Team Network Evolution while Undergoing a Lean Transformation: A Missing Success Indicator?

Jorge Colazo
Trinity University
jcolazo@trinity.edu

Abstract

The Lean paradigm for production process management and improvement can be considered a benchmark for managing operations in many areas, from manufacturing to software development.

Several studies found factors for the success or failure of Lean implementations, but these factors are aggregated or company-level and do not capture the nuances of teamwork at the shop floor level.

In this paper it is contended that as companies embark along a lean transformation their work teams undergo a change in their collaboration patterns, and the degree of such transformation indicates and is correlated to how successful the implementation of Lean has been for that particular team.

After developing propositions based on literature and practical experience, three hypotheses are tested with a small sample of work teams at an industrial company implementing Lean. Results support that as companies become Lean, there is an increase in communication among workers of a team, among different teams and between teams and management. These changes are more pronounced in more successful work teams. The conclusions may be helpful to understand a lean transformation as a communication network transformation, and hence open the game to improving the odds of a successful lean implementation by facilitating communication rather than by insisting in technical or tool-based skills.

1. Introduction

The “Japanese” or “Lean” method for the production of goods and services has been appearing in the practitioner and academic literature for decades but we still do not understand completely what makes some implementations successful and others a failure [1].

Most literature is focused on the practice bundles associated with Lean [2], or the obstacles for its implementation [3], but when it comes to try to explain the deeper underlying phenomena that makes the system work in a sustainable way, we know no better than to pin the reasons to some unclear “cultural change” [4] that 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 [5].

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 [6, 7]. They only can be realized if there is a radical change in the way workers and managers share information about the process, changing their communication and collaboration patterns.

For instance, the Lean concept of Genchi Genbutsu (go and see by yourself) [8] 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, [9] 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. Measuring those changes 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) [10] and also shed light on the kind of core sustained changes that are critical to a successful Lean transformation.

While the main impetus behind this study is finding how Lean teams are distinctive, 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 and 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 [11] 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.

This research question is 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.

In the remainder of the paper section 2 reviews relevant literature and contains both propositions and testable hypotheses. Section 3 explains the methodology for empirical test of hypotheses and section 4 contains results of the tests, while section 5 includes the conclusions, limitations and future research.

2. Literature review and hypotheses

The Lean production paradigm, also known as Lean Manufacturing, Lean Production or Toyota Production System originated at Toyota motor Corporation in Japan after World War II as a manufacturing system based on a few seminal ideas from the company founder Kiichiro Toyoda and other contributors such as Taiichi Ohno [12] and Shigeo Shingo [13].

Core concepts in Lean are Jidoka (“autonomation” or “zero defect”) and Just in Time Production, supported by lower level constructs such as continuous improvement, standardization and work load leveling [14].

The understanding of the system in the Western Hemisphere was in the first couple of decades after its inception 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 [15].

Interest in the so called “Japanese System” rose sharply after the 1973 oil crisis when 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 [14, 16].

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” [14] 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 [17].

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” [2] 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 [18], services [19], healthcare [20] and software development, where there is a fully fledged new software development paradigm based on Lean [21].

Success in the implementation of Lean is variable, both within Japan, in Japanese subsidiaries located in the Western Hemisphere (called “transplants”) [16] and in originally Western firms that tried to implement the system [22].
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 [2, 3].

When researchers have tried to measure the degree of “leaniness”, few if any of those measures relate to human resources. For instance one study [23] 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 [24] and Lean companies very actively seek external information [25].

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 [26]. 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 [27] and create a “Lean culture”[4]. We also know that a rigid hierarchical organization design is bad for Lean success and exacerbates the separation among functions or departments [28] and that Lean and agile performers develop their human resources more intensively than less lean companies [29]. Lean corporations have been found to have a more collaborative and integrative culture [30] where workers are closer to management than in non-lean companies [31].

These studies looked at the aggregate company level, but although it has been noted that cooperative work and teamwork performance associate with Lean performance [32] no studies to date looked at what happens at the working team level in a company embarked on a Lean transformation.

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 [26].

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. 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:

\[ P1: \text{As the company becomes leaner, communication among different production teams increases} \]

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 [33]. 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:

\[ P2: \text{As the company becomes leaner, communication among direct workers increase} \]
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” [8].

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:

P3: As the company becomes leaner, communication between direct workers and management increases

In order to put these propositions into testable hypotheses we assume that as companies become leaner, their evolution towards leanness can be observed by measuring how much 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 of communication is captured by the out degree [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 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.

In the case of communication between workers and management, we can imagine a 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.

Based on the preceding Social Network Analysis conceptualization we can then offer the following testable hypotheses related with the previously mentioned propositions:

H1: Out degree in the inter-team network is positively associated with Lean team performance

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

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

3. Methods

3.1. 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 the selected for this study produces steel tubing of several diameters ranging from 4” to 16” for use primarily in the oil and gas sector in order to transport fluids and to line production wells.

The process to produce these tubing is called Electric Resistance Welding (ERW) whereby rolls of cold-laminated steel are cut into strips of a size depending on the diameter and thickness of the tube to be produced, and then gradually longitudinally bended inwards until a tube is created and the longitudinal opening is arc-welded by means of a low voltage, high current electricity flow [37].

The finished tube is then cut to measure, threaded, fitted with accessories if required and extensively...
tested following international industry standards before being dispatched by truck to the oil and gas fields.

The implementation of Lean in the company began in 2011 and was staggered by design, i.e. at the different production lines the implementation was started at different times, and production lines with different degrees of implementation coexisted at the time data were collected. This provided the necessary variance to determine statistically significant differences in the relationship between degree of leanness and team collaboration network characteristics.

3.2. Sampling
In early 2015 and with permission from the company, members of 10 teams belonging to 5 different production lines in the same business unit were surveyed using an electronic instrument with a set of questions primarily asking for the names of people with whom team members had communication, either outgoing or incoming, and the average number of instances per day for each kind of event. At the same time demographics and other control variable information were collected.

This information was then split by team by crosschecking the names with the 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 daily number of interactions [38]. A company human resources database allowed confirming the hierarchy of all actors as team members, team leaders or supervisors/managers. 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.

Being this an exploratory trial and in anticipation of a full-blown research study, only 10 teams belonging to 5 out of the 12 different production lines or work sectors in the business unit were surveyed. This comprises roughly 15% of the direct workforce of the unit and the measurements were cross sectional.

3.3. 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 external consultant’s latest monthly audit evaluation along the following 11 dimensions, all of them on a 1 to 5 scale:

2. State and enforcement of standardized work documents
3. Implementation and maintenance of a visual dashboard
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 out degree in the inter-team network was measured by the number of daily outgoing communication events from members of a given team to members of a different team, normalized by team size.

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.

4. Results
Teams were categorized into low and high performance by splitting the sample at the median performance score (3.0), leaving 5 teams in each category. The goal was detecting differences in communication patterns between high and low performers.

Table 1 shows a t-test comparing the two groups of teams in terms of their out degree in the inter-team network, their network density and the average degree in communication with managers.

<table>
<thead>
<tr>
<th></th>
<th>High perf.</th>
<th>Low perf.</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out degree</td>
<td>3.80</td>
<td>1.46</td>
<td>2.69</td>
<td>0.054</td>
</tr>
<tr>
<td>Density</td>
<td>7.64</td>
<td>4.70</td>
<td>1.55</td>
<td>0.190</td>
</tr>
<tr>
<td>Degree w/ mgrs</td>
<td>3.98</td>
<td>1.16</td>
<td>2.85</td>
<td>0.046</td>
</tr>
<tr>
<td>N</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Despite the small sample size results show that there is a significant difference (p < 0.1) in terms of out degree in the inter-team network between high and low performing teams, supporting H1.

There is a difference in terms of network density but it failed to be significant at the (p< 0.1) level, not supporting H2, although one could speculate that in a larger sample the difference might turn statistically significant.

The difference between low and high performing teams in terms of the average communication with managers resulted in the direction hypothesized in H3 and significant (p < 0.1) supporting that hypothesis.

5. Conclusions, limitations and future research

Results generally support that as a company turns leaner its communication patterns fundamentally change within teams, between teams, and between management and those work teams. This is the first study showing that a Lean transformation is matched, and could be detected, by looking at their communication patterns.

These results also open up the possibility of an alternative explanation for those unsuccessful cases of Lean implementation: instead of looking at macro level factors one could say that failed attempts to implement Lean could not for some reason establish the more intense communication patterns required by the effective implementation of its tools.

If these results were confirmed by larger samples, they could be very important to boost the probability of success of a Lean implementation: Rather than focusing on the tools and skills that are trademarks of the Lean system, managers could be purposely trying to nurture the kind of communication network associated with sustained Lean success.

This study is exploratory and as such it shows several limitations, some of which could be alleviated in future research designs. First, the small sample, limited by the exploratory intent of the study and the availability of resources, is an obvious limitation. Second, at this time the empirical test did not include possibly important covariates and demographics. Third, it represents a partial view of only one company producing one kind of product.

Work is under way to refine the measurement instruments and expand data collection to all personnel in the studied company.

References


