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Guilherme Alcantara Pinto, Joseph Mansour Salamé, Isabelle Nicolai

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Can we break organizational beliefs in the construction sector? Investigating possible paths to Safety Performance Measurements research.

Guilherme Alcântara Pinto – g.taminha@mail.com

Joseph Mansour Salamé

Isabelle Nicolai

Abstract

The construction industry is claimed to be the most lethal economic sector. Despite efforts to include safety as a relevant indicator, managers are still trying to figure out which organizational buttons they need to push to unleash safety performance. To investigate this problem, we draw from performance measurement lens to develop a systematic literature review aided by VOSviewer to localize safety performance measurement papers within organizational levels. We have found that safety studies are localized in the individual and micro-organizational levels, lacking a connection with macro-organizational level, and firm's organizational performance. We then underpin further investigation on this subject to allow better integration of safety into company's management system and adjacent performance measurements. By doing so we aim to push future studies on this field to conceive safety as a source of organizational performance.

Expanded abstract

Introduction

The construction industry is claimed to be the most lethal sector. Despite researchers' efforts to include safety as a relevant indicator in project and firm performance management, practitioners have been using cost/schedule measures for so long that they are still trying to figure out how to boost safety performance. In fact, this prolonged usage has created a myth: investment in occupational safety negatively impacts financial performance. Fortunately, researchers have been busting this myth!

Research problem and objective

In contrast, the myth we have been busting this myth since 1997! So, what is the problem? Why is it still so difficult to improve safety performance? What does it take to break practitioners' beliefs? To investigate this problem, this study seeks to localize safety performance measurement papers within organizational levels to present possibilities of further investigation that would allow better integration of safety into company's management system and adjacent performance measurements. By doing so, we aim to push future studies on this field to conceive safety as a source of performance.

The performance measurement complexity

Performance measurement is a complex concept. We split it in two: organizational performance and organizational effectiveness (Richard et al., 2009). Despite the complexity, the indicators employed shapes organizational beliefs and workers' behaviors – therefore, the wrong measures provoke wrong workforce reaction (Neely et al., 1997). This leads us to safety culture and behavior analysis (Guldenmund, 2007). To analyze this, we divide the firm in three:

individual, micro, and macro-organizational levels (Hofmann et al., 1995). We prepare a framework to aid further analysis in the next section.

Research Methods

We have chosen systematic review method (Denyer & Tranfield, 2009), searching performance measurement and construction industry as key strings. We have not included safety in this search because we want to analyze its interface with firm's management system. Search took place in Scopus and Web of Science databases. We then employed VOSviewer software to produce a bibliographical map to analyze concept relatedness across clusters. The map was prepared using keywords and we used it to guide our in-depth analysis along snow-ball technique.

Locating Safety Performance Measurements of construction sector companies: to where should we go?

We have found 6 clusters of papers divided by: (i) most frequent terms in the field, (ii) project management, (iii) safety-related terms, (iv) strategic/financial, (v) process management, and (vi) supply chain management. Safety cluster is spatially distant (and hence conceptually distant as well), and it is connected to the other categories by clusters (iv) and (v). We present the interfaces between the clusters regarding management and analytical approaches employed. Safety is localized in the individual and micro-organizational levels, on organizational effectiveness. We propose further investigation clues towards macro-organizational levels and organizational performance, aiming to conceive safety as a source of organizational performance.

Final Contributions

We located safety performance measurement research in the organizational context to propose further investigations towards better integration of safety into firm's management system. Very few studies have proposed methods, or theoretically analyzed safety through the macro-organizational and organizational performance lens – a strategic approach. Future studies should investigate how safety value could flow from the individual and micro-organizational level to macro-organizational level, enhancing company's performance. Finally, we draw research limitations.

Contributions/Research impact

Our greatest contribution is to evidence the research gap, which can leverage studies in the field of safety performance measurement. We try to point out possible ways in which performance measurements can better integrate safety into the management system. Studies on these gaps would break the belief of practitioners by showing them a methodology capable of conceiving safety as a source of performance, rather than just proving the relationship with analytical methods – which researchers have already been doing.

Main references

Denyer, D., & Tranfield, D. (2009). Producing a Systematic Review. In D. A. Buchanan & A. Bryman, *The Sage handbook of Organizational Research Methods* (pp. 671–689).

Guldenmund, F. W. (2007). The use of questionnaires in safety culture research – an evaluation. *Safety Science*, 45(6), 723–743.

Hofmann, D. A., Jacobs, R., & Landy, F. (1995). High reliability process industries: Individual, micro, and macro-organizational influences on safety performance. *Journal of Safety Research*, 26(3), 131–149.

Neely, A., Richards, H., Mills, J., Platts, K., & Bourne, M. (1997). Designing performance measures: A structured approach. *International Journal of Operations & Production Management*, 17(11), 1131–1152.

Paper full version

1. INTRODUCTION

Construction industry is claimed to be the most lethal economic sector (Injury Facts, 2021; OSHA, 2020). Despite researchers' efforts to include safety as a relevant indicator in project management performance (Ali et al., 2013; Dawood et al., 2006; Sibiya et al., 2015), and in firm performance (Deng et al., 2012; Latiffi et al., 2009), managers are still trying to figure out which organizational buttons they need to push unleash safety performance.

In fact, safety is definitively not the most important variable in the construction industry. Across 45 years of literature development in project management research, cost and schedule are still the most discussed terms in this sector (Pollack et al., 2018). On the other hand, all the indicators employed in an organization to measure any variable shapes organizational behavior and beliefs, according to performance measurement literature (Franco-Santos et al., 2007; Neely et al., 1997; Pavlov & Bourne, 2011).

Forty-five years discussing costs and schedule, may have impacted; indeed, they created an organizational myth (Sousa et al., 2021): Investments in occupational safety negatively impacts financial performance. Fortunately, researchers have been “busting” this myth across many industries (Sousa et al., 2021): manufacturing industry (D. K. Kim & Park, 2021), across different sectors (Argilés-Bosch et al., 2014), and even in the construction sector (Fernández-Muñiz et al., 2009; Forteza et al., 2017). In fact, this is not any novelty; researchers have been busting this myth since 1997 (Kjellén et al., 1997)!

We then question: why is it still so difficult to improve safety performance? What does it take to break practitioners' belief? To investigate this problem, this study seeks to localize safety performance measurement papers within organizational levels to present possibilities of further investigation that would allow better integration of safety into company's management system and adjacent performance measurements. By doing so, we aim to push future studies on this field to conceive safety as a source of performance.

A very recent scientometric review on construction safety performance have just been released (Bhagwat & Delhi, 2021) in the same month a preliminary version of this paper is finished. Despite their substantial contribution in the subject, we still opted to develop this research due to different problematic encompassed as well as search string and methods employed. In our study we are approaching the subject with a very specific question, trying to highlight the

interfaces that could increase safety integration into company's management system, instead of a broader comprehension of the literature as (Bhagwat & Delhi, 2021) did.

In the next section we present the theoretical lens we will be using to address this subject, in particular, key concepts of performance measurement. After, we describe the steps used to develop this research, and our findings. Finally, we draw some considerations along with the limitations and further investigations suggested.

2. THE PERFORMANCE MEASUREMENT COMPLEXITY

The subject of performance measurement is of such complexity that current literature relies on six different theories: agency theory, contingency theory, goal-setting theory, equity theory, resource-based view of the firm, and cognitive-based psychology research (Franco-Santos et al., 2012). Even though construction sector papers draw recommendations for designing performance measurement metrics (Biggs et al., 2010; Robinson et al., 2005; Yang et al., 2010), one of the main barriers on adopting performance measurement systems in this industry is the necessary knowledge on this practice (Sabone & Addo-Tenkorang, 2016). This section seeks to underpin studies on performance measurement that support the connection between safety and company performance.

One of the key references on measuring organizational performance is (Richard et al., 2009) which has proposed a methodological best practice guide to aid researchers chose which parameters could be used to assess companies' performance. Their major contribution to this study allows us to see the performance dimensions individually, yet integrated. Two elements are suggested by them for measuring performance: organizational performance (firm), and organizational effectiveness (company).

In other approaches such as the Contemporary Performance Measurement (CPM) both elements are also called respectively: financial and non-financial performance measures (Franco-Santos et al., 2012). To this study, both could be used interchangeably. We adopted (Richard et al., 2009) proposition due to its broader acceptance in literature.

The organizational performance is described in three dimensions according to (Richard et al., 2009): (a) financial performance: profit, return on assets, return on investment, etc.; (b) product market performance (sales, market share, etc.); (c) shareholder return (total shareholder return, economic value added, etc.). Even though other approaches may consider (b) as operational performance (Venkatraman & Ramanujam, 1986), this is not our intention in this study; the definition we adopt as operational performance regards the operation effectiveness, as we explain on the next paragraph.

The organizational effectiveness regards performance outcomes “associated with more efficient or effective operations and other external measures that relate to considerations that are broader than those simply associated with economic valuation (either by shareholders, managers, or customers), such as Corporate Social Responsibility” (Richard et al., 2009, p. 722).

While analyzing and handling performance measurements two key characteristics must be considered to both performances: (i) the multidimensionality and the measures researchers might adopt on this process (Richard et al., 2009; Venkatraman & Ramanujam, 1986); (ii) the “closely tailored” measures of organizational effectiveness for each individual firm and hence the highly dependence on organizational context (Richard et al., 2009). Within the scope of this

paper, we rely on both elements to draw the main discussions around our problematic. We detail them on the following paragraphs.

The first source of multidimensionality regards the fact that stakeholders have different motivations inside of a company, which may demand for different measurement needs (Venkatraman & Ramanujam, 1986). Another source is the time series impact on organizational performance; a company may (Richard et al., 2009; Venkatraman & Ramanujam, 1986). A company may sustain relative performance over time due to industry sector effects.

The impact of safety is very clear before a trade-off between safety and performance. “with economic resources becoming more and more scarce, companies were less and less willing to make ‘nonproductive’ expenditures” (Hofmann et al., 1995, p. 138). Yet, safety investments are even more important during production pressure or when least affordable (Dekker et al., 2008).

Another aspect is that measures adopted might also be highly time-dependent: the accidents impact in company’s performance is claimed to be seen one year ahead the financial performance (Argilés-Bosch et al., 2014). Reputation effect for instance, could also create feedbacks on the same performance dimension, and correlation might exist across years (Richard et al., 2009).

Moving on to the organizational effectiveness, we start by questioning: if performance measurements are only a component of the entire management system (Nunhes et al., 2017; Robson et al., 2007), could we simply propose a robust formula? According to Neely et al. (1997), the answer is no. A well-designed performance measure also comprises the organizational context in the sense that by attaining to the management system, those measures shapes workers behavior and beliefs (Franco-Santos et al., 2007; Neely et al., 1997; Pavlov & Bourne, 2011).

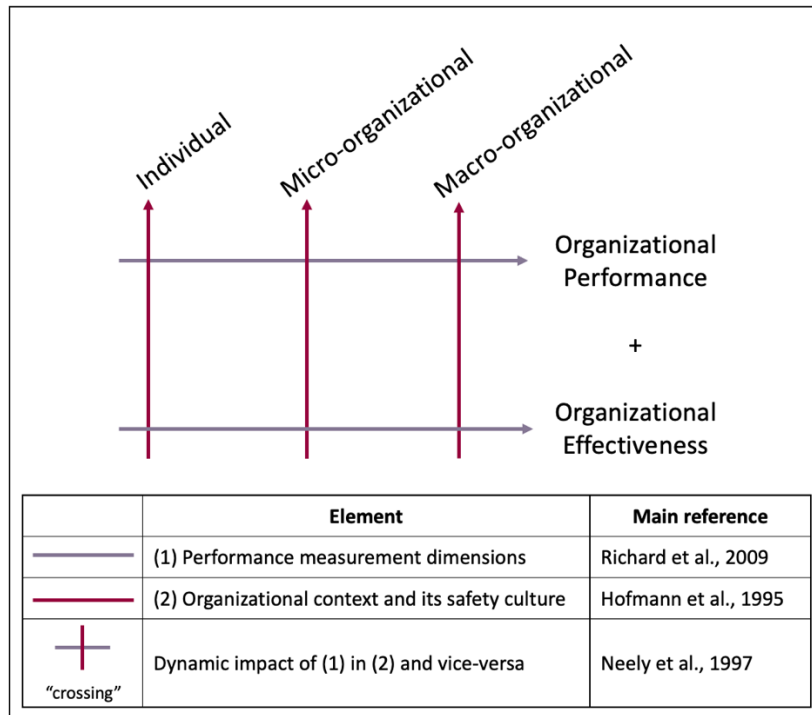
Thus, due to its “closely-tailored” nature, the wrong measures provoke wrong workforce reaction; in other words: the performance measurement (indicators) impact over performance itself – which is another source of multidimensionality (Richard et al., 2009). According to them, each company has their own set of indicators and management practices, following their strategic objectives and trajectory across time – it is highly dependent on the organizational context.

Those aspects, leads us to the culture and safety behavior (more specifically), which its importance have been highlighted in the literature review of (Collins & Gadd, 2002). Despite the most cited study on this matter is (Guldenmund, 2000), in 2007 he updates his paper (Guldenmund, 2007) arguing that a proper analysis considers that each organizational level has different perceptions of safety (Guldenmund, 2007; Yoon et al., 2013). Thus, his proposal is inspired in (Hofmann et al., 1995) that have studied how three organizational levels influence on safety: individual, micro-organizational, and macro-organizational level. We will approach our subject in a similar attempt.

The individual level lies on the comprehension of worker’s attitude, behavior and knowledge given the context and culture s/he is immersed. The micro-organizational level regards organizational self-regulation policies, management practices and attitudes towards safety, work design that create unsafe conditions, and accountability of accidents. The macro-organizational level comprises a broader view of company’s production process, higher

organizational levels (Guldenmund, 2007), the technology employed and required knowledge, vertical and horizontal communication, and the decision-making decentralization/centralization within the organization (Hofmann et al., 1995). The elements discussed on this section is summarized on Figure 1.

Figure 1 – The dynamic impact of performance dimensions on organizational structure and its safety culture (and vice-versa)



Source: Prepared by the authors

3. METHODOLOGY

The objective of this research is to locate performance measurement papers into our Figure 1. After, we need to highlight safety into this framework and then analyze to where our efforts on safety performance measurements should be directed. This objective is congruent to a systematic review of literature method since it is applicable when researchers intend to summarize the results of existing literature given a field problem to produce applicable knowledge and insight to managers, in their turn, design solutions (Denyer & Tranfield, 2009).

The articles were searched on Scopus and Web of Science database with two terms. The former is “construction industry” and its synonyms, followed by the union operator and the latter: “performance measurement”. Even though our theme regards *safety* performance measurement, we decided to not include safety in our search string because we want to assess possible interfaces that safety literature could explore towards a closer integration to company’s management system. Table 1 shows the query results.

Table 1 – Number of papers analyzed*

Scientific DataBase	Number of papers found (total)	Duplicated (-)	Retained on abstract screening (-)	Final sample
Scopus	353	149	50	378
WoS	224			
TOTAL	577			

Source: prepared by the authors

* The review data was collected on June 3rd, 2021. The synonyms employed on the search strings (shown below) were validated by specialists during research group meetings.

Scopus: TITLE-ABS-KEY ((construction_sector OR construction_industry OR construction_compan* OR construction_firm\$ OR construction_enterprise\$ OR construction_site\$ OR construction_project\$ OR construction_organization\$ OR building_organization\$ OR building_sector OR building_industry OR building_compan* OR building_firm\$ OR building_enterprise\$ OR building_project\$ OR building_site\$) AND (performance_measurement)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (LANGUAGE , "English"))

Web of Science: TS= ((construction_sector OR construction_industry OR construction_compan* OR construction_firm\$ OR construction_enterprise\$ OR construction_site\$ OR construction_project\$ OR construction_organization\$ OR building_organization\$ OR building_sector OR building_industry OR building_compan* OR building_firm\$ OR building_enterprise\$ OR building_project\$ OR building_site\$) AND (performance_measurement)) Refined by: LANGUAGES: (ENGLISH)

The duplicates removal took place in Zotero reference manager and Microsoft Excel sheet (double-checked). Articles were single screened on their abstracts only, considering conceptual, review, empirical, and viewpoints articles, published in journals and conferences, following the inclusion criteria:

- Research developed within the building industry, its companies, or implications on adjacent players such as subcontractors, suppliers, and clients.
- Research concerns performance measurement and management practices.
- Research does not analyze performance of technical aspects such as cement, concrete, chemical compounds, neither environmental issue nor objects neither software.

We employed VOSviewer software (van Eck & Waltman, 2010) to produce a bibliographical map of the field study. This is suited to this research because it shows the relatedness of the concepts investigated and their respective clusters (Van Eck & Waltman, 2013). The map was prepared according to the keywords employed by the database (author keywords in WoS and indexed keywords in Scopus). The aim was to guide our in-depth reading across the clusters, especially those that presented conceptual relatedness (we explain this concept in the next section) with our safety subject. We also employed snowball technique to enhance our comprehension when necessary.

4. LOCATING SAFETY PERFORMANCE MEASUREMENTS OF CONSTRUCTION SECTOR COMPANIES: POSSIBLE INTERFACES?

We begin our discussion presenting the result of a keyword map done on VOSviewer (Figure 2). In this Figure, each circle represents a keyword; its size is larger according to the weight of the term. In this network the weight is given by the co-occurrence of this keyword; The line going out of the circles represents the links among the concepts, which also vary its intensity: the stronger, the more papers have explored this connection. The spatial distance between the terms represents their relatedness (which is calculated by co-cited references) and the color represents the cluster from which that term belongs (Van Eck & Waltman, 2013).

We produced this map using 286 keywords considering a minimum number of three occurrences for each keyword (we had 2079 keywords in total, but only 286 were mentioned at least three times). We found six clusters; we interpreted those groups according to their elements. The first cluster (in red, 76 items) is the larger one, and contain terms such as: performance measurement, benchmarking, BSC (Balanced Scorecard), EFQM Model (European Foundation for Quality Management Model), KPI, and value management. We name

this group as most frequent keywords on this entire sample. This is consistent with (Deng et al., 2012; Yang et al., 2010) who stated that BSC and KPI are the most used performance measurement approaches in construction.

The green group has 60 items and is majorly formed by project management related terms such as: budget, quality and project control and indicators. We draw attention for performance measurement and management techniques and concepts such as Cost-Benefit Analysis, Earned Value Management (EVM), Interface Management (IM), and Information Theory.

In the next cluster (blue) we locate safety-related terms (the subject of our interest), with 59 elements: accident prevention, accidents, safety performance, human resource management, labor, and personnel issues, leading and lagging indicators. Note that this group is spatially distant to the others on the far right. It shows a lack of relatedness with other categories regarding performance measurement.

The conceptual similarity of the blue with the previous clusters (red – most frequent terms in performance measurement, and green – project management) is bridged by two clusters: one that we label “strategic/financial” (yellow, 41 items), and the other in pink, 28 terms, which we call “process management”. Those two groups seem to be of key importance of our study because they are the conceptual interface with the other clusters.

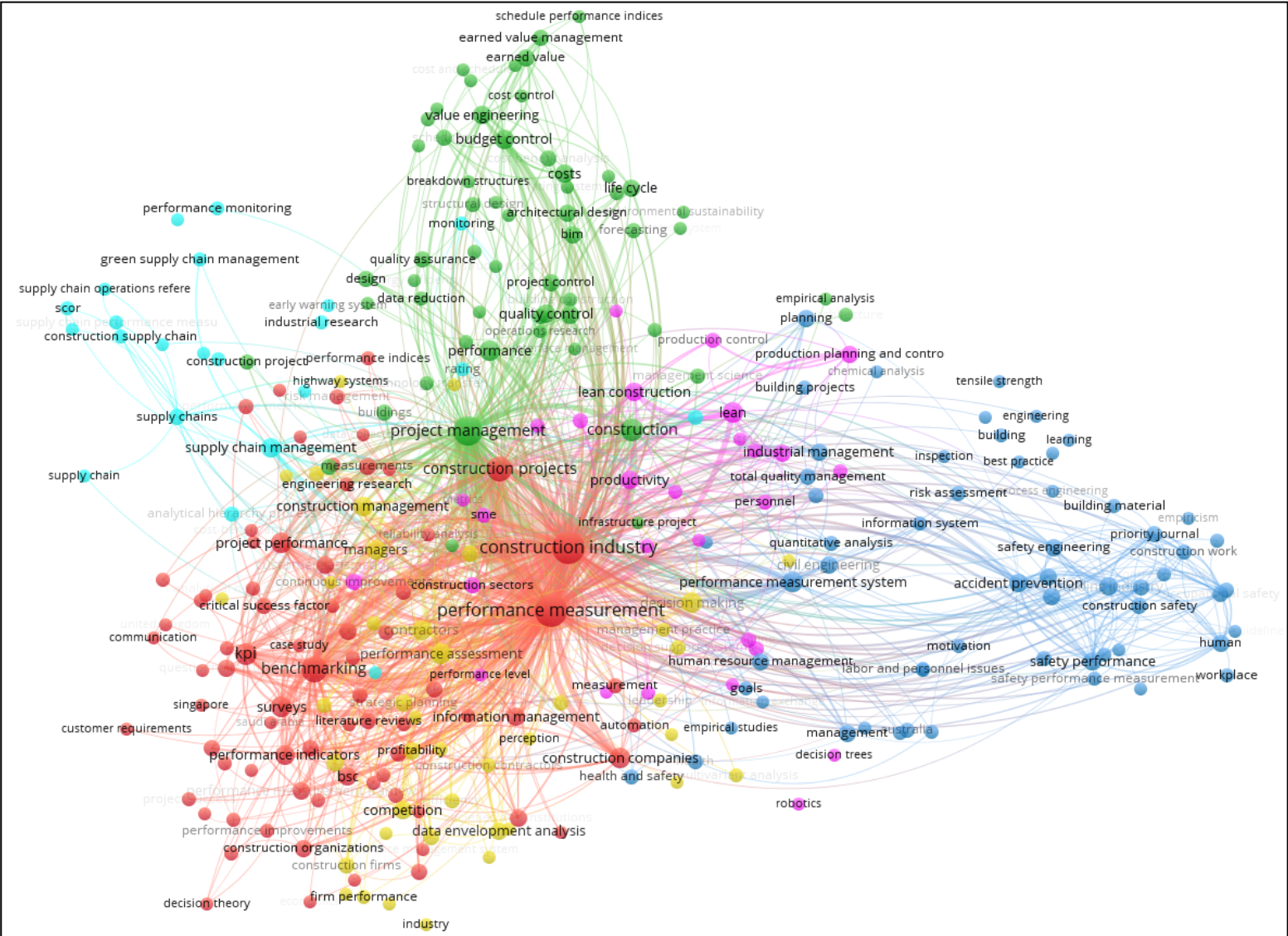
The strategic/financial clusters were as so named due to its higher density on the bottom left of the network. Despite its spreadness, and not so numerous, the terms are mostly ranging from competition, competitive advantage, profitability, firm performance to stakeholders. Its extent means that researchers have been publishing related studies across the map.

Plus, despite its conceptual interface with safety, few studies have attempted to bridge both themes. In our sample, (Latiffi et al., 2009) found out that that safety is an element of strategic non-financial performance using semi-structured interviews. Other approaches to bridge both fields have employed analytical methods rather than management ones.

We labeled the pink cluster as "process management" due to its lean (production and construction), production planning and control, and quality management elements. Bridging with safety, researchers have proposed models to integrate construction production areas to safety. For instance, Safety Planning and Control – SPC Model (Saurin et al., 2004), the integration of lean concepts into the SPC Model (Saurin et al., 2008), the investigation of Last Planner System and its impact on safety when employed together with EVM (Earned Value Management) (S.-C. Kim et al., 2015).

The last cluster (in cyan) has 22 elements; we labeled this group as supply chain due to elements such as supply chain management, green supply chain management, and logistics. Researchers have been adapting SCOR Model (Cheng et al., 2010; Thunberg & Persson, 2014) to analyze the building industry supply chain.

Figure 2 – Keyword network from VOSviewer; data from authors' keywords (WoS) and indexed keywords (Scopus)



Source: Prepared by the authors using VOSviewer software (van Eck & Waltman, 2010)

We provide in Figure 3 possible conceptual paths on performance measurement according to different level of analysis. To do so, we approximate the level of analysis according to the clusters (same colors on both figures) we have found on Figure 2. The aim is to aid practitioners and researchers to have an overview about the analytical and management approaches that have been used on the performance measurement literature in the building sector. It does not seek to cover the entire literature exhaustively on the subject given the steps employed on previous section, though. Plus, researchers must ensure methodological and theoretical fit since we have not discussed these elements here.

Figure 3 – Analytical and management approaches employed in performance measurement

Analysis Level	Site level – Safety	Site level – project (green)	Organizational level Org. effectiveness	Organizational level Strategic/ Financial
Site – project	BSC, Lean approaches; Production Planning and Control; SPC Model; total quality management Interface management	–	–	–
Org. Level org. effectiveness	Benchmarking, BSC, KPI, performance measurement system; human resource management; goal measurement; information management	Project performance; value engineering; earned value management; cost control; Interface Management, Managers Performance, Critical Success Factors; KPI; Benchmarking; technology transfer measures	–	–
Org. Level Strategic/ financial	BSC, (No other clear management approach identified* ; mainly, the methods relied on linear regression, multivariant analysis; data envelopment analysis)	(No clear management approach identified* ; mainly, the methods relied on linear regression, multivariant analysis; data envelopment analysis)	BSC; Benchmarking; Knowledge Management, Information management, Profitability measures; firm performance measures	–
Suppliers	Project/Process Management (green/pink groups); performance monitoring	SCOR Model; Supply Chain Management, logistics measures; technology transfer measures;	Supply Chain Management, Customer Requirement; Value Management;	No clear management approach identified*

* Only analytical approaches have been employed

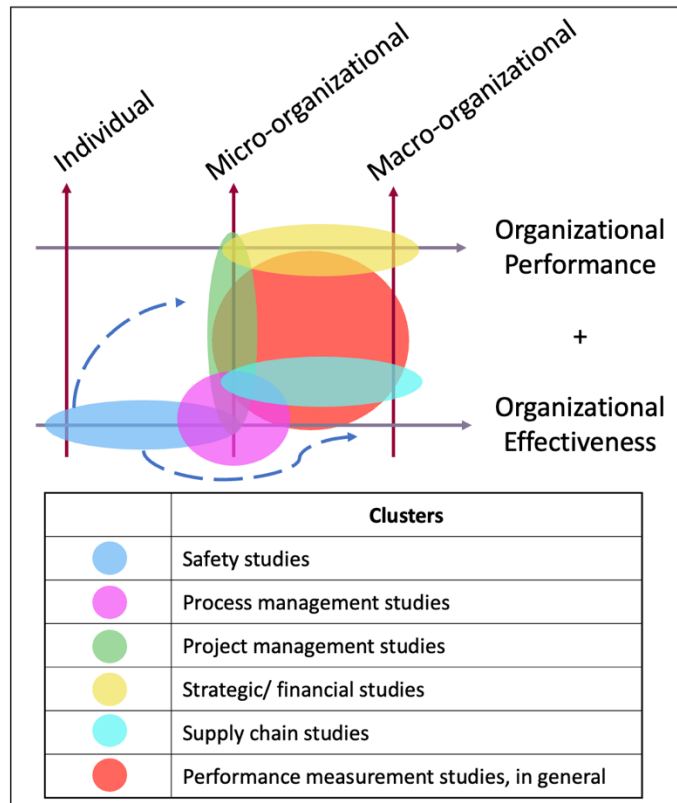
Source: prepared by the authors

On Figure 3, we have chosen to prepare it asymmetrically to highlight the interface among the clusters. Plus, the pink cluster (process management) is not present as a column, or a row. Instead, it is still present due to its “connection capability” among the clusters: its elements are present in many intersections among clusters. We observe that many tools and approaches have already explored the integration of safety, especially on the site and project level. However, on strategic level, studies often rely on analytical techniques, rather than a management and theoretical approach.

4.1 To where should we go?

To answer our research question, in Figure 4 we place the clusters in our theoretical background framework prepared in section 2. We draw our discussion focusing on safety studies on the following paragraphs.

Figure 4 – Performance Measurement research



Source: prepared by the authors

We observe a predominance of safety performance measurement studies on the organizational effectiveness positioning safety on the individual level (workers’ attitudes and behavior) and especially on micro-organizational level (organizational self-regulation policies, management practices, studies of work-design that create and avoid unsafe conditions) (Hofmann et al., 1995). The studies on the individual level are not numerous if compared to the total (performance measurement), and they have tried to propose indicators comprehending worker’s cognition and behavior (Cameron & Duff, 2007), often relying on behavioral-based safety suits the individual dimension (Choudhry, 2014; Lingard & Rowlinson, 1997).

Corresponding to (Neely et al., 1997) statement that performance measurements shape organizational behavior and beliefs, to the best of our knowledge, no studies have investigated the impact of performance measurements (red cluster) into safety behavior. A possible hypothesis could be: “have workers rushed on their task because they felt behind the schedule and hence exposed themselves to unsafe conditions?” This is an example of the impact of a performance measure (red cluster) into safety performance measures (blue cluster), using the culture and beliefs lens.

On the other hand, the studies on micro-organizational level are the majority in Safety Performance Measurement (SPM) (blue). The studies strive to develop the research on SPM Systems, and often rely on the discussion of leading and lagging indicators (Guo & Yiu, 2016; Xu et al., 2021) – in fact, Safety Science journal has an entire special issue on this subject

(Hopkins et al., 2009). Even though recent studies have used Resilience Engineering approach (Penaloza et al., 2020), which is considered to be paradigmatic in safety literature, they still present a punctual assessment of safety systems rather than a continuous measurement that could be of a more recurrent use by practitioners allowing more fluid integration in company's management system – this is the case of the Resilience Analysis Grid (RAG) (Hollnagel, 2017b), in our opinion. Still on this level, researchers have explored risk assessment measures (Mhatre et al., 2017), and deployment of metrics for new technologies that monitors real-time safety data (Ding et al., 2013).

In the macro-organizational level, however, very few studies have considered safety performance measurement on higher organizational levels. To the best of our knowledge, the only tool mentioned, and yet adapted, to this aim was the Balanced Scorecard (BSC) (Dulaimi & Chin, 2009; Kagioglou et al., 2001). However, in an environment of too many stakeholders, BSC is not useful (S.-G. Kim, 2010; Yang et al., 2010), and we add this to the fact that safety has extra-financial values (Latiffi et al., 2009) which could present different value flows inside the organization.

Furthermore, safety have not been proposed as a source of performance, in a more strategic sense. To do so, we see two possible paths (dashed arrows in Figure 4): safety as a source of organizational performance, or as a source of organizational effectiveness.

For the former, studies have explored the impact of safety performance measurements on organizational performance using analytical tools only (Fernández-Muñiz et al., 2009; Forteza et al., 2017). Despite this study importance, it does not translate in a method “how to improve this performance” – the relationship exists, but what do we do? The organizational levels seem to be too far (site level, and strategic level) increasing the difficulty to communicate those levels.

Since cost/schedule are the most important variables to this industry (Ali et al., 2013; Deng & Smyth, 2013; Sibiya et al., 2015), we understand that a possible path to integrate those levels is finding a connection between safety performance measurements and cost/schedule practices. The process management techniques (pink cluster) might have insights on this matter – which leads us to safety as a source of organizational effectiveness. Research should trace safety value considering different organizational levels.

For the latter, further investigation should be done on RE concept (Hollnagel, 2017a), which is as a paradigmatic concept in safety management literature (Righi et al., 2015). There is still space to propose management strategies, tools and indicators basing on Resilience Engineering (Sapeciay et al., 2019) but we see of particular importance to bridge those methods to the macro-organizational level in a sense that safety become seen as source of performance, instead of a conflicting goal inside the organization as it is proposed. Other possible paths rely on the lean practices employed, such as Lean Construction, Last Planner System and Safety Planning and Control Model (Bølviken et al., 2014; Y.-W. Kim & Ballard, 2010; Saurin et al., 2004).

Plus, we highlight that no studies in our sample (i) have proposed safety performance measurements considering ISO 45001:2018; (ii) have proposed subjective performance measures, which has their importance because they are able to translate the context dimension (Richard et al., 2009); (iii) explored safety as a source of extra-financial performance, such as corporate social performance.

5. FINAL CONSIDERATIONS

In this article we have localized safety performance measurement research in the organizational context. By doing so, we have proposed possible further research investigations exploring the interface with other performance measurement tools, towards a better integration of safety into company's management system. Our theoretical lens were the organizational performance and effectiveness to address the performance dimensions a company has, and the impact of the measurements employed on the organizational levels; namely: individual, micro, and macro-organizational level.

The studies on the individual level are not numerous and often rely on behavioral-based safety proposing indicators considering workers' cognition and behavior. None of them have explored the impact of performance measurements into safety behavior, though. Those on micro-organizational level are the majority and develop project and process management practices, including leading and lagging indicators, and measurements for new technologies.

Unfortunately, very few studies have proposed methods, or theoretically analyzed safety through the macro-organizational and organizational performance lens – in a strategic sense. This is the main research gap we have found and draw attention of researchers. Filling this gap is of keen importance because even though the organizational myth has already been busted, practitioners still facing difficulties on seeing safety as a source of performance due to their beliefs. We have proposed possible investigations on this subject, calling for studies to investigate how safety value could flow from the individual and micro-organizational level to macro-organizational level, enhancing company's performance.

More than tackling these research gaps, further studies could address our study limitations: (i) we employed a systematic review using VOSviewer – other software and techniques could provide different insights; (ii) the string employed, could consider more synonyms, especially from the performance measurement field; and (iii) we considered only articles in Web of Science and Scopus databases, even though we applied snow-ball techniques.

6. REFERENCES

- Ali, H. A. E. M., Al-Sulaihi, I. A., & Al-Gahtani, K. S. (2013). Indicators for measuring performance of building construction companies in Kingdom of Saudi Arabia. *Journal of King Saud University - Engineering Sciences*, 25(2), 125–134. <https://doi.org/10.1016/j.jksues.2012.03.002>
- Argilés-Bosch, J. M., Martí, J., Monllau, T., Garcia-Blandón, J., & Urgell, T. (2014). Empirical analysis of the incidence of accidents in the workplace on firms' financial performance. *Safety Science*, 70, 123–132. <https://doi.org/10.1016/j.ssci.2014.05.012>
- Atkinson, R. (1999). Project management: Cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International Journal of Project Management*, 17(6), 337–342. [https://doi.org/10.1016/S0263-7863\(98\)00069-6](https://doi.org/10.1016/S0263-7863(98)00069-6)
- Bhagwat, K., & Delhi, V. S. K. (2021). Review of construction safety performance measurement methods and practices: A science mapping approach. *International Journal of Construction Management*, 0(0), 1–15. <https://doi.org/10.1080/15623599.2021.1924456>

Biggs, H., Dinsdag, D., Kirk, P., & Cipolla, D. (2010). Safety culture research, lead indicators, and the development of safety effectiveness indicators in the construction sector. *International Journal of Technology, Knowledge and Society*, 6(3), 133–140.

Bølviken, T., Rooke, J., & Koskela, L. (2014). The Wastes of production in construction—A TFV based taxonomy. *Proc. 22nd Ann. Conf. of the Int’l Group for Lean Construction*, 13.

Cameron, I., & Duff, R. (2007). Use of performance measurement and goal setting to improve construction managers’ focus on health and safety. *Construction Management and Economics*, 25(8), 869–881. <https://doi.org/10.1080/01446190701268848>

Cheng, J. C. P., Law, K. H., Bjornsson, H., Jones, A., & Sriram, R. D. (2010). Modeling and monitoring of construction supply chains. *Advanced Engineering Informatics*, 24(4), 435–455. <https://doi.org/10/cctzzj>

Choudhry, R. M. (2014). Behavior-based safety on construction sites: A case study. *Accident Analysis and Prevention*, 70, 14–23. <https://doi.org/10.1016/j.aap.2014.03.007>

Collins, A. M., & Gadd, S. (2002). Safety Culture: A review of the literature. https://www.hse.gov.uk/research/hsl_pdf/2002/hsl02-25.pdf

Dawood, N., Sikka, S., Marasini, R., & Dean, J. (2006). Development of Key Performance Indicators to establish the benefits of 4D planning. *Association of Researchers in Construction Management, ARCOM 2006 - Procs 22nd Annual ARCOM Conference*, 2, 709–718. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84861175189&partnerID=40&md5=aaa9e038f6a315fe410bf7b35277fa73>

Dekker, S., Hollnagel, E., Woods, D., & Cook, R. (2008). Resilience Engineering: New directions for measuring and maintaining safety in complex systems (p. 67). Lund University School of Aviation.

Deng, F., & Smyth, H. (2013). Contingency-based approach to firm performance in construction: Critical review of empirical research. *Journal of Construction Engineering and Management*, 139(10). [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000738](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000738)

Deng, F., Smyth, H. J., & Anvuur, A. M. (2012). A critical review of PMS in construction: Towards a research agenda. In S. S.D (Ed.), *Association of Researchers in Construction Management, ARCOM 2012—Proceedings of the 28th Annual Conference (Vol. 2, pp. 807–816)*. Association of Researchers in Construction Management. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84882410666&partnerID=40&md5=cc1e830f90325e719529714132b97e9a>

Denyer, D., & Tranfield, D. (2009). Producing a Systematic Review. In D. A. Buchanan & A. Bryman, *The Sage handbook of Organizational Research Methods* (pp. 671–689). Sage Publications Inc.

Ding, L. Y., Zhou, C., Deng, Q. X., Luo, H. B., Ye, X. W., Ni, Y. Q., & Guo, P. (2013). Real-time safety early warning system for cross passage construction in Yangtze Riverbed Metro Tunnel based on the internet of things. *Automation in Construction*, 36, 25–37. <https://doi.org/10/f5jzs3>

- Dulaimi, M., & Chin, K. Y. K. (2009). Management perspective of the balanced scorecard to measure safety culture in construction projects in singapore. *International Journal of Construction Management*, 9(1), 13–25. <https://doi.org/10.1080/15623599.2009.10773119>
- Fernández-Muñiz, B., Montes-Peón, J. M., & Vázquez-Ordás, C. J. (2009). Relation between occupational safety management and firm performance. *Safety Science*, 47(7), 980–991. <https://doi.org/10.1016/j.ssci.2008.10.022>
- Forteza, F. J., Carretero-Gómez, J. M., & Sesé, A. (2017). Occupational risks, accidents on sites and economic performance of construction firms. *Safety Science*, 94, 61–76. <https://doi.org/10.1016/j.ssci.2017.01.003>
- Franco-Santos, M., Kennerley, M., Micheli, P., Martinez, V., Mason, S., Marr, B., Gray, D., & Neely, A. (2007). Towards a definition of a business performance measurement system. *International Journal of Operations & Production Management*, 27(8), 784–801. <https://doi.org/10.1108/01443570710763778>
- Franco-Santos, M., Lucianetti, L., & Bourne, M. (2012). Contemporary performance measurement systems: A review of their consequences and a framework for research. *Management Accounting Research*, 23(2), 79–119. <https://doi.org/10.1016/j.mar.2012.04.001>
- Guldenmund, F. W. (2000). The nature of safety culture: A review of theory and research. *Safety Science*, 34(1), 215–257. [https://doi.org/10.1016/S0925-7535\(00\)00014-X](https://doi.org/10.1016/S0925-7535(00)00014-X)
- Guldenmund, F. W. (2007). The use of questionnaires in safety culture research – an evaluation. *Safety Science*, 45(6), 723–743. <https://doi.org/10.1016/j.ssci.2007.04.006>
- Guo, B. H. W., & Yiu, T. W. (2016). Developing Leading Indicators to Monitor the Safety Conditions of Construction Projects. *Journal of Management in Engineering*, 32(1). [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000376](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000376)
- Hofmann, D. A., Jacobs, R., & Landy, F. (1995). High reliability process industries: Individual, micro, and macro organizational influences on safety performance. *Journal of Safety Research*, 26(3), 131–149. [https://doi.org/10.1016/0022-4375\(95\)00011-E](https://doi.org/10.1016/0022-4375(95)00011-E)
- Hollnagel, E. (Ed.). (2017a). Prologue: The Scope of Resilience Engineering by Erik Hollnagel. In *Resilience Engineering in Practice: A Guidebook* (1st ed., p. xxix). CRC Press. <https://doi.org/10.1201/9781317065265>
- Hollnagel, E. (Ed.). (2017b). Epilogue: RAG - The Resilience Analysis Grid. In *Resilience Engineering in Practice: A Guidebook* (1st ed., p. 275). CRC Press. <https://doi.org/10.1201/9781317065265>
- Hopkins, A., Hale, A. R., & Kontic, B. (2009, April). Process Safety Indicators / SRAE 2006 [Journal website]. *Safety Science*. <https://www.sciencedirect.com/journal/safety-science/vol/47/issue/4>
- Injury Facts. (2021). Most Dangerous Industries [Blog]. Injury Facts. <https://injuryfacts.nsc.org/work/industry-incidence-rates/most-dangerous-industries/>

- Kagioglou, M., Cooper, R., & Aouad, G. (2001). Performance management in construction: A conceptual framework. *Construction Management and Economics*, 19(1), 85–95. <https://doi.org/10.1080/01446190010003425>
- Kim, D. K., & Park, S. (2021). An analysis of the effects of occupational accidents on corporate management performance. *Safety Science*, 138, 105228. <https://doi.org/10.1016/j.ssci.2021.105228>
- Kim, S.-C., Kim, Y.-W., Park, K. S., & Yoo, C.-Y. (2015). Impact of measuring operational-level planning reliability on management-level project performance. *Journal of Management in Engineering*, 31(5). [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000326](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000326)
- Kim, S.-G. (2010). Risk performance indexes and measurement systems for mega construction projects. *Journal of Civil Engineering and Management*, 16(4), 586–594. <https://doi.org/10.3846/jcem.2010.65>
- Kim, Y.-W., & Ballard, G. (2010). Management Thinking in the Earned Value Method System and the Last Planner System. *Journal of Management in Engineering*, 26(4), 223–228. [https://doi.org/10.1061/\(asce\)me.1943-5479.0000026](https://doi.org/10.1061/(asce)me.1943-5479.0000026)
- Kjellén, U., Boe, K., & Hagen, H. L. (1997). Economic effects of implementing internal control of health, safety and environment: A retrospective case study of an aluminium plant. *Safety Science*, 27(2–3), 99–114. [https://doi.org/10.1016/S0925-7535\(97\)00066-0](https://doi.org/10.1016/S0925-7535(97)00066-0)
- Latiffi, A. A., Carrillo, P., Ruikar, K., & Anumba, C. J. (2009). The need for performance measurement in construction strategy development: A current scenario. *Association of Researchers in Construction Management, ARCOM 2009 - Proceedings of the 25th Annual Conference*, 403–412. <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84861019192&partnerID=40&md5=39dadd6db51ae5fb63b0be1db6d49ec0>
- Lingard, H., & Rowlinson, S. (1997). Behavior-Based Safety Management in Hong Kong's Construction Industry. *Journal of Safety Research*, 28(4), 243–256. [https://doi.org/10.1016/S0022-4375\(97\)00010-8](https://doi.org/10.1016/S0022-4375(97)00010-8)
- Mhatre, T. N., Thakkar, J. J., & Maiti, J. (2017). Modelling critical risk factors for Indian construction project using interpretive ranking process (IRP) and system dynamics (SD). In *INTERNATIONAL JOURNAL OF QUALITY & RELIABILITY MANAGEMENT* (Vol. 34, Issue 9, pp. 1451–1473). EMERALD GROUP PUBLISHING LTD. <https://doi.org/10.1108/IJQRM-09-2015-0140>
- Neely, A., Richards, H., Mills, J., Platts, K., & Bourne, M. (1997). Designing performance measures: A structured approach. *International Journal of Operations & Production Management*, 17(11), 1131–1152. <https://doi.org/10.1108/01443579710177888>
- Nunhes, T. V., Motta Barbosa, L. C. F., & de Oliveira, O. J. (2017). Identification and analysis of the elements and functions integrable in integrated management systems. *Journal of Cleaner Production*, 142, 3225–3235. <https://doi.org/10.1016/j.jclepro.2016.10.147>
- OSHA. (2020). Commonly Used Statistics. OSHA. <https://www.osha.gov/data/commonstats>

- Pavlov, A., & Bourne, M. (2011). Explaining the effects of performance measurement on performance: An organizational routines perspective. *International Journal of Operations & Production Management*, 31(1), 101–122. <https://doi.org/10.1108/01443571111098762>
- Penaloza, G. A., Saurin, T. A., & Formoso, C. T. (2020). Monitoring complexity and resilience in construction projects: The contribution of safety performance measurement systems. In *APPLIED ERGONOMICS* (Vol. 82). ELSEVIER SCI LTD. <https://doi.org/10.1016/j.apergo.2019.102978>
- Pollack, J., Helm, J., & Adler, D. (2018). What is the Iron Triangle, and how has it changed? *International Journal of Managing Projects in Business*, 11(2), 527–547. <https://doi.org/10.1108/IJMPB-09-2017-0107>
- Richard, P. J., Devinney, T. M., Yip, G. S., & Johnson, G. (2009). Measuring Organizational Performance: Towards Methodological Best Practice. *Journal of Management*, 35(3), 718–804. <https://doi.org/10.1177/0149206308330560>
- Righi, A. W., Saurin, T. A., & Wachs, P. (2015). A systematic literature review of resilience engineering: Research areas and a research agenda proposal. *Reliability Engineering & System Safety*, 141, 142–152. <https://doi.org/10.1016/j.res.2015.03.007>
- Robinson, H. S., Anumba, C. J., Carrillo, P. M., & Al-Ghassani, A. M. (2005). Business performance measurement practices in construction engineering organisations. *Measuring Business Excellence*, 9(1), 13–22. <https://doi.org/10.1108/13683040510588800>
- Robson, L. S., Clarke, J. A., Cullen, K., Bielecky, A., Severin, C., Bigelow, P. L., Irvin, E., Culyer, A., & Mahood, Q. (2007). The effectiveness of occupational health and safety management system interventions: A systematic review. *Safety Science*, 45(3), 329–353. <https://doi.org/10.1016/j.ssci.2006.07.003>
- Sabone, M., & Addo-Tenkorang, R. (2016). Benchmarking performance measurement systems in Botswana's construction sector. *Journal of Construction Project Management and Innovation*, 6, 14.
- Sapciay, Z., Wilkinson, S., Costello, S. B., & Adnan, H. (2019). Building Organisational Resilience for the Construction Industry: Strategic Resilience Indicators. *IOP Conference Series: Earth and Environmental Science*, 385, 012068. <https://doi.org/10.1088/1755-1315/385/1/012068>
- Saurin, T. A., Formoso, C. T., & Cambraia, F. B. (2008). An analysis of construction safety best practices from a cognitive systems engineering perspective. *Safety Science*, 46(8), 1169–1183. <https://doi.org/10.1016/j.ssci.2007.07.007>
- Saurin, T. A., Formoso, C. T., & Guimaraes, L. B. M. (2004). Safety and production: An integrated planning and control model. *Construction Management and Economics*, 22(2), 159–169. <https://doi.org/10.1080/0144619042000201367>
- Sibiya, M., Aigbavboa, C., & Thwala, W. (2015). Construction Projects' Key Performance Indicators: A Case of the South African Construction Industry. In Y. Wang, T. Olofsson, G. Q.

Shen, & Y. Bai (Eds.), *Iccrem 2015: Environment and the Sustainable Building* (pp. 954–960). Amer Soc Civil Engineers.

Sousa, S. R. de O., Melchior, C., Da, S. W. V., Zanini, R. R., Su, Z., & da, V. C. P. (2021). Show you the money – firms investing in worker safety have better financial performance: Insights from a mapping review. *International Journal of Workplace Health Management*, ahead-of-print(ahead-of-print). <https://doi.org/10/gkgmqc>

Thunberg, M., & Persson, F. (2014). Using the SCOR model's performance measurements to improve construction logistics. *Production Planning & Control*, 25(13–14), 1065–1078. <https://doi.org/10/f227hv>

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. <https://doi.org/10.1007/s11192-009-0146-3>

Van Eck, N. J., & Waltman, L. (2013). *VOSviewer manual*. Leiden: Univeristeit Leiden, 1(1), 1–53.

Venkatraman, N., & Ramanujam, V. (1986). Measurement of Business Performance in Strategy Research: A Comparison of Approaches. *Academy of Management Review*, 11(4), 801–814. <https://doi.org/10/bxzc8q>

Xu, J., Cheung, C., Manu, P., & Ejohwomu, O. (2021). Safety leading indicators in construction: A systematic review. *Safety Science*, 139. <https://doi.org/10.1016/j.ssci.2021.105250>

Yang, H., Yeung, J. F. Y., Chan, A. P. C., Chiang, Y. H., & Chan, D. W. M. (2010). A critical review of performance measurement in construction. *Journal of Facilities Management*, 8(4), 269–284. <https://doi.org/10.1108/14725961011078981>

Yoon, S. J., Lin, H. K., Chen, G., Yi, S., Choi, J., & Rui, Z. (2013). Effect of occupational health and safety management system on work-related accident rate and differences of occupational health and safety management system awareness between managers in South Korea's construction industry. *Safety and Health at Work*, 4(4), 201–209. <https://doi.org/10.1016/j.shaw.2013.10.002>