Lean and Green Manufacturing Practices: A Multiple Case Study about Synergy

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Abstract

This article aims to evaluate the synergy between Lean and Green Manufacturing practices in the Brazilian furniture manufacturing industry. The life cycle assessment (LCA) and cleaner production (CP) practices were considered for the evaluation of the green manufacturing practices. Thus, the synergy evaluation was determined by the adherence level of Lean Manufacturing (LM), LCA and CP and by their correlations (Pearson coefficient). The research method used was the multiple case studies with 10 Brazilian furniture-manufacturing industries, through interviews and observations in the production units. The main results showed that the Brazilian furniture manufacturing industry has a low level of adherence for LM, LCA and CP practices. The level of compliance for LM was 28.33%; for LCA it was 21.43%, and for CP it was 19.05%. However, the analysis of correlations allowed identifying a strong dependence between LM and CP practices (Pearson coefficient of 0.8849) and the moderate dependence between LM and LCA practices (Pearson coefficient of 0.5817). It was possible to identify 9 synergic practices among a total of 48 practices evaluated. This article contributes to the discussion of methods to evaluate the synergies of Lean and Green Manufacturing practices.

Keywords
Lean and Green Manufacturing, Life Cycle Assessment, Cleaner Production, Furniture Industry, Synergy.

1. Introduction
The discussion related to the inclusion of environmental aspects in manufacturing systems have increased in recent years and this new scenario has motivated the study of integrated solutions and tools that allow to balance the increase of competitiveness in the manufacture with the protection of natural resources (Pampanelli et al., 2014).

Thus, the integration between Lean and Green Manufacturing practices has been presented as one of the main strategies for improving eco-efficiency and integrating manufacturing management with the concepts of sustainability (Campos and Vazquez-Brust, 2016; Vinodh et al., 2016; Bare, 2014; Hajmohammad, et al., 2013). These studies agree that the application of Lean and Green Manufacturing has resulted in increased environmental and operational performance.

However, Sant'anna et al. (2017) point out that there are gaps in relation to the influence of environmental management on lean manufacturing and that there is a relative lack of studies investigating whether the Lean and Green Manufacturing can be applied in a synergic way.

The literature has shown the existence of synergies based on the joint implementation of lean and green manufacturing. However, the studies have been mainly quantitative and did not explore the interactions between lean and green and the conditions under which these interactions generate synergies (Galeazzo et al., 2014; Kumar et al., 2018).

In this context, the following paper has as objective to evaluate the synergy between Lean and Green Manufacturing practices in the Brazilian furniture manufacturing industry. The life cycle assessment (LCA) and cleaner production (CP) practices were considered for the evaluation of the green manufacturing practices. This paper is structured in more four sections besides this introduction. The next section presents the theoretical review, with the main previous works that support this research. Then, the third section explains the method used to achieve the main objective of this research. The fourth section presents the results and the discussions and finally the fifth section the conclusions.

2. Theoretical Review
The main basis of this theoretical review is practices of Lean Manufacturing (LM) and Green Manufacturing (GM). Among the practices that can be considered GM, the following stand out: Cleaner Production (Oliveira et al., 2017); Eco Efficiency (Korhone, 2007); The Life Cycle Analysis (LCA) (Moraes et al., 2010); Environmental Management Systems (Nawrocka et al., 2009; Gavronski et al., 2012); Environmental Performance Assessment (Jasch, 2000).

One of the philosophies that have been widely used by enterprises is the philosophy of LM (Campos, 2013). This philosophy is composed of numerous tools that seek to identify and eliminate wastes from a manufacturing system (Liker, 2004, Bevilacqua et al., 2017). However, although it is widely embedded in companies and in many different sectors of the economy (Garza-Reyes, 2015), there are few studies that seek to determine the level of implementation of Lean Manufacturing.

On the other hand, Green Manufacturing (GM) has been defined as a systematic approach to eliminating waste, optimizing the use and selection of resources and technologies, thus decreasing the impact on the environment (GSN, 2018).

Life Cycle Assessment (LCA) is the compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product throughout its life cycle. The LCA was used as a green manufacturing practice because it allows the reduction of costs by the substitution and / or reduction in the consumption of raw materials, reduction in the emission of pollutants, waste disposal, besides identifying the potential environmental impacts from the extraction of the raw material to the destination (cradle to grave).

Cleaner Production (CP) seeks to integrate a preventive environmental strategy with processes, products and services to increase eco-efficiency and reduce risks to man and the environment (UNIDO, 1991). The CP was used as a Green Manufacturing practice because it presented a large number of environmental requirements.

For Dornfeld et al. (2012), GM's practices have as principle the reduction of environmental impacts over time, which differentiates it from the concept of sustainability of the Triple Bottom Line (Elkington, 1997). In this sense, the integration between LM and GM practices can contribute to the development of a sustainable manufacturing system.

The literature has shown the existence of synergies based on the joint implementation of LM and GM practices. Dües et al. (2013) have identified that LM practices present synergies with GM practices and may even be used as support. However, LM practices when implemented in isolation do not allow the identification of environmental requirements such as: environmental risks; solid and hazardous waste; (Kurdve et al., 2014; Pampanelli et al., 2014).

Thus, LM and GM synergy occurs when the aggregate value to the environmental and financial performance resulting from the joint application of LM and GM practices is higher than the sum of the values obtained by the application of LM and GM individually (LM or GM) (Campos and Vazquez-Brust, 2016). Martinez et al. (2012) pointed out that LM and GM synergy is achieved when there is a catalytic association with mutual LM and GM benefits: The implementation of lean practices triggers a better environmental performance and vice versa.

3. Method

The synergy between Lean and Green Manufacturing practices was evaluated by the level of adherence between LM Practices and LCA and CP (GM) Practices. The Pearson coefficient was used to measure the level of dependence between two variables (LM x CP and LM x LCA).

A multiple case study was carried out in the Brazilian furniture sector. The 10 companies were selected by non-probabilistic sampling called convenience sampling, with more than 90 employees, belonging to important furniture poles in the country. Companies were selected from the South and Southeast regions of the country because they are responsible for 84.3% of all production and account for 77.5% of total industries. Table 1 presents the summary of the main characteristics of these companies.

The furniture market in Brazil represented US$ 13.37 billion in 2015. This market grew 27.8% between 2010 and 2014. In 2015, it had a productive chain of 19.800 industries, generated 327.4 thousand jobs, produced 507.7 million pieces, exported US$ 673.8 million, and invested US$ 0.39 billion (IEMI, 2015). In relation to the world market (US$136.38 billion), Brazil represented 3.5% of the world's furniture production, and the Asia and China represented respectively 56% and 22.3%.

Table 1: Characteristics of the multi-case companies.

Furniture Factories	**City/State**	**Annual revenue (10^6 US$/year)**	**Products**	**N º Employees**	**Environmental Certification**	**Quality Certification**
FF1	Linhares/ES	~11.5	Wardrobes, Beds Headboards, Dressers Created	225	No	No
FF2	Linhares/ES	~12.8	Bedrooms, Modules, Kitchens, Home Office Rooms, Service Areas	368	ISO 14001	ISO 9001
FF3	Mirassol/SP	~8	Bedrooms, Home Office Kitchen, Modules	160	No	No
FF4	Mirassol/SP	~13.7	Wardrobes, Dressers, Created, Beds, Headboards	200	No	No
FF5	Mirassol/SP	~6.9	Panels, Racks Desks, Wardrobe, Headboards, Writing desks.	98	No	No

FF6	Mirassol/SP	~12	Dresser, Chest of drawers Glassware, dressing table Hacker, Panels	178	No	No
FF7	Bento Gonçalves/ RS	~17.1	Cradles, wardrobe, Beds, Planned	200	No	No
FF8	Bento Gonçalves/ RS	~18.6	Kitchens, Bedrooms Planned, Home theater,	152	No	ISO 9001
FF9	Bento Gonçalves/ RS	~170	Projects kitchen, Rooms, Bathrooms, Planned	640	ISO 14001	ISO 9001
FF10	Bento Gonçalves/ RS	~63	Kitchens, Bedrooms, home theater, home office	600	ISO 14001	ISO 9001

The multiple case study was developed through interviews. The interviews were conducted in quality and production managers and supervisors. Three research protocols were determined (Table 2-4) to analyze the level of adherence of LM, LCA and CP practices. Table 2 shows the research protocol used to evaluate Lean Manufacturing practices, which was based on the J4000 standard (SAEJ4000, 1999; SAE J4001, 1999). Table 3 shows the research protocol used to evaluate Life Cycle Assessment practices, which was based on the LCA guide (Remmen, 2007). Table 4 shows the research protocol used to evaluate Cleaner Production practices, which was based on the CP guide (UNIDO, 2016).

The research protocols were tested with two academics and applied a pilot test, whose comments were used to review the protocols. The interviews lasted between 60 to 90 min, followed by a visit to the companies' facilities. The triangulation of data was obtained through comparison with other forms of data, including the notes of the visits in the production processes, data analysis of quality control records and preventive maintenance of equipment, analysis of work instructions, production records, and production control reporting data.

Table 2: Research protocol - Lean Manufacturing practices.

Elements	**Lean Manufacturing practices**
Lean Manufacturing Philosophy	LM 01 - The strategy must include goals of productivity, quality, cost, delivery time, safety and environmental and moral.
Visual Management	LM 02 - Performance indicators should be visually monitored through easily identifiable dashboards (tables, timelines, flowcharts, statistics, flags)
	LM 03 - The work environment is clean, well-organized and audited regularly in relation to 5S practices.
Stable and standardized processes	LM 04-07 - Records and procedures are required: LM 04 -Bill of materials; LM 05 - Sequence of operations; LM 06 - Value Stream Mapping Tool (VSM); LM 07 – Maintenance
Level Production	LM 08 - Use of the Heijunka Tool: This tool controls the use of labor, resources and in-process stock
Just-in-time (JIT)	LM 09 - System pulled according to the demand rhythm. The process flow is controlled by the customer's Takt Time.
	LM 10 - Setup (Single Minute Exchange Die – SMED): Devices and Tools developed to reduce the preparation time for product change.
	LM11 - Continuous Flow: The production flow must be organized according to the sequence of operations and operated with the smallest possible batch size (one-piece flow).
	LM 12 - Integrated logistics: all suppliers, external or internal, must be adapted to operate with fluctuations of demands. The information must be fast and accurate.

Jidoka	LM 13 - Poka-Yoke Tools: Devices must be developed for processes to run continuously and automatically. The process must be able to control and remove defects without human intervention.
	LM 14 - Andon Tools: A light and sound signal must be installed throughout the production system so that problems are identified quickly.
	LM15 - Problems Solving. A methodology for solving problems should be used and evidenced.
	LM 16 - Quality control: A working group should be responsible for the quality and continuous improvement of the process.
Continuous Improvement	LM 17-18 - Continuous improvement is developed with incentives for employee participation in improvement practices. LM 17 - waste reduction practices; LM 18 – The problem solving committees must have authority to implement the solution
	LM 19 - Statistical Process Control: Requisites of process capacity and variability should be monitored and improved.
	LM 20 - People and teamwork: The company must present a system of awards for the improvement of processes.

Table 3: Research protocol - Life Cycle Assessment practices.

Elements	**LCA (Life Cycle Assessment)**
LCA Method	LCA01-A method of visualizing and mapping the flow of materials and energy must be used to identify environmental impacts.
Rethinking	LCA 02 - The product and its functions must be rethought to increase its efficiency.
Wastes	LCA 03 - There is concern about the reduction / elimination of waste generation and the better use of the raw material.
Replace	LCA 04 - The product and its functions should become more sustainable, for example, replacing more sustainable raw material.
Reduce	LCA 05 - Programs to reduce the consumption of products and natural resources throughout the product life cycle.
Reuse	LCA 06 - Packing made with re-use and / or recycling materials.
	LCA 07 - The product design has considered the future stages of disassembly and reuse.
	LCA 08 - The manufacturing system has considered water saving and reuse.
Recycle	LCA 09 - The raw materials that can be recycled have been identified.
Logistics	LCA 10 - Suppliers agreed to reduce environmental impacts.
Sustainable Purchases	LCA 11 - Buyers are able to encourage environmental considerations into its suppliers.
	LCA12 - The raw material used is from renewable sources
Responsibility	LCA 13 - System against corruption are implemented.
	LCA 14 -Initiatives to promote environmental responsibility are developed;

Table 4: Research protocol – Cleaner Production practices.

Elements	**CP (Cleaner Production)**
Housekeeping	CP 01 -The working environment is clean, well organized and audited on a regular.
	CP 02- There is a preventive maintenance program for the equipment in order to save energy, emission control and noise.
Raw Material	CP 03 - No hazardous or non-renewable raw material are used.
	CP 04 - Recycled inputs and raw materials are used in significant percentages (above 50%).
Process Control	CP 05- The processes of consumption of raw material, of energy and scrap are controlled and improved by statistical tools.

	CP 06- Procedures are established and followed, resulting in a continuous decrease in the consumption of raw material, energy and scrap.
Equipment	CP 07- The equipment used was modified or replaced with others with lower consumption of raw material and less emission of residues, noise and pollution.
Technological Change	CP 08- The technology currently used in manufacturing is the most effective in terms of reducing waste and emissions and / or in terms of efficiency in energy and raw material consumption.
	CP 09 - Both customers and suppliers are properly represented in the groups of CP in product/process/project of the organization.
Recovery and Reuse	CP 10-The waste generated in the production process undergoes reworking to be reused in production plant itself.
Production of Sub-useful products	CP 11 -Product and process projects generate by-products that are useful as raw material to other manufacturers inside or outside the supply chain.
	CP 12- product projects and process are expected to reuse by-products in the manufacturing process.
Product	CP 13- Effective incentives for the supply chain and customers are placed to reward the sharing of improvements in efficiency and cost reductions with CP projects.
	CP 14 - Products are designed or modified to be manufactured and used with less environmental impact.

A multivariate analysis was performed through cluster analysis of data of the 10 companies surveyed to investigate which companies had similar characteristics regarding LM, LCA and CP practices. The Euclidean distance measure was used as measure of similarity, with creation of dendrogram to analyze the clusters formed.

To identify the synergistic practices between LM, LCA and CP, the correlation between each practice was calculated. Correlations with a Pearson coefficient (r)> 0.7 were considered synergistic. The limitation of this study concerns the sample of companies obtained (10 companies), which, although adequate according to the multi-case view, does not allow the results and conclusion to be generalized for the whole Brazilian furniture industry.

4. Results and Discussion

The results obtained with the application of the research protocols on LM, LCA and CP practices (Tables 2-4) were tabulated respectively in Tables 5-7. To analyze the data for the 10 companies, the median was used as a measure of central to medium tendency. The median result can be analyzed on the same scale used in the questionnaire. For the cases in which the median resulted in non-discrete values, they were rounded.

Table 5: Level of adherence to Lean Manufacturing Practices

Lean Manufacturing Practices (LM)		FF 1	FF 2	FF 3	FF 4	FF 5	FF 6	FF 7	FF 8	FF 9	FF 10	FF No ISO	FF With ISO	Median (FF1-10)
LM 1	Lean Manufacturing Philosophy	1	3	3	3	1	2	3	3	3	3	3	3	3
LM 2	Visual management	1	2	1	1	0	0	3	2	3	1	1	3	1
LM 3	5S Practices	1	1	2	1	0	1	3	0	3	3	1	3	1
LM 4	Stable and standardized processes (bill of materials)	2	2	2	2	2	2	3	2	3	3	2	3	2
LM 5	Stable and standardized processes (sequence of operations)	2	2	1	1	0	2	2	0	0	1	1	2	1
LM 6	Value Stream Mapping (VSM)	0	0	0	0	0	0	0	0	0	0	0	0	0
LM 7	Stable and standardized processes (maintenance)	1	1	0	1	0	1	1	3	3	3	1	2	1
LM 8	Heijunka Tools	1	2	2	2	1	1	1	2	2	2	2	2	2
LM 9	JIT: Pulled system	0	1	2	0	0	1	0	0	2	2	0	2	1
LM 10	JIT: Setup	0	2	0	0	0	1	0	0	1	0	0	1	0
LM 11	JIT - Continuous flow	1	1	1	1	0	1	0	1	2	2	1	2	1

LM 12	JIT - Integrated logistics	0	0	1	0	1	1	2	1	1	1	1	1	1
LM 13	Jidoka - Poka-yoke	1	1	0	1	0	0	0	0	0	1	0	1	0
LM 14	Jidoka – Andon	0	0	0	0	0	1	1	1	1	0	0	1	0
LM 15	Jidoka – Problems Solving	1	1	0	0	0	0	2	1	2	3	0	2	1
LM 16	Jidoka - Quality control	1	1	2	0	0	0	2	0	2	1	0	2	1
LM 17	Continuous improvement - Waste reduction	1	1	0	0	0	0	2	0	3	0	0	2	0
LM 18	Continuous Improvement - Authority	1	1	0	0	0	1	3	0	3	0	0	2	1
LM 19	Statistical Process Control	0	0	0	0	0	0	1	0	1	1	0	1	0
LM 20	Continuous improvement - (people and work team)	0	1	1	0	0	1	3	0	3	1	0	2	1
	Level of Adherence (%)	25,00%	38,33%	30,00%	21,67%	8,33%	26,67%	53,33%	26,67%	63,33%	46,67%	20,00%	54,17%	28,33%

Table 6: Level of adherence to Life Cycle Assessment practices.

Life Cycle Assessment Practices (LCA)		FF1	FF2	FF3	FF4	FF5	FF6	FF7	FF8	FF9	FF 10	FF No ISO	FF With ISO	Median (FF1-10)
LCA 1	Life cycle assessment Method	0	0	0	0	0	0	0	0	0	0	0	0	0
LCA 2	Rethinking for efficiency	0	0	0	0	0	0	3	0	0	0	0	0	0
LCA 3	Solid waste management	1	3	2	1	1	1	1	1	1	1	1	1	1
LCA 4	Replace for Sustainability	0	1	0	0	0	0	2	0	0	0	0	1	0
LCA 5	Reduce- Energy efficiency	0	2	2	2	1	0	1	0	0	1	1	1	1
LCA 6	Reuse – Packing	0	2	2	1	0	1	2	1	1	1	1	2	1
LCA 7	Reuse - product design	0	0	1	0	1	0	0	0	0	0	0	0	0
LCA 8	Reuse - Water consumption	0	2	0	1	0	0	1	1	2	2	0	2	1
LCA 9	Recycle Identification	1	2	2	2	1	1	3	2	2	1	2	2	2
LCA 10	Logistics – Suppliers environmental impacts	0	1	0	0	0	0	0	0	0	0	0	0	0
LCA 11	Sustainable purchases - Incentives for buyers	1	0	0	0	0	0	0	0	1	0	0	0	0
LCA 12	Sustainable purchases - Renewable Sources	2	1	1	2	1	2	1	2	2	2	2	2	2
LCA 13	Responsibility - System against corruption	1	1	1	1	1	1	0	0	2	0	1	1	1
LCA 14	Responsibility - Environmental responsibility	0	2	0	0	0	0	0	0	1	0	0	1	0
	Level of Adherence (%)	14,29%	40,48%	26,19%	23,81%	14,29%	14,29%	33,33%	16,67%	28,57%	19,05%	16,67%	25,00%	21,43%

Table 7: Level of adherence to Cleaner Production Practices

Clean Production Practices (CP)		FF1	FF2	FF3	FF4	FF5	FF6	FF7	FF8	FF9	FF10	FF No ISO	FF With ISO	Median (FF1-10)
CP 1	Housekeeping	1	1	2	1	0	1	3	0	3	3	1	3	1
CP 2	Preventive Maintenance	1	1	0	1	0	1	1	3	3	3	1	2	1

CP 3	Change in raw material	0	0	0	0	0	0	2	0	0	1	0	1	0
CP 4	Recycling of raw material	0	1	1	1	0	1	1	1	1	1	1	1	1
CP 5	Statistical Process Control	0	0	0	0	0	0	1	0	1	1	0	1	0
CP 6	Continuous decrease in the consumption	1	2	2	2	1	1	2	1	2	2	1	2	2
CP 7	Modification of equipment	1	2	1	1	0	1	1	1	1	1	1	1	1
CP 8	Technological change	1	2	1	1	1	0	1	1	2	2	1	2	1
CP 9	Supply Chain applying CP	1	1	0	0	0	1	0	0	1	0	0	1	0
CP 10	Recovery and reuse in the plant	0	1	1	1	1	1	1	1	1	1	1	1	1
CP 11	Production of sub-useful products	1	1	0	1	0	0	1	0	0	0	0	1	0
CP 12	Process for reuse by-products	0	0	1	0	1	0	0	0	0	0	0	0	0
CP 13	Product modification	0	0	0	0	0	0	0	0	1	0	0	0	0
CP 14	Design of products-principles of CP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Level of Adherence (%)	16,67%	28,57%	21,43%	21,43%	9,52%	16,67%	33,33%	19,05%	38,10%	35,71%	16,67%	34,52%	19,05%

The furniture factory FF9 presented a system of corruption (LCA 12) implemented (Median equal to 2) by means of an ethics manual. The level of adherence of life cycle assessment practices shows the high fluctuation between furniture factories (FF1 5-6: 14.29%, FF2: 40.40%) and none furniture factory presented adherence levels above 50%. The overall adherence level is 21.43%. The ISO-certified furniture factories showed higher adhesion levels (25.00%) compared to factories without ISO certification (16.67%).

The level of adherence of cleaner production practices shows the high fluctuation between furniture factories (FF5: 9.52%, FF9: 38.10%) and none furniture factory presented adherence levels above 50%. The overall adherence level is 19.05%. The ISO-certified furniture factories showed higher adherence levels (34,52%) compared to factories without ISO certification (16,67%).

The result shows that companies with certifications (ISO 9000/14000) improve their level of adherence for LM, LCA and CP practices). This result is evidenced by the multivariate analysis and cluster analysis (dendrogram) shown in Figure 1.

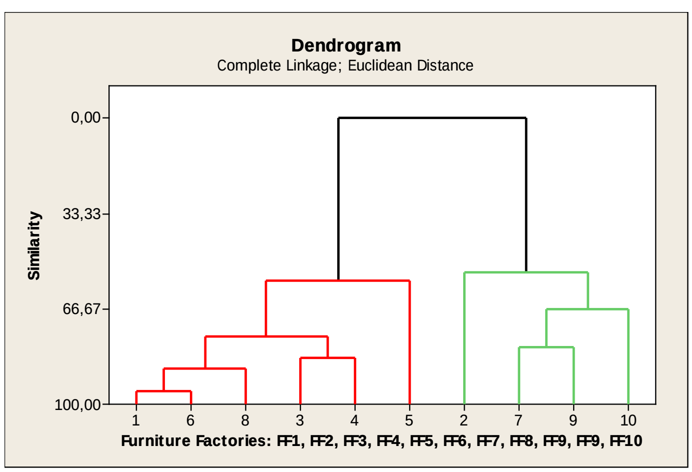

Figure 1. Dendrogram of hierarchical analysis of grouping similarity of furniture factories

Figure 1 shows that two different groups of companies were grouped in relation to the investigated characteristics: group 1 was formed by the companies FF1, FF3-6 and FF8; Group 2 was formed by the companies FF2, FF7, FF9-10. The companies of group 1 do not present any type of ISO certification (ISO 9000 and ISO 14000) and all companies of group 2 are ISO certified (ISO 9000 and/or ISO 14000).

After obtaining the level of adherence of the LM, LCA and CP practices from the furniture factories researched, it was verified the Pearson correlation coefficient between the LM and GM practices.

The Pearson correlation coefficient between LM and CP practices was 0.8849. This means that LM and CP practices are heavily dependent. As a result, when implementing the LM practices, the company will obtain results that will favor the CP practices and the environmental performance. The Pearson correlation coefficient between LM and LCA practices was 0.5802. This means that LM and CP practices are dependent. As a result, when implementing the LM practices in the company, the results obtained tend to promote adherence with the LCA practices and can also improve the environmental performance.

From the analysis of Pearson's correlation coefficients between LM and LCA and CP practices, it was possible to identify a network of practices with strong correlations ($r \geq 0.7$). Figure 2 illustrates the network of correlation between LM and GM practices. Thus, among the 48 LM, LCA and CP practices studied in the Brazilian furniture industry, LM and GM manufacturing synergies were identified in 9 practices: LM01; LM10; LM15; LCA0; LCA08; LCA10; LCA14; CP03 and CP04.

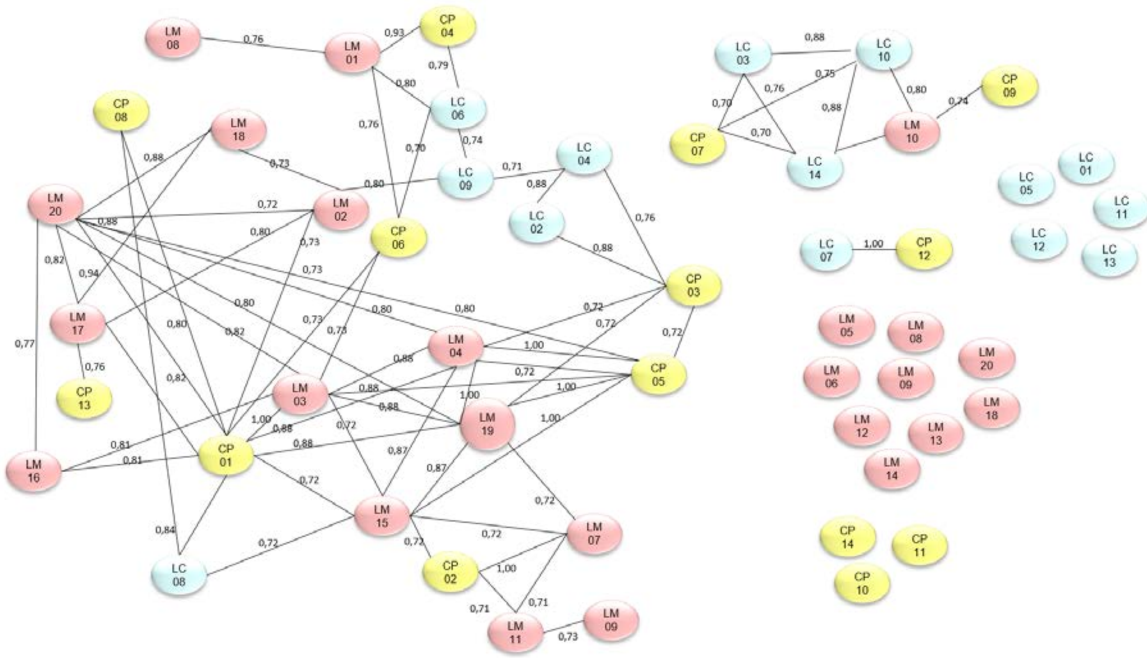

Figure 2. Network of correlation between LM and GM practices

The results found of 28.33%, 21.43% and 19.05% for LM, ACV and CP respectively show that the Lean and Green practices are not part of the managerial practices of the Brazilian furniture industry. The cases studied show a low level of maturity to the application of LM, LCA and CP practices. This result strengthens the need to implement new managerial methods in this segment, preferably integrated with Lean and Green practices, since the literature studied highlights that companies that simultaneously applied Lean and Green practices obtained better results than those that concentrate only in a recent study, in which one of the initiatives (Cherrafi et al., 2017).

However, companies that had certifications (ISO 9000/14000) (FF2, FF7, FF9 and FF10) improve their level of application of LM, LCA and CP practices. ISO 9001: 2015 certification is one of the means for companies to align their quality management system with the environmental management system, helping to simultaneously achieve LM and GM objectives.

The results also pointed out the synergistic practices between LM, LCA and CP. Analysis of the correlations (Figure 2) identified 9 synergistic practices: LM01; LM10; LM15; LCA0; LCA08; LCA10; LCA14; CP03 and CP04.

5. Conclusion

The study of multi-cases in the Brazilian furniture industry showed a low level of adherence of LM (28.33%), LCA (21.43%) and CP (19.05%). The lack of LM, LCA and CP practices is related to the low number of furniture factories that are ISO 9000 and / or ISO 14000 certified. Only 40% (4) of the furniture factories study to present some type of ISO certification.

The analysis of the Pearson correlation coefficient between LM, LCA and CP practices allowed identifying a strong correlation (0.88) between LM and CP practices and a moderate correlation (0.58) between LM and LCA practices. A strong positive relationship means that the LM application eliminates LM and GM waste at one go, thus creating the conditions necessary for CP and LCA to be achieved, improving the company's environmental performance. It reinforces that LM, LCA and CP practices can be integrated. The correlation analysis also showed that ISO 9000 and 14000 certifications positively influence the level of adherence of LM, LCA and CP practices.

Finally, the method of evaluation of synergy used in the multi-case study allowed to clearly identify a group of 9 practices that present Lean and Green synergies: LM01 (Lean Manufacturing Philosophy), LM10 (Just-in-time- JIT: Setup), LM15 (Autonomation- Problems Solving), LCA06 (Reuse - Packing), LCA08 (Reuse - Water consumption), LCA10 (Logistics - Suppliers environmental impacts), LCA14 (Responsibility - Environmental responsibility), CP03 (Raw Material- Change in raw material) e CP04 (Raw Material- Recycling of raw material).

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