Lean manufacturing implementation: Explaining the role of individual and collective worker perceptions

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Abstract

Lean manufacturing leverages on human capital to contribute to wellbeing and operational outcomes through continuous improvements; however previous studies provide controversial results. Building on social exchange and social comparison theories, we propose this depends on social exchanges between workers, team leaders, team members and the organization. We test whether high quality social exchanges positively relate to individual wellbeing and contributions to operational improvements and if diversity of social exchanges in the plant moderates this relationship. Results provide support for the positive relationship between social exchanges and outcomes but a more nuanced picture of the moderation of social exchange diversity.

Keywords: Lean manufacturing, Social exchange, Multilevel

Research Background

The effectiveness of lean manufacturing (LM) in achieving individual worker well-being and operational outcomes have been largely debated in the operations management literature (Shah and Ward, 2003). LM is a manufacturing system whose objective is to streamline the flow of production while continually seeking to reduce the resources (e.g., direct and indirect labour, equipment, materials, space, etc.) required to produce a given set of items; any slack in the system is referred to as 'waste' (Womack et al., 1990). Rather than setting a goal of a specific level of leanness, the lean production philosophy is focused on a continuous improvement process. Each improvement in flow or reduction in waste leads to new goals (Monden, 1983; Womack et al., 1990).

LM has been studied in terms of combination of synergistic and mutually reinforcing practices, which have generally been grouped into four complementary subsystems or bundles; just-in-time (JIT) manufacturing, total quality management (TQM), total preventive maintenance (TPM) and human resources management practices (HRM) (Shah and Ward 2003). LM has been defined by the literature as a socio-technical system made of technical practices (i.e., JIT, TQM, TPM) and social practices (i.e., HRM) (Womack et al., 1990). Researchers maintain that it is the implementation of the whole set of LM practices that leads companies to high performance, due to the synergistic effects among practices (Schroeder and Flynn, 2001). Additionally, previous literature highlights the role of HRM as an important enhancer of the other lean manufacturing bundles (i.e., TPM, TQM and JIT) especially when aiming to improve both worker wellbeing and operational outcomes (Shah and Ward, 2003; Longoni et al., 2013; Furlan et al., 2011).

The fundamental philosophy of LM of continuous improvement summarized in the Japanese word *kaizen* summarizes the emphasis of lean manufacturing on "ongoing improvement involving everyone". Workers are the ones primarily contributing to this continuous improvement. For this reason, the "social" (i.e., human) dimension of LM is considered to be crucial. LM is suggested to be a human-centred production system in which human capital is a valuable resource that managers need to leverage to optimize operational outcomes (Womack et al., 1990). In this "new" organization, workers are encouraged to increase their expertise and to help improve the production system (Ichniowski and Shaw 1999; Ahmad and Schroeder 2003). However, one major omission in the existing research is examination of *whether*, *how*, and *when* workers embrace the role that LM requires them to engage in (e.g., to contribute to operational improvements) and feel being well in such context.

We identify social exchanges as elements of LM to be at the heart of the effectiveness of its implementation. Social exchange theory proposes that social exchange is characterized by long-term and unspecified mutual obligations (Blau, 1964). Core elements of LM are the interaction and mutual obligations between workers and the organization (e.g., at the plant level) and the work team in which they are working. Accordingly, a core pillar of LM is to work in teams. Each team is given the responsibility of performing all the tasks along this part of the product flow which gives workers the opportunity to share issues and to provide support for each other (Kaminski 2001; Conti et al. 2006). Additionally, within a team there are two focal exchange relationships for each individual that are those with the team leader and team members. Therefore, as part of LM implementation, workers should experience social exchanges as:

- *Leader-member exchange* (LMX): the literature proposes this type of social exchange to describe reciprocal exchanges between a worker and his or her supervisor based on trust, respect, and obligations (Graen and Uhl-Bien, 1995).
- *Team-member exchange* (TMX): the literature proposes this type of social exchange to describe a worker's social exchanges with team members in terms of the reciprocal contribution of ideas, feedback, and assistance (Seers, 1989)
- *Organization-member exchange* (OMX): we propose this type of social exchange to describe a worker's social exchanges with the organization in terms of bi-directional exchange of suggestions and feedback and awards.

Hypotheses development

The original understanding of LM was to be positively related to both individual well-being and operational outcomes. The view of LM as a means to improve operational and organizational performance has strong empirical support (Shah and Ward 2003).

Differently, LM impacts on worker well-being outcomes has been widely debated. For example, safety researchers suggest that lean is 'mean' to employees (e.g., Adler, 1999). Recent studies suggest that this may depend on the way in which LM is implemented (Longoni et al., 2013). We propose that the achievement of such outcomes depends on the quality of the social exchanges perceived by workers in the implementation of LM. Accordingly, previous literature suggests high-quality social exchange relationships to enhance workers' organizational commitment, job performance, and organizational citizenship behaviors (e.g., Gerstner and Day, 1997; Ilies et al., 2007). Therefore, we state that:

> *H1. In LM implementation high quality social exchanges between a worker and a) the team leader, b) team members and c) the organization are positively related to individual contributions to operational improvements.*

Additionally, high-quality social exchange relationships are considered to enhance a safe and supportive work environment (Boies and Howell, 2006), which will help workers to reduce aversive states of physiological arousal such as anxiety, fear, and stress while accomplishing job tasks (Liao et al., 2010). Such high-quality social exchange relationships also inform individuals of the nature and predictability of various tasks and contexts as well as the strategies for coping with challenging and threatening situations (Bandura, 1982). In this context, workers will tend to feel safer, less stressed and less fatigue. Thus, we propose that:

> *H2. In LM implementation high quality social exchanges between a worker and a) the team leader, b) team members and c) the organization are positively related to individual well-being.*

Workers within a plant may perceive social exchanges in the implementation of LM to different extent leading to relationship differentiation. Accordingly, different groups of workers may receive different exposure to LM in different ways to match the requirements of particular worker groups and being more or less involved and receive attention by the organization and in their teams (Miles and Snow, 1984). This collectively affects a perception of social exchange differentiation. Previous studies investigating relationship differentiation as a team-level phenomenon proposed this as critically influencing how team members interpret and respond to the social exchange dynamics in the teams (Liao et al., 2010).

Research in social cognitive theory suggests that individuals make comparisons with models who share similar backgrounds and do familiar tasks (Bandura, 1982): teammates (Ford and Seers, 2006) or individuals in the same role (Shah, 1998) and this affect their evaluation of their own condition via comparative evaluation of his or her situation relative to those of others (Bandura, 1982). Such comparison with peer-models may affect how a worker reacts to social exchanges (Liao et al., 2010) and in judging his or her own status (Bandura, 1982).

In organizations, given the realistic constraints in the allocation of resources the advantage of one team or organization member is often perceived at the disadvantage of other members. In support of this view, Colquitt and Jackson (2006) found that team context (vs. individual context) increased members' preference for equality (as compared to equity and need) as the justice rule for resource allocation. Roberson and Colquitt (2005) also pointed out that relationship differentiation is detrimental to the development of shared justice perceptions. As a result, a high level of social exchange

differentiation, which signifies that resources are allocated differentially among and between team and organization members, may violate workers' beliefs about what should be, therefore jeopardizing the norm of fairness and the positive effects of individual high-quality social exchange perception. Overall, collective perception diversity of social exchange in LM implementation may determine lack of a shared view of the organizational environment and work climate, thus providing controversial messages and tensions and a negative interaction with individual social exchange perception (De Jong et al., 2005). Consequently, we advance that:

> *H3. In LM implementation collective perception diversity of social exchange negatively moderates the relationship between high quality social exchanges between a worker and a) the team leader, b) team members and c) the organization of LM implementation and individual contributions to operational improvements.*

> *H4. In LM implementation collective perception diversity of social exchange negatively moderates the relationship between high quality social exchanges between a worker and a) the team leader, b) team members and c) the organization of LM implementation and individual well-being outcomes.*

In Figure 1, we present our research framework summarizing research hypotheses and main constructs analysed.

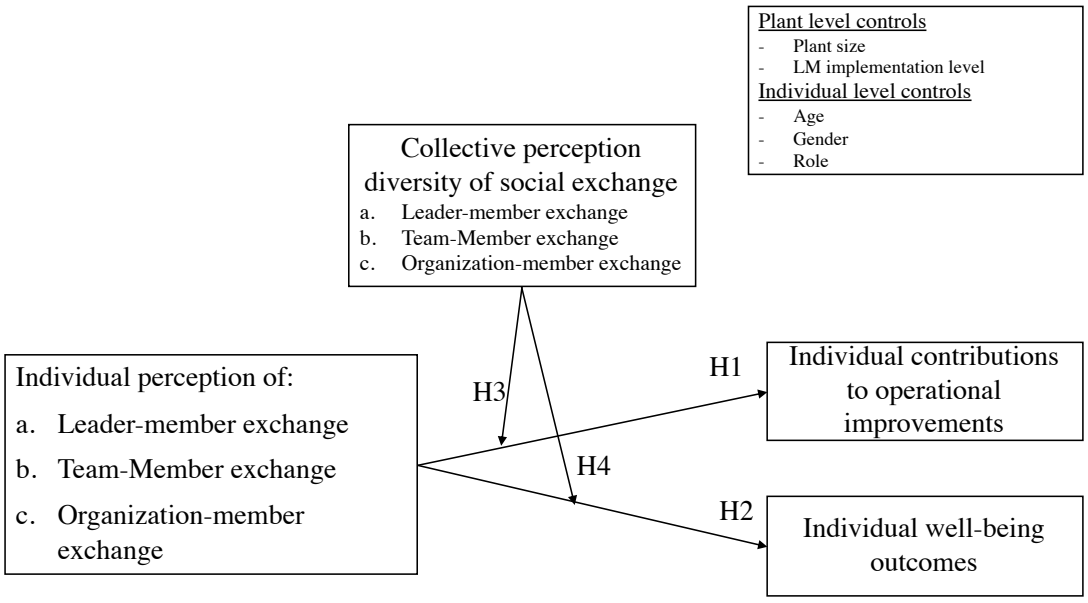

Figure 1 - Research Framework

Methodology

We use secondary data on a single company implementing LM in different plants about individual worker perceptions collected between November 2013 and January 2014 (Campagna et al., 2015). The overall sample include 25 plants with 4,807 respondents.

Construct measurement
Data included *control variables* at the individual (i.e., age, gender, role) and plant level (i.e., LM implementation level assessed by the company).

Independent variables
Survey items measured on a 4-point scale were used to measure social exchanges perception. Individual social exchange perceptions were about three main types of social exchanges in LM implementation perceived by workers:

- *Leader-member social exchange (LMX) perception*: measured via the average of two items regarding team leader role: i) favouring team members cooperation and ii) solving team-related problems;
- *Team-member social exchange (MMX) perception*: measured via the average of two items regarding: i) workers' team inclusiveness and ii) team reciprocal collaboration;
- *Organization-member social exchange (OMX) perception*: measured via two separated items regarding: i) feedback received by the organization and ii) awards received by the organization. In this case, we consider two separate items to consider both relational exchanges (e.g., trust, feedback) and monetary exchanges). In fact, differently that in the other types of social exchanges at the organizational level both types of exchanges can be in place.

Collective perception diversity of social exchange was calculated for each social exchange dimension as the coefficient variation of the individual social exchange perception for each plant in the sample. The interaction effect was calculated as product of individual perception and collective perception diversity.

Dependent variables
Outcomes were also measured based on survey items on a 4-point scale:

- *Individual well-being:* measured as the inverse of perceived stress increase;
- *Individual contributions to operational improvements:* measured has the individual provision of suggestions to improve operational outcomes (e.g., safety, productivity, quality).

Data analysis
Before testing our hypotheses, we assessed differences of outcomes perception within plants through HLM-ANOVA. Results showed that the percentage of variance that resides between plants is between the 7% to the 16% depending on the item and that most of the percentage of variance resides within plants (80/90%). Individual aspects may explain such variance as proposed in our hypothesis. Then, we tested our hypotheses through HLM, regressing control and independent variables on perceived outcomes grouped by plant.

Results and Discussion

Results of the HLM model testing our hypotheses are shown in Table 1 and 2. Specifically, Table 1 presents results about social exchanges between individuals and their team leader (LMX) and their team members (MMX). Table 2 presents results concerning social exchanges between individuals and the organization (OMX).

Table 1 – LMX and MMX Hypothesis testing

	a) LMX				*b) MMX*			
	Individual contributions to operational improvements		*Individual well-being*		*Individual contributions to operational improvements*		*Individual well-being*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	2.723**	2.797**	.382**	.338**	2.495**	2.498**	.385**	.385**
Control variables								
Level I – Individual level								
Age	-.003	-.003	.001	.001	-.000	-.001	.001	.001
Gender	.0227	.0208	-.002	-.003	.009	.010	-.000	-.002
Role – direct worker	-.193**	-.189*	-.0321	-.0284	.006	.004	-.027	-.026
Indirect worker	-.125	-.117	-.001	.005	-.011	-.014	.005	.006
Logistics	-.218*	-.221*	-.0338	-.0338	-.059	-.053	-.028	-.032
Maintenance	.0585	.062	.0303	.0316	-.011	-.011	.029	.028
Technician	.340*	.328	.127*	.119*	.108	.115	.136**	.129**
Level II – Collective level								
LM implementation level	.001	-.001	.000	.000	-.000	-.000	.000	.000
SE collective perception diversity		-.074		.007		-.026		.009
Independent variables								
Level I – Individual level								
SE individual perception	.603**	.615**	.015**	.0231**	.957**	.950**	.025**	.029**
Level II – Collective level								
Individual*Collective perception		-.052*		-.030**		.022*		-.023**
P value	0.000	2.797**	0.000	0.000	2.495**	2.498**	0.000	0.000

**p<0.01, **p<0.001*

Note: Model 1 tests of H1 and H2 (direct effects of social exchanges), Model 2 tests of H3 and H4 (moderation effect of social exchange diversity)

Table 2 – OMX Hypothesis testing

	i) OMX - feedback				*ii) OMX - awards*			
	Individual contributions to operational improvements		*Individual well-being*		*H3c. Individual contributions to operational improvements*		*Individual well-being*	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Intercept	2.720**	2.726**	. 405**	.397**	2.730**	2.740**	2.661**	2.684**
Control variables								
Level I – Individual level								
Age	-.004	-.004	.000	.001	-.004	-.004	-.001	-.001
Gender	.039	.040	-.008	-.007	.054	.054	.048	.048
Role – direct worker	-.290**	-.292**	-.047	-.046**	-.415**	-.415**	-.215**	-.215**
Indirect worker	-.282**	-.283**	-.011	-.008	-.355**	-.355**	.029	.029
Logistics	-.399**	-.400**	-.049**	-.050	-.540**	-.539**	-.095	-.095
Maintenance	-.102	-.101	.022	.025	-.056	-.055	.032	.032
Technician	.201	.204	.121*	.122**	.021	.019	-.281	-.282
Level II – Collective level								
LM implementation level	.002	.002	.001	.001	.003	.003	-.003	-.008
SE collective perception diversity		-.060		.009		-.011		-.027
Independent variables								
Level I – Individual level								
SE individual perception	.480**	.480**	.017**	.020**	.338**	.335**	.248**	.247**
Level II – Collective level								
Individual*Collective perception		-.009		-.016**		.009		.004
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

**p<0.01, **p<0.001*

Note: Model 1 tests of H1 and H2 (direct effects of social exchanges), Model 2 tests of H3 and H4 (moderation effect of social exchange diversity)

Results summarized in Table 3 show that individual and collective social exchange perceptions might explain workers engagement in LM implementation. Specifically, results of Model 1 concerning a) LM, b) MMX and c) OMX provide support for H1 and H2 proposing that individual perception of high-quality social exchanges in LM implementation positively affect respectively individual contribution to operational outcome improvements and individual well-being.

Differently, we found a more nuanced picture about the effects of collective perception diversity of social exchange on these relationships depending on the direction and the nature of social exchanges. H3 and H4 proposed that diversity perception of social exchanges negatively moderates the relationship between individual social exchange perception and outcomes (respectively individual contribution to operational outcome improvements and individual well-being). However, only the models concerning social exchanges between individuals and their team leader support both H3.a and H4.a. Therefore, high diversity of LMX is not a good catalyst of the member perception of social exchanges due to perceived procedural injustice (Liao et al., 2010). This creates

stress and reduces their contributions in proposing suggestions for operational outcome improvement.

Differently, the models concerning social exchanges between team members show the same negative moderation concerning the TMX-individual well-being relationship (i.e., being associated to stress increase) confirming H4.b but a positive moderation of the TMX-operational contribution relationship thus not supporting H3.b. In this case, high diversity of TMX is a good catalyst for individual operational contributions.

Finally, in the models concerning social exchanges between individuals and the organization different results are shown according to the nature of the social exchange. When OMX is measured as feedback high diversity of social exchange negatively moderated the OMX-wellbeing relationship confirming H4.c but there is no significant interaction regarding the relationship with individual contributions to operational outcome thus not supporting H3.c. Instead, in the models concerning OMX measured as awards none interaction effect is significant.

Overall these results show that high diversity of social exchanges negatively affects the relationship between high quality social exchange and individual well-being generating more stress. Additionally, when the social exchange is vertical (i.e., between team leader and team members) the sense of procedural injustice due to diversity in social exchanges negatively moderates the individual social exchange-operational contributions relationship. Instead when the social exchange is horizontal (i.e., between team members) diversity of social exchanges positively moderates the social exchange-operational contributions relationship being a good catalyst. This might be due to the fact that in this case peer comparison regards peer-to-peer relationships. Research in social cognitive theory has emphasized that the role of comparison with models who share similar backgrounds and do familiar tasks is more salient (Bandura, 1986). In a team setting, members possess the same membership, maintain regular interactions, are exposed to similar organizational resources, and work inter-dependently on relevant tasks (Seers, 1989; Tse et al., 2008). The experience of comparing with teammates may affect how a team member reacts to social exchanges with peers in judging his or her own capability (Bandura, 1982). As a result, the member who enjoys high-quality TMX is more likely to view him-/herself as more respected in the team and better off than the comparison others when there is higher relationship differentiation than when such social exchanges are uniform for every team member. Therefore, a high-quality LMX will enhance a team member's perceived capability even more if some peers on the team enjoy high-quality exchange relationships with enhanced positive effects on their contributions to operational outcomes, feeling more self-confident. Finally, at the organizational level when social exchanges are related to awards (and not social relations and feedbacks), peer comparison is just not significant.

Table 3: Summary of hypotheses testing

	Individual contributions to operational improvement	**Individual well-being**
Direct effects		
a) LMX→ outcome variable	Sign. (positive)	Sign. (positive)
b) MMX → outcome variable	Sign. (positive)	Sign. (positive)
c) OMX – feedback → outcome variable	Sign. (positive)	Sign. (positive)
c) OMX- awards → outcome variable	Sign. (positive)	Sign. (positive)
	H1: supported	**H2: supported**
Moderation effects of social exchange diversity on:		
a) LMX→ outcome variable	Sign. (negative)	Sign. (negative)
b) MMX → outcome variable	Sign. (positive)	Sign. (negative)
c) OMX – feedback → outcome variable	Not sign.	Sign. (negative)
c) OMX- awards → outcome variable	Not sign.	Not sign.
	H3: Partially supported	**H4: Partially supported**

Conclusion

Our results support the relevance of high quality social exchanges in LM implementation to leverage the human capital involved improving worker well-being and workers contributions to operational improvement. This is in line with the social exchange theory suggesting the need for mutual contributions (Blau, 1964). Through high quality social exchanges with team leaders, other team members and the organization, workers feel a mutual exchange in place thus better facing the implementation of LM at the individual level.

However, different workers may have different perceptions of social exchanges being exposed to LM in different ways (e.g., directly vs indirectly involved, since the beginning after partial implementation) and this may affect the relationship between individual perception of social exchanges and well-being and individual operational contributions through a comparison process (Bandura, 1986). Specifically, our results show that collective perception diversity negatively affects the relationship between individual social exchanges in LM and well-being increasing individual stress levels. Instead social exchange diversity affects individual operational contributions differently depending on whether it is a horizontal exchange (e.g., between team members)— being a positive catalyst-, or vertical (i.e., with team leaders)— being a deterrent, and on whether it is based on social relations (i.e., trust and feedback) or awards (i.e., monetary incentives).

This study provides several contributions. On the theoretical side, we show that social exchange perceptions should be taken into account to study manufacturing practices (i.e., LM) effectiveness and their implementation process. Specifically, collective perception diversity of social exchanges may negatively impact on individual outcomes due to perceived injustice and conflicts. Instead, in terms of individual contributions to operational improvements collective perception diversity could have the same negative effect or being a catalyst of social exchanges according to whether it is about vertical or horizontal relationships. Additionally, the nature of social exchanges in LM matters being exchanges based on monetary rewards relevant at the individual level but not in a collective comparison logic. For managers, we show that in LM implementation processes organizations should focus on social exchanges with workers and cultivate high quality horizontal and vertical relationships. Such social exchanges are at the heart of LM principles. Also, they should consider the effects of dis-homogeneous social exchange perceptions that might negatively affects individual well-being generating stressful situations. To avoid such negative effects they should consider the relevance of training

to increase worker awareness of their contributions to LM and in their team. At higher level of maturity of LM implementation such differences should also be less visible.

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