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LITERATURE REVIEW

How project management principles affect Lean Six Sigma program and projects: a systematic literature review

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ABSTRACT

Goal: This paper aims to explores and understand which project management principles most contributes to implementing Lean Six Sigma program and projects.

Design/Methodology/Approach: Through a systematic literature review, some key works related to the objective were searched in Scopus and Web of Science databases in order to provide metadata that could be further analysed and used as source of information to answer the research questions of this work.

Results: The research provides evidence that project alignment with organizational goals plays a significant role in Lean Six Sigma program success, referring the importance of a structured portfolio management. To complement the list of principles, stakeholder's management and well-defined project scope also contributes to same success metrics. In the other hand, risk management, project schedule and hybrid project management approaches remain unclear in the literature, do not providing sufficient data to validate its relation to success.

Limitations of the investigation: As principal limitation could be pointed the project selection by title and abstract analysis and the coding scheme. Both points are not easy to be replicated, but the final sample could retrieve closer results.

Practical Implications: For practitioners, this work contributes summarizing in a quantitative form which are the principal principles in project management that could be used to implement or improve Lean Six Sigma project and programs.

Originality/ Value: This work brings for academics what were discussed early about the constructs Lean Six Sigma and Project Management and which are the gaps that remains unclear.

Keywords: Lean Six Sigma; Project Management; Systematic Literature Review.

1. INTRODUCTION

Lean Six Sigma (LSS) is a continuous improvement philosophy widely proved and explored since 80s and 90s when Motorola and General Electric made it public. Nowadays clearly the methodology is implemented in all manufacturing and service sectors as automotive, pharmaceutical, food and beverages, healthcare, banking and so on (Antony et al., 2020). Among lots of critical success or failure factors, Project Management (PM) has been appeared playing an important role. It occurs when some capabilities of project management are well or not used during project selection, execution and conclusion (Galli, 2018b, 2018c; Marzagão & Carvalho, 2016).

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Recent researches are focused on addressing the importance of critical factors in Lean Six Sigma program implementation or project results. Galli (2018a) discuss the benefits of the use of both LSS and Project Management constructs during all project, from start to finish. In the same way, Gijo et. al. (2021) reference project management among factors that are related to the Lean Six Sigma success, including human resources, the link with company strategies, the stakeholders' commitment and so on. In the other hand, only few studies focus on understanding specific project management characteristics related with Lean Six Sigma construct. Marzagão and Carvalho (2016) successfully correlated the Lean Six Sigma project success with project manager skills and also project management techniques as project charts, stakeholder's definition, time scheduling, etc. Antony et al. (2020) did a similar approach but addressing factors correlated with project failures.

Only few studies focusing on specific project management knowledge and LSS projects success or failure still keeps the relationship unclear. Due to these two different approaches, some opportunities remain present in the literature, basically related to project management key factors related to Lean Six Sigma success. Regarding these opportunities, authors suggest researches on project leader capabilities, stakeholders' impact, portfolio management and other project management knowledge related to LSS success. (Antony et al., 2020; Elmezain et al., 2021; Galli, 2018c; Marzagão & Carvalho, 2016).

With the intuit to contribute to the correlation of project management and Lean Six Sigma, this article aims to explore, through a critical literature review, which are the main studied characteristics and which ones remains unexplored in order to better address further researches. The objective took place to answer two research questions:

RQ1: which are the key Project Management factors related to Lean Six Sigma project success?

RQ2: which Lean Six Sigma project management factor still remains unclear in the literature?

To practitioners this paper contributes by summarizing important project management principles used to improve Lean Six Sigma projects and program. Some quantitative researches demonstrated insights, techniques and even practices resulted in many different segments, from manufacturing to service and government companies. To academy, the major contribution is the systematic approach and the sense of many lacks and opportunities for further researches. Is clearly understood the relation between project management and Lean Six Sigma and many works focuses on stakeholders, portfolio and scope management, but a lack of study on communication, risk, schedule and organizational management also exists.

The following work is divided in four sections: a literature review about the existing knowledge about the constructs; a method section when the systematic approach and the research are explained in details, for both bibliometric and content analysis; a results topic where the main insights and research questions are discussed; the final conclusions about the research also containing the work limitations and future suggestions for researchers.

2. LITERATURE REVIEW

Within the competitiveness imposed nowadays in almost every product, process or service, many companies have exhaustively tried to improve its quality, cost, customer needs and other profitability metrics. Lean Six Sigma is a worldwide initiative first bring to life by Motorola and spread by General Electric (Henderson & Evans, 2000). After that, Schroeder et al. (2008) defined it not only as quality management principles but as a structure to improvement. Structure that could fit better organizations than other, what attract attention and demonstrate new possibilities. Mostly recent, Galli (2018c) and Sá et al. (2022) appears with a different point of view, concluding that Lean Six Sigma is a philosophy, even regarding the same definition of, first Lean that aims directly value improvement and waste reduction and then with Six Sigma that is related to reduce process variation. In the final objective, many authors agree that the initiative, methodology, philosophy or structure is utilized in order to improve products and services reducing costs and waste and increasing quality perception by customers. Still agreeing with the results, a particular understanding of Lean Six Sigma is important for this research: project-driven management approach in Kwak et al. (2006) point of view. This particular definition brings two different constructs, "Project Management" and "Lean Six Sigma" as a cooperative concept, that could be used simultaneously (Galli, 2018d, 2018a, 2018b).

In order to determine the success or failure achievement in both program and project, some assumptions must be taken. Marzagão et al. (2016) brings a common projects' success definition called "iron triangle", considering as success factors time, cost and quality. Galli (2018b) used similar definitions increasing the meaning of customer needs as quality, cost and delivery (Q-C-D) as Lean Six Sigma initiative is generally focused on this way. Many authors tend to prioritize quality and its deployment as Lean Six Sigma success factor, maybe due to the research application area or sometimes to the kind of product or service impacted. Although, both Q-C-D and iron triangle refer to same similar success factors: quality, cost and time (Motwani et al., 2004; Sunder M &

Mahalingam, 2018).

Many authors have argued that, structured into a project driven approach, Lean Six Sigma must incorporate Project management capabilities to become successful (Antony & Banuelas, 2002; Galli, 2018a, 2018c; Sreedharan V & Sunder M, 2018). Marzagão et al. (2016) demonstrate de effect of project complexity in its success, the same approach and definition brought from project management to LSS projects. The authors also describe the effect of project managers in managing both project management principles and Lean Six Sigma approach principles(Alves et al., 2021). Galli (2018c), evaluating not the success but the failure of projects, brings concepts of project management related to correct project selection for example, principle that is important to align project scope with business strategic goals and metrics. This point of view is directly correlated with portfolio management. The research also discusses the scope management as a critical point that drive projects to failure, meaning that the usage of resources must be managed and well defined, avoiding or at least reducing some uncertainties in the project. Another unmissable concept in Lean Six Sigma project management is Stakeholder management according to Sunder (2016), due to its influence over implementation and the ability to sustain project results. The author suggests that in the Define phase of a LSS project, stakeholder definition must take place and look at end customers and people who will be involved with providing resources to the project. The importance of project management is to provide and collaborate to team definition, scope aligned with business goals, correct usage of resources reducing time, cost and improving quality (Coronado & Antony, 2002).

3. RESEARCH METHODS

Focused on answering the research questions, this paper uses a systematic literature review to compile, summarize and analyse data from other publications. The systematic literature review approach allows the understand of both researchers and practitioners point of view to better review the knowledge usage and the state of the art about a subject (Tranfield et al., 2003). There are many possibilities in this approach, bibliometric analysis together with content analysis was used by Carvalho et. al. (2013) in order to identify patterns and relevant information among most important research documents. This paper uses the same approach as basis with some minor changes.

3.1 Sampling Process

To obtain and understand publications concerning the research paper, Scopus and Web of Science data bases were used for a vast search. This data bases provide metadata with important kind of information that allow further analysis using variables as authors, titles, abstracts, co-citation networks, keyword and other. Another important point is that these databases indexes journals as International Journal of Project Management, International Journal of Lean Six Sigma, all having impact measure by the Journal Citation Reports (JCR).

The string used to search into the databases used the words “Six Sigma” and “Project manag*”. Six Sigma term will refer for both Lean Six Sigma and Six Sigma projects, not excluding relevant documents that could incorporate the constructs and this work objective. Note that project manag* has a search sign that find all words with this exactly prefix but with different suffix, as for example project management and project manager, both could be found using the “*” sign. The Boolean operator AND was used in order to find documents only where both words were used. The research was done looking for titles, abstracts and keywords, the default setting in the database.

The string resulted initially in 370 documents in the two databases. The major interest is related to academic research so only papers and reviews in English were used, reducing the initial result to 315 documents. Some journals are indexed in both databases, due to this the duplicated documents were removed and a critical review carried out titles and abstracts, looking for documents correlated to the research questions and the objective of this paper. Among 257 unique results, 157 were strictly correlated to the subject researched, resulting in the final sample. The process flow represented on Figure 1 details these points.

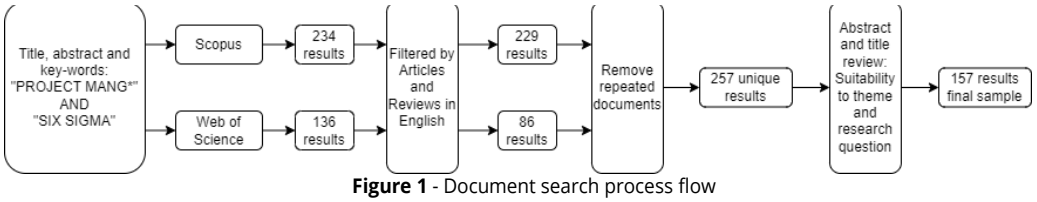


Figure 1 - Document search process flow

3.2 Data analysis

A first analysis concerning the sample resulted from the searches was carried out using biblioshiny by bibliometrix software. According to Aria et al. (2017), that describes the data analysis as an extraction descriptive process from the metadata information. Some of the toolset own by biblioshiny allow the investigation and understanding about the sample, in order to provide insights and determine most important authors, papers, and so on. Some suggestions made by Aria et al. (2017) are: the summary function that presents the main sample results and statistics as documents and authors count, average citations, timespan, countries, etc.

3.2.1 Network analysis

Some network analysis is possible, basically by exploring how authors, documents and sources are related. These networks could be studied by co-citations, co-occurrence or collaboration; most local cited documents and authors is a tool that sort the results by its importance within the sample, not only as a global document, what helps to understand how its findings contribute for the researched topics and strings.

Under some codifications, cross tabulations and network analysis are also possible using UCINET software (Borgatti et al., 2002). The software is a menu-window program that allows analysis related to metric and non-metric clustering information. Based on this information and using also some resources from SPSS software by IBM, it is possible to investigate and analyse how constructs, authors, citations, and coded information are related to each other.

3.2.2 Content analysis

Resulting from the bibliometric analysis, main contribution documents and authors were selected to a deep content analysis. To perform the content analysis, all articles were coded according to the research objective and questions.

First, to project management construct, some techniques (PMT) that are strict correlated with Six Sigma project and program were selected. Galli (2018b) clearly explores that idea where project management techniques were deployed and coded in: project scope and/or project charter use (PMT01); stakeholder management (PMT02); project time / schedule (PMT03); communication plan (PMT04); portfolio management (PMT05) related mainly with the idea of correlating the organization goals with project goals; risk management (PMT06); organizational management (PMT07) related with people training, structure and project manager definition. The author also determines project success (PS) and project goals, referring to the iron triangle: time (PS01); cost (PS02); quality (PS03).

Some documents, sometimes mention Lean Six Sigma project success or program success. Due to this a Lean Six Sigma approach (SSA) code was created in order to understand if the research is focused on the program structure and success or on isolated project efforts. The code is resumed in: program implementation (SSA01); project development (SSA01); (Antony & Banuelas, 2002; Gijo et al., 2021).

Quantitative papers using methods as surveys, case studies or systematic literature review have different sampling methods and, in many occasions, different application areas (AA). Regarding a better understand of the researched area a code was created as follows: manufacturing companies (AA01), construction (AA02), service (AA03), healthcare (AA04), banking and financial (AA05), universities and educational institutes (AA06), government areas (AA07), technology (AA09) and when the research sampled many different areas (AA08).

In order to characterize the methodological impact of the researches, three documental information were coded. Kind of study (T4): modelling (A), theoretical-conceptual (B), literature review (C), simulation (D), survey (E), case studies (F), action research (G) and experimental documents (H). Approach (T5): quantitative research (QT), qualitative research (QL), descriptive research (DE) and predictive (PRE). The source of evidence (T6) used in each document: questionnaire (1), interview (2), document analysis (3), public data (4), press information (5) and bibliography (6).

4. RESULTS

The survey method adopted for the purpose of gathering the data is cross sectional in nature, as it helps to fetch information and analyse the hypothesis. The samples for the present study were incorporated from the workforce who are a part of private sector organizations and currently working in HR Department. The samples were collected from respondents in and around Mysore

and Bangalore region. Simple random sampling method was adopted to collect the responses. The responses were collected with a help of online survey method by using google forms. A total of 345 responses were collected.

4.1 Sample characterization

According to the initial Scopus and Web of Science database search, the final sample have 157 documents published between 2000 and 2021 through 81 different sources. These articles resulted from the work of 314 authors using an average of 32,78 citations per document. As a first view and analysis of the data, it is possible to visualize that many authors research about Lean Six Sigma and Project Management at the same time, exactly as expected. The Figure 2, created by the Three Field Plot function in biblioshiny by bibliometrix represents this detailed information.

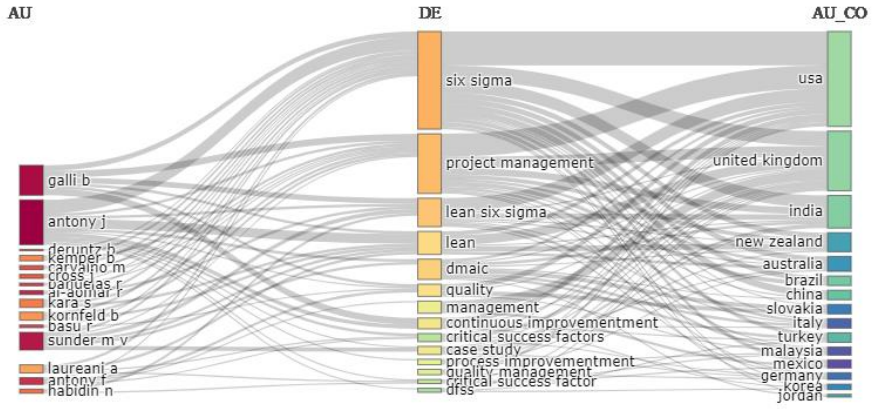
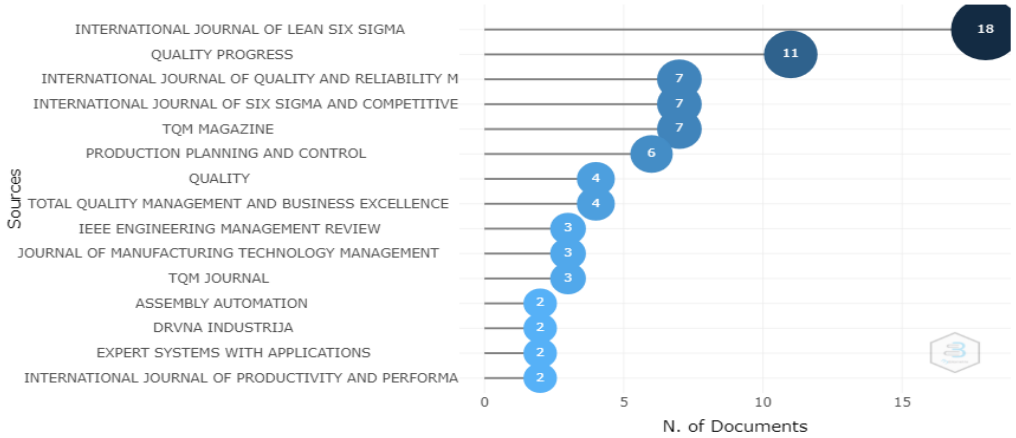


Figure 2 - Three field plot for Authors/keywords/countries

Looking at the journals impact, we can highlight "International Journal of Lean Six Sigma", "Quality Progress" and "International Journal of Quality and Reliability Management". The first source is a relatively recent journal, launched in 2010 focused in publishing Lean Six Sigma content, provided by academics, practitioners, consultants and scientists. Quality Progress is a prestigious monthly magazine from American Society for Quality (ASQ) and are focused on quality principles, tools and techniques. All other found sources are according Graph 1.



Graph 1 - Most relevant sources

Related to the authors within the sample, the five most relevant are responsible for 39,5% of all documents, what is an expressive collaboration and will require special attention in the content analysis. Antony J, principal author has also the main importance in time publications, researching from 2002 to nowadays. His contributions are focused mainly in explaining factors that contributes for Six Sigma program and projects failure or success (Antony & Banuelas, 2002; Coronado & Antony, 2002; Laureani & Antony, 2018). Galli B, Carvalho M, Laureani A and Lizarelli F complement the important authors list, contributing for a short period of time but extremely recent. Galli (2018d), Galli et al. (2019) and Marzagão et al. (2016) are more focused on explain how project management principles could help the improvement of Lean Six Sigma program and projects. Other authors that contribute to this research are also presented in Figure 3.

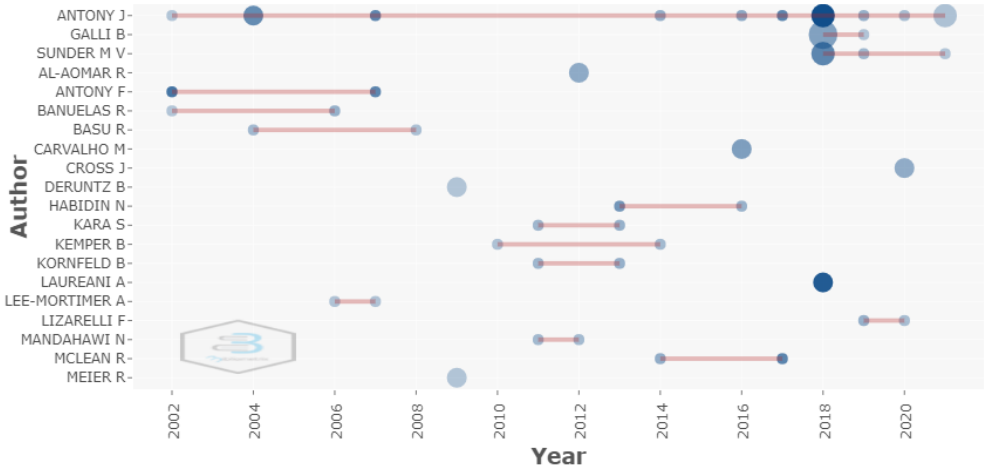


Figure 3 - Authors production over time

4.2 Network analysis

As a starting point, the network of co-occurrence of keywords in Figure 4 shows exactly what was aimed by the strings search in the databases. Project management and Lean Six Sigma along their closely words are correlated. Lean Six Sigma itself is sometimes researched with work simplification and process monitoring and process engineering, as it is possible to notice in some papers (Antony, 2006; Schroeder et al., 2008). In the same way, project management has some connections with Six Sigma and its closer keywords. Even being different concepts, Six Sigma and Lean Six Sigma in this case remains to the same usage and benefits of using project management principles. An interesting point of view is that project management searched with Six Sigma provides keywords related to customer satisfaction, quality control, productivity and other topics related mainly to quality. In this specific kind of research, authors remain focused first in quality as a project success metric (Antony, 2004).

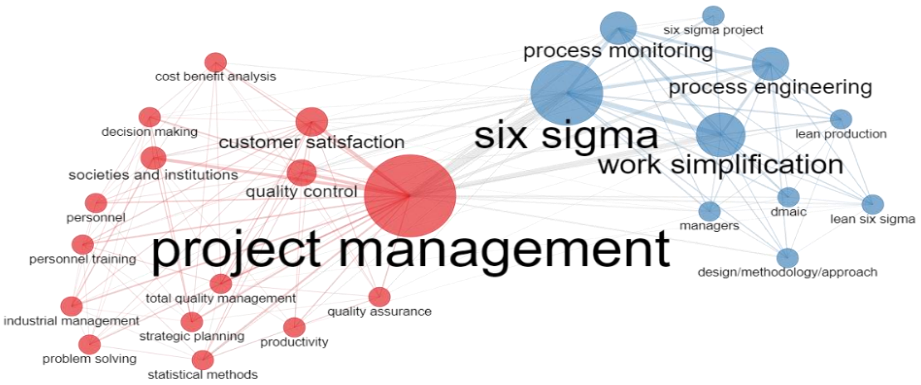


Figure 4 - Keywords co-occurrence network

When looking closer to co-citation network (using 30 nodes to create the network), where is possible to analyse how papers are correlated between then by its citation, three main clusters stand out as shown in Figure 5. As a centre of the green cluster, the article "Benefits, obstacles, and future of six sigma approach" make all principal links with other clusters. In this work, Kwak et al. (2006) in addition to describing Lean Six Sigma fundamentals, the authors also introduce some principal challenges when implementing LSS projects, making reference, in some point, to project management factors.

In a most directly and clear approach in the red cluster, with the work "Key ingredients for the effective implementation of Six Sigma program", Antony et al. (2002) analyse from both literature and UK companies which are the main factors that guarantee the success when implementing a Lean Six Sigma program. This work receives most part of the connections from the other clusters.

The authors present project management as a whole attribute but also discuss about project selection and scope, what is correlated to portfolio management.

The third blue cluster have many connections with the two other discussed before. Brun (2011) and Schroeder et al. (2008) analyse through case studies, mainly in a Lean Six Sigma view, the factors that could cause the success or the failure of Lean Six Sigma projects.

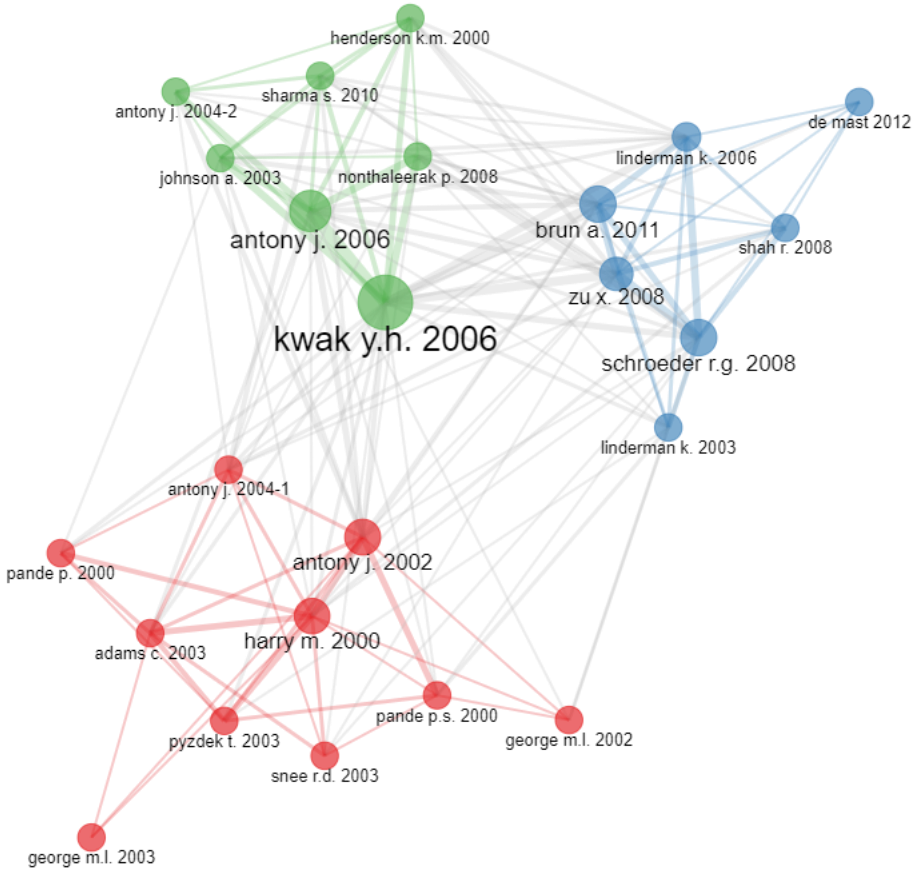


Figure 5 - Papers co-citation network

4.3 Content analysis

In order to analyse the content of the sample, 35 articles were selected based on the bibliometric analysis presented before. These articles were fully read and studied to pass through the codification process, allowing the following understandings. The summary of the content analysis is shown in

Construct	Variabe	Code	#	References
Project Management Techniques (PMT)	project scope	PMT01	26	Lameijer et al. (2021), Antony et al. (2020), Antony et al. (2019),Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean et al. (2017), Garza-Reyes et al. (2016), Mclean and Antony (2014), Kwak and Anbari (2006), Antony (2004), Coronado and Antony (2002), Laureani and Antony (2018), Marzago and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Zhang et al. (2008), Antony and Banuelas (2002), Schroeder et al. (2007), Antony (2006)

	stakeholder management	PMT02	24	Lameijer et al. (2021), Gijo et al. (2021), Antony et al. (2020), Antony et al. (2019), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean et al. (2017), Sunder (2016), Mclean and Antony (2014), Antony et al. (2007), Motwani et al. (2004), Marzago and Carvalho (2016a), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Brun (2010), Schroeder et al. (2007), Antony (2006)
	project schedule	PMT03	6	Galli (2018), Galli (2018b), Antony et al. (2018), Coronado and Antony (2002), Laureani and Antony (2018), Antony (2006)
	communication plan	PMT04	14	Gijo et al. (2021), Antony et al. (2020), Antony et al. (2019), Galli et al. (2019), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Sunder (2016), Mclean and Antony (2014), Coronado and Antony (2002), Laureani and Antony (2018), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Brun (2010)
	portfolio management	PMT05	22	Gijo et al. (2021), Antony et al. (2019), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Mclean et al. (2017), Mclean and Antony (2014), Antony et al. (2007), Kwak and Anbari (2006), Antony (2004), Motwani et al. (2004), Coronado and Antony (2002), Laureani and Antony (2018), Marzago and Carvalho (2016a), Meza and Jeong (2013), Gray and Anantatmula (2009), Zhang et al. (2008), Henderson and Evans (2000), Brun (2010), Antony and Banuelas (2002), Schroeder et al. (2007)
	risk management	PMT06	7	Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Galli (2018b), Galli (2018c), Sunder (2016), Henderson and Evans (2000)
	organizational management	PMT07	14	Gijo et al. (2021), Antony et al. (2020), Antony et al. (2019), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Antony et al. (2007), Coronado and Antony (2002), Marzago and Carvalho (2016a), Sharma and Chetiya (2010), Zhang et al. (2008), Henderson and Evans (2000), Margagao and Carvalho (2016b), Brun (2010)
Project Success (PS)	Time	PS01	9	Galli et al. (2019), Sunder et al. (2019), Galli (2018), Galli (2018b), Galli (2018c), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Margagao and Carvalho (2016b), Antony (2006)
	Cost	PS02	26	Gijo et al. (2021), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Antony et al. (2018), Garza-Reyes et al. (2016), Mclean and Antony (2014), Antony et al. (2007), Motwani et al. (2004), Laureani and Antony (2018), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Zhang et al. (2008), Henderson and Evans (2000), Margagao and Carvalho (2016b), Brun (2010), Antony and Banuelas (2002), Schroeder et al. (2007), Antony (2006)

	Quality	PS03	23		Gijo et al. (2021), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean and Antony (2014), Antony et al. (2007), Antony (2004), Motwani et al. (2004), Laureani and Antony (2018), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Zhang et al. (2008), Henderson and Evans (2000), Brun (2010), Antony and Banuelas (2002), Schroeder et al. (2007), Antony (2006)
Six Sigma Approach (SSA)	Program implementation	SSA01	16		Lameijer et al. (2021), Gijo et al. (2021), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean et al. (2017), Antony et al. (2007), Antony (2004), Motwani et al. (2004), Laureani and Antony (2018), Henderson and Evans (2000), Brun (2010), Antony and Banuelas (2002), Antony (2006)
	Project development	SSA02	19		Antony et al. (2020), Antony et al. (2019), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Garza-Reyes et al. (2016), Sunder (2016), Mclean and Antony (2014), Kwak and Anbari (2006), Coronado and Antony (2002), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Zhang et al. (2008), Margagao and Carvalho (2016b), Schroeder et al. (2007)

and Table 2 shows the core-periphery analysis highlighting the core membership codes extracted from the UCINET software.

Through the summary table, is possible to visualize the preference for particular variables when researching project management. Scope, stakeholder management and portfolio management are common subjects in this specific sample while schedule and risk management have only 6 and 7 references respectively. In project success construct the same preference occurs for quality and cost, leaving time as not commonly researched topics.

Table 1 - Summary of content analysis

Construct	Variabe	Code	#	References
Project Management Techniques (PMT)	project scope	PMT01	26	Lameijer et al. (2021), Antony et al. (2020), Antony et al. (2019),Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean et al. (2017), Garza-Reyes et al. (2016), Mclean and Antony (2014), Kwak and Anbari (2006), Antony (2004), Coronado and Antony (2002), Laureani and Antony (2018), Marzago and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Zhang et al. (2008), Antony and Banuelas (2002), Schroeder et al. (2007), Antony (2006)
	stakeholder management	PMT02	24	Lameijer et al. (2021), Gijo et al. (2021), Antony et al. (2020), Antony et al. (2019), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean et al. (2017), Sunder (2016), Mclean and Antony (2014), Antony et al. (2007), Motwani et al. (2004), Marzago and Carvalho (2016a), Sharma and Chetiya (2010), Gray and Anantatmula

				(2009), Brun (2010), Schroeder et al. (2007), Antony (2006)
	project schedule	PMT03	6	Galli (2018), Galli (2018b), Antony et al. (2018), Coronado and Antony (2002), Laureani and Antony (2018), Antony (2006)
	communication plan	PMT04	14	Gijo et al. (2021), Antony et al. (2020), Antony et al. (2019), Galli et al. (2019), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Sunder (2016), Mclean and Antony (2014), Coronado and Antony (2002), Laureani and Antony (2018), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Brun (2010)
	portfolio management	PMT05	22	Gijo et al. (2021), Antony et al. (2019), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Mclean et al. (2017), Mclean and Antony (2014), Antony et al. (2007), Kwak and Anbari (2006), Antony (2004), Motwani et al. (2004), Coronado and Antony (2002), Laureani and Antony (2018), Marzago and Carvalho (2016a), Meza and Jeong (2013), Gray and Anantatmula (2009), Zhang et al. (2008), Henderson and Evans (2000), Brun (2010), Antony and Banuelas (2002), Schroeder et al. (2007)
	risk management	PMT06	7	Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Galli (2018b), Galli (2018c), Sunder (2016), Henderson and Evans (2000)
	organizational management	PMT07	14	Gijo et al. (2021), Antony et al. (2020), Antony et al. (2019), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Antony et al. (2007), Coronado and Antony (2002), Marzago and Carvalho (2016a), Sharma and Chetiya (2010), Zhang et al. (2008), Henderson and Evans (2000), Margagao and Carvalho (2016b), Brun (2010)
Project Success (PS)	Time	PS01	9	Galli et al. (2019), Sunder et al. (2019), Galli (2018), Galli (2018b), Galli (2018c), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Margagao and Carvalho (2016b), Antony (2006)
	Cost	PS02	26	Gijo et al. (2021), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Antony et al. (2018), Garza-Reyes et al. (2016), Mclean and Antony (2014), Antony et al. (2007), Motwani et al. (2004), Laureani and Antony (2018), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Zhang et al. (2008), Henderson and Evans (2000), Margagao and Carvalho (2016b), Brun (2010), Antony and Banuelas (2002), Schroeder et al. (2007), Antony (2006)

	Quality	PS03	23	Gijo et al. (2021), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean and Antony (2014), Antony et al. (2007), Antony (2004), Motwani et al. (2004), Laureani and Antony (2018), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Zhang et al. (2008), Henderson and Evans (2000), Brun (2010), Antony and Banuelas (2002), Schroeder et al. (2007), Antony (2006)
Six Sigma Approach (SSA)	Program implementation	SSA01	16	Lameijer et al. (2021), Gijo et al. (2021), Galli (2018a), Laureani and Antony (2018), Galli (2018b), Galli (2018c), Antony et al. (2018), Mclean et al. (2017), Antony et al. (2007), Antony (2004), Motwani et al. (2004), Laureani and Antony (2018), Henderson and Evans (2000), Brun (2010), Antony and Banuelas (2002), Antony (2006)
	Project development	SSA02	19	Antony et al. (2020), Antony et al. (2019), Galli et al. (2019), Sunder et al. (2019), Sunder and Mahalingam (2018), Galli (2018), Sreedharan and Sunder (2018), Garza-Reyes et al. (2016), Sunder (2016), Mclean and Antony (2014), Kwak and Anbari (2006), Coronado and Antony (2002), Marzagao and Carvalho (2016a), Meza and Jeong (2013), Sharma and Chetiya (2010), Gray and Anantatmula (2009), Zhang et al. (2008), Margagao and Carvalho (2016b), Schroeder et al. (2007)

Core codes

PS01 - Time
PS02 - Cost
PS03 - Quality
CM04 - Organizational Complexity
CD02 - Uncertainty

		7 PS	8 PS	9 PS	4 CM	11 CD	6 CM	1 CM	2 CM	3 CM	10 CD	5 CM	12 CD
7	PS01	37	33	30	29	26	14	8	14	23	23	7	8
8	PS02	33	36	31	29	27	14	10	14	22	21	8	6
9	PS03	30	31	31	24	24	14	8	12	19	18	8	6
4	CM04	29	29	24	32	24	12	7	11	19	19	7	6
11	CD02	26	27	24	24	29	12	8	14	16	18	7	8
6	CM06	14	14	14	12	12	15	4	7	11	8	4	1
1	CM01	8	10	8	7	8	4	10	8	5	5	4	1
2	CM02	14	14	12	11	14	7	8	16	8	11	5	4
3	CM03	23	22	19	19	16	11	5	8	23	13	4	3
10	CD01	23	21	18	19	18	8	5	11	13	25	6	7
5	CM05	7	8	8	7	7	4	4	5	4	6	8	
12	CD03	8	6	6	6	8	1	1	4	3	7		8

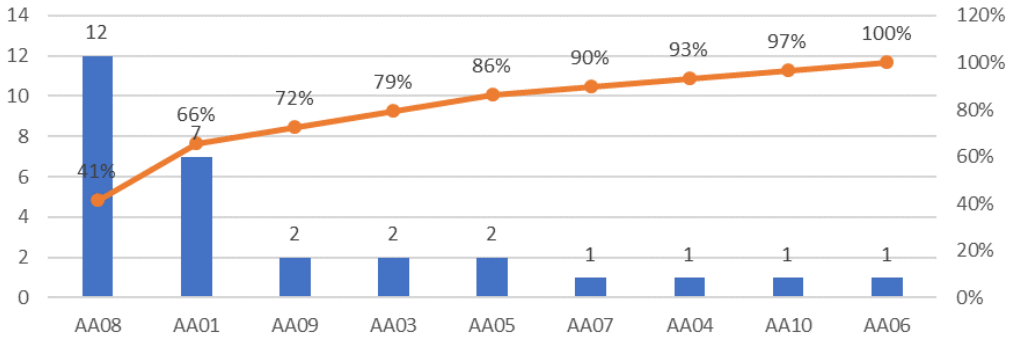
Core/Periphery fit (correlation) = 0,9545v

Table 2 - Core-periphery analysis

As a first step, to understand the academic range of this research, were analysed the codes related to the articles. According to its methods the documents are quite divided in half, 19 documents are based on a qualitative approach that represents 54%, while other 16 documents (45%) are quantitative. Only four different sources of information were used to sustain evidences in the works: based often in qualitative approach, 16 documents used bibliography and among them 12 as its only source of evidence; 14 documents are based on interviews and 11 in questionnaires, the sum of these sources are greater than the count of quantitative documents because some works used both sources of evidences; only 6 documents used general documents in most case studies to make their researches. As majority, 37% (13) of the documents used survey as methodology to study its hypothesis and research questions, making sense the higher number of questionnaires and interviews used. Even so representative 10 articles were based on literature review or systematic literature reviews, what represents 29% of the documents. 8 articles were case

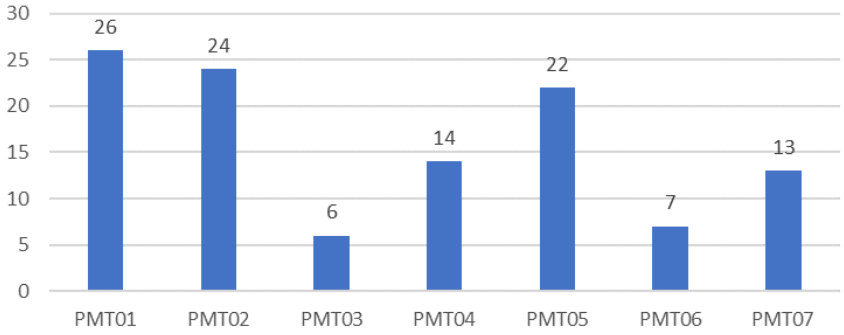
studies, 3 conceptual papers and only 1 action research.

Analysing the impact of this documents for practitioners, the organizational distribution in application areas resulted as Graph 2. Most papers using electronic questionnaires and interviews embrace a wide range of application areas, from service to manufacturing and healthcare. When focused on only one area, researchers tend to find evidence in manufacturing industries, normally because Lean Six Sigma was first delivered by General Electric and Motorola and is growing up in new areas recently (Henderson & Evans, 2000). Technology, service and banking demonstrate it having few articles and many in recent years. It is also important to note that construction area was not researched in this sample, even though it was expected. The documents are discussing about Lean Six Sigma program 46% and projects 54% of the time.



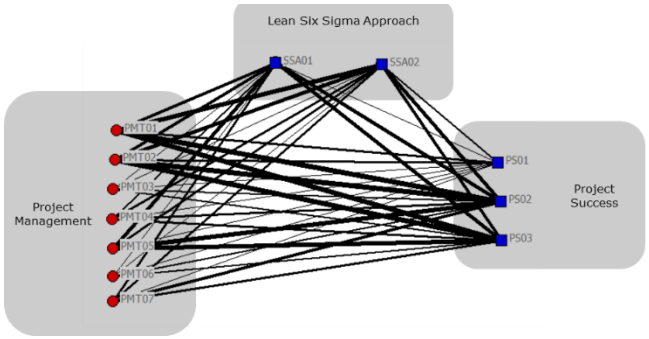
Graph 2 - Application area for content analysis

To correlate areas and principally Lean Six Sigma program and projects with project management techniques, initially we identified how researchers tend to understand success. Directly related to customer, what is a LSS approach characteristic, papers discuss frequently Quality and Cost, 23 and 25 times respectively, remaining only 9 times the importance of time a project success metric. As the main objective of this research and to answer the research questions, the project management techniques most related to Lean Six Sigma is described as Graph 3. Project scope, stakeholder management and portfolio management clearly have more attention and impact in both LSS program and projects. In 69% of the 35 analysed documents, researchers used at least one of the three principal project management technique. Communication plan and organizational management seems to have some attention in the middle field, far ahead of project schedule and risk management. This analysis shows that all expected field were represented in the documents, allowing the interpretation and discussion of the impact for LSS projects and program.



Graph 3 - Project management techniques related to Lean Six Sigma success

Evaluating the relationships between the three constructs, project management, Lean Six Sigma approach and project success factors, there is a clear pattern linking quality and cost with the Lean Six Sigma projects and program. Corroborating with previous results, scope definition, stakeholder management and portfolio management are the main topics related to project management. These patters emerge from the count of the final sample, meaning that some project management techniques are less discussed or even not well discussed in the intersection of these three constructs.



	PS01	PS02	PS03	SSA01	SSA02
PMT01	7	18	17	10	16
PMT02	7	18	17	11	13
PMT03	3	5	5	4	2
PMT04	2	9	7	6	8
PMT05	4	16	15	13	9
PMT06	3	6	5	4	3
PMT07	4	11	9	7	7
SSA01	3	13	12	16	0
SSA02	6	13	11	0	19

Figure 6 - Relationship among PMT, PS and SSA

1. DISCUSSION

As a starting point, as Lean Six Sigma is an approach based on projects, authors wrote about its benefits for the program and projects itself, but initially in a generic and superficial way. Antony et al. (2002) find evidence of the effect of project management capabilities related to Lean Six Sigma program in both literature and in UK companies through survey research. This kind of initial conclusion set a completely new goal in the research, because when analysing the program as a whole picture it brings an initial insight, but when closely paying attention to project management principles and techniques, a more in-deep study must be carried out. Laureani and Antony (2018) performs this in-deep investigation regarding the leadership role as a success factor for Lean Six Sigma implementation, perfectly demonstrating the stakeholder and organizational management importance. In a similar way Marzagão et al. (2016) also identify quantitatively the relationship between project management and Lean Six Sigma project success, among its conclusions is the importance of a project charter with indicators, goals deliverables and scope. The systematic literature review allowed this interpretation and discussion for four specific project management principles and techniques, at least.

First, Antony et al. (2002) finds evidences that management commitment and involvement is one of the most important success factors for Lean Six Sigma program implementation. Looking closely to its definition and conclusions, it is possible to create a parallel though with stakeholder's management. Galli (2018c) complement this understanding with the notion that stakeholder management could be used during the Define phase in Lean Six Sigma, which would allow stakeholders to understand the process, facilitate resources, discuss and understand communication plans, indexes and project scope. A poor stakeholder management could be related to Lean Six Sigma project and sometimes program failures, basically because as consequence projects could be not aligned with business strategies and not receive the needed attention to keep projects in progress (McLean et al., 2017).

Second, when analysing the alignment between business goal and Lean Six Sigma projects, stakeholders play a crucial role, but project selection, or portfolio management also could drive and helps better decisions for managers. The importance described by Kwak et al. (2006) is, in other terms the same role played by the portfolio management team: understand the project feasibility, organizationally and financially, define clear metrics and ways to measure project progress and success, document and track the project and sustain a lesson learned mechanism. Zhang et al. (2008) define a strategic project selection framework and evaluate it benefits not even for Lean Six Sigma project but for many continuous improvement programs. Their intent is to have a more specific and defined framework, just because sometimes portfolio management in literature could be vague and broad. For this research the important understanding is the effect of a structured and systematic project selection in the project success. Once the project is aligned with business strategy and allowed by its sponsors and stakeholders, the chance of success is definitely increased (Sunder, 2016).

Third, selecting projects aligned with business strategy and giving structure and stakeholders to follow it is crucial, to improve these two principles scope definition and management becomes even important (Antony & Banuelas, 2002; Galli, 2018b, 2018c; Marzagão & Carvalho, 2016). After studying the reasons why many Lean Six Sigma project fails, Gray et al. (2009) argues that the projects must be reassessed and redefined its objectives, scope and schedule, basically by redesigning the project charter. This point claims attention in many works, that concludes that a well-done project scope and the use of the project charter enhances the success of the Lean Six Sigma program and projects (Antony, 2004; Garza-Reyes et al., 2016; Meza & Jeong, 2013).

Fourth, to define better projects, always allowed with business strategy, communicate and engage stakeholders and organize it in project charters is not an easy task, but all this effort could

be done with the right organizational structure and management, what means Master Black Belts, Black Belts, Green Belts and Champions well trained and with their roles defined (Coronado & Antony, 2002; Galli, 2018d; Gijo et al., 2021). When benchmarking successful cases as General Electric and Motorola, Handerson et al. (2000) clearly demonstrate the attention and the care took with training competences and team formation, meaning that organizational structure management is a key factor handled by companies that well implemented Lean Six Sigma programs.

Additional principles and techniques such project schedule, communication plans and risk management were not deeply discussed. Sunder (2016) evaluating the impact of a stakeholder in the Lean Six Sigma project success describes that their importance is also to manage risks and it is possible through a clearly communication plan. Specifically related to risks, Galli (2018d) performed a specific research deploying Six Sigma risks inside scope, stakeholders, cost and project management, concluding that poor risk management lead projects to failure. The absence of works like this one represents a lack in the literature, creating opportunity and direction for future works.

2. CONCLUSION

Lean Six Sigma and project management are used by several companies and institutes worldwide, focused on improving quality for customers and reducing costs and time. Some project management principles wide studied and applied in different areas had expressive positive results in LSS projects success, but other must be further investigated, studied and experimented.

Aligning Lean Six Sigma projects with business strategy and goals is one of the most important definitions to the success of the program. This systematic literature review, answering the RQ1 provided evidence that this alignment could be done by three main project management principles: stakeholders management, scope management and portfolio management. These three strategies will provide information and knowledge to define, carry and finish projects totally focused in both customer and business strategy. Note that is not important to only define projects aligned with business goals, but keep them on track, giving necessary resources and monitoring to the end of its implementations, when it you finally bring solid results to the company. To create and sustain all this synergy a fourth important point is required, organizational management. The analysis results had also demonstrated that both Lean Six Sigma and project management require well trained collaborators, what automatic requires the right culture to sponsor the program. Furthermore, many other principles as risk management, project schedule and communication plans remain unclear in the literature, with feel evidences and studies that spend resources focused on the subjects. This difference in the evidences answers our RQ2, providing also insights for future researchers.

Clearly this research has some limitations. Even though a systematic literature review collaborates to reduce authors biases, the document selection in relation to the objective of this research remains as not easy step to be reproduced. Determining papers and works to use as reference to coding the dataset also could be influenced by authors point of view and intent to answer the research questions.

Besides these limitations, some gaps were brought to evidence with this research, motivating future works to find quantitative evidence about how better companies may perform when implementing both Lean Six Sigma and project management principles compared with companies that do not. Furthermore, subjects as risk management techniques and new hybrid approaches using agile and traditional project management could be explored through surveys and case studies for both two constructs, shading light in an important and unexplored knowledge area for both academics and practitioners.

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