Lean and green practices: are they synergic?

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Abstract
The objective of this paper is to discuss the synergy and implementation of lean and green practices in a company from Appliance Industry (white goods). We selected integrated lean and green practices from literature and discuss if they are synergic or not through an in-depth case study.

Keywords: lean and green; practice; appliance; GSCM.

INTRODUCTION

In an independent way both visions (lean and green) can be considered deeply explored in academy and in companies. However, studies of both paradigms together are relatively new (Azevedo et al. 2012; Dües et al. 2013; Garza-Reyes 2015) and only some research has highlighted the importance of studying the influence of both paradigms on supply chain performance (Carvalho et al. 2010; Dües et al. 2013; Wiengarten et al. 2013). Therefore there is a lack of studies addressing the relationship between lean and green approaches (Dües et al. 2013; Jabbour et al. 2013).

The objective of this paper is to discuss the synergy and implementation of lean and green practices in a company from Appliance Industry (white goods). Our intention is from literature review identify some integrated lean and green practices and showing through an in-depth case which of them can be identified as implemented and synergic in a focal company from appliance sector.

In order to achieve the aforementioned objective, this paper is organized as follows. First, we select the lean and green practices presented in literature. Next, we present the methodology we used to develop this study. The fourth section presents the results and some discussions from the case study. Finally, the main conclusions are drawn at the fifth section.

LITERATURE REVIEW

The lean manufacturing concept was popularized in the United States from the 1990s, with the publication of the book "The Machine that Changed the World" by James P. Womack, Daniel T. Jones and Daniel Roos, which illustrates the significant difference performance achieved by the implementation of this concept in the Japanese automotive industry compared with Western industry. The concept proposed by Womack, Jones and Roos (1990)

assumes that there is waste everywhere in an organization and the lean vision emerges as an "antidote" to do more with less, and always in order to offer customers what they really want, at the time they need. So, the main objective of lean is to find out and eliminate waste (Shah and Ward, 2007), and waste can be defined as any activity in a process that does not add value for customers

Despite the existence of many papers related to lean and lean practices, there are few that link the lean and green point of view and they are relatively recent (Garza-Reys, 2015). Even if it is a relatively new topic, we can find out some research that has been investigating this relationship (Azevedo et al. 2011; Azevedo el al. 2012; Florida 1996; King and Lenox, 2001; Maxwell et al. 1998; Pampanelli et al. 2013; Rothenberg et al. 2001; Vais et al. 2006; Wiengarten et al. 2013). Some of them focused in similarities (Dües et al. 2013; Simpson and Power, 2005), or differences (Dües et al., 2013) between the two areas or advantages in adopting a model lean and green (Pojasek 2008). And many argue that the environmental perspective linked with lean can improve the performance of the organization in general (Corbett and Klassen, 2006; Hajmohammad et al. 2013; Miller et al. 2010;), adding value to the company.

As our focus is on lean and green practices in supply chain, studying in depth this issue, we construct the Table 1. This table shows the main lean and green practices from literature review. To construct this table we analysed 26 papers, which, in some way, addressed lean and green practices together. Five papers were not considered due at least one of these reasons: i) they present only one practice, or iii) they were authored for authors considered before (presenting the same practices). So, in the final analyse we became with 21 papers that had more information about lean and green practices in a supply chain perspective.

The first column corresponds to the categories according Shah and Ward (2007): suppliers (Sx), operations (Ox) and customers (Cx); the second column corresponds to the practice from literature; and, the third one corresponds to the references. From literature review we select 31 lean and green practices (7 related to suppliers, 19 linked with operations and 5 related to costumers). All of them in some way have any type of integration or link between lean and green.

Table 1: Integrated Lean and Green practices from literature review

Category	Practice	References
S1	Supplier network/collaboration/training (long-term relationship)	1, 2, 5, 7, 8, 10, 12, 13, 14, 18, 20, 21
S2	Supplier evaluation/certification/auditing (environmental requirements)	2, 5, 7, 9, 10, 13, 19, 21
S3	Use of green/less packages (from suppliers)	11, 12, 13, 15, 18
S4	Geographic concentration	13, 18
S5	Environmental risk sharing with suppliers	5, 7, 10, 12, 18
S6	Reducing number of suppliers	11, 18
S7	JIT delivery	2, 7, 10, 12, 14, 15, 18, 21
O1	Employees involvement, training and empowerment	1, 2, 3, 5, 6, 7, 9, 10, 14, 20
O2	Continuous improvement/Kaizen	1, 2, 3, 5, 6, 8, 9, 11, 14, 16
O3	Inventory reduction	1, 2, 3, 4, 7, 11, 12, 14
O4	Information shared through the chain or Information system	2, 3, 5, 6, 7, 10, 13, 18, 20
O5	5S	1, 2, 8, 11, 16
O6	Total Productive/Preventive Maintenance (TPM)	1, 2, 8, 16
O7	Six sigma	8, 16, 21
O8	3Rs (Reduce, Reuse and Recycle)	2, 7, 8, 12, 13, 14, 17, 19
O9	TQM[1] and/or TQEM[2]	8, 10, 14, 15, 19, 21
O10	Kanban	2, 11, 16
O11	Waste reduction	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 19, 20, 21
O12	Pollution prevention	2, 3, 4, 8, 10, 14, 17, 19

O13	ISO systems certifications (or other systems)	2, 4, 7, 8, 9, 10, 14, 15, 17, 19, 21
O14	Lead time and/or set-up reduction and/or total time reduction[3]	7, 11, 12, 13, 17, 19, 21
O15	Emissions reduction	3, 4, 10, 12, 14
O16	Reduction of hazardous/materials/resources consumption[4]	3, 7, 10, 12, 14, 15, 21
O17	Use of green technology	2, 3, 12, 14
O18	Value stream map/focus or sustainable VSM	7, 11, 16
O19	JIT philosophy	2, 7, 10, 12, 15, 16, 17, 19, 21
C1	Customer relationship/interaction	5, 7, 10, 12, 13, 14, 21
C2	Reverse logistics	10, 12, 13, 21
C3	Environmental risk sharing with costumers	5, 7, 10, 13
C4	Environmental products and/or eco-design	7, 10, 12, 14
C5	Use of green/less packages (to costumers)	7, 10, 11, 12, 13, 15, 21
References	1-Sobral et al. (2013); 2-Jabbour et al. (2013); 3-Rothenberg et al. (2001); 4-King and Lenox (2001); 5-Simpson and Power (2005); 6-Maxwell et al. (1998); 7-Dües et al. (2013); 8-Vais et al. (2006); 9-Pojasek (2008); 10-Corbett and Klassen (2006); 11-Miller et al. (2010); 12-Carvalho et al. (2011); 13-Espadinha-Cruz et al. (2011); 14-Florida (1996); 15-Govindan et al. (2015); 16-Parveen et al. (2011); 17-Wiengarten et al. (2013); 18-Azevedo et al. (2012); 19-Hajmohammad et al. (2013); 20-Duarte and Cruz-Machado (2015); 21-Carvalho et al. (2010).	

As we can check from Table 1, "waste reduction" was the most cited practices involving lean and green. Approximately 76% of the papers (16 from 21) mentioned waste reduction as a lean and green integrated practice, even if the reduce of waste can have a distinct perspective from lean and for green. As pointed out by Corbett and Klassen (2006), Dües et al. (2013) and Zokaei et al. (2013) waste reduction in lean perspective is more related with elimination of waste in all operational processes, internally and externally, that arise from overproduction, waiting, transportation, inappropriate processing, defects and unnecessary inventory. On the other hand, waste reduction for green perspective is more related to disassembly, redesign, waste segregation, and reuse and recycling.

METHODOLOGY

In order to achieve the main objective, an in-depth case study approach was adopted for this research. As this is a relatively new subject (Dües et al., 2013; Garza-Reyes, 2015) an exploratory and qualitative research method can be justified, in order to better explain the adoption and synergy of lean and green practices. Our intention was to answer the following questions: which of the main lean and green practices are really implemented in a focal company from appliance sector? And how the employees who directly and indirectly work with lean and environmental management recognize the lean and green synergy of these practices?

The case study was applied in a Brazilian big focal company from appliance sector. For conducting the in-depth case study we made some visits at company during first semester of 2015. Each visit lasted about a day. Data triangulation has been adopted, based on interviews, in-plant observations and document analysis (Yin 1994). We made formal interviews, in addition to shorter and informal interviews. The formal interviewed were managers from the following areas: Product & Development, Sustainability, Lean and Quality. The interviews lasted between 30 and 90 minutes each one and were conducted face-to-face. We asked opened questions and all interviews were recorded, transcribed and codified.

RESULTS AND DISCUSSION

Analysing the results and findings, we could observe that both, the lean and the green, are clearly present in the company. They use lean in many process of the company and we can

consider that this philosophy is one of the pillars of the company. In the case of green, they developed many of the activities of green area until 2000, when they began the ISO 14001 implementation process for subsequent certification in 2003.

However, what we could note is that the lean and green are treated in a separately way within the company. There are no lean and green department or area or a person treating this subject together.

As mentioned before, a script of questions was created based on integrated lean and green practices from literature (Table 1). The intention was to verify the presence or absence of these practices within the company. We classified the practices in three different categories: a) totally implemented; b) partially implemented; and c) not implemented (no existence). As the company does not have a formal lean and green department or sector, another contribution was an analysis regarding the potential of synergy of each practice. So, we tried to find out (if the practice was partially or totally implemented): i) if the people recognizes the lean and green potential, respectively.

In order to better organize our findings, we divided the results and discussions in three parts. The first one (Table 2) will discuss the lean and green practices related to suppliers. The second part (Table 3) will treat the operation. And the third one (Table 4) will be related to costumers. The Table 2 below shows the main practices we could recognize in the focal company, related to suppliers. After each table we discuss the findings.

Table 2: Lean and Green Practices related to Suppliers.

Cat.	Practices	Situation on the company	Does the responsible for lean recognize the green potential?	Does the responsible for green recognize the lean potential?
S1	Supplier network/collaboration/ training (long-term relationship)	Totally implemented	YES	YES
S2	Supplier evaluation/certification/ auditing (environmental requirements)	Totally implemented	YES	YES
S3	Use of less/green packages (from suppliers)	Partially implemented	YES	YES
S4	Geographic concentration	Partially implemented	YES	YES
S5	Environmental risk sharing with suppliers	Totally implemented	YES	YES
S6	Reducing number of suppliers	Partially implemented	YES	YES
S7	JIT delivery	Totally implemented	NO	YES

According to all interviewed and our observations, the company has a great concern with their suppliers, regarding both, the lean and green aspects. And that is an important finding, because as pointed out for Simpson and Power (2005), suppliers can have a direct impact on a customer's critical dimensions of cost, quality, technology, delivery, flexibility and profits. So, in a supply chain perspective having a good relationship with suppliers is crucial.

About S1, "Supplier network/collaboration/training (long-term relationship)", we also could perceive they have more than one program of evaluation and training for suppliers, trying to achieve long-term relationship with them and the collaboration and communication is easily recognized. Regarding the lean and green synergy, we can affirm that the practice S1 is synergic as the both responsible (for lean and green) recognize the potential of the other area. In other words, lean recognizes the practice as green and vice and versa.

This finding corroborates with Simpson and Power (2006) study that also consider this practice as synergic. According to the authors developing and maintaining a supply

relationship can be achieved through either collaboration or compliance. Specifically, trust provides a basis for achieving collaboration, while power serves as a mechanism for achieving compliance. Dües et al. (2013) also argue that supply chain relationship, with a close collaboration with supply chain partners, especially suppliers, is a synergic lean and green practice.

The S2 "Supplier evaluation/certification/auditing (environmental requirements)" is also present in the company and lean and the green areas both recognize this practice as synergic. Likewise we can recognize the same from some previous works (Azevedo et al. 2012; Pojasek 2008) that explain the influence of green and lean upstream SCM practices on business sustainability.

Regarding the "Use of less/green packages (from suppliers)" (S3) there are some actions in the company. But we can affirm from our observation and from interviews that this practice is not totally implemented. The reason is because they do not have a program for all the suppliers in order to reduce packages, just for some of them. From Table 1 we can perceive that this practice was mentioned only for 24% of the papers and very little is discussed in depth about that. One of the works that mentions environmentally friendly packaging is Govindan et al. (2015), that consider as one of the ten variables to study the influence of lean, green and resilient practices on supply chain performance. Regarding the synergy, as it is consider a waste, it is recognized as a synergic practice for both areas.

The S4 "Geographic concentration" is a practice also identified and synergic according to both areas (lean and green). Azevedo et al. (2012) consider that geographic concentration contributes to a decrease in the distance between SC entities and, therefore, reductions in energy consumption and CO_2 emissions from material transportation. They also argue in their paper that there is a set of green and lean practices that influence positively not only the economic (operational cost, inventory cost, and environmental cost), and social (corruption risk, supplier screening, local suppliers) but also the environmental measures (business wastage and green image). One of these practices, according the authors, is geographical concentration. However, although we have identified this practice and this finding, we verified that actions in order to reduce the geographic concentration are limited. So the practice is not fully implemented.

The same situation is for the practice S6 "Reducing number of suppliers". According our observations, there is a synergic practice for both point of view (lean and green), however it is not totally implemented by the company because the actions are limited.

The next evidence we can highlight is related to "Environmental risk sharing with suppliers" (S5). To become a supplier, the companies have to sign and fulfil a code of conduct for suppliers. This code has concerns such as anti-corruption, freedom from slave labour, no child labour, environmental protection and biodiversity, protection of indigenous communities, among other things. According to Corbett and Klassen (2006), environmental surprises can cause financial harm through disruptions or product liability in supply chains. So, these aspects and concerns seek to somehow protect the focal company against any legal problems or liabilities that may be associated indirectly to its activities, through its suppliers. And, in some way, it is a covenant of trusting and risk sharing between the focal company and the suppliers that accept and fulfil the code. The practice is totally implemented and the synergy is also recognized.

The only practice not synergic is the S7 "JIT delivery". It is one of the pillars of the company and they have many actions to guarantee the JIT delivery from their suppliers. Although, the synergy could not be recognized for both areas. The lean manager does not consider this practice with green potential, as according to him JIT needs many delivers as necessary and sometimes it is not a sustainable vision because it can increase CO_2 emissions.

This trade-off was previous discussed by some works (Florida 1996; Carvalho et al., 2011;

Dües et al. 2013; Govindan et al. 2015; King and Lenox, 2001; Rothenberg et al. 2001). In some way they agree that lean prescribes an increase in the replenishment frequency whereas green practices aim at reducing transport time and replenishment frequencies.

Next, the Table 3 presents the results of the lean and green practices from the operation.

Table 3: Lean and Green Practices related to Operations.

Cat.	Practices	Situation on the company	Does the responsible for lean recognize the green potential?	Does the responsible for green recognize the lean potential?
O1	Employees involvement, training and empowerment	Totally implemented	YES	YES
O2	Continuous improvement/Kaizen	Totally implemented	YES	YES
O3	Inventory reduction	Partially implemented	NO	YES
O4	Information shared through the chain or Information system	Totally implemented	YES	YES
O5	5S	Totally implemented	YES	YES
O6	Total Productive/Preventive Maintenance (TPM)	Totally implemented	YES	YES
O7	Six sigma	Totally implemented	YES	YES
O8	3Rs (Reduce, Reuse and Recycle)	Totally implemented	YES	YES
O9	TQM and/or TQEM	Totally implemented	YES	YES
O10	Kanban	Totally implemented	YES	YES
O11	Waste reduction	Totally implemented	YES	YES
O12	Pollution prevention	Totally implemented	YES	YES
O13	ISO systems certifications (or other systems)	Totally implemented	YES	YES
O14	Lead time and/or set-up reduction and/or total time reduction	Totally implemented	YES	YES
O15	Emissions reduction	Totally implemented	YES	YES
O16	Reduction of hazardous/materials/ resources consumption	Totally implemented	YES	YES
O17	Use of green technology	Totally implemented	YES	YES
O18	Value stream map/focus or sustainable VSM	Partially implemented	YES	YES
O19	JIT philosophy	Totally implemented	NO	YES

The company has a great concern with training for employees (Practice O1), related to lean, green and other subjects such as health and safety, security, quality, communication, among others, corroborating with Sobral et al. (2013), that argue that lean and green practices are related in different aspects such as the involvement of employees in various production levels, with continuous improvement, with the reduction of inventories and collaboration of the suppliers. These practices make the product liability extends to all employees and also for the entire supply chain (suppliers) in order to expand environmental awareness.

"Information shared through the chain or Information system" (O4) is another concern. According to interviewers, the company has as a disseminate policy sharing

information internal (with their employees), and external (with their main suppliers and costumers). Information systems and sharing of key information are also considered as a synergic practice from some authors before (Corbett and Klassen, 2006; Simpson and Power, 2005) and it is considered important to maintain the integration of lean and green (Carvalho et al. 2011; Espadinha-Cruz et al. 2011).

Many other practices such as "Continuous improvement/Kaizen" (O2), "5S" (O5), "TPM" (O6), "six sigma" (O7), TQM and/or TQEM" (O9), "Kanban" (O10) and "ISO systems certifications (O13)" were considered synergic and totally implemented. All of them are very known and used by the company. According the interviews they may help to improve a possible integration of lean and green. The same idea was shared from Wiengarten et al. (2013), with special attention for "Continuous improvement/Kaizen" that was one of the most cited synergic practice from literature and "ISO systems certifications (or other systems)" that is mentioned as an important base for the integration.

About "waste reduction", we can discuss some points related to our findings. Besides "waste reduction" (O11), also "3Rs" (O8), "pollution prevention" (O12), "Lead time and/or set-up reduction and/or total time reduction" (O14), "Emission reduction" (O15), "Reduction of hazardous/materials/resources consumption" (O16), and "Use of green "technology" (O17) are, in some way, practices related to reduction of waste, or from the lean point of view or from the green point of view. All of them are very consolidated in literature review, they are totally implemented in this company, and they are considered synergic. So, if we think in a synergic model for lean and green, we can argue that these practices can have an especial attention.

The practice VSM/SVSM (O18) is considered synergic as well, but only VSM in totally implemented. And about "inventory reduction" (O3) and "JIT philosophy" (O19), the first one was considered partially implemented and the second one totally implemented. But both were considered no synergic. The reason is that the JIT and a reduction of inventory demand many delivers as necessary and as we discussed before, it may cause a trade-off by environmental point of view, with more transportation and some extra CO_2 emissions (Carvalho et al. 2011; Dües et al. 2013; Govindan et al. 2015; King and Lenox, 2001; Rothenberg et al. 2001).

The next findings and discussions are about the lean and green practices related to costumers (Table 4).

Table 4: Lean and Green Practices related to Costumers.

Cat.	Practices	Situation on the company	Does the responsible for lean recognize the green potential?	Does the responsible for green recognize the lean potential?
C1	Customer relationship/interaction	Totally implemented	YES	YES
C2	Reverse logistics	Partially implemented	YES	YES
C3	Environmental risk sharing with costumers	Partially implemented	YES	YES
C4	Environmental products and/or eco-design	Partially implemented	YES	YES
C5	Use of green/less packages (to costumers)	Totally implemented	YES	YES

According information from interviews, observations and some documents, there is strong relationship with costumers and also Florida (1996), one of the first studies about lean and green relationship, pointed out customer demands as one of synergy point between lean and green.

Different from the suppliers, the practice "Use of green/less packages (to costumers)" (C1) is totally implemented in this company. They have projects to reduce and improve the packaging of products. It is also considered synergic practice as it is related to waste reduction and corroborates with some previous research (Carvalho et al. 2011; Corbett and Klassen, 2006; Govindan et al. 2015; Miller et al. 2010, among others).

Regarding "Reverse Logistics" (C2) and "Environmental risk sharing with costumers" (C3), they have programs implemented and the programs are aligned with new Brazilian waste management legislation, "Politica Nacional de Residuos Solidos n.12305/2010 (PNRS)" that came into force at the end of 2010. The main objective of the PNRS is to prioritise a national integrated waste management system under a shared responsibility principle, setting reverse logistics as the key instrument to achieve that aim.

But even finding this evidence, they are considered partially implemented practice due the fact that the initiatives do not cover all products, but only some. About the synergy, both can be considered synergic practices. Previous work also mentioned them as synergic practices (Carvalho et al. 2011; Carvalho et al. 2010; Corbett and Klassen, 2006; Espadinha-Cruz et al. 2011).

The fourth practice identified was "Environmental products and/or eco-design" (C4). They have been using DfE (Design for Environment) methodology within the Product Development department to develop some new products. But even if it is a synergic practice because bring benefits to lean and green, it is considered partial implemented because it is not used for all products and situations. However, this is not a consensus in literature review. Dües et al. (2013), for example, consider it is not a synergic practice, and that the synergic will depend to each situation or company.

Finally, the practice "Environmental risk sharing with costumers" (C5) is partially implemented and no synergic. It is considered with green potential, but the lean potential was not recognized. Only four papers (Corbett and Klassen, 2006; Dües et al. 2013; Espadinha-Cruz et al. 2011 and Simpson and Power, 2005) discussed this practice before. So this is a practice that must be more explored.

CONCLUSIONS

The main objective of this paper was to discuss the synergy between lean and green practices through an in-depth case study and try to better understand which of the main lean and green practices are really implemented in a focal company from appliance sector, and how the employees who directly and indirectly work with lean and environmental management recognize the lean and green synergy of these practices. After our analysis we found 3 practices from the 31 not synergic, one related to suppliers (S7), and two related to operations (O3 and O19). All have some relations to JIT and inventory reductions, which in some way bring a trade-off of CO_2 emissions.

About the situation of lean and green practices within the company and the potential to develop a lean and green model for management, from 31 practices we have 8 not totally implemented, but at least with some presence in the company. In percentage, the operation has more practices implemented (89,5%), then the suppliers (57%) and the customers (40%). So, for a total implementation of lean and green practices, the company should start improvements working on the practices related to customers.

We can point out some limitations of this research. The first one is that we started our research from practices from literature review considered integrated. This has made it more difficult to find some practice not synergic in lean and green at the same time. And as we chose to study a big focal company, it became even more difficult find practices not implemented or not existent. Another limitation is that it is a case study and the results cannot

be widespread. Our results are closely related to the situation of this company, and in that moment. However, we consider that there is a contribution as these thematic lean and green synergic practice is still less explored and discussed.

As suggestions for future studies we highlight studying in-depth the trade-offs or the "no synergic practices".

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