Systems & Management 14 (2019), pp 382-399

SYSTEMS & MANAGEMENT
Electronic magazine

A SYSTEMIC ANALYSIS OF COST OVERRUNS IN PROJECT SALES COMPANIES

Iris Jonas Gontijo
irisjonasgontijo@gmail.com
Institute of Technological Education - IETEC, Belo Horizonte, Minas Gerais, Brazil.

José Luis Braga
zeluisbraga@gmail.com
Institute of Technological Education - IETEC, Belo Horizonte, Minas Gerais, Brazil.

ABSTRACT

Factors that influence the risk of cost overruns in project execution attract the attention of many researchers. However, each study available in the literature focuses its efforts on understanding some factors assessed as relevant in the context of the problem of that study and usually without considering the interactions between factors. This consideration gap can lead to inaccurate conclusions about the potential damage caused by problems that occur throughout the project life cycle, undermining assertiveness in the decision making process and potentially posing additional risk to project performance. The aim of this study is to identify and integrate, in a systemic way, the factors and their causal relationships that influence the risk of execution cost overruns in companies based on project sales. For this, a systematic literature review (SLR) was performed, and the relationships between the identified factors were integrated into a causal diagram through a systemic approach. The results obtained may contribute to a better understanding of the complex system that involves the cost overruns phenomenon and support a more assertive decision making process. In the end, some limitations and possibilities of study sequence are presented as, for example, the development of a cost overruns risk prediction system, based on Artificial Neural Networks (ANN).

Keywords: Project management; Cost Overruns; Causal relations; Systematic literature review; Artificial neural networks.

PROPPI / LATEC
DOI: 10.20985/1980-5160.2019.v14n4.1561

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

1. INTRODUCTION

According to the report Pulse of the Profession® - Success in Disruptive Times (PMI®, 2018), in disruptive times, cost control and risk mitigation are key elements in increasing the value delivery of projects.

Considering a high level view, there is a significant similarity between the aspects involved in project development. This contributes to good management practices being applied comprehensively in both public and private enterprises (PMI®, 2017).

The project's "performance" depends on the quick and assertive actions of the key figures driving it. However, according to Senge (2012), The assertiveness of decision making is compromised when decision makers do not use a systemic approach to understand the multiple relationships between the factors involved in the problem. As stated by Sterman (1992), to effectively understand the dynamic system of the project, it is necessary to apply structured models that demonstrate the multiple relationships and impacts that changes may entail. Lopes *et al.* (2015) point out that risk factors interact dynamically and nonlinearly, hindering decision making.

Companies, whose business is the sale of projects, are those that carry out projects for other organizations, their clients, through commercial and contractual agreements that fit the project perimeter. For these companies, the cost overruns, i.e. the extrapolation of the budget originally foreseen for project implementation, is an even more relevant problem, as they, as suppliers, do not have the option to reevaluate project continuation, even if it costs more than expected. In this respect, the elucidation of the factors that influence the cost overruns and their interactions can contribute to reduce the risk of its occurrence or the magnitude of their impact in cases where it is already present.

However, each study available in the literature focuses its efforts on understanding some factors assessed as relevant in the context of the problem of that study and usually without considering the interactions between factors. Ahiaga-Dagbui *et al.* (2017) address the fragility of this traditional form of research and suggest that research on this theme should evolve towards causal relationships through systemic thinking that represents the high-level interaction between the multiple factors involved.

Therefore, this study aims to systemically identify and integrate the factors and their causal relationships that influence the risk of execution extractions in companies based on project sales.

2. THEORETICAL REFERENCE

The references presented in this section were obtained as a result of the systematic literature review (SLR), the process of which is detailed in the "methodology" section, but are anticipated in this paper as they are part of the theoretical framework.

Factors that influence cost overruns risk

Figure 1 contains a summary of the 27 identified factors, according to the authors who studied them.

Figure 2 represents a graph showing the number of studies that address each factor. It is noteworthy that the frequency of studies involving a factor does not determine its relevance in isolation. In this sense, the interpretation of the figure highlights factors in which research is still scarce, representing potential for future studies.

Relationship between factors related to cost overruns risk

Following are the researchers' basic insights into the relationships between factors they have studied. The imbalance in the number of studies is also reflected in this section, with some factors containing more content than others. This synthesis can also be useful as a source of lessons learned and supplementary information, which can be found in the consultations of the studies cited.

Rework

The more rework occurs, the more difficult it will be to maintain the schedule due to the time spent on corrections (Han *et al.*, 2012; Han *et al.*, 2013; Love *et al.*, 2010; Love *et al.*, 2014; Safapour; Kermanshachi, 2019). Inaccurate field data collection for project execution leads to rework and jeopardizes lead time (Jiayuan; Hongping, 2017). In addition, the greater the risk of rework, the greater the risk of cost overruns (Adoko *et. al.*, 2015; Doloi, 2013; Han *et al.*, 2012; Han *et al.*, 2013; Love *et al.*, 2010, Love *et al.*, 2014; Safapour; Kermanshachi, 2019).

Moreover, lack of technical excellence in drawings and specifications and failure to apply proper manufacturing methods and technologies increase staff workload (Heravi; Eslamdoost, 2015; Han *et al.*, 2012), besides generating delays in receiving materials (Han *et al.*, 2013). According to Bauer and Gann (2007), a high failure rate can damage the relationship with customers, as they are uncertain whether the project will actually be successfully completed.

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
Item	**Author & Year**	Rework	Scope Control	Change Requests	Time	Customer Relationship	Proactive Customer Participation	Tacit Customer Knowledge	Project Team Performance	Project Team Integration	Project Team Autonomy	Competition for Adequate Resources	Adequate Resource Allocation	Response Time	Workload	System Pressure	References Availability	Effective Communication	Top Management Involvement	Project Manager Experience	Technical Team Performance	Customer Experience	Project Duration	Motivation	Lack of Materials	Supplier Performance	Customer Distance	Contract Value
1	Adoko et al. (2015)	X			X																							
2	Anastasopoulos et al. (2010)			X																			X					X
3	Anvuur e Kumaraswamy (2016)								X	X	X									X								
4	Bergerud (2012)					X								X														
5	Bonghez (2013)					X						X	X	X						X								
6	Castro-Lacouture et al. (2009)				X							X													X			
7	Cerpa; Verner (2009)				X	X			X				X			X					X	X		X				
8	Cervone (2014)					X												X										
9	Chang Lee et al. (2009)			X		X	X	X				X	X	X			X		X	X		X	X					
10	Cheng et al. (2009)								X				X															
11	Doloi (2013)	X							X	X			X					X							X	X		
12	Forcada et al. (2017)	X																									X	X
13	Gudienė et al. (2014)								X				X							X		X						X
14	Günsel e Açikgöz (2013)									X	X																	
15	Han et al. (2012)	X			X				X						X									X				
16	Han et al. (2013)	X			X											X									X			
17	Heravi; Eslamdoost (2015)	X							X	X			X		X					X				X	X			
18	Jiayuan Wang; Hongping Yuan (2017)	X		X	X				X		X					X				X	X							
19	Kang et al. (2013)	X	X		X				X																			
20	Kiani Mavi; Standing (2018)																	X	X									
21	Ko; Chung (2014)	X			X				X																			
22	Li; Taylor (2014)	X			X				X																			
23	Love et al. (2010)	X		X	X													X			X	X						
24	Love et al. (2014)	X			X																							
25	Masudifar; Fardad (2013)		X	X		X														X								
26	Meier (2010)				X	X														X	X							
27	Olaniran et al. (2015)	X											X			X		X					X					X
28	Ozorhon e Karahan (2017)											X	X						X	X								
29	Paul et al. (2016)								X	X										X				X				
30	Qianqian JU et al. (2017)				X					X																X		
31	Rojas (2013)								X				X											X	X			
32	Safapour; Kermanshachi (2019)	X			X								X								X							
33	Tennant et al. (2011)				X	X				X					X									X				
34	Vargas (2015)					X																	X				X	X
35	Yang et al. (2010)					X																						
	Total Autores	14	2	5	15	10	1	1	13	7	3	4	11	3	3	4	1	5	3	10	5	4	4	6	5	2	2	5

Figure 1. Summary of factors related with cost overrun risk

Source: The authors.

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

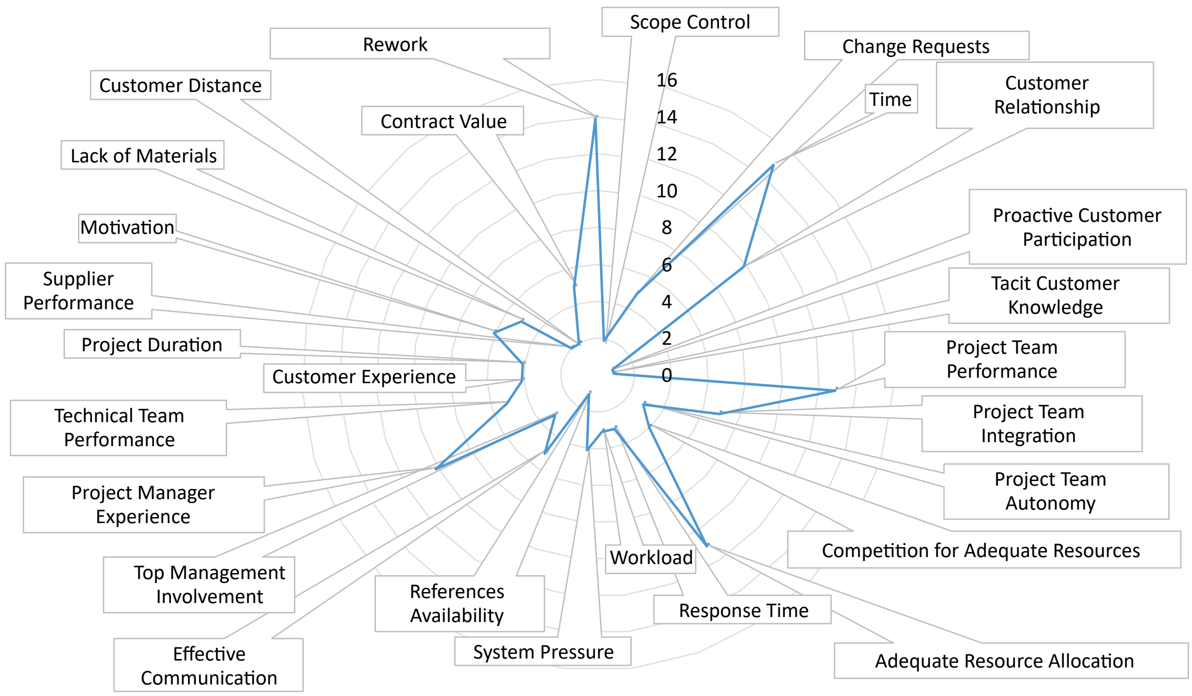

Figure 2. Number of citations per factor related to cost overruns

Source: The authors.

Scope control

Since this process is related to identifying and controlling what is inside or outside the project perimeter, the better the scope control, the lower the risk of reworking for realigning tasks to the supply perimeter (PMI®, 2017) and the lower the risk of extra expenses to correct non-scope tasks (PMI®, 2017; Kang *et al.*, 2013).

Change requests

Change requests increase deadline risk and the more advanced the project the greater the impact (Jiayuan; Hongping, 2017). Similarly, change requests increase the risk of rework (Love *et al.*, 2010) and the project team workload (Bayer; Gann, 2007). Still in this context, the more change requests occur the harder it will be to control the scope. Change requests must have their impact evaluated in an integrated change control system so as not to lose control of the project and its profitability (Masudifar; Fardad, 2013).

Time

Difficulty in customer relationships increases as customers realize the risk of being impacted by schedule issues (O'Connor *et al.*, 2016). In addition, the higher the term risk, the greater the cost overrun risk due to complementary actions to readjust the project schedule (Adoko *et al.*, 2015; PMI®, 2017) and the higher the system pressure (Bayer; Gann, 2007; Han *et al.*, 2013). In this regard, the greater the risk of missed deadlines, the greater the pressure on the project team to take on more activities, increasing their workload (Bayer; Gann, 2007; Jiayuan; Hongping, 2017).

Customer Relationship

The good relationship with the client has a positive impact on its proactive participation in the project, contributing to the maintenance of expected costs (Chang *et al.*, 2009). In addition, the best solutions are implemented with less conflict and more success when driven by the stakeholders who will suffer the consequences (Voinov; Bousquet, 2010). In addition, according to Meier (2010), Excessive stakeholders are one of the critical factors that can influence customer relationships and lead to delays and cost overruns in the project.

Proactive customer participation and tacit customer knowledge

Customer participation in the project makes it more flexible with the solutions adopted, reducing the risk of change requests (Chang *et al.*, 2009). Therefore, the client's tacit knowledge, that is, knowing the client's intrinsic expectations and way of thinking and acting, helps to reduce the risk of rework, improving project performance (PMI®, 2017;

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

Voinov; Bousquet, 2010). In addition, the longer the customer relationship history, the lower the risk of deviations that could impact performance (Chang *et al.*, 2009)

Project team performance

The better the performance of the project team, the lower the risk of project development delays (Gudienė et al., 2014; Tennant et al., 2011). According to Kang et al. (2013), the use of planning "best practices" helps with team performance against project deadlines and reduced project rework. Specifically about engineering development, Jiayuan and Hongping (2017), Ko and Chung (2014) and Li and Taylor (2014) point out that the poor performance in the management of this activity generates significant delays, rework and cost overruns for the project.

According to PMI® (2017), Team performance has a fundamental impact on the project outcome. A well-performing team tends to better control the scope of the project, as well as gain credibility and reputation, contributing to a better customer relationship. PMI® (2017) It also points out that the rework and deadline risks are higher in poorly managed projects. In addition, non-value-added activities such as rework and error-driven deployments can be reduced if the project is well planned, executed, monitored and controlled (Han *et al.*, 2012).

According to the report "Success in disruptive times: Expanding the value delivery landscape to address the high cost of low performance" (PMI®, 2018), Project practitioners' skills and performance will be increasingly critical in disruptive scenarios, not only to achieve project outcomes, but also to gain competitive advantage from disruption itself. The report also shows that champion companies realize the strategic value of investing in the development of project team talent.

Project Team Integration

Teamwork is an essential factor for the success of the project. The more integrated the project team, the better its performance (Doloi, 2013; PMI®, 2017). In this sense, the climate and cohesion among the project team members positively influence the activities (Anvuur; Kumaraswamy, 2016; Paul *et al.*, 2016). In addition, the lack of common values, in a limited view of how one discipline affects others, generates interface conflict, affecting team and project effectiveness (Anvuur; Kumaraswamy, 2016).

In this sense, coordination between the executing parties prevents interference and congestion, being a positive factor in project productivity and performance (Heravi; Eslamdoost, 2015; Tennant *et al.*, 2011). Moreover, according to Günsel and Açikgöz (2013), synergy between team members can improve performance and shorten project duration.

Customer satisfaction is directly related to team integration (Tennant *et al.*, 2011). One explanation for this is that team integration contributes to more effective problem solving, as well as alignment of communication in managing stakeholder relationships (PMI®, 2017).

Project team autonomy

The team's performance also depends on the formal authority given to them in decision making on a day to day basis. In fact, project team-centric authority and decision-making help improve the customer relationship, which values more autonomous interlocutors (PMI®, 2017).

In addition, the autonomy granted to team members contributes to improving the team's mood and performance (Anvuur; Kumaraswamy, 2016). In the same direction, Günsel and Açikgöz (2013) indicate that the freedom given to team members to perform their duties and fulfill their duties and responsibilities on projects results in better performance.

Competition for adequate resources

The availability of qualified personnel, as well as information technology resources for project allocation, is an essential requirement in any organization for best performance results (Ozorhon; Karahan, 2017). In contrast, the limited availability of resources, such as skilled workers, machinery and equipment, creates allocation problems, negatively affecting performance (Castro-Lacouture *et al*., 2009).

The more qualified people available for the project, the better the performance and outcome (Olaniran et al., 2015). In contrast, lack of key resources undermines quality and overall outcome (Bayer; Gann, 2007; Gudienė et al., 2014; Joglekar; Ford, 2005). In this sense, according to Kerzner and Saladis (2009), it is necessary for the project manager to understand the business as a whole in order to guide decision making with a focus on value creation, not just the immediate and isolated outcome of the project. Therefore, the continuous forcing of appropriation of the best resources demonstrates managerial inability.

Adequate resource allocation

Proper resource allocation, team sizing, staff composition, and the presence of appropriate skills positively impact productivity and performance (Heravi; Eslamdoost, 2015; Rojas,

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

2013; Safapour; Kermanshachi, 2019). Moreover, according to Doloi (2013), team technical competencies should be aligned with project size and complexity.

Late allocation of resources is a major factor in project failure. Adding workforce to a delayed project will slow it down even further. Such a principle is known as the "Brooks Law" (Cerpa; Verner, 2009). In addition, according to the PMBOK® Guide (PMI®, 2017), the participation of team members, still in the planning phase, results in greater assertiveness of the plan and strengthens commitment to the project. However, as stated by Joglekar and Ford (2005), The greater the risk of cost overruns, the greater the pressure for cost containment actions, reducing or delaying the allocation of key resources.

In accordance with Chang *et al.* (2009), proper resource allocation has a positive effect on the client's relationship and participation in the project. Proper work infrastructure at the project site improves productivity and performance (Heravi; Eslamdoost, 2015). Still on the application of resources, *Cheng et al.* (2009) argue that applying tools with artificial intelligence capabilities can help improve team performance in decision making.

Response Time and Workload

The longer the customer waits for a solution to their demands or problems, the more dissatisfied they will be (Chang *et al.*, 2009). According to Bergerud (2012), the difficulty in grouping project information and data in a timely manner impairs team performance and the relationship with the Client. In addition, complex approval procedures and authorization bureaucracy impact performance, increasing project timeframe risk (Jiayuan; Hongping, 2017).

The more overloaded the project team, the worse their productivity and performance (Bayer; Gann, 2007; Heravi; Eslamdoost, 2015; Jiayuan; Hongping, 2017). In addition, exhaustion due to excessive workload undermines team motivation (Han *et al.*, 2012; Houston *et al.*, 2001).

System pressure and motivation

High pressure to meet deadlines impairs staff performance, leading to lost productivity and increased rework (Bayer; Gann, 2007; Houston *et al.*, 2001). Under pressure to complete delivery, the team tends to focus more on time rather than cost, increasing the risk of cost overruns (Olaniran *et al*., 2015). And according to Ahiaga-dagbui *et al.* (2017) the mere fact that the project team signals the risk of cost overruns is enough to increase the system's stress and pressure level

Workforce motivation, in turn, has a positive effect on productivity (Han *et al.*, 2012; Heravi; Eslamdoost, 2015; Rojas, 2013). However, pressures to meet very aggressive deadlines can have a negative effect on the team, such as reducing motivation (Cerpa; Verner, 2009; Houston *et al.*, 2001), besides being a latent condition for the generation of errors and consequent rework (Han *et al.*, 2013; Houston *et al.*, 2001).

References Availability

Using references or knowledge previous or acquired in the very project helps reduce risks and improve results (Chang *et al.*, 2009).

Managing project knowledge is the process of utilizing previous or acquired knowledge within the project itself to produce or enhance results (PMI®, 2017); thus, the greater the use of tested solutions and concepts, the lower the expectation of rework. Still according to PMI® (2017), it is a common misconception that lessons learned should be recorded only at the end of the project for use in future projects. The contribution of tacit knowledge to project performance is recognized as important in this management process, which also addresses the need for building enabling environments for people to share their knowledge for the sake of the project.

Effective communication

The team's ability to communicate is one of the success factors in project implementation. Large projects use many multidisciplinary resources that eventually have different cultural orientations and work remotely. In this context, effective communication is essential for the correct exchange of information (Olaniran *et al.*, 2015). In addition, clearly defined work procedures and communication lines positively impact performance, leading to reduced stated by rework risk (Love *et al.*, 2010).

As stated by Doloi (2013), communication gaps between costumers and suppliers at various stages of the project life cycle undermine the relationship and increase the risk of cost overruns. Therefore, the project team must establish a strong communication connection with the costumer in order to better capture their requirements and ensure project performance (Cervone, 2014; Kiani *et al*., 2018).

Top management involvement

Senior management's commitment and posture to the project contributes to good team performance and project

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

progress (Ozorhon; Karahan, 2017), besides having a positive effect on customer participation and relationship (Chang *et al.*, 2009).

This involvement is essential for the team to have access to adequate and timely resources to carry out the activities and achieve the project objectives (Kiani *et al.*, 2018). However, the involvement of top management also increases the level of pressure on the project team (Houston *et al.*, 2001).

Project Manager Experience

Supervisor performance in reviewing activity progress has positive effect on team productivity (Gudienė et al., 2014; Heravi; Eslamdoost, 2015; Olaniran *et al.*, 2015; Paul *et al.*, 2016; Tennant *et al.*, 2011). Moreover, from the adequate resource allocation point of view, project team selection is one of the most critical activities performed by the manager as it will directly influence future performance (Bonghez, 2013). However, according to Meier (2010), an inexperienced manager has difficulty understanding project requirements. Jiayuan and Hongping (2017) add that poor management and poor estimation negatively impact performance and increase project risk.

As argued by Chang *et al.* (2009), More experienced managers are more effective at managing customer relationships as they promote greater participation in decisions and solutions, and a clear understanding of roles and responsibilities. For Yang *et al.* (2010), Customer behavior and needs are situational, and it is up to the project manager to identify contextual characteristics to better serve customers.

Technical Team Performance

Poor staff qualification greatly affects the quality of activities, reducing the approval rate, and jeopardizing project deadlines (Jiayuan; Hongping, 2017). In addition, the inefficiency of the engineering team, the use of information technology resources, and the inability to implement product quality improvement actions impact performance and increase the risk of rework (Love *et al.,* 2010). By contrast, according to Safapour and Kermanshachi (2019), a more experienced project team delivers better performance generating less rework.

In accordance with Meier (2010), inexperienced decision-makers impact team performance and contribute to the risk of cost overrun as well as delays. Still according to the author, standards and processes are important, but the key to successful performance is having people make good decisions in the day to day of the project.

Customer Experience

More experienced customers are easier to relate to, as they know their role and responsibilities better, and become more flexible about solutions (Chang *et al.*, 2009). In addition, according to Gudienė *et al.* (2014), the project outcome is impacted by the client's clarity and objectivity, as well as his speed in decision making.

When the customer does not spend enough time with the supplier to adequately clarify the requirements, misalignment of expectations may occur. This damages the relationship and increases the likelihood of change requests (Cerpa; Verner, 2009). On the other hand, excessive customer interference with project development is counterproductive as it increases rework (Love *et al.*, 2010).

Project Duration

The longer a project lasts, the greater the chances of scope change requests (Anastasopoulos *et al*., 2010; Chang *et al*., 2009). As stated by Olaniran *et al.* (2015), This greater tendency for change is associated with the fact that projects are dynamic and characterized by continuous developments.

Lack of materials

Late delivery of materials, defective materials or inadequate equipment and tools hinder work progress (Heravi; Eslamdoost, 2015; Rojas, 2013). According to Castro-Lacouture *et al.* (2009), the lack of material causes activities that were not critical to become critical, increasing the risk of time and cost of the project.

Customer Distance

In their study, Forcada *et al.* (2017) concluded that the greater the distance between the supplier's central office and its customer, the greater the risk of rework. In this study, the author found that the further away the client is, the greater the effects of managerial problems and the greater the complexity of coordinating activities. The effect of distance tends to be more significant in international projects due to cultural and socio-political factors.

Suppliers Performance

According to Doloi (2013), the better the performance of suppliers, the lower the risk of cost overruns. The author also points out that a poor program of procurement and delays in suppliers can lead to a lack of materials, as well as

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

impairing project performance. In the same vein, improving supplier performance through interface conflict management contributes to reducing the risk of project delays and cost overruns (Qianqian *et al.*, 2017).

Contract value

According to a study by Anastasopoulos *et al.* (2010), the higher the contract value, the more change requests occur. In addition, the larger the project size, the greater the number of interfaces, increasing the risk of failure to properly integrate activities (Gudienė *et al*., 2014; Olaniran *et al.*, 2015). This increased risk of rework associated with the value of the contract is also reported by Forcada *et al.* (2017), who suggests further future studies on the subject.

Summary of causal relationships between factors

This synthesis is constructed from the relationships elucidated in the previous subitem and serves as support for the construction of the causal diagram of the results and discussion section. A positive (+) polarity indicates that an increase in the source variable (cause) implies an increase in the variable affected by it (effect). A negative sign (-) represents an inverse relationship between the variables, i.e. an increase in the source variable implies a reduction in the variable affected by it.

Figure 3 contains the cause and effect relationships associated with term risk. The cause and effect relationships related to scope control are summarized in Figure 4.

Figure 5 summarizes the cause and effect relationships of factors directly related to cost overruns risk.

The cause and effect relationships related to system pressure are summarized in Figure 6.

Figure 7 contains the summary of cause and effect relationships associated with change requests.

The cause and effect relationships associated with the customer relationship are summarized in Figure 8.

Figure 9 contains the cause and effect relationships related to team performance.

Finally, the cause-and-effect relationships associated with rework risk are summarized in Figure 10.

3. METHOD

The research method adopted in this study is exploratory, as it seeks greater familiarity with the problem. The use of bibliographic review and research techniques is applied when using the knowledge obtained to solve existing problems in a practical way (Marconi; Lakatos, 2003). As a research flow, a Systematic literature review (SLR) is performed, identifying the factors and their causal relationships. Then, the findings are tabulated and applied in the construction of the causal diagram, which allows the structural analysis of the relationships between factors in the system.

Systematic literature review

SLR is a structured form of research that uses systematic and explicit methods to identify, select and critically evaluate relevant research on a particular topic (Moher *et al*., 2010).

Cause	Effect	Polarity	References
Project Team Performance	Time Risk	-	Gudienė et al.(2014); Guia PMBOK® (2017); Jiayuan Wang e Hongping Yuan(2017); Kang et al.(2013); Ko e Chung(2014); Li e Taylor(2014);Tennant et al.(2011)
Change Requests	Time Risk	+	Jiayuan Wang e Hongping Yuan(2017)
Rework Risk	Time Risk	+	"Han et al.(2012); Jiayuan Wang e Hongping Yuan(2017); Love et al.(2010); Han et al.(2013); Love et al.(2014); Safapour e Kermanshachi(2019)"
Supplier Performance	Time Risk	-	Qianqian JU et al.(2017)
Lack of Materials	Time Risk	+	Castro-Lacouture et al.(2009); Heravi e Eslamdoost(2015); Rojas(2013)
Supplier Performance	Lack of Materials	-	Doloi(2013)
Rework Risk	Lack of Materials	+	Han et al.(2013)
Time indicator	Time risk	-	Relação Lógica

Figure 3. Factors related to term risk

Source: The authors themselves and adapted from Bayer and Gann (2007).

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

Cause	Effect	Polarity	References
Project Team Performance	Scope Control	+	Guia PMBOK® (2017)
Change Requests	Scope Control	-	Masudifar e Fardad(2013)
Scope Control Indicator	Scope Control	+	Relação Lógica

Figure 4. Factors related to scope control

Source: The authors themselves and adapted from Bayer and Gann (2007).

Cause	Effect	Polarity	References
Scope Control	Cost Overrun Risk	-	Guia PMBOK® (2017); Kang et al.(2013)
Rework Risk	Cost Overrun Risk	+	Adoko et al. (2015); Doloi(2013); Han et al.(2012); Han et al.(2013); Love et al.(2010); Love et al.(2014); Safapour e Kermanshachi(2019)
Supplier Performance	Cost Overrun Risk	-	Doloi(2013); Qianqian JU et al.(2017)
Customer Relationship	Cost Overrun Risk	-	Voinov e Bousquet(2010)
Time Risk	Cost Overrun Risk	+	Adoko et al. (2015); Guia PMBOK® (2017);

Figure 5. Factors related directly to cost overruns risk

Source: The authors themselves and adapted from Bayer and Gann (2007)

Cause	Effect	Polarity	References
Time Risk	System Pressure	+	Bayer e Gann(2007); Han et al.(2013)
Cost Overrun Risk	System Pressure	+	Ahiaga-Dagbui et al.(2017)
Customer Relationship	System Pressure	-	Voinov e Bousquet(2010)
System Pressure	Rework Risk	+	Han et al.(2013); Houston et al.(2001)
Top Management Involvement	System Pressure	+	Houston et al.(2001)

Figure 6. System pressure related factors

Source: The authors themselves and adapted from Bayer and Gann (2007)

Cause	Effect	Polarity	References
Project Duration	Change Requests	+	Anastasopoulos et al.(2010); Chang Lee et al.(2009); Olaniran et al.(2015)
Contract Value	Change Requests	+	Anastasopoulos et al.(2010)
Proactive Customer Participation	Change Requests	-	Chang Lee et al.(2009)

Figure 7. Factors related to change requests

Source: The authors themselves and adapted from Bayer and Gann (2007).

Cause	Effect	Polarity	References
Project Team Performance	Customer Relationship	+	Guia PMBOK® (2017)
Project Team Integration	Customer Relationship	+	Guia PMBOK® (2017); Tennant et al.(2011)
Project Manager Experience	Customer Relationship	+	Chang Lee et al.(2009); Masudifar e Fardad(2013); Meier(2010); Yang et al.(2010)
Top Management Involvement	Customer Relationship	+	Chang Lee et al.(2009)
Response Time	Customer Relationship	+	Bergerud(2012); Chang Lee et al.(2009)
Effective Communication	Customer Relationship	+	Cervone(2014); Doloi(2013); Kiani Mavi e Standing(2018);
Adequate Resource Allocation	Customer Relationship	+	Chang Lee et al.(2009)
Customer Experience	Customer Relationship	+	Cerpa e Verner(2009); Chang Lee et al.(2009); Gudienė et al.(2014); Love et al.(2010)
Customer Relationship	Proactive Customer Participation	+	Chang Lee et al.(2009)
Project Team Autonomy	Customer Relationship	+	Guia PMBOK® (2017)
Customer Satisfaction Indicator	Customer Relationship	+	Relação Lógica
Time Risk	Customer Relationship	-	O'Connor et al.(2016)
Rework Risk	Customer Relationship	-	Bayer e Gann(2007)

Figure 8. Factors related to customer relationships

Source: The authors themselves and adapted from Bayer and Gann (2007).

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

In this study, the elementary precepts of the research, selection, eligibility and inclusion of references advocated in the PRISMA method recommendations are applied (Moher *et al*., 2010). The scheme in Figure 11 shows how these elementary steps are implemented. In this scheme, the numbers entered in parallelograms represent the amount of articles present in that segment of the flow.

Search for article identification

The process of defining keywords and subsequent search is divided into two phases: the first with broad search terms and the second with more specific terms based on the first search result.

The first phase search was performed in the EBSCOhost database, in the "Academic Source" and "Academic Search Premier" databases, using the "Boolean/phrase" search mode. The keywords of this phase were: *Project Management AND Failure AND Cost overrun; Project Failures AND Project Management AND Reason; Project Failures AND Project Management AND Cause; Project Failures AND Project Management AND Factor; Project Management AND Critical Factors AND Success; Project Management AND Critical Factors AND Success; Systems Dynamics AND Project Mana-*

Cause	Effect	Polarity	References
Workload	Project Team Performance	-	Bayer e Gann(2007); Heravi e Eslamdoost(2015); Jiayuan Wang e Hongping Yuan(2017)
Workload	Motivation	-	Han et al.(2012); Houston et al.(2001)
System Pressure	Project Team Performance	-	Bayer e Gann(2007); Houston et al.(2001); Olaniran et al.(2015)
System Pressure	Motivation	-	Cerpa e Verner(2009); Houston et al.(2001)
Adequate Resource Allocation	Project Team Performance	+	"Bayer e Gann(2007); Cerpa e Verner(2009); Cheng et al.(2009); Doloi(2013); Joglekar e Ford(2005); Gudienė et al.(2014); Heravi e Eslamdoost(2015); Olaniran et al.(2015); Rojas(2013); Safapour e Kermanshachi(2019)"
Project Team Integration	Project Team Performance	+	Anvuur e Kumaraswamy(2016); Doloi(2013); Günsel e Açikgöz(2013); Guia PMBOK® (2017); Heravi e Eslamdoost(2015); Paul et al.(2016); Tennant et al.(2011)
Solicitações de Mudança	Workload	+	Bayer e Gann(2007)
Rework risk	Workload	+	Han et al.(2012); Han et al.(2013); Heravi e Eslamdoost(2015)
Time risk	Workload	+	Bayer e Gann(2007); Jiayuan Wang e Hongping Yuan(2017)
Effective Communication	Project Team Performance	+	Love et al.(2010); Olaniran et al.(2015)
Top Management Involvement	Project Team Performance	+	Kiani Mavi e Standing(2018); Ozorhon e Karahan(2017)
Competition for Adequate Resources	Adequate Resource Allocation	-	Castro-Lacouture et al.(2009); Ozorhon e Karahan(2017);
Project Team Autonomy	Project Team Performance	+	Anvuur e Kumaraswamy(2016); Günsel e Açikgöz(2013); Guia PMBOK® (2017)
Response Time	Project Team Performance	+	Bergerud(2012); Jiayuan Wang e Hongping Yuan(2017)
Motivation	Project Team Performance	+	Heravi e Eslamdoost(2015); Han et al.(2012); Rojas(2013)
Project Manager Experience	Project Team Performance	+	Gudienė et al.(2014); Heravi e Eslamdoost(2015); Jiayuan Wang e Hongping Yuan(2017); Tennant et al.(2011); Olaniran et al.(2015); Paul et al.(2016);
Project Manager Experience	Adequate Resource Allocation	+	Bonghez(2013)
Technical Team Performance	Project Team Performance	+	Jiayuan Wang e Hongping Yuan(2017); Love et al.(2010); Meier(2010); Safapour e Kermanshachi(2019)
Cost Overrun Risk	Adequate Resource Allocation	-	Joglekar e Ford(2005)

Figure 9. Factors related to team performance

Source: The authors themselves and adapted from Bayer and Gann (2007).

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

Cause	Effect	Polarity	References
Change Requests	Rework risk	+	Love et al.(2010)
Project Team Performance	Rework risk	-	Guia PMBOK® (2017); Han et al.(2012); Kang et al.(2013); Ko e Chung (2014); Li e Taylor (2014)
Contract Value	Rework risk	+	Forcada et al.(2017); Gudienė et al.(2014); Olaniran et al.(2015)
Customer Distance	Rework risk	+	Forcada et al.(2017)
Tacit Customer Knowledge	Rework risk	-	Chang Lee et al.(2009); Guia PMBOK® (2017); Voinov e Bousquet(2010)
References Availability	Rework risk	-	Chang Lee et al.(2009); Guia PMBOK® (2017)
Rework Indicator	Rework risk	-	Relação Lógica
Scope Control	Rework risk	-	Guia PMBOK® (2017)

Figure 10. Factors related to the risk of rework

Source: The authors themselves and adapted from Bayer and Gann (2007).

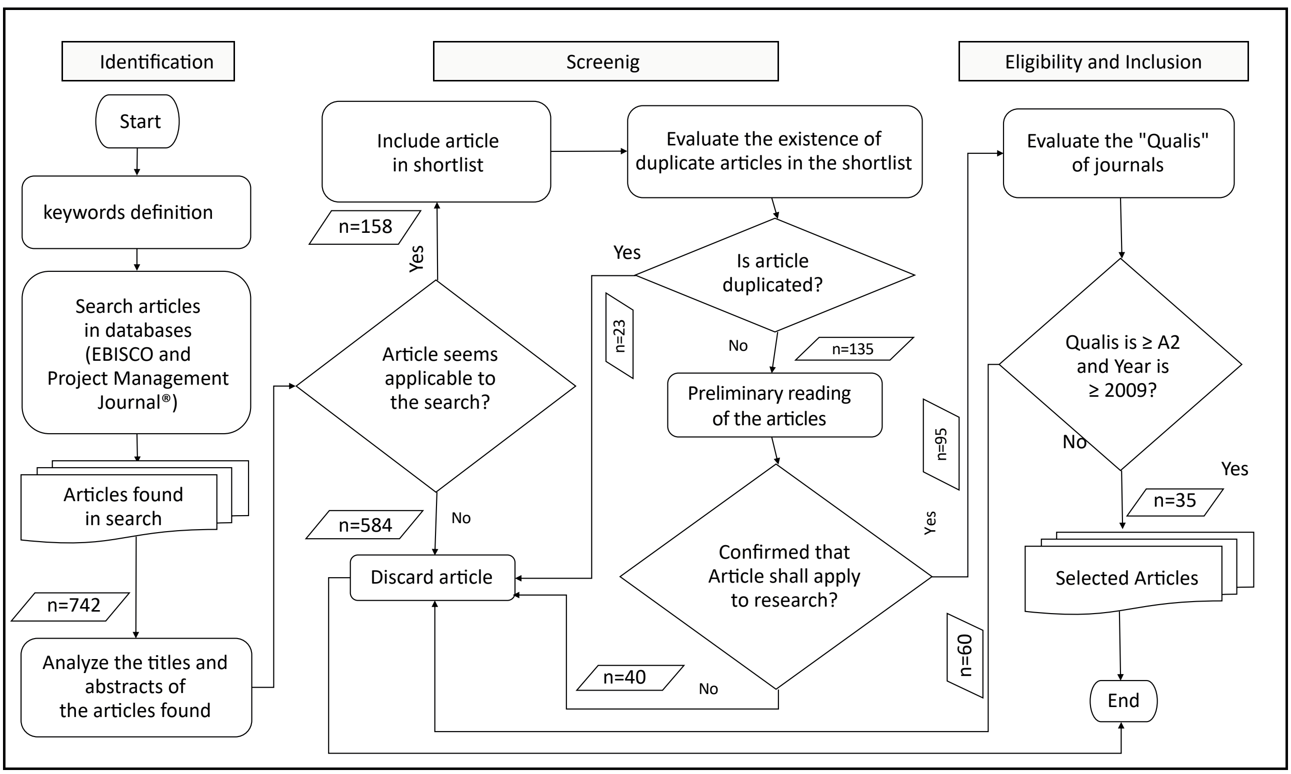

Figure 11. Flowchart of systematic literature review

Source: The authors

gement; Systems Dynamics AND Project Success; Systems Dynamics AND Project Cost; Systems Dynamics AND Cost Overruns; Systems Dynamics AND Project Failure.

The keywords of the second phase of the EBSCOhost search were: *"project management" AND AB "customer" AND "cost overrun"; "project management" AND "team performance" AND "cost"; "project management" AND "scope creep" AND "cost"; "project management" AND AB "delay" AND AB "cost"; "project management" AND AB "rework" AND AB "cost"; "project management" AND "team performance"; "neural network" AND AB "project management"; "neural network" AND "cost prediction"; "neural network" AND "cost overrun"; "neural network" AND "project risk".*

In the second phase, the Project Management Institute (PMI) website was also consulted at https://www.pmi.org/learning/library?topics=Cost+Control, with selection filters in "*Project Management Journal*" and "*Conference Papers*".

As a result of the two research phases, 742 articles were found that followed the selection stage (Figure 11).

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

Selection, eligibility and inclusion of references

In the selection stage (Figure 11), 584 articles were discarded after reading titles and abstracts for immediate observation that are not applicable to the context and purpose of this research. The remaining 158 articles were uploaded to the "Zotero" tool (available at https://www.zotero.org/) to facilitate data organization and extraction.

By performing isolated searches with each keyword, there is a possibility that articles can be found in more than one search, generating duplicates. Performing this verification, 23 articles in duplicate were found and were also discarded, remaining a total of 135 potentials. The reading of the methodology and results described in these articles was made to confirm its applicability in this research. After this reading, 95 articles were selected as applicable to this research and the remaining 40 were discarded.

Finally, in the stages of eligibility and inclusion (Figure 11), the credibility assessment of the journals for the placement of articles was performed, based on the Brazilian assessment standard, which is the "Qualis" indicator (available on "Plataforma Sucupira"; address: "https://sucupira.capes.gov.br/sucupira/"). For reasons of objectivity and rigor, it was defined that only those whose Qualis classification was A1 or A2 and whose year of publication was equal to or greater than 2009 would be part of the final selection. Following these criteria, another 60 articles were discarded, concluding the selection process with 35 articles for study.

In addition to the 35 articles selected with the SLR, which represent the basis for identifying the factors involved in the problem, this research also uses support from 16 other references obtained through manual searches in other sources. These references contain the basic project management fundamentals and methodologies applied in this research. In addition, they are recognized for the relevance of the organizations that publish them or the authors themselves in their domain areas.

Tabulation of factors and causal relationships

A tabulation of the findings is then performed to facilitate an overview of the factors and their relationships in the form of causal relationships, as proposed by Bayer and Gann (2007). This tabulation is a particularly useful resource for grouping and synthesizing the evidence found, as well as facilitating the construction of the causal diagram. The "theoretical framework" section contains the results of applying this process.

Causal diagram

The development of system dynamics techniques has its origins in Electrical Engineer Jay W. Forrester at the Massachusetts Institute of Technology (MIT) (Forrester, 1968), and today there are different software programs that allow the construction of causal diagrams. In this study, Vensim®PLE software was chosen because it meets the research needs and offers free distribution for educational use.

Based on Morecroft (2015), the causal relationship diagram is a useful tool for better understanding the relationship between the factors involved and for visualizing the systemic complexity that permeates the problem under study, in this case, the risk of cost overruns. Every diagram is constructed from basic elements such as keywords and connectors, which are organized to represent the connection between variables. In turn, the polarity ("+" and "-" signs) indicates the balance of this relationship. A positive polarity indicates that increasing the value of the source variable implies increasing the value it affects. A negative sign represents an inverse relationship between the variables; that is, an increase in the source variable implies a reduction in the destination variable.

After the causal diagram has been consolidated, the analysis tool called the "diagram tree" was used. It serves to isolate and elucidate the causal structure associated with variables of interest. In this structure, when the name of a variable is enclosed in parentheses, it means that it has already been cited earlier.

4. RESULTS AND DISCUSSION

In addition to the results already anticipated in the composition of the theoretical framework, this section contains the causal diagram resulting from the grouping of relationships between the identified factors, as well as analyzes and discussions on merit.

Causal diagram

Figure 12 shows the causal diagram that represents the system resulting from the integration of cause and effect relations, presented in the theoretical framework.

Using the Vensim®PLE Loop Analysis Tool, 233 loops (closed loop where feedback occurs) are related to the cost overruns risk. Some of these loops are almost immediately visualized because they involve few causal relationships. However, the complexity increases as the number of factors involved also increases and, in this diagram, some loops involve up to 12 factors, making a systemic assessment unfeasible without adequate computational resources.

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

An example of a loop that involves few factors is that of the following route: Cost Overrun Risk → Adequate Resource Allocation → Project Team Performance → Rework Risk → Cost Overrun Risk. This loop highlights a classic managerial misconception that it seeks to reduce the risk of cost overruns only with resource containment actions. However, as can be seen from the causal diagram, this isolated action may even increase the risk of cost overruns due to causal interactions between the factors.

On the other hand, an example of an extensive loop highlighted with the diagram in Figure 12 may be as follows: Cost Overrun Risk → System Pressure → Motivation → Project Team Performance → Customer Relations → Proactive Participation Scope Requests → Scope Control → Rework Risk → Shortages → Term Risk → Cost Overrun Risk. Following analogous reasoning to the previously exemplified loop, this cycle shows that, in a cost overruns scenario, exacerbated or uncontrolled system pressure can contribute to increasing the risk of cost overruns rather than reducing it.

Diagram Trees

The diagram trees presented in this section are just some practical examples in order to elucidate the possibilities of extracting information from the causal diagram resulting from this research.

The tree of Figure 13 presents the visualization of the factors that influence the cost overruns risk, according to the model and causal relations obtained in this research. The tree structure presents the factors grouped into levels according to their direct or indirect impact on cost overruns risk. For example, the lack of materials is a direct cause for project term risk; however, as project delays increase the risk of cost overruns, the lack of materials is an indirect cause of cost overruns.

In the diagram tree of Figure 14, you can see the factors impacted by the project team performance.

Figure 15 presents the cost overruns splitting tree. This tree represents the potentially negative effects of the cost overruns risk itself. This is a point that requires special attention from project managers and the sponsor, so as not to make hasty or uncontrolled decisions, the unfolding of which may increase the problem of cost overruns rather than control it.

Limitations and Risks

For the focus of the study, a context simplification was considered, since no elements related to the organizational environment, the process of selling the projects themselves,

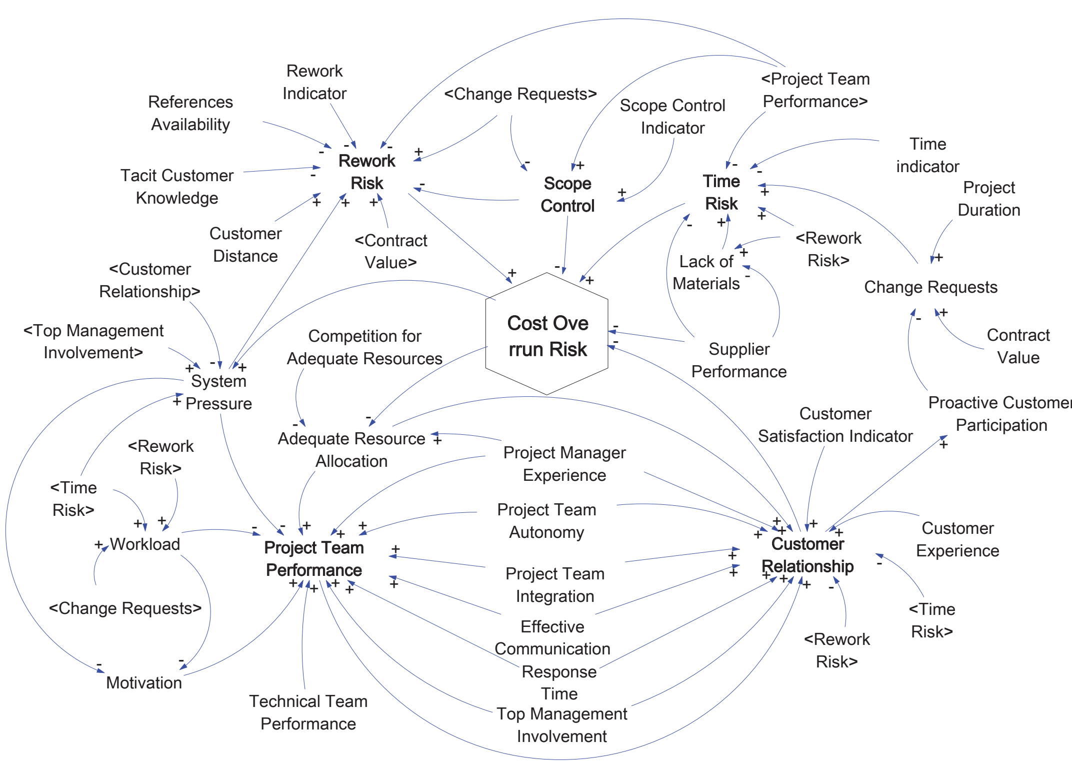

Figure 12. Causal diagram
Source: The authors

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

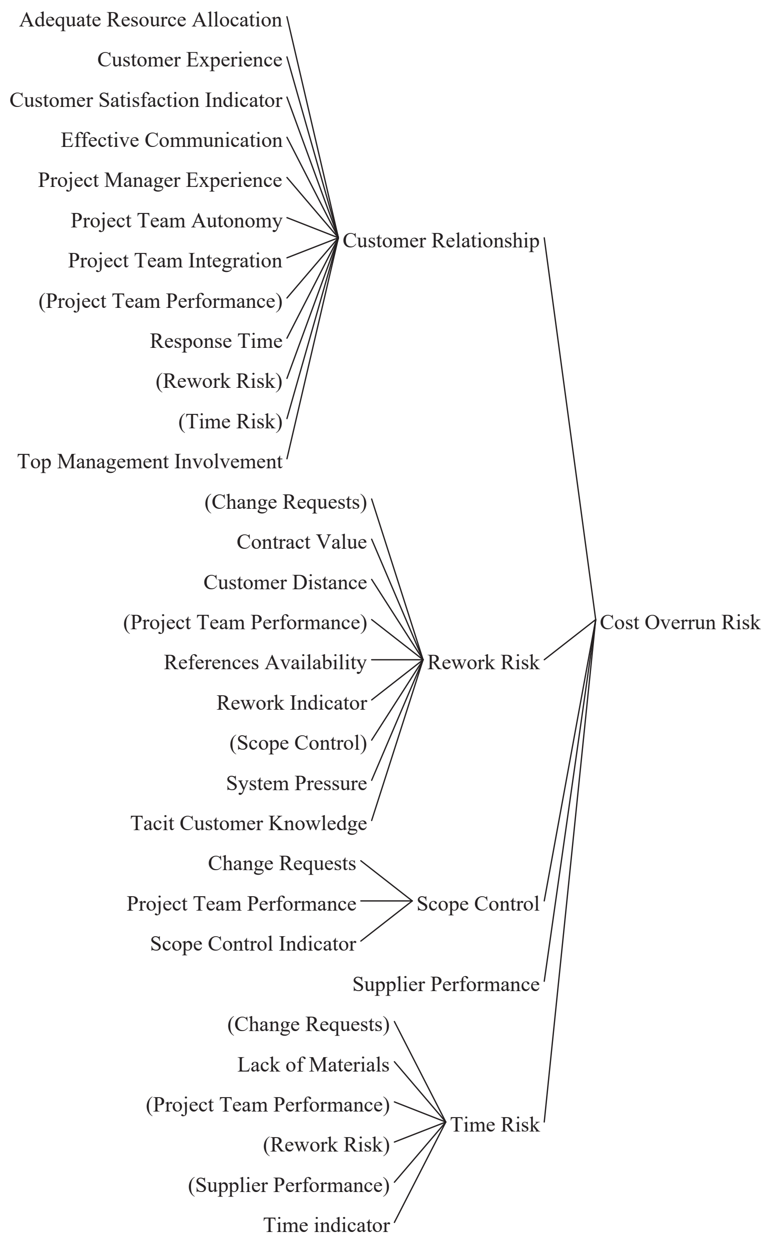

Figure 13. Diagram tree: Factors influencing cost overrun risk
Source: The authors

or the relationship of the project with other projects, such as programs and portfolio, were selected.

It is noteworthy that one of the difficulties inherent in this research is the interpretation of the elements studied by each author, so that it is possible to group in high level factors. In this context, "high level" means that the factor must be representative of the problem, but at the same time broadly applicable, allowing for management and systemic approaches. Thus, specific problems, such as redoing a technical specification or rebuilding a component by manufacturing error, are all grouped into a high-level factor called "rework". Since it is not a trivial activity, both from a technical and operational effort point of view, this grouping of elements into high level factors may contain misinterpretations and association.

Even though the limitations and risks presented represent low potential for deviation in the results, due caution and critical judgment is recommended when applying the findings of this study.

5. CONCLUSION

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

The main objective of this study was to identify and integrate, in a systemic way, the factors, and their causal relationships that influence the risk of execution cost overruns in companies based on project sales. By performing the SLR, 27 factors that, after related in a causal diagram, enabled the visualization of the complex system as a whole were identified. The diagram trees allowed the isolation of factors to understand the causal structure associated with variables of interest.

Thus, it is concluded that the expected objective for this work was achieved, even with the limitations presented. In addition, the results obtained may contribute to better understand how the cost overruns phenomenon occurs in projects, and may support management actions aimed at risk reduction and cost control.

Final Considerations and Possible Research Outcomes

Even though the direction and polarity of the causal relationship between factors impacting on cost overruns are the same for many organizations, it is expected that each of these organizations will deliver unique results for the strengths of factor relations. This does not reduce the aggregate value of the proposed causal diagram, on the contrary. This consideration helps to understand one more particularity of the complex system, in which the phenomenon of cost overruns is inserted.

In this sense, proposing predictive models based on mathematical formulations obtained from project data specific to a business environment tends to limit the application of the model to that environment.

One possible solution to obtain more cost-effective predictive risk models that are more assertive and adaptable to a broader spectrum of scenarios would be to apply Artificial Neural Networks (ANN) resources. This vision is aligned with Vargas (2015), who advocates the application of ANN as a useful tool for accurately forecasting project budget aspects without the need for a formula-based process.

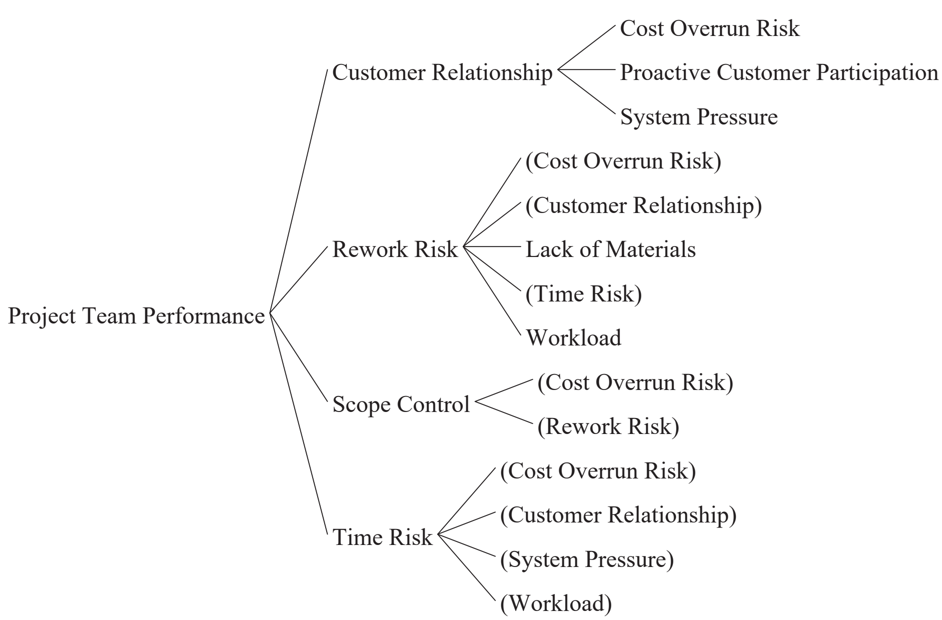

Figure 14. Diagram tree: Factors impacted by team performance
Source: The authors

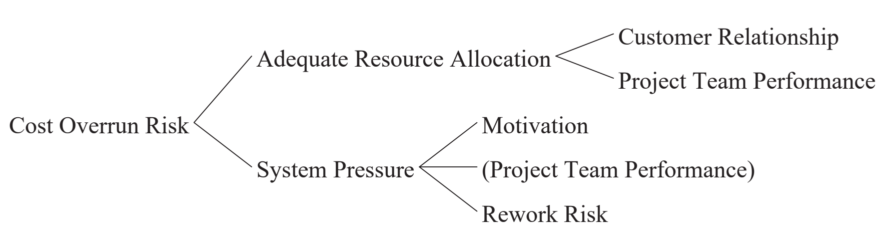

Figura 15. Diagram tree: Factors impacted by cost overrun risk
Source: The authors

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

However, according to Vargas (2015), one of the challenges for more assertive models is the preliminary effort, both time and cost, to determine the most relevant factors. Therefore, this research can help advance the application of ANN for cost overruns predictions in projects, as it contributes to the referential basis of factors related to this risk.

Since factor relevance is strongly determined by the business context, the company, by evaluating its projects against the factors proposed in this study, will not only obtain the data to develop its predictive model in ANN, but will also have a diagnosis about the strengths of correlations between all factors in its projects. This information is a valuable base of lessons learned and can be very helpful in highlighting structural problems that require corporate action because they are outside the perimeter of the project team.

The flowchart elaborated to guide the SLR can be used, totally or partially, as a guide to consult the literature for the most varied subjects.

REFERENCES

Adoko, M.T.; Mazzuchi, T.A.; Sarkani, S. (2015). "Developing a Cost Overrun Predictive Model for Complex Systems Development Projects". *Project Management Journal*, Vol. 46, p.p. 111–125, disponível em: https://doi.org/10.1002/pmj.21545 (acesso em 13 fev. 2019).

Ahiaga-Dagbui, D.D.; Love, P.E.D.; Smith, S.D. et al. (2017). "Toward a Systemic View to Cost Overrun Causation in Infrastructure Projects: A Review and Implications for Research". *Project Management Journal*, Vol. 48, pp. 88–98, disponível em: https://doi.org/10.1177%2F875697281704800207 (acesso em 13 fev. 2019).

Anastasopoulos, P.Ch.; Labi, S.; Bhargava, A.; et al. (2010). "Frequency of Change Orders in Highway Construction Using Alternate Count-Data Modeling Methods". *Journal of Construction Engineering & Management,* Vol. 136, pp. 886–893. DOI: 10.1061/(ASCE)CO.1943-7862.0000198.

Anvuur, A.M.; Kumaraswamy, M.M. (2016). "Effects of Teamwork Climate on Cooperation in Cross functional Temporary Multi-Organization Workgroups". *Journal of Construction Engineering & Management,* Vol. 142, pp. 1–13. DOI: 10.1061/(ASCE)CO.1943-7862.0001029.

Bayer, S.; Gann, D. (2007). "Innovation and the dynamics of capability accumulation in project–based firms". Innovation: Management, Policy & Practice, Vol. 9, pp. 217–234, DOI: 10.5172/impp.2007.9.3-4.217.

Bergerud, C. (2012). "The top 10 challenges to effective cost controls", artigo apresentado no PMI® Global Congress 2012—North America, Vancouver, British Columbia, Canada.

Bonghez, S. (2013). "Red pill, blue pill". Artigo apresentado no PMI® Global Congress 2013—North America, New Orleans, LA.

Castro-Lacouture, D.; Süer, G.A.; Gonzalez-Joaqui, J. et al. (2009). "Construction Project Scheduling with Time, Cost, and Material Restrictions Using Fuzzy Mathematical Models and Critical Path Method". *Journal of Construction Engineering & Management,* Vol. 135, pp. 1096–1104. DOI: 10.1061/(ASCE)0733-9364(2009)135:10(1096).

Cerpa, N.; Verner, J.M. (2009). "Why Did Your Project Fail?". *Communications of the ACM* Vol. 52, pp. 130–134. DOI: 10.1145/1610252.1610286.

Cervone, H.F. (2014). "Effective communication for project success". *OCLC Systems & Services,* Vol. 30, pp. 74–77. DOI: 10.1108/OCLC-02-2014-0014.

Chang Lee, K.; Lee, N.; Li, H. (2009). "A particle swarm optimization-driven cognitive map approach to analyzing information systems project risk". *Journal of the American Society for Information Science & Technology*, Vol. 60, pp. 1208–1221. DOI: 10.1002/asi.21019.

Cheng, M.-Y.; Tsai, H.-C.; Liu, C.-L. (2009). "Artificial intelligence approaches to achieve strategic control over project cash flows". *Automation in Construction*, Vol. 18, pp. 386–393. DOI: 10.1016/j.autcon.2008.10.005.

Doloi, H. (2013). "Cost Overruns and Failure in Project Management: Understanding the Roles of Key Stakeholders in Construction Projects". *Journal of Construction Engineering & Management,* Vol. 139, pp. 267–279. DOI: 10.1061/(ASCE)CO.1943-7862.0000621.

Forcada, N.; Gangolells, M.; Casals, M. et al. (2017). "Factors Affecting Rework Costs in Construction". *Journal of Construction Engineering & Management*, Vol. 143, pp. 1–9. DOI: 10.1061/(ASCE)CO.1943-7862.0001324.

Forrester J.W. (1968), *Principles of Systems*, MIT Press, Cambridge, MA.

Gudienė, N.; Banaitis, A.; Podvezko, V. et al. (2014). "Identification and evaluation of the critical success factors for construction projects in Lithuania: AHP approach". *Journal of Civil Engineering & Management,* Vol. 20, pp. 350–359. DOI: 10.3846/13923730.2014.914082.

Günsel, A.; Açikgöz, A. (2013). "The Effects of Team Flexibility and Emotional Intelligence on Software Development Performance". *Group Decision & Negotiation*, Vol. 22, pp. 359–377. DOI: 10.1007/s10726-011-9270-6.

Han, S.; Lee, S.; Peña-Mora, F. (2012). "Identification and Quantification of Non-Value-Adding Effort from Errors and Changes in Design and Construction Projects". *Journal of Construction Engineering & Management,* Vol. 138, pp. 98–109. DOI: 10.1061/(ASCE)CO.1943-7862.0000406.

Han, S.; Love, P.; Peña-Mora, F. (2013). "A system dynamics model for assessing the impacts of design errors in construc-

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

tion projects". *Mathematical & Computer Modelling,* Vol. 57, pp. 2044–2053. DOI: 10.1016/j.mcm.2011.06.039.

Heravi, G.; Eslamdoost, E. (2015). "Applying Artificial Neural Networks for Measuring and Predicting Construction-Labor Productivity". *Journal of Construction Engineering & Management,* Vol. 141, 4015032–1. DOI: 10.1061/(ASCE)CO.1943-7862.0001006.

Houston, D.X.; Mackulak, G.T.; Collofello, J.S. (2001). "Stochastic Simulation of risk factor potencial effects for software development risk management". *The Journal of Systems and Software*, Vol. 59, pp. 247-257. DOI: 10.1016/S0164-1212(01)00066-8.

Jiayuan W.; Hongping Y. (2017). "System Dynamics Approach for Investigating the Risk Effects on Schedule Delay in Infrastructure Projects". *Journal of Management in Engineering,* Vol. 33, pp. 1–13. DOI: 10.1061/(ASCE)ME.1943-5479.0000472.

Joglekar, N.R.; Ford, D.N. (2005). "Product development resource allocation with foresight". *European Journal of Operational Research*. Vol. 160, pp. 72-87. DOI: 10.1016/j.ejor.2003.06.021.

Kang, Y.; O'Brien, W.J.; Dai, J. et al. (2013). "Interaction Effects of Information Technologies and Best Practices on Construction Project Performance". *Journal of Construction Engineering & Management*. Vol. 139, pp. 361–371. DOI: 10.1061/(ASCE)CO.1943-7862.0000627.

Kerzner, H.; Saladis, F.P. (2009). *Value-Driven PROJECT MANAGEMENT*. John Wiley & Sons, Inc., Hoboken, NJ.

Kiani Mavi, R.; Standing, C. (2018). "Critical success factors of sustainable project management in construction: A fuzzy DEMATEL-ANP approach". *Journal of Cleaner Production* Vol. 194, pp. 751–765. DOI: 10.1016/j.jclepro.2018.05.120.

Ko, C.-H.; Chung, N.-F. (2014). "Lean Design Process". *Journal of Construction Engineering & Management*, Vol. 140, DOI: 10.1061/(ASCE)CO.1943-7862.0000824.

Li, Y.; Taylor, T.R.B. (2014). "Modeling the Impact of Design Rework on Transportation Infrastructure Construction Project Performance". *Journal of Construction Engineering & Management*, Vol.140, DOI: 10.1061/(ASCE)CO.1943-7862.0000878.

Lopes, J.S.; Braga J.L.; Filho M.A.R. (2015). "Systems dynamics model for decision support in risk assessment in software projects". *Journal of Software: Evolution and Process*, Vol. 27, pp. 976–989. DOI: 10.1002/smr.1754.

Love, P.E.D.; Edwards, D.J.; Watson, H. et al. (2010). "Rework in Civil Infrastructure Projects: Determination of Cost Predictors". *Journal of Construction Engineering & Management*, Vol. 136, pp. 275–282. DOI: 10.1061/(ASCE)CO.1943-7862.0000136.

Love, P.E.D.; Sing, C.-P.; Wang, X. et al. (2014). "Overruns in transportation infrastructure projects". *Structure & Infrastructure Engineering: Maintenance, Management, Life-Cycle Design & Performance,* Vol. 10, pp. 141–159. DOI: 10.1080/15732479.2012.715173.

Marconi, M.A.; Lakatos, E.M. (2003). *Fundamentos da Metodologia Científica*, 5ª ed. Atlas, São Paulo.

Masudifar, P.; Fardad, F. (2013). "Integration of income management and cost management". Artigo apresentado no PMI® Global Congress 2013—EMEA, Istanbul, Turkey.

Meier, S.R. (2010). "Causal Inferences on the Cost Overruns and Schedule Delays of Large-Scale U.S. Federal Defense and Intelligence Acquisition Programs". *Project Management Journal*, Vol. 41, pp. 28–39. Disponível em: https://doi.org/10.1002/pmj.20142. (Acesso em em 13 fev. 2019).

Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; The PRISMA Group (2010). "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA statement". *International Journal of Surgery*. Vol. 8, pp. 336–341. DOI: 10.1016/j.ijsu.2010.02.007.

Morecroft, J.D.W. (2015). *Strategic Modelling and Business Dynamics: A Feedback Systems Approach*, 2ª ed. John Wiley & Sons, Padstow, Cornwall, UK.

O'Connor, J.T.; Choi, J.O.; Winkler, M. (2016). "Critical Success Factors for Commissioning and Start-Up of Capital Projects". *Journal of Construction Engineering & Management*, Vol. 142. DOI:10.1061/(ASCE)CO.1943-7862.0001179.

Olaniran, O.J.; Love, P.E.D.; Edwards, D. et al. (2015). "Cost Overruns in Hydrocarbon Megaprojects: A Critical Review and Implications for Research". *Project Management Journal,* Vol. 46, pp. 126–138. Disponível em: https://doi.org/10.1002/pmj.21556 (acesso em 13 fev. 2019).

Ozorhon, B.; Karahan, U. (2017). "Critical Success Factors of Building Information Modeling Implementation". *Journal of Management in Engineering,* Vol. 33, pp. 1–10. DOI: 10.1061/(ASCE)ME.1943-5479.0000505.

Paul, R.; Drake, J.R.; Liang, H. (2016). "Global Virtual Team Performance: The Effect of Coordination Effectiveness, Trust, and Team Cohesion". *IEEE Transactions on Professional Communication*, Vol. 59, pp. 186–202. DOI: 10.1109/TPC.2016.2583319.

PMI®- Project Management Institute (2017), Guia PMBOK®, 6ª ed. Newtown Square.

PMI®- Project Management Institute (2018). "Success in Disruptive Times: Expanding the Value Delivery Landscape to Address the High Cost of Low Performance". *Pulse of the Profession*. Disponível em: https://www.pmi.org/-/media/pmi/documents/public/pdf/learning/thought-leadership/pulse/pulse-of-the-profession-2018.pdf. (acesso em 15 mar. 2019).

Qianqian JU.; Lieyun D.; Skibniewski, M.J. (2017). "Optimization Strategies to Eliminate Interface Conflicts in Complex Supply Chains of Construction Projects". *Journal of Civil Engineering & Management,* Vol. 23, pp. 712–726. DOI: 10.3846/13923730.2016.1232305.

Electronic Journal of Management & System
Volume 14, Number 4, 2019, pp. 382-399
DOI: 10.20985/1980-5160.2019.v14n4.1561

Rojas, E.M. (2013). "Identifying, Recruiting, and Retaining Quality Field Supervisors and Project Managers in the Electrical Construction Industry". *Journal of Management in Engineering*, Vol. 29, pp. 424–434. DOI: 10.1061/(ASCE)ME.1943-5479.0000172.

Safapour, E.; Kermanshachi, S. (2019). "Identifying Early Indicators of Manageable Rework Causes and Selecting Mitigating Best Practices for Construction". *Journal of Management in Engineering,* Vol. 35, pp. 1–13. DOI: 10.1061/(ASCE)ME.1943-5479.0000669.

Senge, P. (2012). *A Quinta Disciplina: Arte e Prática da Organização que Aprende*, 28ª ed. Best Seller, São Paulo.

Sterman, J.D. (1992). "*Systems Dynamics Modeling for Project Management"*. Disponível em: http://web.mit.edu/jsterman/www/SDG/project.html. (acesso em 23 mar. 2019).

Tennant, S.; Langford, D.; Murray, M. (2011). "Construction Site Management Team Working: A Serendipitous Event". *Journal of Management in Engineering*, Vol. 27, pp. 220–228. DOI: 10.1061/(ASCE)ME.1943-5479.0000053.

Vargas, R.V. (2015). "Applying neural networks and analogous estimating to determine the project budget". Artigo apresentado no PMI® Global Congress 2015—North America, Orlando, FL.

Voinov, A.; Bousquet, F. (2010). "Modelling with stakeholders". *Environmental Modelling & Software,* Vol. 25, pp. 1268–1281. DOI: 10.1016/j.envsoft.2010.03.007.

Yang, J.; Shen, G.Q.; Drew, D.S. et al. (2010). "Critical Success Factors for Stakeholder Management: Construction Practitioners' Perspectives". *Journal of Construction Engineering & Management,* Vol. 136, pp. 778–786. DOI: 10.1061/(ASCE)CO.1943-7862.0000180.

Received: Aug 02, 2019

Approved: Nov 18, 2019

DOI: 10.20985/1980-5160.2019.v14n4.1561

How to cite: Gontijo, I. J.; Braga, J. L. (2019), "A systemic analysis of cost overruns in project sales companies", Sistemas & Gestão, Vol. 14, No. 4, pp. 382-399, available from: http://www.revistasg.uff.br/index.php/sg/article/view/1561 (access day month year).