proposition can be stated:

H1: Degree centrality in the inter-team network is positively associated with Lean team performance

Team leaders in a Lean plant are also in charge of team member training and team members are cross trained by both their qualified peers and by the team leader with the help of skill maps, graphical aids that help track the progress in cross-training [37]. Teams are also expected to hold daily meetings at the start of the day ("asakai") and the end of the shift ("yuichi") where they conduct a roll call, review possible challenges for the day ahead, discuss changes or improvements to processes and review past performance. All in all, the team is expected to be in constant communication for feedback. The following proposition captures this effect:

H2: Team network density is positively associated with team Lean performance

Supervisors are expected to spend most of their time at the shop floor watching the process, understanding problems and getting and giving feedback to and from team members, following the concept of “Genchi Genbutsu” or “Go and see for yourself” [20].

Supervisors are even expected to note their observations and their proposed countermeasures in the team’s or group’s control dashboard. Other activities formally require communication between supervisors and team members, such as coaching for quality circle activities, feedback for creative suggestions and supervision of 5S and standardized work.

All these instances of communication among team members and between team members and supervisors are not optional and cannot be skipped if the system is going to work as expected, yet most of these activities do not exist formally in a non-lean plant. These characteristics of the Lean management system allow suggesting the following proposition:

H3: Average degree centrality in the two-mode network between work teams and managers is positively associated with Lean team performance

4. Methods

4.1. Research background

Data for the empirical tests were extracted from field work executed at a company where the author has been consulting to help implement a complete Lean Manufacturing system.

The company is located in South America and has several business units, of which four plants were selected for this study (plants A, B, C, D) that produce ceramic tile products for residential and commercial flooring applications.

The process to produce ceramic tile comprises the mixing of clays, pigments, other minerals, water and additives to produce a base paste that is molded in presses in the shape of individual tiles which go through a digital printer that prints patterns on the tiles and another process that covers the tiles with enamel. After the enamel stage, the tiles are baked in an oven, cooled down, rectified if necessary, classified by quality, packaged and distributed to customers.

The implementation of Lean in the company began in 2014 with plants A and B starting in February and at the same time and plants C and D six months later.

4.2. Sampling

During the first month of Lean implementation all workers, supervisors and managers were given an electronic survey instrument with a set of questions asking for the names of people with whom they would typically expect to have had communication, either outgoing or incoming, and the average number of instances per day and week for each kind of event. At the same time demographics and other control variable information were collected, such as type and place of work, line, products made, education, age, gender, etc.

Before implementing Lean the company adapted their organizational structure to that found in most experienced Lean operations, following the team member/tem leader/group leader structure. Group leaders and above were considered managers.

The communication frequency information was then split by team by crosschecking the names with the company’s organization charts and transformed into a matrix representation of communication intensity, where the link between actors i and j had a value equal to their weekly number of interactions [38]. Once in matrix form the data were fed into R [39] to obtain network information. The same information was obtained for the inter team network considering teams as nodes of a higher order network. Measurements were repeated approximately six months after the initial round, and Lean performance recorded at that time.

In the end, 226 people belonging to 34 teams at the four plants and 9 different production lines were surveyed. Including personnel attrition by the second measurement, this comprises roughly 85% of the direct workforce and 95% of management and the measurements were cross sectional.

4.3. Measurement

Team Lean performance was measured using the company’s internal performance measure of Lean achievement, a composite score that is the average of the latest monthly audit evaluation along the following 11 dimensions, all of them on a 1 to 5 scale. These dimensions cover the whole realm of Lean effectiveness and are measured in monthly audits:

1. State of 5S [13]
2. State and enforcement of standardized work documents
3. Implementation and maintenance of a visual dashboard and visual controls
4. State of key performance indicators for the line / team
5. Compliance with daily meetings
6. Compliance with supervisory weekly planning
7. Implementation of total productive maintenance

8. Implementation of SMED [40] (where applicable)
9. Implementation of Kanban [41] (where applicable)
10. Implementation and evidence of Genchi Genbutsu
11. Number and impact of worker suggestions

The metrics are at the team level. Lean performance was also measured initially before any Lean activities took place, to obtain a baseline. Success in implementation was defined as the percent change in the Lean score after six months. Given that most operations nowadays have incorporated some Lean concepts prior to formally embark on a Lean transformation, and also given that Lean does have elements of other production systems predating it, it is expected that there will be some non-zero activity associated with Lean in the plants before the system is launched formally, i.e. there will be some visual controls, some attempts to standardize work, some housekeeping done, which would produce a non-zero baseline score. In fact, the baseline score for the four plants on average was 17.5% or 0.875 in the 1 to 5 scale. At the end of the first six months the four plants scored 1.2, 1.8, 3.1 and 4.2 from worst to best, with an average of 2.575 in the 1 to 5 scale, or approximately 51.5%.

The degree centrality in the inter-team network was measured by the number of daily outgoing communication events from members of a given team to members of different teams, normalized by focal team's size. This is the standardized out-degree centrality of the team.

The team network density was measured following the standard definition of degree density for a valued network [36], i.e. the average number of communication instances between members of the team, normalized by team size.

The average degree in the two-mode network between teams and managers was measured as the total number of communication instances, normalized by team size, between the team and any managers, including Group Leaders and above.

5. Results

For this exploratory study we decided to go with a simple ordinary least squares model with performance score change as dependent variable and network characteristics as independent variables, with a few control variables added to the model. All teams belonging to all four plants were included.

Results show that difference in performance is positively associated with team degree centrality, positively associated with team network density and positively associated with the team's degree centrality with management. These results support all three hypotheses.

Table 1: OLS Model

	Coeff.		SD
Intercept	0.15	*	0.044
Team Degree centrality	0.201	**	0.012
Density	0.189	**	0.035
Team vs. Mgmt Degree Centrality	0.325	***	0.001
Avg tenure	0.589		0.15
Type of team (1)	0.254	*	0.104
Avg. Familiarity	0.082		0.042

DV: Change in performance after six months	*	p<0.1
n= 34	**	p<0.05
(1) 0=Maintenance, 1=Production	***	p<0.01

Taking all teams and splitting them into low and high performing at the median performance increase score (3.52/5) allows comparing the network parameters of the two groups. Higher performing teams have in fact higher centrality, density and degree centrality with management.

Table 2: High vs. Low Performers

	Low perf.	High Perf.		t-score
Team Degree centrality	0.584	0.808	**	-2.584
Density	0.411	0.688	**	-1.998
Team vs Mgmt Degree Centrality	0.369	0.541	***	-1.745

*	p<0.1
**	p<0.05
***	p<0.01

6. Conclusions, limitations and future research

Results generally support that as a company turns leaner its communication patterns fundamentally change. This change happens within teams, between teams, and between management and those work teams.

The changes observed are 1) teams have a higher frequency of communication among members. 2) Teams communicate more with individuals from other teams and 3) Teams communicate more with managers. Also, 4) The more pronounced all these changes, the higher performing teams are in regards to Lean.

In light of these results a lean transformation could be evaluated not only by external indicators such as the assessment of how different practices are visible, but also by monitoring, measuring and looking at their communication patterns.

These results open up the possibility of an alternative explanation for those unsuccessful cases of Lean implementation: instead of looking at macro level factors such as expressed top management support, hours of training, etc. [42], which may still be important, one could look at failures from embracing and supporting the more intense communication patterns associated with lean success, or one could detect barriers to communication by measuring how these patterns change or fail to change and try to unlock communication by working on those barriers. Anecdotal evidence from conversations with workers in the studied plants seem to support that at least some managerial attitudes in those underperforming plants are related to resistance in changing how people communicate. We plan to issue formal interviews to dig deeper into this in the near future.

This study is exploratory and as such it shows several limitations, some of which could be alleviated in future research designs. The small sample size, within only one company and the few covariates included may be limiting the external validity of the conclusions. Having access to the subjects, the plan is to further study relevant literature and try to measure and include in the model more relevant covariates. Also given the nature of the data it could be argued that after this exploratory model, for a more thorough study a fixed/random effects model or a hierarchical model should be used instead of OLS.

An interesting future study would be to look at communication patterns in clearly failed lean implementations and observe if they had a different kind of evolution compared to those in successful experiences. We expect that some of the limitations will be ameliorated and more data will be available in a follow up paper.

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