

Managing environmental sustainability tensions in leagile manufacturing within the furniture manufacturing industry

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Abstract

Developing sustainable supply chains that seek economic viability without harming the environment remains a challenge. Lean manufacturing practices can facilitate the transition from traditional supply chains to sustainable supply chains. However, firms often adopt a combination of lean and agile practices. Empirical evidence so far is limited in articulating the emergent tensions between environmental sustainability and lean/agile manufacturing. This research adopts a multiple case study approach to explore such tensions and to investigate different mechanisms to manage them. The paper develops three design propositions that articulate three types of tensions and the corresponding managerial interventions to develop sustainable supply chains.

Keywords: Lean, Agility, Sustainability

Introduction

The relationship between operations management and sustainability has received a great deal of attention in academic and business fields because of an intuitive link that makes lean manufacturing a suitable vehicle for sustainability. Lean manufacturing has been considered as a preferred carrier that can facilitate the transition from traditional supply chains to sustainable supply chains (Roy *et al.*, 2018). Past literature suggest that lean methods can significantly affect the improvement of environmental sustainability in firms (Garza-Reyes *et al.*, 2018). However, manufacturing firms often adopts a combination of lean and agile practices (Fadaki *et al.*, 2020). On one hand, lean aims to continuously improve efficiency by standardised processes, while agility is concerned with introducing product variety. It is far more difficult in wide product variety circumstances to optimise efficiency, and indeed reduced efficiency can be expected. With efficiency being measured in environmental sustainability measures such as energy consumption and waste raw materials, tensions can emerge due to this misalignment.

A critical review of previous literature integrating sustainability into lean and agile manufacturing found a win-win approach was the most prevalent in the extant literature (Dües *et al.*, 2013). However, there is a downside to the win-win approach in exploring sustainability integration into supply chains. Such a research approach tends to avoid the tensions due to misaligned logic between economic elements and environmental sustainability and underestimates the effects of these tensions on environmental performance (Van der Byl and Slawinski, 2015). They tend to argue that the economic focus of operations management does not negatively impact other elements of sustainability, in this case, environmental sustainability.

An examination of previous research findings reveals a more complex relationship between environmental sustainability and lean/agile manufacturing practices. Evidence for both supportive and conflicting relationships has been found. For example, JIT is based on not holding raw material stocks and instead ordering small quantities as actually needed by or pulled into the manufacturing process. This results in more frequent deliveries increasing carbon emissions from logistics activities. Moreover, agile manufacturing requires customisation. Cutting material to customised sizes will lead to more waste than with standardised sizes for which cutting can be better planned and

optimised to reduced waste. Similarly, agile manufacturing has also been found to diminish environmental sustainability performance due to excess resources needed to maintain the surplus capacity (Carvalho *et al.*, 2011). Tensions from these misalignments between economic and environmental sustainability elements are obvious in practice.

A few studies acknowledging tensions have represented them as trade-offs (for example, Cabral *et al.*, 2012; Fahimnia *et al.*, 2015). However, this representation is limiting as it suggests an either/or option which might diminish the overall SC performance. Trade-off implies a preference of one thing over another, which may result in a win-lose proposition. A firm focused on economic performance could implement management practices that harm the environment (Pagell and Shevchenko, 2014). Thus, while the characterisation of tensions as trade-offs helps to understand the negative effect of operations management on environmental sustainability, it is limited as it does not explain whether and how companies address the tensions.

Research has not yet moved beyond making a case that achieving financial objectives will lead to environmental sustainability. While early studies have hinted at the possible environmental tensions from adopting lean and agile manufacturing practices, the empirical evidence so far is not sufficient in clearly articulating these inherent tensions (Marco-Ferreira *et al.*, 2019). Taking a win-win approach leads to the avoidance of tensions by focusing on the elements that are aligned. Similarly, representing tensions as tradeoffs suggests a win-loss proposition. These approaches could lead to the development of inadequate models that practitioners may find difficult to adopt. Further, a win-win approach can lead to the development of theory that focuses on intuitively similar practices as evidenced by the dominance of studies on the lean-sustainability relationship. To move beyond these limitations, it is essential to explore the types of tensions that may emerge between environmental sustainability and lean/agile manufacturing. Doing so will help to develop practical mechanisms for managing such tensions in order to improve environmental sustainability performance. Therefore, this paper contributes to this research gap in the extant literature by addressing the following key questions.

- **RQ 1** - What tensions emerge from the misaligned logic between environmental sustainability and lean/agile manufacturing practices?

- **RQ 2** - What interventions and mechanisms are enacted to address specific tensions and exploit any synergies present in the focal firm?

Methodology

To answer these research questions, this research adopts a variance-based case study approach grounded in critical realism (CR) philosophy (Fletcher, 2017). Rather than producing a law-like prediction, this study unpacks what causes better environmental performance in leagile supply chains. It sought to develop plausible generative causal explanations for the leagile-sustainability relationship, thus CR is suitable for the identification of the mechanisms that can explain the different outcomes. An abductive approach was used to explore the relevant structures and mechanisms, drawing from both empirical data and previous findings in research.

Theoretical sampling was used to select five case studies from the furniture manufacturing industry based on their ability to illustrate the tensions and managerial interventions. As recommended by (Bansal *et al.*, 2018), five case companies that vary in the degree of customisation were selected to elicit different explanatory variables. Data were collected through 21 semi-structured interviews with senior managers. This data was supplemented with site observations, company documents, and publicly available data. The interviews were transcribed and coded for thematic analysis using template analysis.

The upholstered furniture manufacturing industry was a suitable research setting for exploring leagile manufacturing because of several reasons: First, the industry has generic manufacturing processes making it feasible to explore the effects of varying degrees of customisation with a homogeneous setting (Yin, 1981). Second, the findings from this industry have significant environmental implications for other manufacturing industries as several key manufacturing processes are common to many other manufacturing industries (Handfield *et al.*, 1997). Lastly, the industry has a very competitive climate characterised by wide product variety. The market winner for furniture is usually cost and quality, yet the firms frequently introduced new features and finishes, making the industry agile. The furniture manufacturing industry is concentrated (Klassen and Whybark, 1995); thus, five cases considered in this research are representative of the industry.

Findings

All five companies have varying degrees of customisation indicative of agile manufacturing. Company A offers solutions for several types of office furniture applications. The company mostly designed and manufactured furniture based on customers' orders and therefore their customer segment is characterised as a low-volume-high-variety segment. Its product range included office desking systems, office screens, breakout furniture, and office storage systems. Company B specialises in providing furniture solutions for businesses that may include refurbishing projects for the hospitality sector. It supplies a wide variety of sofas, chairs, tables, and desks to other businesses, and customers have a high influence on the product designs which results in high product variety. Company C is a manufacturer of high-quality furniture solutions for the workplace, education, hospitality, retail, and leisure sectors. It's a high product variety company since it provides consultation, design, production, and installation of a wide variety of furniture for complete projects for other businesses. Company D, a bed and mattress manufacturer, is characterised as 'high volume-low variety' because it produces about half of the furniture to stock because of the low product variety. Company E is a coffin manufacturer that operates on a make-to-order. The manufacturing process of company E is similar to all other case companies except it does not do upholstery on its products. All the companies had an environmental sustainability policy to show commitment to sustainability.

The cross-case analysis showed that lean practices aimed at efficiency improvement within the workplace tend to be supportive of environmental sustainability. However, some temporal tensions related to JIT existed in the dyadic relationships with suppliers. In contrast, considerable tensions were observed between the agile goal of customisation and material waste. The tensions persisted, and companies continually managed them. As for the dyad relationship, the lean practice of JIT generated tensions because of air pollution from frequent deliveries. Table 1 shows the type of tensions arising from the misalignment of the predominant logic in the lean and agile practices. The cross-case analysis found several mechanisms for managing the tensions; integration approach for exploiting the low tensions to generating synergetic effects, trade-off and mitigation approach for moderate tensions, and Paradoxical resolution approach for the tensions that continued to co-exist, requiring continuous decision making.

Table 1 Cross-case analysis of tensions and mechanisms

Leagile Practices	Tensions from misaligned predominant logic	A	B	C	D	E	Mechanisms
Workplace improvement	<i>Quality vs (Material usage and waste production)</i> Low tension - common logics There were examples of quality improvement that supported a reduction in material usage and waste production.	Present	Present	Present	Present	Present	Vertical alignment <ul style="list-style-type: none"> Total quality environmental management (TQEM)
	<i>5S, Employee empowerment vs waste production</i> Low tension - common logics The 5S programmes and employee empowerment were supportive of waste identification and clean management in the workplace.	Present	Present	Present	Present	x	Vertical alignment Collective commitment
	<i>Process mapping vs waste production</i> Low tensions – common logic VSM helped in waste identification in company D but was regarded as too complex for other companies.	x	x	x	Present	x	Horizontal alignment (Tools) <ul style="list-style-type: none"> Modified value stream mapping (GIVSM)
	<i>Sorting (NVA) vs waste management (recycling)</i> Temporal tension - No overlapping logic Sorting and storage of waste before recycling was a non-value-adding activity but a necessary sustainability activity.	Present	Present	Present	Present	Present	Trade-off approach and mitigate <ul style="list-style-type: none"> Send waste to landfill or Invested in storage space and compacting technology
Just in Time	<i>Delivery frequency vs transport emission</i> Temporal tension – No overlapping logic Frequent deliveries contributed to increased carbon emissions in transportation.	Present	Present	Present	Present	Present	Trade-off approach and mitigate Long-term mitigating measures to minimise the tension. e.g. <ul style="list-style-type: none"> coordinated delivery outsourcing (3PL)
Customisation	<i>Product van vs Generated solid waste</i> Persistent tension – No overlapping logic High variety led to increased waste generation from offcuts.	Present	Present	Present	x	Present	Paradoxical resolution <ul style="list-style-type: none"> Resource fluidity Collective commitment

Discussion

The discussion over the findings draws on the CIMO logic to propose design propositions for managing the tensions between environmental sustainability and Leagile manufacturing practices. The CIMO logic is useful for developing practical propositions because it states that for a generalisable class of contexts (C), by using particular management intervention (I), it is possible to enable a generative mechanism (M) to achieve outcomes (O) (Denyer et al., 2008). Based on Hahn's *et al.* (2015), this paper identified three contexts (C) of tensions that might come into play when integrating sustainability into lean and agile supply chains. In this case, rather than the features such as geographical or industry, the context is determined based on the spatial and time elements (Hahn *et al.*, 2015). Spatial elements refer to whether the predominant logics in the practices exist in the same space without confliction. For example, if practices have common or overlapping logics, they can exist in the same space without conflict resulting in a context of low tensions. However, if the predominant logics in the practices oppose, tensions result, and time becomes an essential dimension. If the tension can be eliminated over time, then the tension is temporal. However, it persists over time; then, the tension is regarded as paradoxical (Lewis, 2000).

Management literature on tensions suggests three *interventions* (I) to managing tensions (Hahn *et al.*, 2015). First, the *Synthesis* intervention which introduces new elements that link common elements. Second, *Separation* intervention addresses the opposing elements at different locations or different points in time. These two strategies result in the resolution of the tensions. Lastly, *Acceptance* intervention accommodates the opposing elements in the tensions and keeps the paradox open. Rather than resolving the tension, it is managed over time. These three strategies correspond to *integration, separation, and paradoxical resolution*, respectively, because the assumptions in the strategies are the same.

This paper proposes three contexts of tensions - low tensions, temporary tensions, and paradoxical tensions. Within each context, specific managerial interventions initiate mechanisms for better environmental sustainability performance. As shown in the framework in figure 1, the paper develops three propositions that have implications for

further research and practice. The elements of this framework are discussed in more detail below.

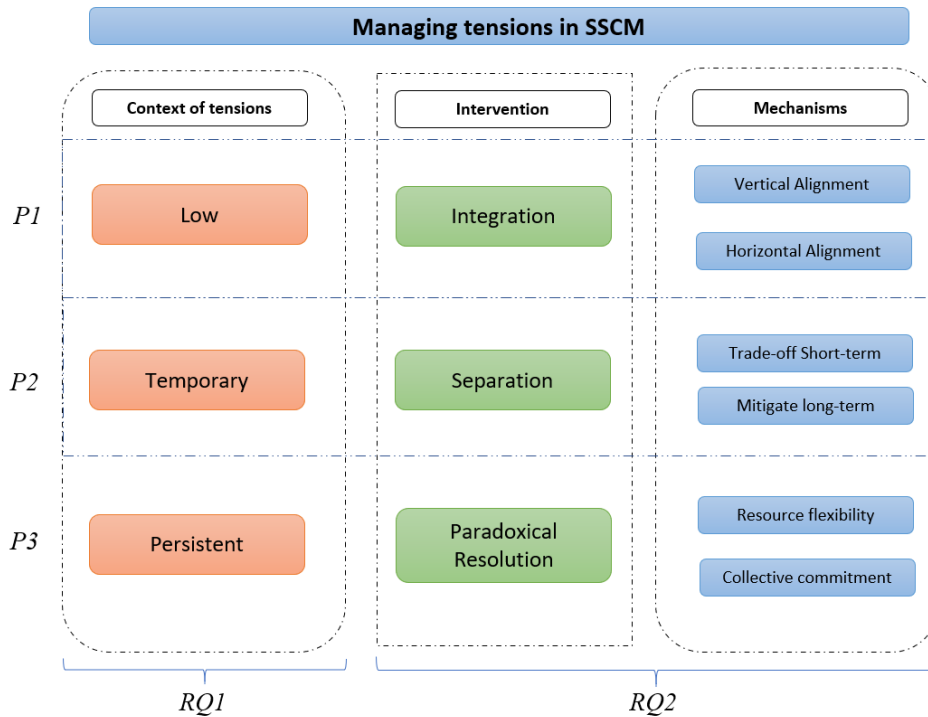


Figure 1 Research Framework for managing tensions in leagile supply chains

Context of low tensions relates to a situation where there was common predominant logic between the practices and no examples of tensions. This context was identified between lean workplace improvements and waste production. The lean practices, such as 5S programs, quality management, and process mapping, exhibited common predominant logic with environmental sustainability. They were supportive of environmental sustainability because they predominantly focus on eliminating waste in the focal organisation. However, there was a need to integrate environmental measures into lean practices to contribute to environmental sustainability. In terms of intervention, this research found that the practices that exhibited low tensions were managed through integration. Integration involved the alignment and expansion of the predominant logics of the practices to incorporate environmental goals. Thus, in the context of low tensions, an organisation used the integration approach to create synergetic outcomes. The generative mechanisms were initiated by vertical and horizontal alignment of leagile manufacturing and environmental sustainability. Therefore, the first proposition is:

P1: In the presence of low tensions, an organisation can use the integration approach to create synergetic outcomes through the generative mechanisms initiated through vertical and horizontal alignment of leagile manufacturing and environmental sustainability.

Context of temporary tensions relates to partially overlapping predominant logic that resulted in short-term negative environmental effects in the supply chain. The findings showed that Just-In-Time had a dual effect on the environment at the supply chain level. On the one hand, it was supportive of the efforts to reduce industrial waste by enabling procurement of exact production quantities. However, frequent deliveries contributed to pollution emissions, presenting tensions. This paper found that a pure trade-off was not adopted in the furniture manufacturing industry in contrast to previous research. Instead, the companies sacrificed sustainability in the short-term but mitigated the impact in the long-term. The mitigation measure includes outsourcing, local sourcing, and consolidated deliveries to ensure full truck loads (Piercy and Rich, 2015). Therefore, within the context of temporary tensions, an organisation might use the trade-off approach to avoid the tension in the short term but apply mitigation mechanisms for minimal impact on environmental sustainability. The second proposition is:

P2: Within the presence of temporary tensions between Leagile manufacturing and environmental sustainability, an organisation may use a trade-off approach to avoid the tension in the short term but apply mitigation mechanisms for minimal impact on environmental sustainability

In terms of agile production, the study found that customisation generated paradoxical tensions that the organisations had to address continuously. The current study further extends previous research by asserting that such resulting tensions are paradoxical. On the one hand, offering the customers a wide range of products was profitable to the organisation and allowed them to get customers' orders that they otherwise would not. However, customisation stressed the manufacturing processes resulting in more industrial waste, which negatively affected sustainability goals. The paradoxical resolution of the tensions initiated two generative mechanisms; resource fluidity, and collective commitment. Resource fluidity, the ability to respond rapidly to changes in customers' demands, is a key precursor to environmental sustainability (Green et al., 2019).

Therefore, within persistent tensions, an organisation may use a paradoxical approach to manage the tension through collective commitment and resource fluidity. The third proposition:

P3: Within the presence of persistent tensions, an organisation may use a paradoxical approach to manage the tension through collective commitment and resource fluidity.

Conclusions

This research builds on previous studies by suggesting three types of tensions and the corresponding mechanisms to improve environmental sustainability. It elaborates the environmental impact of pursuing economic viability through leagile manufacturing and contributes in providing empirical evidence to address the specific tensions between environmental sustainability and leagile manufacturing.

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