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GREEN AND LEAN PRACTICES TOWARDS SUSTAINABLE AND OPERATIONAL PERFORMANCE IMPROVEMENTS

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“We are what we repeatedly do. Excellence, then, is not an act, but a habit.”

(Will Durant)[1].

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ABSTRACT

In the last few decades, the importance of sustainable concerns for organizational survival has grown, and Lean Thinking (LT), Six Sigma and Lean Six Sigma (LSS) approaches are becoming more and more notable to improve sustainability performance. The integration between Green, Lean and Six Sigma approaches in service systems seems necessary in order to balance the need for operational efficiency with environmental commitment and social fairness.

The overall aim of this thesis was to present Green and Lean practices towards sustainable and operational performance improvements. The methodological approach consisted of the development of the thesis by aggregation of articles, composed of three studies. Study I aims to verify the sustainability performance of Brazilian organizations in performance measures and to propose sustainable guidelines with the intention of directing future efforts to the transition to sustainable development (SD). Study II aims to evaluate the degree of importance of sustainable performance measures of Brazilian organizations and to propose guidelines to achieve sustainability aligning these measures with operational improvement programmes. The purpose Study III is to critically review the LT and LSS methodologies and highlight their importance to achieve sustainable services.

Study I and II utilised a triangulated approach by collecting qualitative and quantitative data acquired through multiple collection methods of a theoretical literature review, documentary analysis of corporate reports, questionnaire survey and semi-structured interviews with industry professionals and academic researchers. In Study III, a systematic literature review (SLR) of the subjects under investigation was conducted.

Study I' results shows that internal organizational factors are the main inductors of the sustainable environment in organizations, and sustainability must be tied to strategic planning, starting from upper management to lower levels; and it is essential to use sustainable performance measurement systems in order to respond to external and internal levers. In addition, Study I and II show that it is the corporate responsibility to focus their efforts on both operational improvement programmes and sustainable initiatives in order to achieve better environmental protection, corporate reputation, quality management, cost performance and suppliers relations, as they are considered to be more important on organizational sustainability. The Study III provides a holistic Green LSS (GLSS) framework attempting to help practitioners to find ways of institutionalizing it in numerous kinds of services, by pointing out nine critical factors for its implementation. such as continuous customer satisfaction, and an effective Jidoka automation.

This thesis brings multiple contributions, providing academics and practitioners with a better picture of achieving SD through sustainable (green) and operational (lean) performance measures and by pointing out through a GLSS Framework some compatibilities between LSS and triple bottom line sustainability in services; helping to understand the perceptions and expectations of stakeholders; expanding the literature review on the subject studied, as well as presenting theoretical, managerial and political implications to organizational sustainability.

Keywords: Sustainable development; Performance measures; Lean Thinking; Lean Six Sigma. Survey; Systematic review; Nonparametric methods; Interdisciplinary; Services

RESUMO

Nas últimas décadas, a importância de preocupações sustentáveis para a sobrevivência organizacional cresceu, e as abordagens *Lean Thinking* (LT), Seis Sigma e *Lean* Seis Sigma (LSS) estão se tornando cada vez mais notáveis para melhorar o desempenho da sustentabilidade. A integração entre as abordagens *Green*, *Lean* e Seis *Sigma* nos sistemas de serviços parece necessária para equilibrar a necessidade de eficiência operacional com o compromisso ambiental e a justiça social.

O objetivo geral desta tese é apresentar práticas verdes e enxutas para melhorias de desempenho sustentável e operacional. A abordagem metodológica consistiu no desenvolvimento da tese por agregação de artigos, composto por três estudos. O objetivo do Estudo I é verificar o desempenho de sustentabilidade das organizações brasileiras em medidas de desempenho e propor diretrizes sustentáveis com a intenção de direcionar esforços futuros para a transição para o desenvolvimento sustentável (DS). O Estudo II tem como objetivo avaliar o grau de importância das medidas de desempenho sustentável das organizações brasileiras e propor diretrizes para alcançar a sustentabilidade, alinhando essas medidas com os programas de melhoria operacional. O objetivo do Estudo III é revisar criticamente as metodologias LT e LSS e destacar sua importância para alcançar serviços sustentáveis.

Os Estudos I e II utilizaram uma abordagem de triangulação, coletando dados qualitativos e quantitativos adquiridos através de múltiplos métodos de coleta de uma revisão teórica da literatura, análise documental de relatórios corporativos, pesquisa por questionário e entrevistas semiestruturadas com profissionais da indústria e pesquisadores acadêmicos. No Estudo III, uma revisão sistemática da literatura (RSL) foi realizada.

Os resultados do Estudo I mostram que os fatores organizacionais internos são os principais indutores do ambiente sustentável nas organizações, a sustentabilidade deve estar vinculada ao planejamento estratégico, começando da alta administração até os níveis mais baixos; e é essencial usar sistemas sustentáveis de medição de desempenho para responder a pressões externas e internas. Além disso, os Estudos I e II mostram que é responsabilidade corporativa concentrar seus esforços em programas de melhoria operacional e iniciativas sustentáveis para obter melhor proteção ambiental, reputação corporativa, gerenciamento de qualidade, desempenho de custos e relações com fornecedores, conforme forem considerados mais importantes na sustentabilidade organizacional. O Estudo III fornece uma estrutura holística de *Green* LSS (GLSS) que tenta ajudar os praticantes a encontrar maneiras de institucionalizá-lo em vários tipos de serviços, destacando nove fatores críticos para sua implementação, como a satisfação contínua do cliente e uma automação efetiva do *Jidoka*.

Portanto, esta tese traz múltiplas contribuições, proporcionando aos acadêmicos e profissionais do mercado uma melhor imagem de alcançar o DS através de medidas de desempenho sustentável (*Green*) e operacional (*Lean*) e apontando através de um *Framework* GLSS algumas compatibilidades entre LSS e sustentabilidade de *Triple bottom line* em serviços; ajudando a entender as percepções e expectativas das partes interessadas; ampliar a revisão de literatura sobre o tema estudado, bem como apresentar implicações teóricas, gerenciais e políticas para a sustentabilidade organizacional.

Palavras-chave: Desenvolvimento sustentável; Medidas de desempenho; Pensamento Lean; Lean Seis Sigma; Survey; Revisão sistemática; Métodos não paramétricos; Interdisciplinar; Serviços

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I. Measurement of Sustainability Performance in Brazilian Organizations

Rodrigo Goyannes Gusmão Caiado, Osvaldo Luiz Gonçalves Quelhas, Daniel Luiz Mattos Nascimento, Rosley Anholon, Walter Leal Filho.
International Journal of Sustainable Development and World Ecology, 25:4, 312-326, Dec. 2017. DOI: 10.1080/13504509.2017.1406875

II. Towards Sustainability by Aligning Operational Programmes and Sustainable Performance Measures

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Rodrigo Goyannes Gusmão Caiado, Osvaldo Luiz Gonçalves Quelhas, Janice Helena de Oliveira Dias, Maria de Lurdes Costa Domingos, Sergio Luiz Braga França, Marcelo Jasmim Meiriño,
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List of Abbreviations

AD	Anderson-Darling
DMAIC	Define-Measure-Analyze-Improve-Control
GDP	Gross Domestic Product
GLSS	Green Lean Six Sigma
GRI	Global Reporting Initiative
GSCM	Green Supply Chain Management
HR	Human Resources
KPIs	Key Performance Indicators
KS	Kolmogorov-Smirnov
LCA	Life Cycle Assessment
LM	Lean Manufacturing
LS	Lean Services
LSS	Lean Six Sigma
LT	Lean Thinking
MDGs	Millennium Development Goals
PDCA	Plan-Do-Check-Act
SD	Sustainable Development
SDGs	Sustainable Development Goals
TBL	Triple Bottom Line
VSA	Value Stream Analysis
VSM	Value Stream Mapping
TPM	Total Productive Maintenance

CONTENTS

1 INTRODUCTION

In the current context, sustainability issues are gaining greater prominence among organizations and their stakeholders around the world, and with it the effective measurement of sustainability performance has been a challenge for sustainable transition (ROCA; SEARCY 2012; ADAMS *et al.* 2014; MORIOKA; CARVALHO 2014; SILVESTRE *et al.*, 2015). The transformation of resources from the Earth into wealth through industrial activity has led to an increasing level of consumption of materials and energy, a trend that has been one of the fundamental drivers of global and local environmental change and which has led to adverse consequences for ecosystems and societies (LINNENLUECKE; GRIFFITHS, 2013; CAIADO *et al.*, 2017a; CAIADO *et al.*, 2017b).

The growing concern over the impact of organizational activities on the environment and society has led to increased global pressure to improve corporate performance, commitment and accountability, while maintaining a non-competitive operational environment and reporting this to external and internal stakeholders (LABUSCHAGNE *et al.* 2005; MAAS *et al.* 2016).

The paradigm of the 21st century is to enable organizations to relate otherwise to the environment in which they coexist (ELKINGTON, 1998), or through the adoption of sustainable principles that in addition to generating environmental and social benefits will bring improvement in economic value of the organization (FIKSEL *et al.*, 1999), and the impetus for corporate social responsibility that lead to the creation of decision-making tools geared to social impacts (HUTCHINS; SUTHERLAND, 2008).

Among the challenges for an organization to become sustainable, we have: for meeting the needs of stakeholders (DYLLICK; HOCKERTS, 2002), the Triple Bottom Line (TBL) proposed by Elkington (1998) needs to be achieved in an integrated manner (HART; MILSTEIN, 2003) and an effective environmental performance measurement is necessary (HOURNEAUX JR. *et al.* 2014). A crucial aspect to accomplish this task is to use an adequate definition of environmental performance indicators. For Ramos and Caeiro (2010), there are various methods and tools for the assessment of sustainable performance in the organizational level. From this, designing reliable measures to quantify this performance, considering the variety of factors on the subject, is essential for the decision-making process of the stakeholders and for business management (KOCMANOVA; SIMBEROVA, 2012).

The relationship between measurement practices with sustainability and/or environmental performance has been investigated in previous studies (NORMAN; MACDONALD, 2004; LABUSCHAGNE *et al.*, 2005; ADAMS *et al.*, 2014). In general,

previous studies are focussed on some of the dimensions of sustainability, and fewer studies present a simultaneous approach that takes into account the dimensions of TBL in an integrated way (MORIOKA; CARVALHO 2014). Also, there is a lack of studies focussed on the economic, environmental, social, technical and governance dimensions of sustainability (SINGH *et al.*, 2007) in assessing the impact of sustainable measures on organizational sustainability performance in emerging countries.

There are some researchers who have empirically assessed the sustainability performances of projects, organizations and industries (e.g. YUSUF *et al.* 2013; ZHOU *et al. 2013;* MORIOKA; CARVALHO, 2014; LUZZINI *et al.* 2015; KOCMANOVÁ *et al.* 2016; BOLIS *et al.* 2016; ABDUL-RASHID *et al.*, 2017). However, in the Brazilian context, there is lack of practical research that points out the inductors to achieve sustainable development and evaluates the importance of sustainable measures to corporate sustainability. On the other hand, sustainability literature has documented the importance of those constructs on influencing the organizational sustainability, including their actions to a better performance (LABUSCHAGNE *et al.*, 2005; DELAI; TAKAHASHI, 2011; BESKE-JANSSEN *et al.*, 2015). Thus, it is important to perform research that develops mixed methodological approaches composed by qualitative data from an extensive literature review, documentary analysis using as reference the Global Reporting Initiative (GRI) (GRI, 2013) and interviews with academics and quantitative data acquired from questionnaire survey.

Moreover, there is lack of practical studies, especially in an emergent economy like Brazil, that evaluates the importance of performance measures aligned to operational and TBL dimensions to simultaneously achieve operational excellence and sustainability objectives and highlight the integration of operational improvement programmes into sustainable performance measures.

Previous researches has also investigated the relationship between measurement practices with sustainability performance (NORMAN; MACDONALD, 2004; LABUSCHAGNE *et al.*, 2005; ADAMS *et al.*, 2014) and the importance of operations and quality improvement methodologies, such as Lean Manufacturing (LM) among others to influence "Green" initiatives (GARZA-REYES, 2015), including their actions to a better performance (VERRIER *et al.*, 2014). However, there are no standardized methods for assessing sustainability in manufacturing processes and no consensus on which indicators should be used (HELLENO *et al.*, 2016).

In addition, services permeate all aspects of a modern economy and are key to connecting nations with each other with information, knowledge, goods and services. In this perspective,

the services sector has been presented as a key factor in the growth and competitiveness of developed countries (JAVALGI *et al.*, 2011). Although in most developed economies, the services sector represents a large proportion of the Gross Domestic Product (GDP) (JIMÉNEZ-ZARCO *et al.*, 2011), the service industry still has few studied about the Lean Six Sigma (LSS) (ALBLIWI *et al.*, 2015) and even less regarding the sustainable development (SD) (GARZA-REYES 2015b; HALLAM; CONTRERAS, 2016; CHERRAFI *et al.*, 2016; CHUGANI *et al.*, 2017). Thus, there is lack of studies about ways of achieve the SD in services through LSS. In addition, while there are separate streams of research on Lean, sustainability, and services, the intersection of these three strategic areas has not been extensively addressed in the past.

2 BACKGROUND

2.1 SD and organizational sustainability insights

Historically, the concept of sustainable development emerged in the 1987 report from the UN World Commission on Environment and Development, in a document entitled Our Common Future. It requires development to be achieved "which meets the needs of the present generation without compromising the ability of future generations to meet their needs" (WCED 1987). However, Govindan *et al.*, (2013) affirm that it is challenging to make this sustainable concept operational and they propose an alternative definition: "projects and operations of human and industrial systems that ensure that the use of natural resources and cycles by mankind does not lead to a decline in the quality of life due to loss of future economic opportunities or adverse impacts on social conditions, human health and the environment". In a complementary way, Griggs *et al.*, (2013) states that for the implementation of SD, the resolutions of the Brundtland Commission must be redefined to: "development that meets the needs of the present while safeguarding the life-support system of the Earth to which the well-being of present and future generations depends".

In the Rio+20 United Nations Summit of 2012, the idea of creating the Sustainable Development Goals (SDGs) emerged, in which members of states agreed to adopt a set of guidelines towards global development in order to increase the baseline for developing countries and poorer populations (GUPTA; VEGELIN, 2016), as well as to build a stronger commitment towards people-centered development, human rights, and environmental sustainability (JAYASOORIA, 2016).

The SDGs - successors to the millennium development goals (MDGs) - were agreed upon on September 2015 in New York, USA, by 193 countries, and focused on an extremely comprehensive set of development goals. It is expected that the new SDGs and their targets - in force since January 1st 2016 – will guide the decisions to be made throughout the next fifteen years and will fundamentally influence international politics and the finance available for sustainable development, and so will therefore shape the future political efforts and the dynamics of natural capital (TERAMA *et al.*, 2015).

The growing industrialization and the scale of economic activity has transformed the Earth's resources into wealth, and have significantly molded modern life and the physical world in which we live (LINNENLUECKE; GRIFFITHS, 2013). To Hutchins and Sutherland (2008), the necessity of SD and the drive towards social corporate accountability has lead to the creation of decision making tools for social impact. Luzzini *et al.*, (2015) believe that environmental,

social and economic performance does not have to necessarily be negotiated in a gain versus loss relation, and can be improved simultaneously instead.

In the last two decades, much has been written on the principles of sustainable development and the need for organizations to build on sustainable practices which drastically change the way in which they conduct business (LINNENLUECKE; GRIFFITHS 2013), creating great impact on the performance of companies (YUSUF *et al.*, 2013). From the literature, it can be inferred that there is much pressure towards the transition of organizations and industries to sustainable development.

Sustainability is not only good for the environment and society, but also for organizational economic health. Sustainable business practices can help organizations reduce risks, avoid or reduce waste generation, increase energy efficiency and used materials and innovate, creating new and environmentally friendly products and services (GUNASEKARAN; SPALANZANI, 2012). In addition to this, the adoption of sustainable strategies helps to obtain information for internal and external benchmarking of organizational activities, compliance with environmental laws and regulations, improvement of corporate image and constant monitoring, aiming to improve operational efficiency (CAIADO; QUELHAS; LIMA, 2015).

Concerning the pressure within organizations, Schrettle *et al.* (2014) stress the cultural influence through motivation, disseminating information, and management commitment with sustainability in the long term. Labuschagne *et al.*, (2005) state that the strategy must guarantee the integration of sustainable principles in the decision making process as "institutional sustainability". Adams *et al.*, (2014) stresses that the increase of care in the performance evaluation by managers, consultants and scholars is a reflection of the increase in pressure on organizations to improve on sustainable development.

On regulatory, competitive and market pressure, the increase in the consumption of materials and energy can be highlighted, leading to adverse consequences to ecosystems and to societies. (LINNENLUECKE; GRIFFITHS 2013), followed by the need for environmental protection and the increase in demand for natural resources (WU; PAGELL 2011). Furthermore, the client demand for green products (WU *et al.*, 2012), market stakeholders - consumers, suppliers, competitors and shareholders - respond favourably to sustainable initiatives and innovation (RIVERA-CAMINO, 2007), and meanwhile, new policies and shapes of environmental regulation come up, which determine the type of technology that may be used, potentially creating economic structures to redistribute environmental costs and benefits (ETZION, 2007).

However, there are also some obstacles for organizational sustainability, such as the

supply of human resources and materials for implementing sustainable processes (BARNEY 1991) and financial resources for adopting and sustaining green practices (YUSUF *et al.* 2013), the integration of environmental interests in interorganizational practices (SARKIS *et al.* 2011), and meeting the needs of direct and indirect stakeholders without compromising the necessities of future ones (DYLLICK; HOCKERTS, 2002). To Rivera-Camino (2007), many stakeholders - the planet, several species of animals and plants, and future generations - are foggy, and maybe for that reason, cannot exercise direct influence on the strategies. Nonetheless, there must be a clearer communication of the demands of stakeholders to the company (WAGNER, 2015) and the managers require further knowledge of the inductors of sustainability in order to reduce uncertainty in the decision making process (SCHRETTLE *et al.* 2014). Therefore, according to Atkinson *et al.*, 1997, Epstein and Roy (2001), Teixeira *et al.*, (2012), Yusuf *et al.*, (2013), Lozano (2015) and Silvestre *et al.*, (2016), the main sustainable inductors are:

Table 1. Main inductors of organizational sustainability

Drivers	Description
ISO 14001	Certificate which attests that an organization has defined an environmental policy and strives for improvement in its environmental performance. This inductor is also associated with sustainability reports.
Internal and Organizational Factors	Personal commitment and management leadership initiative in the field, "entrepreneurial policy" and investors. It is also associated with: company's culture; moral and ethical obligations to contribute to social responsibility, proactive leadership; employees' shared values and personal engagement.
Client Perception	The will of the organization to convince the client that its processes and products are rooted in sustainable means. This is associated with customer demands and expectations.
Public Expectation	Non-governmental support groups and environmental campaigns are specially effective in exercising pressure on companies. This inductor is associated with raising society awareness; and collaboration with external organisations; reputation; negative publicity; stakeholder expectations; and shareholder activism
Competition	Competitive forces were observed due to their greater power of persuasion for pressuring companies to adopt green practices, over legislative regulation and the organizational will to save the world. This is also associated with: regulations and legislation; market opportunities; environmental or social crises; political lobbies; and ease regulatory pressure.
Supply Chain Integration	Reduction in the supplier base has the capacity of reducing the initial costs of adopting and perpetuating green traditions. This inductor is associated with: alliances and partnerships; and collaboration with external organisations.

From this, it can be inferred that the organizations start to see their supply chain as means to improve their global sustainability profile (GOVINDAN *et al.*, 2013). To Lin (2013),

the improvement of Green Supply Chain Management (GSCM) practices have become a proactive approach to improve the economic and environmental performance of companies, having been influenced by practices such as green purchase, green design, product recovery and client and supplier collaboration. GSCM has emerged as an important organizational philosophy to reduce environmental risks. Walker, Sisto and McBain (2008) have identified factors that make implementation of GSCM initiatives easier or more difficult, including internal inductors such as organizational factors and external inductors such as regulation, customers, competitors, society and suppliers (DIABAT; GOVINDAN, 2011).

Thus, for Wu, Ding and Chen (2012), companies can apply their social capital to engage in environmental inter-organizational collaboration in order to achieve a supply chain oriented strong relationships and should make full use of organizational support, social capital and government involvement in order to implement the management of the green supply chain.

Although the internal organizational resources have significant effects in the implementation of environmental corporate management (WU; DING; CHEN 2012), it is also up to public policy developers to know which stakeholders are more influential in order to promote environmental proactiveness in companies, which is essential for the environmental policy project (RIVERA-CAMINO 2007) and for fostering change strong enough to alter the dynamic capacity of organization fields and ensuring the continuity of the drive towards improving organizational sustainability (WAGNER 2015).

2.2 Sustainability performance measurement

The conceptual idea of performance measurement in sustainability consists in collecting measurable and trackable data from companies which reflect main aspects or pressure points. The biggest challenge is to generate and disseminate information for decision making on sustainability which is robust, relevant, accurate and financially feasible for users (OLSTHOORN *et al.* 2001; JIN; HIGH, 2004).

According to Epstein and Roy (2001), many organizations have developed performance evaluation systems to aid in measuring the sustainable performance of organizations, business units, facilities, teams, managers and all other employees. The effective measurement of environmental performance has been a challenge to organizations, and a crucial aspect for accomplishing this task is the appropriate definition of measurements as well as the utilization of environmental performance indicators (HOURNEAUX Jr. *et al.* 2014).

According to Leite *et al.*, (2011), the measurement of performance is important not only for understanding the changes which seem to be caused by sustainability, but also for clarifying

the process for other companies. Despite the diversity of methods and tools, in order to measure sustainable development, and different types of structures, and to evaluate the sustainable performance in the organizational level, the indicators are one of the most utilized approaches (RAMOS; CAEIRO 2010). The Global Reporting Initiative (GRI) is the most acknowledged volunteer communication structure of environmental and social performance in the world.

Kocmanova and Simberova (2012) state that, for corporate management and the decision making process of stakeholders, it is necessary to evaluate and compare the global performance of individual companies in the environmental, social relations and corporate governance fields and it is essential to conceive a reliable method of quantifying this performance, considering the variety of factors in the subject.

In a rapidly changing environment, organizational survival depends heavily on it operating in the most effective and efficient manner possible. Thus, the effectiveness of a Performance Measurement System (PMS) is important, due to it being able to provide an indication of the current market position of the organization, and to aid in the development of future operations and strategies (LANGFIELD-SMITH *et al.*, 2009). Moreover, these PMS may facilitate the creation of a more eco-efficient and socially responsible production system, which aims to foster sustainable production (VELEVA; ELLENBECKER, 2001) and the implementation of information systems for development management provides opportunity to incorporate measures aligned with the results of sustainability and to supply relatable indicators (ADAMS *et al.*, 2014) Organizations with good performance may utilize their efforts in proactive environmental transparency, as a way of achieving more objective and verifiable communication of the current operational capacity and their good performance, aiming to improve corporate image and to gain a green competitive advantage (MENG *et al.*, 2014).The measurement of performance is important not only for understanding the changes which seem to be caused by sustainability, but also for clarifying the process for other companies (LEITE *et al*., 2011).

In the following table, some of the main sustainable measures have been selected from the performance measurement literature and Brazilian GRI reporting standards from company documents and websites, and categorized according to the technical, economic, environmental, social and governance dimensions (SINGH *et al.*, 2007).

Table 2. Main sustainable performance measures

Question	Dimension	Code	Sustainable performance measures	Researchers

Q1	Economical	M1	Cost performance	Nagalingam, Kuik, and Amer (2013); Luzzini et al. (2015); León and Calvo-Amodio (2017)
Q2	Economical	M2	Environmental and social performance	Silva, Vaz, and Ferreira (2013); Luzzini et al. (2015); Helleno, de Moraes, and Simon (2016); Gandhi, Thanki, and Thakkar (2018)
Q3	Social	M3	Inter-firm collaborative capabilities	Luzzini et al. (2015);
Q4	Social	M4	Intra-firm collaborative capabilities	Luzzini et al. (2015);
Q5	Environmental	M5	Environmental protection	Valiente et al. (2012); Verrier et al. (2016); Fu, Guo, and Zhanwen (2017)
Q6	Social	M6	Employee satisfaction	Fiksel et al. (1999); Singh et al. (2007); Valiente et al. (2012); Golini et al. (2014); Helleno et al. (2016); León and Calvo-Amodio (2017)
Q7	Social	M7	Supplier relations	Valiente et al. (2012); Verrier et al. (2014)
Q8	Governance	M8	Corporate reputation	Golini et al. (2014); Galeazzo et al. (2014); León and Calvo-Amodio (2017)
Q9	Governance	M9	Environmental logistics policy	Ciliberti et al. (2008)
Q10	Technical	M10	Quality management	Valiente et al. (2012); Godinho Filho, Ganga, and Gunasekaran (2016); Prasad, Khanduja, and Sharma (2016)
Q11	Social	M11	Social benefits, medical-legal	Valiente et al. (2012)
Q12	Technical	M12	Customer satisfaction	Valiente et al. (2012); Godinho Filho et al. (2016); León and Calvo-Amodio (2017)
Q13	Social	M13	Balancing professional and family life	Valiente et al. (2012)
Q14	Governance	M14	Transparency in information	Valiente et al. (2012); Lee and Saen (2012); Ahuja, Sawhney, and Arif (2016)
Q15	Environmental	M15	Green Marketing	Jabbour et al. (2013); Thieme et al. (2015)
Q16	Environmental	M16	Environmental Policy	Miller et al. (2010); Puvanasvaran, Tian, and Vasu (2014)
Q17	Governance	M17	Investor Relations	Lee and Saen (2012)
Q18	Social	M18	Representation and dialogue with employees	Valiente et al. (2012); Verrier et al. (2014)
Q19	Governance	M19	Code of conduct	Kocmanová and Šimberová (2016); Campos and Vazquez-Brust (2016)
Q20	Governance	M20	Corporate Governance	Lee and Saen (2012); Vlachos (2015); Kocmanová and Šimberová (2016)
Q21	Technical	M21	Labor practice indicators	Kocmanová and Šimberová (2016)
Q22	Governance	M22	Human capital development	Singh et al. (2007); Ciliberti et al. (2008); Zhan et al. (2015)
Q23	Social	M23	Support of social setting	Valiente et al. (2012); Lee and Saen (2012)
Q24	Environmental	M24	Energy conservation	Dhingra et al. (2014); Thieme et al. (2015)
Q25	Social	M25	Sustainable working condition	Fiksel et al. (1999); Yusuf et al. (2013); Camuffo and Stefano (2017)
Q26	Environmental	M26	Carbon footprint reduction	Fiksel et al. (1999); Yusuf et al. (2013); Fercoq, Lamouri, and Carbone (2016); Garza-reyes, Villarreal, and Kumar (2017)

Q27	Environmental	M27	Reduction in amount of energy use	Yusuf et al. (2013); Nagalingam et al. (2013); Verrier et al. (2016); Fu et al. (2017)
Q28	Environmental	M28	Reduction of air pollution	Vinodh et al. (2011); Yusuf et al. (2013); Garza-reyes et al. (2017)
Q29	Environmental	M29	Waste management	Vinodh et al. (2011); Yusuf et al. (2013); Thieme et al. (2015); Helleno et al. (2016); Verrier et al. (2016); León and Calvo-Amodio (2017)
Q30	Environmental	M30	Reduction in amount of resource use	Fiksel et al. (1999); Yusuf et al. (2013); Nagalingam et al. (2013); Verrier et al. (2016); Fu et al. (2017)
Q31	Environmental	M31	Sources of recyclable raw material	Fiksel et al. (1999); Yusuf et al. (2013); Nagalingam et al. (2013)

Table 2 depicts the existence of a great diversity of performance indicators, each group being more adequate to a specific context or analysis field. Aside from the objective behind these measures, the type of company must also be considered, as well as the sector studied, the size of the company, the proximity to markets sensitive to environmental issues, external regulation, and to the organization's corporate culture (FIKSEL *et al.* 1999).

Besides that, sustainability measures can affect the choice of quality improvement programmes (CHUGANI *et al.* 2017), as this new concepts and approaches should direct companies to more efficiently operations, with less waste and commitment to deliver the triple bottom line. By adopting a Green perspective, organizations can become more productive and efficient, increasing their profits and reputation (LEÓN; CALVO-AMODIO, 2017). As Garza-reyes, Villarreal, and Kumar (2017) nowadays environmental sustainability must be aligned to the traditional priorities of profitability, efficiency, customer satisfaction, quality, and responsiveness.

2.3 Lean Thinking – from manufacturing to services

Lean Thinking (LT) is considered a western adaptation of the Toyota Production System (TPS) (SHAH; WARD, 2007) that was originated in the Toyota Motor Corporation around the time of the Second World War (RADNOR; JOHNSTON, 2013). Lean was popularized since the 80's, in the book "*The Machine that Changed the World*" (WOMACK *et al.*, 1990), as "*a way to specify value, to do more with less – less human efforts, less equipment, less time and space - while coming closer to providing customers with exactly what they want*" (WOMACK; JONES, 1996). The Lean methodology identifies five core principles or phases, which are (WOMACK *et al.*, 1990; WOMACK; JONES, 1996; MAARSE; JANSSEN, 2012):

(1) define value from the customer's point of view;

(2) identify the value stream for each product;

(3) make the product flow continuously;

(4) introduce pull between all steps where continuous flow is impossible;

(5) manage towards perfection so that non-value adding activity will be removed so that the number of steps, amount of time and information needed to serve the customer continually falls.

According to Agbodzakey and McCue (2015), LT is a philosophy to minimize waste – activities that do not create value – variability and inflexibility (BHATIA; DREW, 2006), respectively known by the following Japanese terms: *muda* (wastes), *mura* (irregularities) and *murí* (overload), in order to maximize value to both customers and the entity (RADNOR, 2010). For Maarse and Janssen (2012), LT operates at the operational level, eliminating wastes as well as at the strategic level that is about understanding value.

As Aziz and Hafez (2013), LT was formed by two main conceptions: (1) Just-in-Time flow (producing according to the demand) and (2) Jidoka automation (man-machine separation, in which a single operator manages several machines). Taj and Morosan (2011) claim that lean is a multidimensional approach that is supported by the following methods: JIT, cell layout, Total Preventative Maintenance (TPM), TQM, and Human Resource Management (HRM). For Chaurasia, Garg and Agarwal (2016), the factors that typify a lean environment are:

- Reduce delivery times;
- Accelerate time to market;
- Reduction of operating costs;
- Exceed customer expectations;
- Manage the company globally;
- Streamline outsourcing processes;
- Improve the visibility of business performance; and
- Use energy, equipment and people more productively.

Thus, LT aims to reduce waste, achieve a holistic approach in relationships with employees, suppliers and customers, and practice kaizen problem-solving events. It provides a means to do more with less - less human effort, less equipment, less staff and less space - aiming at reaching what customers want and results in eliminating waste through more efficient processes that generate valued core competencies by the client (COMM, MATHAISEL, 2003).

In today's business world, lean represents an operational philosophy for all, and should be adopted by employees at all organizational levels to produce truly sustainable results (VOEHL *et al.*, 2010). According to Chaurasia, Garg and Agarwal (2016): "*lean is an endless*

journey to reach the most innovative, effective and efficient way in an organization". For Voehl *et al.*, (2010), organizations that follow a lean philosophy should have the following characteristics: business focus; teaching managers; support; customer orientation; sharing success; opportunities for improvement; real teams; sense of community; customer-focused processes; flexible equipment; quick change; multifunctional; control of workers; learning environment; alliance with supplier; information sharing; customer as a resource; the employee as needed; cost factor analysis; external focus; thorough knowledge of the process; prevention of quality problems; flat organization (little bureaucracy in decision making); balanced thinking; executive accountability (management); reward is equal to pride; cooperation; be simple. According to Sacks *et al.*, (2010) there are sixteen lean principles:

a) Reduction of variability;
b) Reduction in number of cycles;
c) Reduction of sample size;
d) Increased flexibility;
e) Selection of an appropriate method of production control;
f) Standardization;
g) Institution of continuous improvement;
h) Use of visual management;
i) Design of the production system to flow the value chain;
j) Guarantee of comprehensive catch of applications;
k) Focus on concept selection;
l) Guarantee of operational flow requirements;
m) Verification and validation;
n) Go and see for yourself (*Gemba*);
o) Decision by consensus, considering all options;
p) Cultivation of an extensive network of partners.

LT supports two basic disciplines to accelerate the process of knowledge creation: short and frequent learning cycles and late commitment (VOEHL *et al.*, 2010). LT offers a unique methodology, which is to do more with less – less human effort, less equipment, less staff and less space – in order to achieve the real needs of its clients. It results in the elimination of waste through more efficient processes, and that generates the essential capabilities a customer values (COMM; MATHAISEL 2005).

Levitt (1972), in his article entitled Production-line approach to service, suggests the adoption of manfacturing principles in the customer service industry to increase the quality and

efficiency of these services. Lean Services (LS) refers to the application of LM tools in a service context and has the following characteristics, according to Bowen and Youngdahl (1998):

- reduction of performance conflict: the objectives of the operation include both internal efficiency and customer-defined flexibility;
- pull production flow (or just-in-time - JIT): minimizes set-up time, allowing for smoother flow and in-and-out JIT levels;
- value chain oriented: applies the service blueprint and value analysis to eliminate non-value-added activities;
- customer focus and training: engages the customer in the design and service package, trains employees in customer service skills and behaviors, and empowers customers to contribute to quality service;
- employee autonomy: invests in employees (ability, training and participation) and autonomy for employees to leverage value for the client.

In the last decade, Levitt's (1972) original model was revised and there was a re-industrialization of service with the adoption of the so-called LS principles in many organizations (ABDI *et al.* 2006). Service companies that deploy the Lean approach quickly gain control of the key processes that deliver customer service, the practice of Lean behaviors helps to reduce ambiguity and re-work in interpersonal relationships and the Lean tools, such as value stream mapping and pull techniques, make people see the whole instead of only their part and thus, they come to understand better the paradox related to flexibility versus efficiency (ABDI *et al.* 2006).

Besides that, compared with the manufacturing processes, the service processes have more noise or uncontrollable factors, are subject to greater influence of human behavior characteristics and should devote more attention in timeliness and service non-conformity characteristics, which emphasizes the use of methodology Six Sigma, focused on improving service effectiveness and efficiency and reducing non-value added activities (Antony 2004).

2.4 Six Sigma

Six Sigma was created in the 80's by Bill Smith, at the Motorola Corporation, and aims to reduce errors and defects by applying the DMAIC (Define, Measure, Analyze, Improve and Control) methodology. Sigma represents a statistical term that measures the extent to which a given process deviates from perfection (POPA *et al.*, 2005).

Popa *et al.* (2005) argue that Six Sigma is a highly disciplined process that helps organizations focus on delivering lower cost products with improved quality and reduced cycle

time, where Sigma represents a statistical term that measures the extent to which a given process deviates from perfection and Lean Sigma is a methodology of process improvement used in organizations of international standard in order to eliminate waste in the processes and to deliver exceptional products and services to its clients.

The Six Sigma methodology evolved from the Total Quality Management (TQM) methodology and consists of a managerial approach focused on long-term success through focus on customer satisfaction, involvement of all employees for the continuous improvement of processes, products and services, strategic approaches and process-centric, integrated systems and statistical application to identify and eliminate defects and quality problems (GOETSCH; DAVIS, 2012).

In addition, Six Sigma can help in developing skills and improving knowledge, employee morale and the ability to use a wide range of tools and techniques. This concept has some advantages over TQM, such as (FRANCHETTI, 2015):

- establishing zero defaults targets;
- creating the DMAIC process improvement cycle;
- intensive use of statistics and data to make managerial decisions and reduce process variation.

Six Sigma is a highly disciplined process that helps organizations focus on delivering lower-cost products with improved quality and reduced cycle time, where Sigma represents a statistical term that measures the extent to which a given process deviates from perfection (POPA *et al.* 2005).

Moreover, Six Sigma can help in developing skills, improving knowledge and skills, improving employee morale and the ability to use a wide range of tools, techniques and has the following advantages over total quality management: Establishing zero defaults targets, creating the DMAIC process improvement cycle, and intensive use of statistics and data to make managerial decisions and reduce process variation (FRANCHETTI, 2015). However, it is crucial to have the Six Sigma connection with the strategy for successful deployment in service organizations (ANTONY *et al*., 2007).

The Six Sigma field has designated several levels of customized competence in applying this methodology: *green belt* - novice to Six Sigma with some experience in Six Sigma projects, *black belt* - application specialist and leadership in Six Sigma improvement projects and *master black belts* - organizational leaders who oversee all efforts and Six Sigma execution plans within an organization (FRANCHETTI, 2015).

On the other hand, by focusing on process improvement and variability reduction, Six Sigma programs do not guarantee a sustainable competitive advantage, and mechanisms need to be developed that address innovation and product differentiation, the pattern of change in the customer base, and uncertainty environmental, while improving organizational processes, considering radical changes and the formation of new markets and / or customers (PARAST 2011).

As Ferguson (2007), Six Sigma is about exclusion (trains only a team for specific area or project), it encourages maintaining the status quo (tests hypotheses and uses control charts to avoid that processes are out-of-control), is aimed at realizing a level of improvement using DMAIC, and is considered a change management (focus on cost, quality, and schedule), while Lean is an inclusive philosophy that is all about continuous improvement (a never-ending process) aimed at a transformational change, which involves the business strategy, organizational structure, culture, and processes of the entire value stream.

2.5 Lean Six Sigma

As George (2002), it is essential to merge LT with Six Sigma to reduce cost and complexity. As Antony and Cudney (2016) described both methodologies complement and reinforce each other, creating a powerful vehicle for achieving value creation and process efficiency and effectiveness. While Lean can not statistically control a process, Six Sigma alone can not dramatically improve process speed or reduce invested capital (GEORGE, 2003). Because of that, these methodologies are complementary in terms of one making up for the limitations of the other (GOFFNETT *et al.*, 2016).

Six Sigma helps connect business leaders and key project teams in a potent two-way fact-based dialogue, which is considered a blind spot of LT (VOEHL *et al.*, 2010). For George (2002), the questions that the synergies between LT and Six Sigma can answer, which neither methodologies can separately, are:

- Which Lean Six Sigma tools?
- Which process steps should we apply first?
- In what order and to what degree?
- How to get the most cost, quality and lead time improvement quickly?

Chaurasia, Garg and Agarwal (2016) highlight the main differences between lean and Six Sigma approaches (Table 3):

Table 3. Main differences between LT and Six Sigma

Factor	Lean Production	Six *Sigma*

Origin	JIT	Total Quality Management (TQM)
Theory	Eliminate waste and improve processes	Reduce variability
Focused Area	Flow of value	Problem solving
Key factor	Reducing waste without added value improves process flow	Reducing variability reduces the problem
Primary Key Benefit	Reduces lead time	Standardizes and controls process output
Secondary key benefit	Reduces waste Uniform output Inventory control Flow Matrix Improves quality Reactive issues "empowered"	Reduces variability Improves the first processing time Inventory control Matrix of variability Quality rate is high Reactive issues "empowered"
Drawbacks	Less concentrated in statistical process control tools	Process system is not considered; Improves independently and has no standard solution to common problem and its failure will affect the entire chain
Key Tools	Value Stream Analysis Error protection or poka-yoke Takt time or pull schedule based on customer demand Kaizen-blitz Visual control 5S Standardized work Kanbans - JIT delivery One–Piece Flow Smed or quick tool change Total productive maintenance Overall Equipment Efficiency (OEE) Heijunka Jidoka Yokoten	Process Mapping / Process Flow Cause and effect diagrams Supplier-input-process-output-customer diagrams Pareto Charts Histograms-distribution analysis Statistical Process Control Regression analysis - scatter plots; Variation analysis Hypothesis test Root Cause Failure Analysis Fault mode and effect analysis 7 quality tools Lean Tools
Key instrument	Kaizen event	DMAIC

Source: Adapted from Chaurasia, Garg and Agarwal (2016)

Both methodologies have become two of the most important initiatives for continuous improvement in organizations, improving processes through Six Sigma and productivity through Lean philosophy (WANG, CHEN, 2012; GUTIERREZ-GUTIERREZ et al. 2016).

Some of the advantages of the joint use of Lean and Six Sigma methodologies in services are the identification of the real causes for customer's dissatisfaction and defection (LUBOWE; BLITZ, 2008), the improvement of responsiveness and efficiency in delivering customer demands (ANTONY *et al.*, 2003; PSYCHOGIOS, TSIRONIS, 2012)

In the right situation, approaches to process improvement can be integrated to form a more powerful tool than any other is alone, since practically all lean concepts integrate well with any DMAIC project , regardless of size or scope, and root cause analysis is the common cross-point between these approaches (VOEHL *et al.*, 2010).

For George (2003), the LSS incorporates the principles of speed and immediate action of lean with the vision Six Sigma of quality without defect and reduction of the impact of the variation in the times of queue. From this, LSS attacks the hidden costs of complexity and is a mechanism that seeks the engagement of everyone for joint reach and without trade-offs of quality, speed, and cost (GEORGE, 2003).

LSS is a methodology of process improvement used in organizations of international standard in order to eliminate waste in the processes and deliver products and services with extreme quality to its clients (POPA *et al.*, 2005). Furthermore, LSS can be considered a broad well-structured, systematic, strategic, integrated and long-term decision-making approach to improve quality, cost, speed, delivery and customer satisfaction performance that focuses on reducing variation in critical processes to achieve bottom-line benefits through merger of tools and principles of Lean and Six Sigma and enables organizations to meet and exceed customer expectations in a competitive global environment (RAY; JOHN, 2011, LAUREANI; ANTONY 2012, NICOLETTI; VERGATA, 2013; ANDERSSON *et al.*, 2014; GUTIERREZ-GUTIERREZ *et al.*, 2016) Thus, the LSS methodology has a systemic method that uses a holistic approach to problem solving and consists of combining the LT cost reduction benefits with the quality and benefits of customer satisfaction of Six Sigma, used to minimize waste and reduce variability, respectively (FRANCHETTI, 2015).

As Gupta *et al.* (2016), the Lean approach is applicable in the context of the service, which is a knowledge intensive industry, and can be a valuable complement to the improvement of services that leads to customer satisfaction. Some of the important improvement tools used in services are value stream mapping, waste elimination, standardization, visual management / visual control, 5S, Human Resources (HR) management and Kaizen.

Besides that, some of the critical factors for the success of the LSS methodology in services are customer satisfaction (KONDIĆ; MAGLIĆ, 2008), the enthusiasm, support and commitment of top management, LSS's connection to business strategy, its connection to

training, and education (MANVILLE *et al.*, 2012) and the personal experience of senior management team members with LSS projects, the development of leadership skills (TIMANS *et al.*, 2012). Hilton; Sohal, (2012) also argue that the success of LSS deployment depends on the level of influence as well as the levels of technical and interpersonal competence of the facilitators who manage and lead the projects. On the other hand, factors such as internal resistance, lack of resources, changing business objectives and lack of leadership impede success (TSIRONIS; PSYCHOGIOS, 2016).

Therefore, in light of the increasing importance of the service sector, the key message is that the integration of Lean and Six Sigma aims to incorporate the problem-solving and analysis tools to meet quality management standards, save costs and also meet sustainable services. It is necessary to view services as a system, considering LS as a strategic approach that places the customers at the centre and invests in mechanisms of engagement of the employees at the team and individual levels. In addition, Six Sigma could be used in order to achieve stable and predictable process results and it encourages creating a process thinking mind-set in the organization. Hence, LSS uses tools from both toolboxes, in order to get the synergetic-best of the two methodologies, being essential to enhance customer satisfaction and triple bottom line results as well as to improve key performance indicators (KPIs) and to foster sustainable development.

2.6 The use of Lean, Six Sigma and LSS operational programs in the context of Sustainable Development

In a rapidly changing environment, organizational survival depends not just on it operating in the most profitability, effective and efficient manner possible, but also on its compromise with environmental regulations and social demands and the adoption of evolving strategies (GARZA-REYES, 2015) For this reason, operational improvement programmes, as LM, Six Sigma and LSS are becoming more and more outstanding in order to improve sustainability performance and underpin competitive advantage.

While LM aims to reduce wastefulness, achieve an engaging approach in the relationship between employees, suppliers and customers; Six Sigma seeks to reduce errors and defects; and Lean Six Sigma incorporates Lean's principles of speed and immediate action with the Six Sigma vision of flawless quality and reducing the impact of variation on queue times, being a mechanism that seeks the engagement of everyone for joint reach and no trade-offs of quality, speed, and cost (GEORGE, 2002).

The literature suggests that those approaches make a positive contribution to the

sustainable performance of organisations and offer a better culture to deploy sustainability philosophies, tools and methods (POWELL *et al.*, 2017; CHERRAFI *et al.*, 2017). Lean practices has some synergies with sustainability as waste reduction, reduction of environmental impacts such as emissions into the air, water and soil, as well as efficiency of water and conservation of energy, creation of greener supply chains, lead time reduction, product design and techniques to manage people (CHIARINI, 2014; GARZA-REYES, 2015; CHUGANI et al., 2017), and this actions could be enhanced when used together (VERRIER *et al.*, 2014).

Moreover, it can be seen that Six Sigma aims to reduce defects and cost by controlling the necessary resource consumption (CHUGANI *et al.*, 2017) and can contribute to improve sustainable production and service systems, because through its principles firms can manage energy use and implement, manage, sustain and improve sustainability performance (GARZA-REYES, 2015), as DMAIC cycle could make suitable to measure sustainability.

In addition to, Lean Six Sigma represents a cultural transformation that makes organizations consider and accept environmental innovation and can reduce marginal cost of sustainability initiatives (CHERRAFI *et al.*, 2016). Their techniques also contribute to a more environmentally sustainable supply chain and improve process performance (POWELL et al. 2017). In fact, Lean and Six Sigma are catalysts for the implementation of sustainability in manufacturing companies (VERRIER *et al.* 2014). However, there are also some obstacles for corporate sustainability, such as the supply relationship, a critical part in LM (SIMPSON; POWER, 2005) and the supply of human and material resources for implementing sustainable processes. As LM is an integrated approach that incorporates a wide variety of practices, including supplier management (SHAH; WARD 2003), the supplier development requires the firm's commitment with financial, capital and personnel resources, as well as, their collaboration and compliance (SIMPSON; POWER, 2005).

Thus, there are compatibilities and complementarities between those emergent manufacturing practices (THOMAS *et al.*, 2016) and sustainability in terms of waste elimination and efficient use of resources, continual improvement and implementation strategies, measurement metrics, supply chain relationships, satisfying customer needs and tools and practices (CHERRAFI *et al.*, 2016; CHUGANI *et al.*, 2017).

On the other hand, unlike sustainable initiatives, Lean and Six Sigma approaches don't consider social and governance dimensions of sustainability and neither the lifecycle and don’t pay attention to the sustainable value of products or the environmental risk of the materials transformation processes used to produce products (CHERRAFI *et al.*, 2016).

Sagnak and Kazancoglu (2016) emphasized the need for the application of Six Sigma

methodology to the Green Lean approach in order to fill up its gaps and assess performance. Therefore, as there are divergences between sustainability and operational improvement approaches - Lean aims to reduce waste, Six Sigma aims to achieve continuous improvement of quality by minimising the defects and Green aims to decrease the negative ecological impacts (KUMAR *et al.*, 2016) – the integration between those approaches are necessary in order to aid organisations to balance the need for operational efficiency in their production and service systems with environmental commitment and social fairness.

Furthermore, its essential to integrate those programmes with measurement system and control techniques to satisfy the need for measurement (SAGNAK; KAZANCOGLU, 2016). Verrier *et al.*, (2014) proposed a framework to measure both productivity and environmental performance, including indicators for integrating Green and Lean to improve economic, environmental and social performance, allowing the companies to measure their ability to run a Lean and Green policy and benchmark their practices and experiences with other companies. Helleno *et al.*, (2016) contribute to the current sustainability assessment methods by developing and applying a method to integrate a new group of sustainability KPIs based on the TBL concept into the Value Stream Mapping – Lean manufacturing tool - (Lean KPIs) to assess the manufacturing process parameters in Brazilian industry. The method helps to measure the parameters that influence the productivity and thereby promote the improvement of sustainability. Therefore, sustainable organizations can integrate and align operational improvement programmes into their sustainability strategies through development of assessment models and measures that effectively contribute to increasing sustainability in manufacturing processes. Because of that, the effectiveness of a PMS is important, being able to provide an indication of the current market position of the organization, and to aid in the development of future operations and strategies (LANGFIELD-SMITH *et al.*, 2009). Furthermore, to Veleva and Ellenbecker (2001), these PMS may facilitate the creation of a more ecoefficient and socially responsible production system, which aims to foster sustainable manufacturing.

However, there are some challenges to implementing Green and LSS regarding expertise training programme, support of management, customer involvement and the adequate technologies, facilities, human resources, time management and organizational culture (KUMAR *et al.*, 2016).

3 RESEARCH AIMS AND QUESTIONS / HYPOTHESES´

The overall aim of this thesis by aggregation of articles is to present Green and Lean practices towards sustainable and operational performance improvements.

3.1 Study I: Measurement of sustainability performance in Brazilian organizations

The objective of study I is: to evaluate the measurement of sustainability performance of Brazilian organizations. To achieve this, the work aims to verify in which aspects the company adopts sustainable measures; identify the main inductor of corporate sustainability; assess the degree of importance of sustainable performance measures for the organization's sustainability; and also highlight which sustainable measures have the strongest relation with the organizational sustainability performance. To meet some of these aims, the exploratory study is guided by the following hypotheses:

- Ho_1. Technical dimension is positively related to organizational sustainability.
- Ho_2. Governance dimension is positively related to organizational sustainability.
- Ho_3. TBL measures are associated with the Technical and Governance measures.

3.2 Study II: Towards sustainability by aligning operational programmes and sustainable performance measures

Study II seeks to answer the question: How effectively organizations achieve sustainability through alignment of key sustainable measures and operational improvement programmes? To answer this question and the emerging gaps, the objective of this study is threefold:

- assess the degree of importance of sustainable performance measures for the organization's sustainability;
- investigate the key sustainable performance measures to achieve sustainability
- find out the impact of operational improvement programmes to handle the key sustainable measures and achieve more sustainable production and services;

Moreover, taking into account the theoretical arguments, and the results obtained in previous studies, Study II also want to examine the following hypotheses:

- Ho_4. There is a positive relation between socio-environmental measures and quality management;
- Ho_5. There is a positive relation between supplier relations and customer satisfaction;

3.3 Study III: Towards sustainability through Green, Lean and Six Sigma integration at service industry: review and framework

Study III aims to critically review the Lean and LSS methodologies and highlight their importance to achieve sustainable development in service industry. To do this, a systematic literature review (SLR) of the subjects under investigation was conducted in order to locate the relevant existing studies and to evaluate and synthesize their respective contributions (CAIADO et al., 2017a). This review explores the following questions:

- What are the compatibilities and divergences between Green and Lean /LSS in service industry?
- What are the challenges and enablers to align Lean/LSS with organizational sustainability?
- What are the main implications of Lean and LSS for achieving green services?

4 MATERIALS AND METHODS

4.1 Study I

4.1.1 Study design and research steps

The research study applied a triangulated methodology with qualitative and quantitative data collection mechanisms. The data was collected using three mechanisms:

(1) a literature review and a documentary analysis of corporate reports;

(2) a questionnaire survey of fifty practitioners;

(3) a semi-structured interview with nine experts in sustainability.

It may be observed that the research counts on multiple sources of information and iteration with the constructs developed from the literature, which enables further constructive validity (EISENHARDT, 1989). To Miguel (2005), the use of multiple sources allows for the support of the constructs, propositions or hypotheses, in other words, the technical use of triangulation helps in the iteration and convergence between various sources of evidence.

The first methodology step consists in the literature review of the main inductors of organizational sustainability, the aspects in which it is adopted, the environmental and sustainable performance measures, all aiming to support the design of the research survey. From the literature review and the extensive documentary analysis (the G4 version of GRI Sustainability Reporting Guidelines accessed in June 2016) and indicators, it was possible to identify the main inductors and sustainable performance measures which would be evaluated by organizations. The documentary analysis in the GRI guidelines is justified, considering that the structure of this report is internationally accepted, is adaptable to any business and represents TBL dimensions (SILVESTRE *et al.*, 2015). In our analysis, we considered eight corporate sustainability reporting documents, referring to the period from 2014 to 2015 of four large-sized companies of different sectors (oil and gas, construction, energy, mining) and with operations in Brazil.

In the second step, the application of a survey was conducted with market specialists in order to verify which inductors and sustainability measures are most important to organizational sustainability. The survey was carried out on August of 2016 to enhance the power of generalization of the relevance of the sustainable measures across the perception of a wide range of professionals working in the industry. Prior to sending out the questionnaire, a pilot study was undertaken in order to eliminate potential problems. A draft of the survey questionnaire was reviewed by four people, two being industry professionals who were familiar with sustainability. Thus, the revised questionnaire offers a better refinement of the questions,

ensuring that experts, professionals and academics would have no difficulty in answering the questions. In order to organize the questionnaire in a logical sequence and to better understand the subject studied, the survey questionnaire consists of three parts. The first part was intended to determine the demographical details of the participating experts, including the gender, age, education, and years of experience with corporate sustainability and stage in which the respondent has experienced or observed the use of sustainability on the organization. The second part focussed on determining the inductor agent of organizational sustainability and the degree of importance of the measurement for the company. The third part aimed to measure the importance of sustainable performance measures for organizations in which the specialists worked. All responses on the importance of sustainable measures items were recorded using a five-point Likert-type scale (1 – "very low" to 5 – "very high").

Lastly, in the third step, the questionnaire results were crossed with the state of the art, and semi-structured interviews were conducted with nine sustainability specialists. Among them, there were industry professionals and academic researchers, for identifying the reason for the strong relation between certain measures, and for identifying how organizations may achieve better performance in implementing and controlling these measures. Many of the interviewed professors have master's degrees and used to or are still working in management positions in Brazilian organizations. The interviews took place on February 17th of 2017, in the Pontifical Catholic University of Rio de Janeiro, Brazil. The outcome of the interviews provided the guidelines for more effective measuring of sustainable performance in organizations. The aim of the interviews was to provide the researchers with the opportunity of direct and personal interaction with professionals with ample industry and academic experience.

4.1.2 Sampling

The intended population of this study consists in public and private sector professionals and academics who were present during a Conference on Sustainable Management in the city of Rio de Janeiro, but who work in companies or institutions throughout various regions of Brazil.

Given that the true characteristic of the intended population was unknown; convenience sampling was performed (SEKARAN; BOUGIE, 2010), because this research aims to test the relationships of variables (CALDER *et al.*, 1981). The data collection was performed using a survey, through the application of printed questionnaires. The length of time to answer the questionnaire was about 15 minutes. The research sample, a total of 50 questionnaires, was collected and after the manual screened check of the data, ignoring those with incomplete questions, this resulted in 30 (60%) valid questionnaires. As Hines and Montgomery (1990)

and Sureeyatanapas *et al.*, (2015) point out, in small populations, a sample of at least 30 usable responses for every part of the questionnaire enables a reasonable statistical analysis of the data. The majority of the respondents work in organizations which adopts sustainable measures (86.7 percent). In terms of respondents' age, the majority of respondents are 51-60 years old (30.0 percent) and over half of respondents (56.7 percent) have at least a master's degree, which shows a high level of maturity and academic formation. More completely, Table 4 shows the respondents' demographic profile.

Table 4. Specialists Profile

Variables	Sample (N=30)	Percentage
Age		
<18	0	0.0%
18-30	5	16.7%
31-40	4	13.3%
41-50	7	23.3%
51-60	9	30.0%
61-70	5	16.7%
Education		
Incomplete College Education	0	0.0%
Complete College Education	7	23.3%
Specialization or Extension	6	20.0%
Master's Degree	14	46.7%
Doctoral Degree	2	6.7%
Post-Doctoral	1	3.3%
Engagement time in Sustainability		
None	2	6.7%
Less than 1 year	3	10.0%
1 to 3 years	7	23.3%
4 to 6 years	6	20.0%
7 to 10 years	4	13.3%
Over 10 years	8	26.7%
Sector		
Public	14	46.7%
Private	14	46.7%
Academic	2	6.7%
Size of Organization		
Micro, Small and Medium	9	34.6%
Large	17	65.4%
Organization adopts Sustainable Measures		
Yes	26	86.7%
No	4	13.3%

4.1.3 Data analysis

The data analysis was done using the R software (R DEVELOPMENT CORE TEAM, 2017). Descriptive statistics were used, including frequencies and percentages and mode, to describe sample characteristics analyzed and the Cronbach's alpha to verify the internal reliability. The reliability of the variables was assessed based on the value of Cronbach α coefficient, which measures the correlation between responses to a questionnaire by profile analysis of the answers given by respondents. The Cronbach α coefficients range from 0.9674 to 0.9693. The values

exceed the recommended cut off value of 0.6, which means that a group of items is homogeneous or internally consistent and the reliability of each variable was confirmed (HAIR Jr *et al.*, 2009; SUREEYATANAPAS *et al.*, 2015). Then, to check the data normality, Kolmogorov-Smirnov (K-S) test was applied. According to Fávero *et al.*, (2009), K-S is recommended for samples equal to or greater than 30 individuals. Normality tests were performed with a confidence level of 99% (significance level (α) of 1%) and the lower the p-value, the lower the consistency between the data and the null hypothesis, which corresponds to the Normal distribution. Furthermore, as part of the inferential statistical technique, the Chi-square test (BRYMAN, 2008; YUSUF *et al.*, 2013; GOLINI *et al.*, 2014) was used to check if there is an independency (no importance) or a dependency (importance) relation between the items (sustainable measures) and the organization's sustainability. The Chi-squared test (X^2) was conducted at 5% level of significance (95% confidence interval). The results of the normality test, internal reliability coefficient and Chi-square test of each variable are shown in Table 5.

Then, as the data did not present a normal distribution, we used Spearman's correlation between the dimensions of measures (Table 6) and the sustainable performance measures (Table 7), which is the most appropriate for non-parametric data, because the coefficient measures the intensity of the relationship between variables, using only the order of observations instead of the observed value (FRUGOLI *et al.*, 2015).

4.2 Study II

4.2.1 Research Method

The explorative research study adopted a triangulation method with qualitative and quantitative data collection mechanisms to operationalise the research questions and constructs (YUSUF *et al.*, 2013). As triangulation involves using more than one method to gather data, in our study we used three mechanisms: (1) a literature review; (2) a survey conducted across fifty industry professionals; and (3) semi-structured interviews with eleven academics. The use of different methods through the data triangulation to study the same phenomenon increases the validity of the research results (PSYCHOGIOS; TSIRONIS, 2012).

In addition, it may be observed that the research also counts on multiple sources of information (source triangulation) such as content analysis of articles, questionnaires survey, interview and direct observation and iteration with the constructs developed from the literature, which enables further constructive validity (EISENHARDT 1989); To Miguel (2005), the use of multiple sources allows for the support of the constructs, propositions or hypotheses, in other

words, the technical use of triangulation helps in the iteration and convergence between various sources of evidence.

4.2.2 Survey design, sampling and data analysis

The first step consists of an extensive literature review of the sustainable performance measures, in order to support the design of the research survey. As in the work of Sureeyatanapas *et al.,* (2015), in this review, 31 measures were preliminary identified by examining works focusing on the manufacturing sector in general, rather than on a specific industry, in order to cover the general concerns within the field. These identified measures are then evaluated by the organizations.

The second step seeks to enhance the power of generalization of the relevance of the sustainable measures across the perception of a wide range of professionals working in the industry. A survey was conducted with industry professionals on August of 2016 in order to verify which sustainable measures are most important to organizational sustainability. Prior to sending out the questionnaire, a pilot study was undertaken in order to eliminate potential problems. A draft of the survey questionnaire was reviewed by four industrial practitioners experienced in sustainability to offer a better refinement of the questions, ensuring that experts would have no difficulty in answering the questions. In order to organize the questionnaire in a logical sequence and to better understand the subject studied, the survey questionnaire consists of two parts. The first part was intended to determine the demographical details of the participating experts, and the second part aimed to measure the importance of sustainable performance measures for organizations in which the specialists worked. All responses on the importance of sustainable measures items were recorded using a five-point Likert-type scale (1 – "very low" to 5 – "very high").

The intended population of this survey consists in public and private sector professionals who were present during a Conference on Sustainable Management in the city of Rio de Janeiro, but who work in companies or institutions throughout various regions of Brazil. Given that the true characteristic of the intended population was unknown; convenience sampling was performed (SEKARAN; BOUGIE, 2010), because this research aims to test the relationships of variables (CALDER *et al.* 1981). The research sample, a total of 50 questionnaires, was collected and after the manual screened check of the data, ignoring those with incomplete questions, this resulted in 30 (60%) valid questionnaires. As Hines and Montgomery (1990) and Sureeyatanapas *et al.* (2015) point out, in small populations, a sample of at least 30 usable responses for every part of the questionnaire enables a reasonable statistical analysis of the data. The majority of the respondents work in organizations which adopts sustainable measures (86.7

percent) and have master's degrees (56.7 percent).

The data analysis was done using the R software (R DEVELOPMENT CORE TEAM, 2017). Descriptive statistics were used, including frequencies / percentages to describe sample characteristics analyzed and we verified the degree of importance of the measures, obtaining an average ranking based on the weighted frequency (WF) of the scores attributed to the answers by the following Equation (1):

$$Weighted\ Frequency\ (WF) = \sum(f_i \times W_i) \qquad (1)$$

Where:

- f_i = observed relative frequency of each response to each measure
- W_i = weight value of each likert scale response

The reliability of the variables was assessed based on the value of the Cronbach's alpha coefficient, which is one of the main ways of estimating the internal consistency of each construct in a questionnaire (FORZA, 2012), and should reach the minimum level of 0.70 and can admit 0.60 in exploratory research (HAIR Jr *et al.*, 2009). Then, to check the data normality, Lilliefors (LF) and Anderson-Darling (AD) normality tests were applied. According to Razali and Wah (2011) LF test always outperforms Kolmogorov-Smirnov test and AD is quite comparable with Shapiro-Wilk test, and has a high power for samples equal to or greater than 30 individuals. Normality tests were performed with a confidence level of 99% (significance level (α) of 1%) and the lower the p-value, the lower the consistency between the data and the null hypothesis, which corresponds to the Normal distribution. As the data did not present a normal distribution, the Spearman coefficient ρ was used, which is a bivariate correlation procedure that does not require the relationship between the variables to be linear, to measure the strength of the association between the ordinal variables and uses the order of observations, instead of the observed value, only (PESTANA; VELOSA, 2006).

4.2.3 Interviews design, sample and data analysis

Lastly, in the third stage, after identifying 10 most important measures, we conducted eleven semi-structured interviews in the Portuguese language with academics. Each interview lasted around half hour. We applied a questionnaire with five professors, which have at least master's degrees, in Fluminense Federal University, Niterói, Brazil on November 22th and six managers from Tecgraf Institute on November 24th 2017 in the Pontifical Catholic University of Rio de Janeiro, Brazil. Given that all the respondents were familiar with Lean Six Sigma methodology or have already worked at least once in a project involving Lean, Six Sigma, LSS or Green techniques, during face-to-face meetings with them, the authors didn´t need to explain these methodologies and their concepts. The experts were asked to fill out the questionnaire

using a 3-point scale (i.e., 0 = no influence, + = moderate, ++ = strong) to indicate the influence of each operational improvement programme to handle the key sustainable measures in their respective organization.

After collecting questionnaire data from all the respondents, we calculated the mode of the respondents' opinions in order to reach a consensus. In addition, as Caffieri *et al.*, (2017) a manual content analysis - systematic classification process of coding and identifying themes or patterns - was used to analyze the interviews. It enabled the researchers with the opportunity of direct and personal interaction with professionals with ample industry and academic experience in order to make inferences about the reasons of the relationships between the key sustainable performance measures and some operational improvement programmes, and for identifying how organizations may achieve better sustainable performance in implementing programmes and controlling these measures.

4.3 Study III

4.3.1 Literature search, study characteristics, and data extraction

In this study was conducted a systematic literature review in order to locate relevant existing studies based on prior formulated research questions, to evaluate and synthesize their respective contributions. In this review, just as Caiado *et al.*, (2017a) and Saieg *et al.*, (2018) many articles were read, focusing on the scope of the research and limiting the sample to selecting, evaluating, and interpreting only relevant and adherent works for the particular subject. This SLR consists of five consecutive phases: (a) formulation of the question, (b) location of studies, (c) evaluation and selection of studies, (d) analysis and synthesis, and (e) reporting and use of the results (GARZA-REYES, 2015b).

Identifying the keywords is extremely critical to a comprehensive and unbiased review. The search is limited to a set of search terms ('Lean', 'Six Sigma', 'Lean Sigma', 'Lean Six Sigma', 'LSS', 'Environment', 'Sustainable', 'Sustainability', 'Green', 'Green Lean Six sigma', 'Green LSS', 'Sustainable Lean Six Sigma' and 'Service'). We searched these keywords in the following databases: Scopus, ISI Web of Science, PubMed, Emerald, Taylor and Francis, IEEE Xplore and Wiley Publication.

The conducted research had combined the search terms into title, abstract or keywords, limited to papers published in peer-reviewed journals up to March 2017, when they were available. Additional papers were identified by reading the papers included in the review. 272 records were identified through databases searching. Then, they were refined by titles/abstracts screening analysis and 207 records were excluded. Following that, 65 articles were analized in

depth in an interative process. Based on the full text analysis, a total of 43 articles complied with the selection criteria. Hence these were all the articles that, to a certain extent, referred to Lean, Six Sigma or Lean Six Sigma related to sustainable development in services.

In the next stage, researchers discussed and created a database using Microsoft Excel. There was a synthesis analysis, in which individual articles were categorized and organized by concepts.

5 RESULTS AND DISCUSSIONS

5.1 Study I

5.1.1 Descriptive results

Concerning the organizational aspect in which sustainability is adopted, it can be inferred from Figure 1 that in 34% of organizations sustainability is allocated throughout the entire company and in 22% of the business management. This shows the necessity of an initial-stage support from high management (organization management) for the transition to sustainability to occur in a global manner, in all levels.

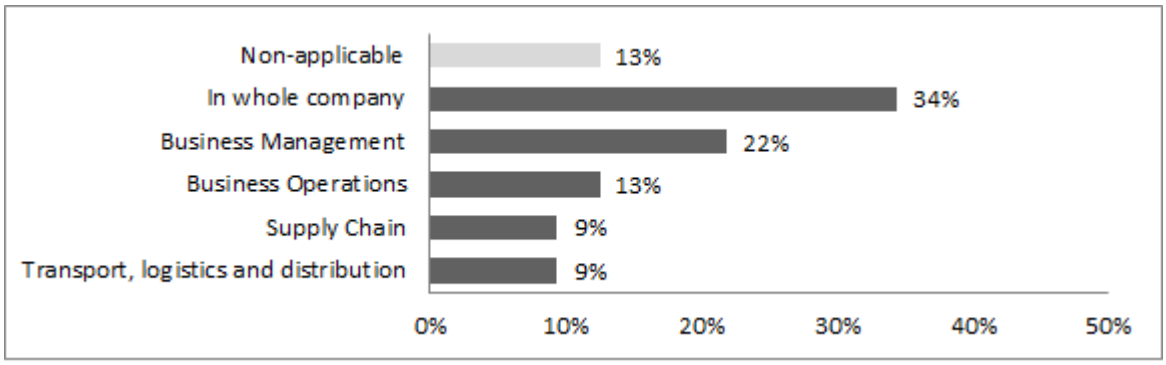

Figure 1. Aspects of the adoption of organizational sustainability

On the other hand, aspects like supply chain and transport, logistics and distribution account for a joint 18% of the organizational sustainability. This shows the lack of chain integration, which is the main cause of the bullwhip effect, generating waste of resources and loss of efficiency in processes. The poor communication between departments and carelessness in the middle areas of organizations may generate reworking, increase in costs and social and environmental losses.

On the inductors or motivators of organizational sustainability, it can be observed in Figure 2 that the internal organizational factors account for 27%, and for that reason, are the main promoters of the sustainable environment in organizations. This happens due to the growing awareness of internal stakeholders, mainly employees, who are the main asset of the organization and also to working in a sustainable location no longer being a differential and a necessity to retain the best talents.

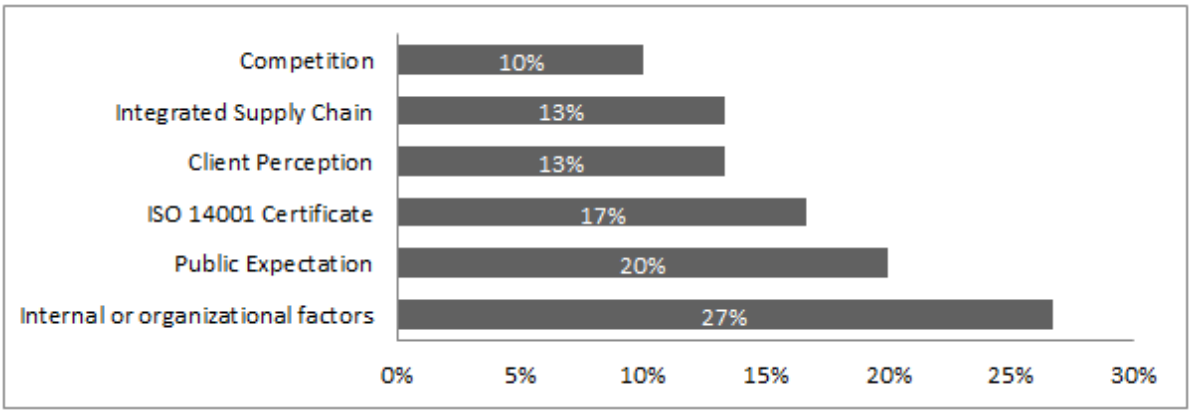

Figure 2. Percentage of Inductors for organizational sustainability

However, a low representation of the competition factor (10%) can be observed for sustainable induction, which may be an indication of sustainable awareness coming not just from imitating others or from fear of the competition, but from the will of the organization itself to become sustainable.

On the degree of importance of measuring organizational sustainability, Figure 3 shows that, from current analysis, sustainable measures which are considered more important by the interest group's perception are: Information Transparency (environmental reports), Environmental Protection, Energy Saving, Quality Management, Reduction of Energy used by the organization, Reduction in Quantity of Resources used, Supplier Relationship, Organizational Reputation, Client Satisfaction and Investor Relationship.

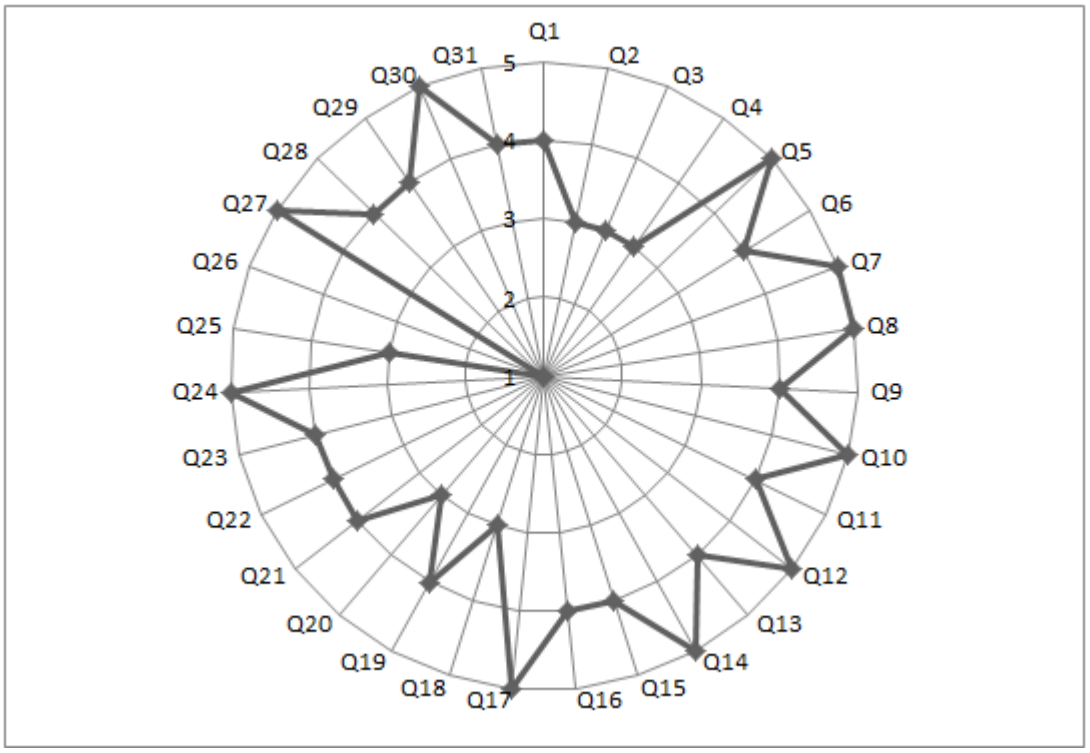

Figura 3. Degree of importance of sustainable development measures

Although, the measure with the least perceived importance to respondents was Reduction of Carbon Emission (Q26). Despite the gases derived from this chemical element being the main agents of the greenhouse effect, and thereby resulting in a devastating global-scale impact, this measure still lacks its due importance in organizations.

5.1.2 Inferential results

The internal reliability and non-parametric tests results of normality and Chi-square tests are observed on Table 5.

Table 5. Results of non-parametric tests and Cronbach's alpha

Measures	K-S test		Cronbach's alpha	Chi-square test (n=30; df=4)		
	Statistic	p-value		Statistic	p-value	Decision
Q1	0.231	<0.01	0.9683	8.3333	0.08	Independent
Q2	0.179	0.02	0.9676	5.6667	0.225	Independent
Q3	0.186	<0.01	0.9686	9.3333	0.053	Independent
Q4	0.217	<0.01	0.9681	8.6667	0.07	Independent
Q5	0.29	<0,01	0.9677	14.6667	0.005	Dependent
Q6	0.244	<0.01	0.968	6.3333	0.176	Independent
Q7	0.229	<0.01	0.9678	9	0.061	Independent
Q8	0.258	<0.01	0.9686	17	0.002	Dependent
Q9	0.211	<0.01	0.9676	2.3333	0.675	Independent
Q10	0.211	<0,01	0.9679	9.6667	0.046	Dependent
Q11	0.277	<0.01	0.9675	12.6667	0.013	Dependent
Q12	0.251	<0.01	0.9685	11.6667	0.02	Dependent
Q13	0.231	<0.01	0.9682	4	0.406	Independent
Q14	0.179	0.02	0.9675	4.66667	0.323	Independent
Q15	0.186	<0.01	0.9678	4	0.406	Independent
Q16	0.217	<0.01	0.9675	5	0.287	Independent
Q17	0.29	<0.01	0.9693	11	0.027	Dependent
Q18	0.244	<0.01	0.9674	3.6667	0.453	Independent
Q19	0.229	<0.01	0.968	6.6667	0.155	Independent
Q20	0.258	<0.01	0.9682	13.6667	0.008	Dependent
Q21	0.211	<0.01	0.9685	11	0.027	Dependent
Q22	0.211	<0.01	0.9682	7.3333	0.119	Independent
Q23	0.277	<0.01	0.9679	5.33333	0.255	Independent
Q24	0.251	<0.01	0.9676	11	0.027	Dependent
Q25	0.192	<0.01	0.9675	17	0.002	Dependent
Q26	0.194	<0.01	0.9688	2.6667	0.615	Independent
Q27	0.199	<0.01	0.9682	11.3333	0.023	Dependent
Q28	0.25	<0.01	0.9681	4	0.406	Independent
Q29	0.257	<0.01	0.9683	7.3333	0.119	Independent
Q30	0.184	<0.01	0.9675	9.3333	0.053	Independent
Q31	0.252	<0.01	0.9678	5	0.287	Independent

The value of Cronbach's alpha of the entire set was 0.969, which shows high reliability (HAIR Jr. *et al.*, 2009). By normality test it was noticed that there was no statistical significance between the K-S values of the variables of the test and the comparison of the p-value measures less than 0.01 it was possible to verify that the data is not normally distributed. The Chi-squared importance test (X^2) of the performance measures for Organizational Sustainability considered X^2 critical (gl=4 e α=0.05) = 9.488 and, complementarily, for p-value < 0.05, the null hypothesis is rejected due to the existence of a dependency relation. Through the results of Table 5, it can be observed that the measures Environmental Protection; Organizational Reputation; Quality Management, Social Benefits, Medical-Legal; Client Satisfaction; Investor Relations (IR); Corporate Governance; Labor Indicators; and Reduction of Amount of Energy have a dependency relation with the Organizational Sustainability variable, and thus are important to its achievement.

In that manner, the organization which seeks to adopt sustainability in its projects, processes and products must create a performance measurement system which in turn must cover these nine variables (measures), aiming to transition to organizational sustainability.

In order to analyze the Spearman correlation between the performance measures, firstly was evaluated the relationship between the Dimensions of the Measures (Table 6). As the data did not present a normal distribution, we used the Median (Md) of the measures for the characterization of the dimensions, since it is considered a robust or resistant position measurement, aiming at representing the position of the data, resisting any outliers.

Table 6. Correlation between the dimensions of sustainable performance measures

Dimensions	Social	Environmental	Economical	Governance	Technical	Sustainability
Social	1					
Environmental	**0.7059****	1				
Economical	0.5316**	0.6169**	1			
Governance	0.6872**	0.6276**	0.6258**	1		
Technical	0.6085**	0.5175**	0.4771**	**0.7644****	1	
Sustainability	**0.8655****	**0.8617****	0.6529**	**0.841****	**0.7504****	1

*p<0,05; **p<0,01

By the p-value analysis, the null hypothesis at the 1% level of significance was rejected, and it was possible to verify that the Social and Environmental dimensions (ρ = 0.7059). And the Technical and Governance dimensions (ρ = 0.7644) show a strong correlation with organizational sustainability, with the Social dimension being the highest correlation with sustainability (ρ = 0.8655). Thus, the hypotheses H_{01} and H_{02} were corroborated, since both the technical and governance dimensions are positively related to organizational sustainability, as well as one dimension is positively related with the other.

Then, the correlation between the sustainable measures was calculated (Table 7). It can be seen that in the Environmental dimension there is a strong correlation between the measures: Carbon footprint reduction and Reduction of air pollution (ρ = 0.8242); Carbon footprint reduction and Waste management (ρ = 0.7015); Energy conservation and Reduction in amount of energy use (ρ = 0.9205); Energy Conservation and Reduction in amount of resources use (ρ = 0.7576); Energy conservation and Sources of recyclable raw material (ρ = 0.7142); Green Marketing and Environmental Policy (ρ = 0.7492). In the Governance dimension there is a strong correlation between the measures: Code of conduct and Corporate Reputation (ρ = 0.7071); Code of conduct and Corporate Governance (ρ = 0.7212); Environmental logistics policy and Transparency in information (ρ = 0.7170). In the Social dimension there is a strong correlation between the measures: Balancing professional and family life and Sustainable working condition (ρ = 0.7280); Balancing professional and family life and Representation and dialogue with employees (ρ = 0.7177); Balancing professional and family life and Inter-firm collaborative capabilities (ρ = 0.7617). In the Technical dimension there is a strong correlation between the measures: Quality management and Customer satisfaction (ρ = 0.7381).

In addition, there is a strong correlation between measures of different dimensions such as Technical-Governance: Labor practice Indicators and Code of Conduct (ρ = 0.7462); Environmental-Governance: Environmental Policy and Code of Conduct (ρ = 0.7474); Economical-Governance: Eco-efficiency and Environmental Logistics Policy (ρ = 0.7856). Therefore, there is a positive correlation between the TBL measures and the technical or governance measures, which corroborates the H_{03} hypothesis.

Hence, it is perceived that as organizational sustainability is a multidimensional concept, in which all dimensions must be evaluated in an integrated way. It is up to the organization to measure its performance in relation to the most important measures considered, taking into account which of these have stronger relationships in order to invest the right resources, avoiding waste and promoting integrated management for long-term sustainable development.

Table 7. Correlation between sustainable performance measures

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31
Q2	0,332	1																													
Q3	0,269	0,442	1																												
Q4	0,448	0,513	0,674	1																											
Q5	0,319	0,645	0,387	0,315	1																										
Q6	0,143	0,499	0,497	0,424	**0,779**	1																									
Q7	0,430	0,483	0,633	0,562	0,463	0,514	1																								
Q8	0,535	0,306	0,283	0,368	0,458	0,491	0,419	1																							
Q9	0,340	**0,786**	0,614	0,699	0,561	0,488	0,555	0,360	1																						
Q10	0,502	0,338	0,482	0,606	0,346	0,502	0,644	0,556	0,409	1																					
Q11	0,342	0,593	0,369	0,604	0,574	0,571	0,391	0,289	0,600	0,486	1																				
Q12	0,518	0,150	0,419	0,402	0,342	0,390	0,569	0,573	0,307	**0,738**	0,326	1																			
Q13	0,237	0,505	**0,762**	0,615	0,331	0,567	0,607	0,215	0,521	0,518	0,554	0,396	1																		
Q14	0,643	0,597	0,529	**0,715**	0,399	0,296	0,530	0,397	**0,717**	0,602	0,609	0,548	0,487	1																	
Q15	0,377	0,629	0,287	0,362	0,641	0,460	0,552	0,486	0,537	0,606	0,415	0,530	0,353	0,613	1																
Q16	0,467	0,686	0,371	0,551	**0,751**	0,626	0,416	0,593	0,696	0,553	0,560	0,347	0,285	0,674	**0,749**	1															
Q17	0,487	0,382	0,175	0,139	0,507	0,510	0,529	0,519	0,248	0,354	0,278	0,361	0,224	0,343	0,516	0,558	1														
Q18	0,270	0,603	**0,804**	0,610	0,575	0,650	0,638	0,307	0,696	0,540	0,675	0,451	**0,718**	0,597	0,465	0,535	0,407	1													
Q19	0,452	0,444	0,411	0,436	0,619	0,598	0,377	**0,707**	0,497	0,605	0,474	0,532	0,397	0,622	0,626	**0,747**	0,443	0,467	1												
Q20	0,461	0,396	0,559	0,443	0,462	0,374	0,570	0,503	0,454	0,589	0,382	0,584	0,426	0,617	0,578	0,483	0,364	0,486	**0,721**	1											
Q21	0,180	0,376	0,569	0,479	0,497	0,593	0,283	0,505	0,397	0,439	0,465	0,325	0,574	0,429	0,448	0,525	0,255	0,598	**0,746**	0,533	1										
Q22	0,207	0,500	0,564	0,568	0,403	0,456	0,639	0,274	0,434	0,531	0,612	0,267	0,696	0,480	0,407	0,363	0,213	0,594	0,369	0,470	0,601	1									
Q23	0,203	0,570	0,437	0,417	0,605	0,653	0,405	0,337	0,461	0,422	0,644	0,261	0,653	0,330	0,531	0,546	0,421	0,631	0,473	0,307	0,668	0,690	1								
Q24	0,428	0,529	0,407	0,583	0,432	0,302	0,461	0,243	0,482	0,503	0,652	0,444	0,505	0,668	0,564	0,500	0,335	0,609	0,401	0,394	0,529	0,635	0,641	1							
Q25	0,432	0,589	0,579	0,582	0,493	0,553	0,607	0,154	0,547	0,428	**0,705**	0,382	**0,728**	0,656	0,392	0,434	0,437	0,685	0,466	0,528	0,510	0,632	0,547	0,591	1						
Q26	0,241	0,611	0,309	0,358	0,440	0,384	0,328	0,018	0,425	0,265	0,568	0,161	0,448	0,385	0,439	0,362	0,380	0,539	0,176	0,242	0,248	0,268	0,435	0,554	0,602	1					
Q27	0,356	0,399	0,294	0,560	0,386	0,282	0,411	0,179	0,442	0,448	0,615	0,493	0,456	0,603	0,491	0,400	0,240	0,463	0,335	0,325	0,381	0,506	0,519	**0,921**	0,533	0,538	1				
Q28	0,271	0,643	0,352	0,500	0,512	0,514	0,512	0,102	0,591	0,319	0,659	0,297	0,558	0,461	0,457	0,440	0,509	0,635	0,214	0,167	0,230	0,367	0,581	0,581	0,697	**0,824**	0,604	1			
Q29	0,276	0,523	0,395	0,556	0,474	0,401	0,507	0,204	0,514	0,487	0,416	0,259	0,334	0,425	0,516	0,523	0,353	0,451	0,334	0,443	0,332	0,326	0,275	0,518	0,482	**0,702**	0,498	0,595	1		
Q30	0,511	0,426	0,465	0,576	0,485	0,412	0,547	0,196	0,478	0,392	**0,712**	0,454	0,582	0,559	0,344	0,382	0,409	0,557	0,373	0,501	0,400	0,568	0,604	**0,758**	**0,779**	0,579	**0,784**	0,679	0,526	1	
Q31	0,557	0,511	0,364	0,551	0,537	0,299	0,393	0,334	0,485	0,343	**0,712**	0,305	0,396	0,652	0,547	0,553	0,382	0,556	0,469	0,561	0,456	0,522	0,561	**0,714**	0,564	0,468	0,592	0,463	0,400	0,691	1

5.1.3 Guidelines for sustainability performance improvements

This section provides a discussion of the main results of qualitative and quantitative methods used in Study I. The triangulation of literature, documents, and empirical findings, generated from data collected during surveys and interviews yielded valuable insights. Thus, based on the triangulation approach, some critical points can be stressed:

I. Internal Management Process

The internal organizational factors (i.e. alignment of expectations, demands, regulation and legislation) are the main promoters of the sustainable environment in organizations, and therefore, workshops, talks and organizational learning practices in sustainability are of interest in order to perpetuate this cultural change, a challenging obstacle which is being gradually overcome, as demontrated this research indicates. Besides, in order to improve social and environmental performance, incentives must be established to encourage excellence (EPSTEIN; ROY 2001; TUNG *et al.*, 2011). The development of performance measurements has a connection to the organization's strategies and from evaluations and rewards these have the power to change the organizational structure.

From this, organizations must use methodologies through metrics fed by engineering systems to manage processes with critical success indicators for continuous and incremental improvement. The measures identified in the survey that stand out to manage the internal processes are Information Transparency (environmental reports), Environmental Protection, Energy Saving, Quality Management, Reduction of Energy used by the organization, Reduction in Quantity of Resources used, Supplier Relationship, Organizational Reputation, Client Satisfaction and Investor Relationship.

II. Supply chain integration

It is important to have supply chain integration, so as to decrease resource waste and loss of efficiency in processes, by making complete use of organizational support, social capital practices and the government participation towards the implementation of green supply chain management. Above all, reverse logistics is fundamental to promoting a collaborative and / or circular economy, where suppliers, customers and internal processes of the organizations are integrated through information technologies, using interoperability and value chain monitoring via the web. From the integrated processes, it is possible to carry out semiautomatic verifications that measure the lead time, scope, cost and quality on demand. These technologies can improve communication among those involved.

III. Holistic and interdisciplinary outlook

Sustainability must be adopted in the entirety of the company, starting with high management and working towards lower levels (top-down approach), due to the close relation of sustainability with strategic planning. Organizational sustainability is a multidimensional and interdisciplinary concept which must evaluate more than one dimension in an integrated manner, such as the Technical and Governance ones, or Environmental and Social. The performance of a dimension may impact the performance of another dimension differently, if there is a strong correlation. So, the improvement of social performance may impact environmental performance, and the same may happen between the Technical and Governance dimensions.

IV. Performance measurement system with strategic measures

It is important to conceive a sustainable system which produces periodic information on the facilities' performance; continuously measures performance to track progress in sustainability; updates and improves company performance through external benchmarking; establishes communication channels with stakeholders, in a way that the demands of society, external levers, and management practices are met in the same way and encourages participation of stakeholders in the decision making process. It is the responsibility of organizations to focus their efforts on measures as environmental protection, reduction of energy, corporate reputation, quality management, customer satisfaction and investor relations, as they are considered to be more important and have a relationship of dependency on organizational sustainability. The use of PMS (Performance Measurement Systems) encourages the congruence of objectives, communicating the organization's strategy and goals and aligning them with the employee's objectives (LANGFIELD-SMITH *et al.*, 2009). Thus, it may enable managers and leaders to control their own performance, evaluate the team's performance effectively and efficiently, and possibly serve as benchmarking for organizations and aid them in the development of future operations and strategies.

V. Identification, selection and implementation of sustainable measures

The sustainable performance measures should keep track of internal factors through transversal lines of action and key performance indicators, aligned with the strategic goals of the organization. The identification and selection of the appropriate measures must be constantly adapted and changed according to the objectives of the organization. Furthermore, it is essential that the measures reflect the concerns of all stakeholders. The implementation

must begin with simple measures in order to ensure compliance with regulations and standards (REEFKE; TROCCHI, 2013). From there, organizations can standardize their professional practices concerning verified performance and expand their influence and their stakeholder engagement practices (BROWN *et al.*, 2009).

5.1.4 Study I implications

5.1.4.1 Theoretical implications

Measuring companies' sustainable performance is an important factor for the management of private and public organizations (ATKINSON *et al.*, 1997; EPSTEIN; ROY, 2001; NEELY *et al.*, 2007; HOURNEAUX *et al.*, 2014) and the lack of sustainable measures could turn into an obstacle for the firm's management itself. This is due to the issues of performance measurement and performance indicators which are well related with organisational effectiveness (WADONGO; ABDEL-KADER, 2014). Thus, the sustainable performance management of companies depends on sustainable measures that can only be operationalized by the use of a measuring system which must be precise, accurate and reliable for performance improvement in meeting set targets (goals) (CHOONG, 2014). In the existing literature, there are few studies that evaluate the importance of sustainable measures to corporate sustainability considering simultaneously the economic, environmental, social, technical and governance dimensions of sustainability and even less in an emerging country. Given this, this research has fulfilled the gap in the literature by proposing guidelines for better measurement of sustainable performance in Brazilian organizations, given a glimpse of the current situation of corporate sustainability and indicating fertile areas for further academic inquiry.

5.1.4.2 Managerial implications

The results of this research offers some managerial implications for professionals who want to start measuring and continuously improve the sustainability performance of their organizations. This research work also helps to understand the perceptions and expectations of stakeholders. First, the findings show that internal organizational factors are the main inductors of the sustainable environment in organizations, and sustainability must be tied to strategic planning, starting from upper management to lower levels. Furthermore, it is essential to use sustainable performance measurement systems in order to respond to external and internal levers. Second, it is the responsibility of organizations to focus their efforts on environmental protection, reduction of energy, corporate reputation, quality management, customer satisfaction and investor relations, as they are considered to be more important and have a

relationship of dependence on organizational sustainability. Third, our guidelines provide both academics and practitioners a better panorama to understand the critical sustainable measures and these analyses serve as benchmarking for future corporate sustainability operations and strategies.

5.1.4.3 Political implications

Government initiatives could facilitate the adaptation of strategies as sustainable environmental management and the financing through the private sector have the capacity of promoting capital allocation to organizations which are interested in pursuing sustainable operation strategies (KHALILI; DUECKER, 2013). To achieve a better corporate sustainable performance in products and services, government policies should determine rules and restrictions to put the environmental and social responsibilities in a higher priority. Besides that, incentive policies may encourage the organizations to invest more on sustainability improvement and optimization which benefit the stakeholders. Our findings show that the environmental policy directly impacts the code of conduct and the green marketing of firms, because the stakeholders' pressure could make organizations look for actions that make it appear to be more sustainable. The environmental logistics policy (e.g. environmental transportation, packaging, warehousing, and reverse logistics) (CILIBERTI *et al.*, 2008) is strongly associated with transparency of information between actors in the chain and the delivery of outputs with higher added value and less environmental impact in their life cycle (eco-efficiency) (CAIADO *et al.*, 2017c). Governments and decision making organizations may find the guidelines proposed interesting as they have the major roles in terms of investment, training, legislation and management, planning, operationalizing and controlling the sustainable performance.

5.2 Study II

5.2.1 Survey results

Concerning the degree of importance of measuring organizational sustainability, Table 8 shows that, from weighted frequency analysis, sustainable measures which are considered more important by the interest group's perception are: Cost performance (M1), Environmental protection (M5), Supplier relations (M7), Corporate reputation (M8), Quality management (M10), Customer satisfaction (M12), Human capital development (M22), Energy conservation (M24), Reduction in amount of energy use (M27) and Reduction in amount of resource use (M30).

Table 8. Degree of the importance of sustainable performance measures

Sustainable Performance Measures	Very Low (1)	Low (2)	Medium (3)	High (4)	Very high (5)	Weighted frequency
Corporate reputation (M8)	7%	10%	10%	27%	47%	96.7%
Environmental protection (M5)	13%	7%	7%	33%	40%	80.0%
Customer satisfaction (M12)	7%	13%	17%	20%	43%	80.0%
Quality management (M10)	3%	13%	20%	27%	37%	80.0%
Reduction in amount of energy use (M27)	10%	10%	17%	20%	43%	76.7%
Cost performance (M1)	7%	10%	20%	33%	30%	70.0%
Supplier relations (M7)	10%	10%	20%	20%	40%	70.0%
Energy conservation (M24)	10%	13%	20%	13%	43%	66.7%
Reduction in amount of resource use (M30)	10%	10%	30%	13%	37%	56.7%
Human capital development (M22)	7%	10%	30%	30%	23%	53.3%
Investor Relations (M17)	20%	10%	13%	13%	43%	50.0%
Code of conduct (M19)	10%	13%	17%	37%	23%	50.0%
Corporate Governance (M20)	7%	7%	43%	20%	23%	46.7%
Waste management (M29)	17%	7%	17%	37%	23%	43.3%
Environmental and social performance (M2)	13%	7%	30%	27%	23%	40.0%
Social benefits, medical-legal (M11)	17%	3%	20%	43%	17%	40.0%
Employee satisfaction (M6)	13%	10%	20%	37%	20%	40.0%
Transparency in information (M14)	17%	10%	23%	17%	33%	40.0%
Representation and dialogue with employees (M18)	13%	10%	27%	27%	23%	36.7%
Sustainable working condition (M25)	7%	7%	40%	37%	10%	36.7%
Environmental Policy (M16)	20%	10%	13%	33%	23%	30.0%
Intra-firm collaborative capabilities (M4)	3%	23%	37%	20%	17%	23.3%
Environmental logistics policy (M9)	17%	13%	20%	30%	20%	23.3%
Support of social setting (M23)	13%	13%	27%	33%	13%	20.0%
Inter-firm collaborative capabilities (M3)	3%	27%	30%	30%	10%	16.7%
Labor practice indicators (M21)	10%	17%	27%	40%	7%	16.7%
Sources of recyclable raw material (M31)	10%	23%	20%	33%	13%	16.7%
Green Marketing (M15)	27%	7%	20%	27%	20%	6.7%
Carbon foot print reduction (M26)	27%	10%	17%	23%	23%	6.7%
Reduction of air pollution (M28)	27%	7%	20%	27%	20%	6.7%
Balancing professional and family life (M13)	13%	23%	23%	30%	10%	0.0%
Weights	-2	-1	0	1	2	

Considering the results described in Table 8, we identified the importance ranking of the measures as: M8>M5=M12=M10>M27>M1>M7>M24>M30>M22 based on their WF. Thus, these measures are considered the key sustainable performance measures.

Hence, environmental, social, economic, technical and governance measures were all

considered as the most important. In that manner, it is perceived that as corporate sustainability is a multidimensional concept all dimensions must be evaluated in an integrated way (CAIADO *et al.*, 2017c). It is up to the organization to measure its performance in relation to the most important measures considered in order to invest the right resources, avoiding waste and promoting integrated management for long-term sustainable development and to create a performance measurement system which in turn must cover these ten measures, aiming to transition to sustainable development.

The internal reliability and non-parametric tests results of normality tests are observed on Table 9.

Table 9. Results of non-parametric tests and Cronbach's alpha

Measures	Lilliefors (Kolmogorov-Smirnov) normality test		Anderson-Darling normality test		Cronbach's alpha
	statistic (D)	p-value	statistic (A)	p-value	
M1	0.2314	0.0003	1.4132	0.0009	0.9683
M2	0.1794	0.0148	1.2033	0.0032	0.9676
M3	0.1856	0.0098	1.2251	0.0028	0.9686
M4	0.2170	0.0009	1.21	0.0031	0.9681
M5	0.2901	6,39E-04	2.5863	1,07E-03	0.9677
M6	0.2441	8,26E-02	1.3973	0.0010	0.968
M7	0.2289	0.0003	1.7541	0.0001	0.9678
M8	0.2583	2,06E-02	2.5052	1,71E-03	0.9686
M9	0.2105	0.0015	1.1611	0.0041	0.9676
M10	0.2108	0.0015	1.5915	0.0003	0.9679
M11	0.2775	2,69E-03	2.0456	2,43E-02	0.9675
M12	0.2510	4,24E-02	1.9975	3,21E-02	0.9685
M13	0.1916	0.0065	1.0253	0.0091	0.9682
M14	0.1941	0.0054	1.4343	0.0008	0.9675
M15	0.1988	0.0038	1.4919	0.0006	0.9678
M16	0.2502	4,60E-02	1.6232	0.0003	0.9675
M17	0.2571	2,33E-02	2.2914	5,88E-03	0.9693
M18	0.1836	0.0113	1.1079	0.0056	0.9674
M19	0.2519	3,86E-02	1.4001	0.0010	0.9680
M20	0.2259	0.0004	1.5064	0.0005	0.9682
M21	0.2389	0.0001	1.4925	0.0006	0.9685
M22	0.1887	0.0079	1.1317	0.0049	0.9682
M23	0.2067	0.0021	1.1355	0.0047	0.9679
M24	0.2590	1,90E-02	1.9714	3,74E-02	0.9676
M25	0.2235	0.0005	1.6021	0.0003	0.9675
M26	0.1928	0.0059	1.4669	0.0007	0.9688
M27	0.2473	6,10E-02	2.0377	2,55E-02	0.9682
M28	0.1988	0.0038	1.4919	0.0006	0.9681
M29	0.2591	1,88E-02	1.6946	0.0002	0.9683
M30	0.2213	0.0006	1.5745	0.0004	0.9675

M31	0.2169	0.0009	1.1285	0.0049	0.9678

The value of Cronbach's alpha of the entire set was 0.969, which shows high reliability (HAIR Jr. *et al.*, 2009). The Cronbach α coefficients range from 0.9674 to 0.9693. The values exceed the recommended cut off value of 0.6, which means that a group of items is homogeneous or internally consistent and the reliability of each variable was confirmed (HAIR Jr. *et al.* 2009; SUREEYATANAPAS *et al.* 2015). By normality test it was noticed that there was no statistical significance between the LF and AD values of the variables of the test and the comparison of the p-value measures less than 0.01 it was possible to verify that the data is not normally distributed.

As the data did not present a normal distribution, we used Spearman's correlation between measurements (Table 10), which is the most appropriate for non-parametric data, because the coefficient measures the intensity of the relationship between variables and is suitable for both continuous and discrete variables including ordinal variables (RASHIDI; FARZIPOOR SAEN 2015).

Table 10. Spearman correlation between the key sustainable performance measures

	M1	***M5***	***M7***	***M8***	***M10***	***M12***	***M22***	***M24***	***M27***	***M30***
Cost performance (M1)	1									
Environmental protection (M5)	0.3185	1								
Supplier relations (M7)	0.4304	0.4631	1							
Corporate reputation (M8)	0.5347*	0.4585	0.4194	1						
Quality management (M10)	0.5017	0.3456	0.6441*	0.5561*	1					
Customer satisfaction (M12)	0.5183*	0.3416	0.5692*	0.5733*	0.7382*	1				
Human capital development (M22)	0.2068	0.4034	0.6389*	0.2744	0.5311*	0.2672	1			
Energy conservation (M24)	0.4281	0.4324	0.4612	0.2433	0.5031*	0.4443	0.6352*	1		
Reduction in amount of energy use (M27)	0.3563	0.3862	0.4113	0.1788	0.4478	0.4927*	0.5056*	0.9205*	1	
Reduction in amount of resource used (M30)	0.5114*	0.4853*	0.5472	0.1961	0.3920	0.4543	0.5675*	0.7576*	0.7842*	1

*$p < 0.01$

Based on the correlation between the key measures (Table 4), it can be seen that there is moderate and positive correlation between the following measures: M1 and M8 (ρ = 0.5347); M1 and M10 (ρ = 0.5017); M1 and M12 (ρ = 0.5183); M7 and M10 (ρ = 0.6441); M7 and M12 (0.5692); M7 and M22 (ρ = 0.6389); M10 and M22 (ρ = 0.5311); M10 and M24 (ρ = 0.5031); M22 and M24 (ρ = 0.6352); M22 and M27 (ρ = 0.5056); M22 and M30 (ρ = 0.5675). These results imply that the hypothesis H_1 was corroborated, since energy conservation (M24) - an

environmental measure - and human capital development (M22) - a social measure – are both positively associated with quality management (M10).

One possible case for this would be in organizations that invest in quality management, through continuous improvement methodologies such as the Plan-Do-Check-Act (PDCA) used in LM, or the DMAIC cycle along with Six Sigma statistical tools, which usually improve efficiency in the use of natural resources, and reduce energy expenditure and environmental impacts throughout their processes. In addition to this, it is common that organizations that implement operational improvement programs such as the LSS methodology, seeking to increase quality management, also have an increased participation of all human capital in a never-ending process, since the lean philosophy seeks to engage all employees at a transformational change.

Besides that, these results indicated that the hypothesis H_2 was confirmed, since there is positive correlation between supplier relations (M7) and customer satisfaction (M12). A possible reason for that is: the agility of the supply chain depends on customer satisfaction, as well as improvement of quality management. Thus, companies have been forced to rethink how they manage their supply chain operations and the "lean supply chain" - strategy based on cost reduction and flexibility, focused on processes improvements - (CARVALHO; DUARTE; CRUZ MACHADO, 2011) linked to agility becomes paramount to fulfil customers' needs.

Also, there is a strong association between the variables: M10 and M12 ($\rho = 0.7382$); M24 and M27 ($\rho = 0.9005$); M24 and M30 ($\rho = 0.7576$); M27 and M30 ($\rho = 0.7842$). It indicates a conclusion that seems obvious: the consumption of resources and energy is directly bonded with the conservation of energy. Thus, the implementation of methodologies like GLSS could be a good solution to contain the waste of resources and reduce energy expenditure through more efficient processes.

Finally, there is a weak correlation between M12 and M22 ($\rho = 0.2672$); M8 and M27 ($\rho = 0.1788$); M8 and M30 ($\rho = 0.1961$); M1 and M22 ($\rho = 0.2068$). These results portray two conclusions. First, that human capital development (such as training, development and empowerment) has little influence on cost performance and customer satisfaction. One possible reason for this would be the low concern with staff and the social issue for greater technical and financial performance.

In addition, it is noted that there is a weak relationship between corporate reputation and the reduction of the amount of energy and resources. This leads to the conclusion that, in the evaluated organizations, environmental issues have little influence on reputation, which seems to be more impacted by customer satisfaction and quality management.

5.2.2 Interview results

Based on the interviews, the academics were asked to indicate some relations between the sustainable performance measures and the operational improvement programmes. Table 11 summarizes the intensity of impact of these programmes to handle the key measures that are acting as driver forces for adoption of sustainable development.

Table 11. Relations between operational improvement programmes and key sustainable performance measures

Dimension	Key sustainable performance measures	Operational improvement programmes				
		Lean	Six Sigma	LSS	Green Lean	GLSS
Economic	Cost performance	+	+	++	+	++
Environmental	Environmental protection	+	0	+	++	++
	Energy conservation	+	0	+	++	++
	Reduction in amount of energy use	+	0	+	++	++
	Reduction in amount of resource use	+	0	+	++	++
Governance	Corporate reputation	0	+	+	0	+
Social	Supplier relations	+	0	0	++	++
	Human capital development	+	0	+	+	+
Technical	Quality management	+	+	++	++	++
	Customer satisfaction	+	+	++	++	++

As Table 11, those programmes can have a more important, a strong positive impact on bottom line performance when implemented together because the combination of Lean / Six Sigma and Green could generate better results rather than separately (MILLER *et al.*, 2010).

According to content analysis, among all the key sustainable performance measures, quality management, cost performance, and corporate reputation were considered the most important measures to operational improvement. In addition, environmental protection, supplier relations, and cost performance were considered the most important measures for TBL sustainability view. Besides that, from the operational improvement programmes perspective, quality management was considered the most important for Six Sigma, cost performance was considered the most important for LM, environmental protection was considered the most important for Green, Supplier relations was considered the most important for Lean Green, and corporate reputation was considered the most important for GLSS.

Hence, quality management (technical issue), corporate reputation (governance issue), environmental protection (environmental issue), supplier relations (social issue) and cost performance (economic issue) are the most important factors. Thus, these key sustainable measures are highlighted in grey color in Table 11, as they are considered essential for improvement of operational and sustainability performance.

As noticed in this analysis, the Lean/Six Sigma programmes usually has no influence over some measures associated to governance and social dimensions. However, as Singh *et al.*, (2007), the TBL needs to add those dimensions in order to improve the sustainable management in a complete way. Because of that, there is a need to integrate operational and financial methods with green practices, corporate social responsibility and governance to achieve sustainable development in a global perspective.

5.2.3 Guidelines to achieve sustainability through alignment of key sustainable measures and operational improvement programmes

This subsection provides a discussion of the proposed guidelines from Study II.

I. Enviromental Protection

Lean can contribute to decrease in pollution and thereby combat global warming through the development of an efficiency metric that can help to decrease the environmental impacts (CHUGANI *et al.*, 2017). To achieve the environmental protection some important actions are necessary:

- to engage employees, empowering and motivating them in order to increase their participation and to propose collaborative initiatives through cultural changes to build stronger and more sustainable-oriented organizations. The internal organizational factors are the main promoters of the sustainable environment in organizations, and therefore, kaizen events, workshops, talks and organizational learning practices in sustainability are of interest in order to perpetuate this cultural change, a challenging obstacle which is being gradually overcome, as the research indicates;
- to improve the use of natural resources through a higher productivity and the support from top management, as sustainability must be operationalized in a top-down way, starting with high management and working towards lower levels, due to the close relation of sustainability with strategic planning;
- to use LM methods as total productive maintenance (TPM) to improve reliability and decrease environmental impacts and cellular manufacturing in order to facilitate the focus on sustainability at the operational level;
- to adapt value stream mapping (VSM) to asses energy and resource consumption;
- to use Lean methods associated with Green approaches as cleaner production, eco-efficiency and life cycle analysis (LCA). In fact, Lean and Green actions could be and could provide a method for companies to develop a tool to measure both productivity and environmental performance based on qualitative and quantitative analysis

(VERRIER *et al.*, 2014);

- to adopt Green and Lean methods as 5S (housekeeping) process that allows a visual management for reducing inefficiency, the lot size and the stock reduction and 3R (reduction, reuse and recycle) for reduction of redundant and unnecessary materials and reuse of materials throughout the value stream;
- to create new and smarter technologies, which can contribute to the alignment of Lean/Six Sigma and sustainable operations and may suggest better choices in the use of energy and materials;

II. Cost Performance

Achieving the improvement of cost performance requires a holistic and targeted strategy for change by means of the following actions:

- to promote cost reduction through improvement/kaizen circles and effective counter measures to the root causes of previously identified problems;
- to achieve a significant reduction in amount of resources and energy use through the integration of Green, Lean and Six Sigma methodologies seeking efficiency and effectiveness.
- to support the human resources and practices with sustainable issues and to promote a clear policy and training for all employees in order to bring an integrated consensus about the definitions of Lean and sustainability, enhancing their skills and providing know-how;

III. Supplier relations

The improvement of relations with suppliers requires a clear communication which is associated to the following actions:

- to integrate the supply chain in order to decrease resource waste and loss of efficiency in processes, by making complete use of organizational support, social capital practices and the government participation towards the implementation of green supply chain management;
- to develop performance measurement systems (PMSs) that integrate TBL metrics with other governance and technical metrics within the entire company and across the supply chain;
- to deploy a proactive Green Supply Chain Management (GSCM) through green purchase, green design, product recovery and client and supplier collaboration (LIN 2013);

- to select suppliers based on sustainability criteria and to establish vendor development/collaboration.

IV. Corporate reputation

Achieving the corporate reputation requires the improvement of public image and corporate governance, seeking the following actions:

- a voluntary promotion of information on sustainable performance by using Six Sigma metrics and tools to show transparency to stakeholders and to better control emissions of pollutants and profit margins. It is important to conceive a sustainable system which produces periodic information on the facilities' performance; continuously measures performance to track progress in sustainability; updates and improves company performance through external benchmarking; establishes communication channels with stakeholders, in a way that the demands of society, external levers, and management practices are met in the same way and encourages participation of stakeholders in the decision making process;
- a strong committed leadership and dedication of the employees, resources of the entire firm and senior management support;
- to create a Green innovative product design and sustainable services through a transformational change involving jointly concepts of lean manufacturing, Six Sigma and sustainability;
- to promote environmental care with the adoption of standards or guides as ISO 14000 in order to pursue ethical relations and to comply with regulations. From there, organizations can standardize their professional practices concerning verified performance.

V. Quality Management

Improving quality management and practices is associated to improve environmental performance and requires the following actions:

- to apply Lean concepts as zero defect manufacturing led to durable products, quick changes and delivery, Just-in-Time to produce exactly what the customer wants, Kanban for creating a pulled flow and continuous improvement of products and services to optimize time, people, space and machines;
- to stablish a structured solving methodology as DMAIC with the performance measures to asses customer returns through Six Sigma tools to increase loyalty;

- to integrate Lean and Six Sigma methodologies to assist in identifying and eliminate waste, with no delay, at fair price and minimum waste;

5.2.4 Study II implications

5.2.4.1 Theoretical implications

Study II has fulfilled the gap in the literature by proposing guidelines for better measurement of sustainable performance through the effective alignment of triple bottom line objectives and operational improvement programmes in Brazilian organizations, given a glimpse of the current situation of corporate sustainability and indicating fertile areas for further academic inquiry.

The study results reveal that very little attention is paid to governance and societal concerns in the operational improvement programmes context, and emphasizes some key areas where the academic studies still need to upgrade and to delve more deeply. This study act as pioneering work in terms of an exploratory in-depth investigation in order to align Lean, Six Sigma and Green methodologies within corporate sustainable performance measures with a specific geographical perspective.

5.2.4.2 Practical implications

The results of Study II offers some managerial implications for professionals who want to integrate operational improvement programmes such as Lean/Six Sigma into sustainable performance measures. First, the findings show that it is essential to use sustainable performance measurement systems in order to respond to external and internal levers. Second, it is the responsibility of organizations to focus their efforts on environmental protection, corporate reputation, quality management, supplier relations and cost performance, as they were evaluated as essential performance measures for operational and sustainability improvement, considering a holistic view of the operational improvement programs and the triple bottom line in an integrated way. Third, our guidelines assists industrial managers to focus on the essential operational improvement programmes that will further improve their chances of successful implementation of sustainable manufacturing. Recent business environments force managers to concentrate on many factors, and they are urged to make fine decisions every time. Hence, it is difficult for industrial managers to select and work around the most important performance measures. With this concern, this study supports their decision in terms of the key sustainable performance measures with proper programmes.

The use of PMS may enable managers and leaders to control their own performance, evaluate the team’s performance effectively and efficiently, and possibly serve as

benchmarking for organizations and aid them in the development of future operations and strategies.

5.2.4.3 Political implications

Besides that, to achieve a better corporate sustainable performance in products and services, transformational challenges such as cultural barriers, complex organizational designs and organizational structures, complex processes, and technology systems should be overcame and government policies should determine rules and restrictions to put the environmental and social responsibilities in a higher priority. Furthermore, incentive policies may encourage the organizations to invest more on sustainability improvement and optimization which benefit the stakeholders. At this point, this study assists governments and decision making organizations to revisit the policies with a focus towards sustainability. As they have the major roles in terms of investment, training, legislation and management, planning, operationalizing and controlling the sustainable performance, it is time for those policy makers to accept the importance of implementing sustainable manufacturing practices aligned with operational improvement programmes.

5.3 Study III

5.3.1 Content analysis results

Table 12 indicates some of the main compatibilities and divergences between green and Lean / Lean Six Sigma approaches in the service industry, including general points for all sectors.

Table 12. Compatibilities and divergences between Green and Lean / LSS

Compatibilities	Source(s)	Themes
Green practices as "using green purchasing guidelines and sourcing from environmentally responsible sources" contributes to the improvement of businesses' social performance. Lean practices as "deliveries directly to the point of use" and "geographical concentration" could influence positively the local community, through job creation, infrastructure development, and collaboration with universities and knowledge centers. Synergies can be used to facilitate supplier monitoring by providing an early warning system and timely recognition and prevention of environmental and social irregularities in the upstream supply chain	Azevedo *et al.* (2012)	Lean and green
Lean serves as a catalyst for the implementation of Green, which in turn generates benefits for existing business practices, and both have waste reduction techniques, while green waste can be incorporated into Lean wastes and simultaneously reduced, they seek to reduce cycle time, relate to the supply chain, have key performance indicators as the service level, and share tools and practices	Dües *et al.* (2013)	Lean and Green

Lean and Green can be also integrated into other models like ISO 9001 and 14001	Kurdve, (2014)	Lean and green
Lean tools and practices may facilitate the focus on sustainability at the operational level	Verrier *et al.* (2014)	Lean and green
Lean facilitates sustainability, and people integration is the key to Lean success, which drives the organization towards sustainable operations management. Sustainable processes reduce ecological impacts and may eliminate wasteful depletion of scarce resources. The synergies from the horizontal and vertical directions of human integration can lead to value creation in the organization	Wong, Wong (2014)	Lean and green
Lean and Green maintain synergies related to waste reduction, lead time reduction, product design and the use of various approaches and techniques to manage people, organisations and the supply chain	Garza-Reyes (2015a)	Lean and green
Lean and Green thinking focuses on improving business results in terms of cost, market position, product reputation and design, and improving customer value by collaborating with suppliers and customers, analyzing existing operations, and identifying opportunities to reduce the waste operating more efficiently	Wiese *et al.* (2015)	Lean and green
The use of the DMAIC (define-measure-analyse-improve-control) model can provide Green Lean with a more specific and holistic project-based orientation to the implementation of Green Lean initiatives.	Cherrafi *et al.* (2016)	LSS and green
The combination of the seven deadly wastes of Lean Management and the 3R (Reduction / Reuse / Recovery) hierarchy in a Lean / Green matrix improves the performance of a manufacturing minimization program	Fercoq *et al.* (2016)	Lean and green
Many Lean practices increase the level of "transparency" of the workplace, such as clear visibility of hazards and a cleaner working environment so that workers have the opportunity to identify, evaluate and suggest controls (such as visual and other signs visualization artifacts) that make human / technological interaction more effective and help reduce health and safety hazards in the workplace, helping to address the human side of organizational sustainability.	Camuffo, Stefano (2017)	Lean and green
Just like Lean, Green advocates the elimination of seven wastes: unnecessary usage of water, unnecessary power usage, exploitation of resources, pollution, litter, greenhouse effects and eutrophication	Chugani *et al.* (2017)	Lean and green

Divergences	Source(s)	Themes
These paradigms diverge as to focus, what is considered as waste, customer, product design and manufacturing strategy, end of life product management, KPIs, the dominant cost, the main tool used and certain points As the frequency of replacement. It is hoped that trade-offs will be made between multiple objectives. While Lean practices focus on maximizing performance and reducing costs, green practices apply life cycle assessment (LCA) to design products for environmental optimization at each stage of the lifecycle	Dües *et al.* (2013)	Lean and green
Green is focused on environmental performance, Lean is focused on waste and its elimination and Six Sigma focuses on the continuous improvement of quality of products and services in an organisation by minimising the defects	Kumar *et al.* (2016)	LSS and green
Sustainability is concerned with the capability of meeting those needs in the present and future (efficacy, effectiveness and ethics), whereas Lean is more oriented to delivering	Martínez León, Calvo-	Lean and green

products or services with the minimum use of resources (efficiency and effectiveness)	Amodio, (2017)	
While Lean is more concerned with respecting people, including customers and employees, sustainability appears to expand the concern by seeking the well-being of all stakeholders in the long term	Martínez León, Calvo-Amodio (2017)	Lean and green

As Azevedo *et al.*, (2012), the Green paradigm aims to minimize environmental impact, while the Lean paradigm seeks to minimize waste, but there is a set of green practices, as "using green purchasing guidelines and sourcing from environmentally responsible sources", and Lean practices, as "just-in-sequence" and "deliveries directly to the point of use", that could positively influence economic, social and environmental measures. From this, it is also vital to investigate approaches for delivering products and services without endangering the environment, society and the return on investment, concept called triple bottom line (TBL) sustainable performance (GARZA-REYES, 2015b).

Lean, environmental, and social management systems should be combined to assess sustainability in a broader sense, focusing on environmental issues or issues related to corporate social responsibility. This will contribute to overall performance, brings financial gains, regulatory compliance and penalty prevention, talent and greater employee retention and better market position and greater reputation (HADDACH *et al.*, 2016).

According to Dües *et al.*, (2013), the synergy between the Lean and Green paradigms could be described by the equation 1 + 1 = 3, since one practice improves the other, generating a result greater than the sum of the separated performances. Moreover, if the strategy and goal of a basic organizational business model is to reduce waste and maximize profit, integrated Lean and Green principles will be more effective than other methods to deliver a specific result (WIESE *et al.*, 2015).

Besides that, Table 13 shows some challenges and enablers of the alignment between Green and Lean/LSS operational programs.

Table 13. Challenges and enablers to Green-Lean or Green LSS in organizations

Challenges	Enablers	Source(s)
To know how to deploy Lean and Green as a systematic way, implementing the Green-Lean culture through all areas of an organization and its supply chain, considering the minimization of trade-offs between the two approaches and recognizing the "ideal formula" for each business	To create an appropriate culture, have a leadership commitment, have a Lean and Green adequate structure, engage all employees, set the right strategy for transformation, and make a long-term alliance with partners	Duarte, Cruz-Machado (2009)

To improve social and environmental aspects but also to achieve operational improvements in logistics processes	Some internal adaptations and changes must be made previously, requiring strategic orientation, organizational structure and the ability to explore market information and innovate; have stronger links with key suppliers and train a team through classrooms and Lean events	Azevedo *et al.* (2012)
Make managers and executives rethink the organization's approach to environmental practices and clarify the confusion about what is really green, given that there are few models, regulations, and best practices to support their implementation	It is necessary to establish regulations and standards to translate green costs into financial terms in order to compare Green and Lean measures across the supply chain of different industries, such as services.	Dües *et al.* (2013)
Simultaneously develop Lean and Green methodologies, seeking environmental benefits and productivity together and in an active rather than "incidental" manner and incorporate economic considerations into green tools	Existence of a sustainability champion who understands all triple bottom line dimensions and objectives of sustainability with integrated use of Lean tools and green methodologies and communicates environmental and business issues to all stakeholders, expanding improvements along the supply chain	Dhingra *et al.* (2014)
Change management that includes employees, suppliers, customers and human virtues (attitude and behavior), such as leadership, teamwork, cooperation, habits, etc.	Focus on knowledge management, seeking to extract, compile, preserve and share the knowledge gained through experience	Jadhav *et al.* (2014)
Implement Lean and Green business strategies to recognize savings and develop best practice solutions that enhance and sustain business competitiveness within an industry	Commitment to Lean and Green business principles and determination of a clear link between the company's environmental approach, the basic principles and established culture of best practice	Wiese *et al.* (2015)
Ensure involvement of managers and leaders, select the right people based on leadership skills and psychological factors, identify the concerns and sustainability priorities of stakeholders, select the right and appropriate tools	The effective implementation of Green LSS (GLSS) depends on greater attention in key points: (i) leadership and people, (ii) Green and Lean Six Sigma tools, (iii) continuous process improvement, (iv) strategic planning, Vi) results and knowledge management.	Cherrafi *et al.* (2016)
Developing people, pushing them to work better in a constructive way, developing their problem-solving and project management skill sets and empowering them to become better and more efficient problem solvers, to consider the ethical issue by uniting efforts Green Lean and concern about responsible selection of resources (focus	An appropriate mix of Lean-for-sustainability practices should be focused at the design stage where structural changes can be applied. A systemic approach is needed to promote the appropriate degree of flexibility, human asset should be the focal point of improvement changes	León, Calvo-Amodio (2017)

on renewables) and not only on their efficient use.		
Relationship with external stakeholders, improving the communication channel to understand their needs	To take a holistic and systemic approach to corporate sustainability and make it part of companies' cultures and activities.	Lozano *et al.* (2017)

Therefore, Lean is an integrated socio-technical system (TORTORELLA *et al.*, 2017) and must be complemented by green practices in order to achieve sustainable development. For this, as seen in Table 2, from the internal point of view it is essential that there be strategic orientation to the Green-Lean practices, with support and leadership of the top management, linking this to strategic planning. In addition, it is important to have a culture engaged with empowered and committed people and the management of knowledge generated from experiences. From the external point of view, it is necessary to have regulations and standards for the sector, supply chain integration with the correct and ethical use of appropriate tools and practices, strengthening alliances with partners and involving all internal and external stakeholders.

5.3.2 Integrated Framework to implement GLSS in Services

This subsection provides a discussion of the implications of LT / LSS to reach SD in different sectors and proposes an integrated Framework to implement Green Lean Six Sigma in Services.

Table 14 portrays some implications about how different services could achieve green through Lean and Lean Six Sigma.

Table 14. Implications of Lean and LSS for achieving sustainability

Sectors	Implication	Source(s)
Education	The university can become Lean using the "value stream mapping" (VSM) technique and using benchmarking to encourage improvement in product volume and quality, reducing a university's operating costs and increasing profits to maintain and / or strengthen their position in an increasingly competitive environment. The use of benchmarking can provide a university with a better understanding of the needs of its clients (students). Thus Lean sustainable initiatives in terms of reallocation and / or restructuring can benefit a university by generating more future value	Comm, Mathaisel (2003)
	The focus on higher education lies in the implementation of cost reduction or budget containment initiatives, Lean practices that generally reduce waste, improve operational efficiency and contribute to sustainability. Due to government constraints, public schools are driven to the operational dynamics of Lean initiatives more quickly while private schools resist Lean for fear of being seen with lesser quality. The most popular Lean practices are outsourcing non-core services, collaboration with other schools or organizations, and leveraging technology.	Comm, Mathaisel (2005)

	The education system must adjust to meet customer expectations at a high-quality, just-in-time level, as well as the modern green Product Lifecycle Management, and the manufacturing / automation industry does. Quality educational methods that stimulate students, case-based learning objects (using interactive 3D eBooks, supported by DVD and HD videos) to encourage team-oriented analysis and teaching-learning and problem solving with real-world challenges	Ranky, Kalaba (2012)
	Courses should combine Lean and Green thinking to teach these concepts and approaches, and also integrate studies such as green productivity, eco-efficiency, eco-effectivity, and sustainable business practices. University schools of business and engineering could be ideal candidates for incorporating these curricular changes	Dhingra *et al.* (2014)
	Creating an environmentally sustainable building - applying Lean basics principles for delivering sustainable services, support processes and workflows - which will be a hub for collections that move between campus libraries and across libraries across the country province with which the university has fundamental partnerships. The efficiency of the library is sought by efficiently delivering a relatively small number of highly specific and individualized services to a large, diverse and widely distributed customer base. According to the Lean principle of pulling from the customer, providing specialized services for a fee ensures that the university library is only delivering what users are willing to pay. While many of the leading library services respond to the historical expectations of the service and the expressed needs of users, others are designed to anticipate needs and grow over time, such as search metrics	Beasley, Rosseel (2016)
General	It is important that employees have a deep understanding of the concepts underpinning green and Lean practice and the employee development processes must be linked to the overall green and Lean transformation process, because human capital is at the very core of green and Lean practice.	Zhan *et al.* (2015)
Air	It is important to reduce fuel consumption by eliminating network redundancy and by reorganizing hub networks, and balancing this against possible service level degradation.	Ryerson,Kim (2014)
Offices	The research highlights the relevance of Lean, particularly the application of *muda* - waste in Japanese - (such as on perceived job productivity) as enhancement of users' requirement assessment for the sustainable improvement diagnosis technique of existing office buildings in Nigeria. Besides tangible waste as garbage, refuse, scraps, this study also shows that intangible waste has also been identified, promoted by models such as Lean Thinking and Zero Emissions and considers waste in a different perspective in environmental management,	Adeyemi *et al.* (2017)
Sales	Green may be a useful support to Six Sigma as a programme that helps to save resources.	Wei *et al.* (2010)
Food processing	It is perceived that the Value Stream Mapping analysis, a basic Lean Thinking tool, can be used effectively and efficiently for a series of improvements not only to identify wastes, but synergistically with green initiatives for the determination of Greening the supply chain of agrifood products, a large and complex chain. It is necessary to balance points of conflict and understand the various trade-offs between Lean and Green to deal with the complex network of entities and interactions of the agrifood chain.	Folinas *et al.* (2013)

	This work explores the application of the VSM tool, considered viable to determine the waste in a specific agrifood supply chain of the maize product for animal feed. VSM has been suggested to determine waste in terms of water, energy and delivery time of the production process. The introduction of global supply chain management in the Green and Lean equation increases the potential conflict between these initiatives, so it is necessary to balance possible points of conflict, especially when there is a decline in the agrifood sector.	Folinas *et al.* (2014)
	The important tools of implementing Lean supply chain include the collaboration of the demand, continuous improvement, inventory management practices, value-added activities, reducing waste, company and industry standard, human resources, data pattern, planning and Standardization of the production process, sales and operations planning and demand signal.	Manzouri *et al.* (2014)
	Lean Six Sigma might be successfully applied in the food processing industry through VSM-DMAIC, in which the value stream mapping – is used to identify the type of waste and the DMAIC improvement cycle was applied in order to understand and address the wastes by applying relevant Lean and Six Sigma tools. Also, LSS can be effectively applied in the food processing industry as a contributor toward the environmentally sustainable fresh food supply chain.	Powell *et al.* (2017)
Information and Communication Technologies (ICTs)	In this age of science and information, it is important to build bridges between disciplines, between academics and industry. More specifically, the field of Life Cycle Assessment (LCA) can adopt and apply a substantial amount of tools and lines of thought from operational management such as the Lean heritage and six sigma and vice versa.	De Soete, (2016)
Banking	The LSS project management approach was adopted in banking and financial services, organizations that are at high risk at all levels of decisions taken to implement change. Stakeholder management becomes the key element, employee collaboration and engagement being an important feature for the success of the LSS in a bank or financial institution.	Vijaya Sunder (2016)
Petroleum	LSS concepts, specifically Value Stream Mapping (VSM) and Value Stream Analysis (VSA) were performed to investigate underperforming activities in the support service for the maintenance of sustainable petroleum operations, allowing to reduce the barriers to maintaining sustainable petroleum operations, minimizing waste in the engineering contractors and asset owners' organizations and indicating possible improvements in overall TBL sustainable performance.	Ratnayake, Chaudry (2017)
Logistics	Lean practices implemented to improve inventory management at the retail level can contribute to a reduced amount of greenhouse gas emissions. With this, capacity development and supply chain flexibility can be achieved through strategic investments at the retail level, such as the adoption of product postponement practices and Vendor Managed Inventory. Thus, under certain operating conditions, just-in-time systems can be lean, reducing the overall carbon intensity of the supply chain.	Ugarte *et al.* (2016)

Heathcare	While lean approach is used to reduce the use of water, materials and pharmaceuticals in medication processes, without, however, undermining patient safety, Six Sigma approach is used to monitor actions before and after interventions and improve medication processes from the point of view of environmental sustainability. Thus, they must complement each other and the LSS is method by which hospitals can control costs, reduce the likelihood of errors and improve patient safety and health care quality, promoting sustainability practices yields not only environmental benefits, but also economic ones for the institution.	Furukawa *et al.* (2016)

As stated by Suárez-Barraza *et al.*, (2012) more than reach cost reduction and failures correction, we expect that Green LSS service focus on a cultural change, bringing a new sense of discovery, experience or re-discovery internally and externally, maximising a collaborative value creation, developing new behaviours and skills for employees and delivering environmental-friendly services to the clients.

As seen in education services, there must be advanced planning and management commitment with cultural change in college or university to show the benefits that re-allocation and restructuring can generate. In addition, we must seek the understanding and integration between the administrative and academic side to implement a sustainable lean structure, because in the future this issue will be even more important for higher education (COMM; MATHAISEL, 2003).

However, for Lean sustainability to succeed in higher education, there must be a top-down approach, starting from the top and then spreading to the rest of the school. These practices are a good fit for higher education as they help universities identify which areas help education thrive and survive, and whether or not to invest in those areas, thereby improving services at a reduced cost (COMM; MATHAISEL, 2005).

The Lean and Green transformation is a long-term journey, a new form of strategy and a new form of management that must be built around values of sustainability and excellence in order to model a Green-Lean business culture with specific tools and principles, according to the business models (DUARTE; CRUZ-MACHADO, 2009). It is also necessary for managers to have a complete and strategic perspective of the organization to customize the LSS implementation and to extrapolate solutions and positive experiences to their processes, considering the particularities of their organizational context (GUTIERREZ-GUTIERREZ *et al.*, 2016).

Based on the above implications, it was shown that there is a need for more holistic approaches aligning Lean, Six Sigma key concepts and tools with green practices. From the

literature review, it was discovered that by integrating Green and Lean/LSS in service processes it will facilitate the organization in managing and assuring customer needs, dealing with qualities and strategies, and considering the welfare of all stakeholders, thus improving the TBL performance in an integrated way. In addition, based on the derived insights, a conceptual framework to implement Green Lean Six Sigma in services was proposed (Figure 4). Therefore, it attempts to help practitioners to identify opportunities in Lean and Six Sigma not only towards operational excellence but also to fulfil their responsibility towards the environment in a collective effort.

Based on the above discussion, the conceptual framework points out nine critical factors to implement GLSS in services: continuous customer satisfaction, long-term comunication with entire supply chain, ethic relations and regulatory compliance, team training and empowerment, leadership commitment, integrated TBL-KPIs, strategy and culture for tranformation, focus on knowledge management and human behavior, and effective Jidoka automation.

Moreover, the both cultural change and implementation of LSS tools and principles can ensure sustainability and critical aspects as respect for people and employee engagement depends on responsibility along with ownership, human-centric approach, deeper problem-solving capabilities and cross-functional relationship, which are fundamental for continuous improvement (GUPTA *et al.*, 2016). It is also observed that workers' empowerment and capability development are behaviors that positively impact workers' safety, which corroborate studies on what type of Lean leadership is needed to foster the human side of organizational sustainability and to support socially sustainable operations. (CAMUFFO; STEFANO, 2017)

In addition, some key tools for improving services through the use of Green and Lean practices are: VSM, waste elimination, standardization, visual management / visual control, Human Resources management and Kaizen. An essential requirement for using these tools is employee collaboration and engagement, as human capital is at the heart of Green-Lean integration. On the other hand, it is still necessary to understand the various trade-offs between Lean and Green.

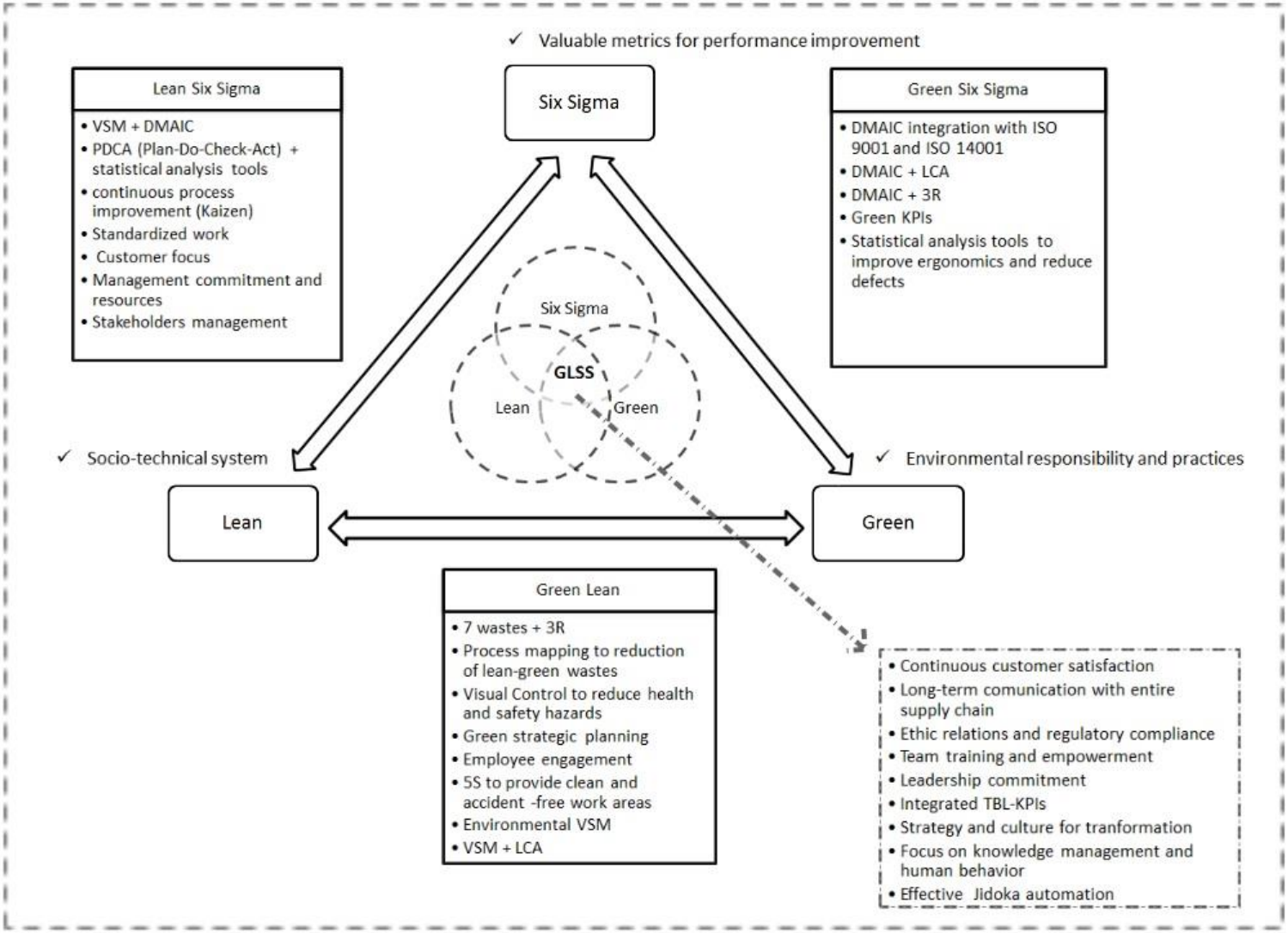

Figure 4. Integrated Framework to implement Green Lean Six Sigma in Services

Regarding the integration of Lean and Six Sigma into services, it is observed that while Lean adds value to services, eliminating redundancies and reorganizing networks in the case of information and communication technology services; Six Sigma is used to monitor actions before and after interventions and to improve processes from the point of view of environmental sustainability; and LSS helps control costs, reduce the likelihood of errors, and improve consumer safety in the health area. One of Lean Six Sigma's main tools is VSM-DMAIC, in which value stream mapping is used to identify the type of waste and the DMAIC improvement cycle has been applied to understand and resolve waste.

5.3.3 Study III implications

Hence, Study III aims to contribute to the scientific community on the theme studied, since it present a representative selection of international research in interdisciplinary area as it is a relevant issue in which there is a dialogue of sustainability science, business management and industrial engineering, enabling the researchers to contribute with relevant research. It is expected that the proposed framework benefit both researchers and industrialists in gaining valuable information on the influence of Lean and Six Sigma practices in increasing corporate TBL-sustainability, and thereby provide new paradigms and pathways to achieve a balance in technical, economic, social and environmental priorities in sustainable business practices.

The research reviewed the evolution of published research on Lean Thinking and Lean Six Sigma focused on sustainability in Services, to comprehend what Lean/LSS is in sustainable services, to classify the studies and suggest points of attention for scholars and practitioners to carry out future research. The majority of the research on the application of Lean and Green practices has talked about them as a complementary and integrated approach. Studies of the application of a Green LSS methodology to a service enterprise are missing.

6 CONCLUSIONS, INTERDISCIPLINARY EVIDENCES AND FUTURE PERSPECTIVES

6.1 Concluding remarks between the studies

Study I and II has responded to the growing need for sustainability performance measures, which are grouped into five dimensions (economic, environmental, social, technical and governance) of sustainability in order to ensure greater comprehensiveness and robustness in supporting the decision-making process.

Study I also aims to bridge the knowledge gap on sustainable performance measures by comparing the state of the art with the results of an applied study. The main findings of this work have implications from both theoretical and the managerial point of view, making a contribution to the academic literature on sustainability performance measures and point to core sustainable measures and guidelines that may lead to performance improvements in practice.

Furthermore, Study II aims to provide both academics and practitioners a better panorama to understand the alignment of the key sustainable performance measures and operational improvement programmes and these analyses can serve as benchmarking for future organizational sustainability operations and strategies. The main contribution of this work is the proposal of guidelines which highlights the integration and alignment of operational improvement programmes into sustainable measures to aid organisations to balance the need for operational excellence in their production and service systems with environmental commitment and social fairness.

Finnaly, Study III has responded to the growing need of studies about Lean and sustainability in service industry (CHERRAFI *et al.*, 2016) and the lack of systematic reviews about LSS (ALBLIWI *et al.*, 2015). It also aims to bridge the knowledge gap on the integration of Lean Six Sigma and Green practices.

In addition to, Study III has two major contributions. Firstly, to expand the existing body of knowledge on how Lean Thinking and Lean Six Sigma can foster sustainability outcomes, focusing on the service industry. Thus, it delves deeper into the compatibilities, divergences between Lean/LSS and Green, the challenges and enablers to integrate these approaches, which seems to be neglected by the current literature and explores the related implications for the configuration of these interrelationships. Secondly, to provide a holistic framework integrating Lean, Six Sigma and Green approaches that can be investigated in many different sectors, attempting to find ways of institutionalising Green LSS philosophy in any service. Furthermore, it is expected that this framework serves as a guide for managers, leaders and decision makers

pointing out a path to the alignment of these approaches. The main findings of Study III have implications from both theoretical and the managerial point of view, providing a better panorama to understand the present status of Lean/LSS methods towards greener services.

This thesis by aggregation of articles can provide academics and practitioners with a better panoramic picture to understand the alignment of key sustainable performance measures and operational improvement programs. Thus, the results may offer managerial implications for professionals wishing to integrate operational improvement programs, such as lean / Six Sigma, into sustainable performance measures, and analyzes from sustainable performance assessment can serve as benchmarking for future operations and organizational sustainability.

As exploratory research was fetched the novelty, by the intersection of Lean, Six Sigma, sustainability and performance measurement subjects. In this sense, this thesis brings multiple new contributions, providing academics and practitioners with a better picture for achieving sustainable development through alignment of lean, Six Sigma or lean Six Sigma methodologies with sustainability.

Governments and public organizations may find the proposed GLSS framework interesting as they have the leading role in terms of investment, training, legislation and management, planning, operation and control of sustainable performance. Thus, government initiatives could facilitate the implementation of the green lean Six Sigma approach and encourage the adoption of these sustainable operating strategies in the public and private sectors.

6.2 Adherence to PPSIG and interdisciplinarity

This thesis is adhered to the line of research of the Postgraduate Program in Sustainable Management Systems of the Federal University of Fluminense (PPSIG / UFF), entitled "management of sustainable organizations". It is intended to contribute to the understanding of the points considered fundamental by the Program. The adherence to the PPSIG comes from his contribution with the scientific community on the subject studied, since it presents the representative selection of international research in an interdisciplinary area. In summary, the main distinguishing features of this doctoral thesis are the following: 1) to point out the main measures / indicators to achieve the improvement in the operational and sustainable performance of Brazilian organizations; 2) to measure the contribution of quality improvement programs (LT / Six Sigma / LSS) to organizational sustainability; and 3) to expand the literature review of Green Lean Six Sigma in services industry.

In addition, one can also point out the adherence of this thesis to the interdisciplinarity of the PPSIG, due to the need to seek multiple perspectives on the object of study in order to understand it. That is, for the development of the three studies, it is necessary to seek theoretical support in different sciences, such as administration, statistics and engineering and thus to build an interdisciplinary path for the elaboration of the methodology that based the proposed method.

As far as the research approach is concerned, we can not only respond to the complexity of the causes of the problems, but also require new paradigms and epistemologies, a dialogue between different knowledge and the need for theoretical support in different areas (social science, environmental science, management , engineering, economics, mathematics, statistics and decision science). Thus, there is interdisciplinarity in the objects of study and in the methodological procedures, being constituted of qualitative-quantitative research with triagulation in the data collection. It is also observed that there is a critical distance from previous theoretical and empirical knowledge, facilitating the crossing of different worldviews and accepting the learning of a new way to solve the problems already known, which allows the opening of a dialogue beyond the borders of a single discipline.

Finally, like Freire's (2012) research, this thesis was intended to be considered as an example of an interdisciplinary study for the PPSIG when referring to two of the the three facets of interdisciplinary training determined by Raynaut (2014) through the search for interdisciplinary answers to respond the complexity of the research questions, listening to professionals from different areas and different organizations during the survey and specialists during the focus group, allowing to cross different worldviews.

6.3 Limitations and suggestions for further work

6.3.1 Study I

The study I's limitations and suggestions for future studies are presented. First, the study is mainly related to the non-probabilistic sample and to the specific context in which it was done, a Conference on Sustainable Management in Rio de Janeiro, Brazil. As a sequence to this work, aside from the possibility of counting on a survey with a larger sample composed by more organizations and replicating this instrument in other circumstances, we suggest the attribution of different relevance to professionals of the strategic, tactical and operational levels in order to obtain a more accurate perception analysis. Also, more in-depth research can be done in order to improve sustainability performance measurement and to evaluate organizational sustainability. The continuity of the research on this theme can lead to new ways of better understanding the correlation results between the sustainable measures of the

organizations and investigating the reasons for the relevance of one measure or indicator over others in order to enhance the quality and robustness of the corporate sustainable performance.

6.3.2 Study II

As a sequence to this work, aside from the possibility of counting on a survey with a larger sample composed by more organizations and replicating this instrument in other circumstances, we suggest the continuity of the research on this theme can lead to new ways of better understanding the correlation results between the TBL measures and operational measures of corporate sustainability and investigating the reasons for the relevance of one measure or indicator over others in order to enhance the quality and robustness of the corporate sustainable performance.

More research should therefore focus on social and governance concerns and companies should achieve sustainability not only by implementing practices such as LM, Six Sigma or Lean Six Sigma, but also by improving their key sustainable performance measures. The identification and selection of the appropriate measures must be constantly adapted and changed according to the objectives of the organization. Furthermore, it is essential that the measures reflect the concerns of all stakeholders. Aside from the objective behind these measures, the type of company must also be considered, as well as the sector studied, the size of the company, the proximity to markets sensitive to environmental issues, external regulation, and to the organization's corporate culture (FIKSEL *et al.*, 1999).

6.3.3 Study III

Study III's limitations and suggestions for future studies are presented. Firstly, more in-depth research can be done in order to improve the findings as the proposal of an integrated Green Lean Six Sigma business model or a roadmap to implement green LSS in service industry. The continuity of the research on this theme can lead to new ways of better understanding the integration of Lean Six Sigma, sustainability and services.

As a sequence to this work, aside from the possibility of counting on descriptive analysis through bibliometric analysis, we suggest the application of a survey with different service organizations to perform statistical analyzes or an in-depth case study by interviewing professionals from a service company applying LSS tools and having environmental concerns. Also, it is recommended that future studies explore the application of the LSS and green best practices in other industries and comparative studies explore the application of it in different countries.

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