Revista Científica Nexo
Vol. 37, No. 1, pp. 63-82/Julio 2024

ISSN-E 1995-9516
Universidad Nacional de Ingeniería (UNI)
https://www.camjol.info/index.php/NEXO
http://dx.doi.org/10.5377/nrc.v37i01.18330

QUALITATIVE ANALYSIS ABOUT BEST PRACTICES AND PROJECT MANAGEMENT TOOLS IN INTRALOGISTICS

ANÁLISIS CUALITATIVO SOBRE MEJORES PRÁCTICAS Y HERRAMIENTAS DE GESTIÓN DE PROYECTOS EN LA INTRALOGÍSTICA

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(recibido/received: 20-03-2024; aceptado/accepted: 04-07-2024)

ABSTRACT

Project management in automotive manufacturing is crucial due to the dynamism in updating operating models and high investment in the supply chain and logistics. This article presents a systematic literature review of 134 articles (2011-2023) from four relevant databases (IEEE, ScienceDirect, Scopus, Taylor & Francis) with the purpose of exploring the best practices in project management applied in intralogistics activities. Analyzing aspects such as country, management methods and techniques, solution levels in internal logistics projects, business line, among other items. The findings will identify opportunities that contribute to academic indicators and the generation of proposals in the automotive industry in Mexico, focused on the fulfillment of projects and management according to their context.

Keywords: Project Management; Risk Management; Earned Value; Simulation.

RESUMEN

La gestión de proyectos en la manufactura automotriz es crucial debido al dinamismo en la actualización de modelos operativos y alta inversión en la cadena de suministro y logística. Este artículo presenta una revisión sistemática de 134 artículos (2011-2023) de cuatro bases de datos relevantes (IEEE, ScienceDirect, Scopus, Taylor & Francis) con la finalidad de explorar las mejores prácticas en gestión de proyectos aplicadas en la actividad intralogística, analizando aspectos como país, métodos y técnicas de gestión, niveles de solución en proyectos de logística interna, línea de negocio, entre otros rubros. Los hallazgos identificarán oportunidades que contribuyan a indicadores académicos y a la generación de propuestas en la industria automotriz en México, enfocadas en el cumplimiento de proyectos y gestión según su contexto.

Palabras clave: Gestión de Proyectos; Gestión de Riesgos; Valor Ganado; Simulación.

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1. INTRODUCTION

A project is a temporary effort to create a unique expected product, service, or result; it is designed to achieve specific objectives with a defined start and end time over a period. Generally, projects are often driven by the need to solve a problem, seize an opportunity or meet a set of requirements, which compliance with planned activities being important. In this context, some authors indicate their experience about adopting an Integrated Project Delivery (IPD) perspective, which develop a more holistic view that allows them to measure the underlying economic value of sustainable construction projects by incorporating long-term cost efficiency into decision-making (Goh et al., 2023). Different situation is seen in most of software projects that fail due to lack of project managers who are not familiar with Project Management Knowledge Areas (PMKA) and do not consider the company conditions or project contexts (Taye & Feleke, 2022).

The car production in Mexico is one of the industries with a significant market share even in adverse situations, as it rebounded by 9.24% annually in 2022 after two consecutive years of declines due to the SARS-COV-2 virus pandemic, also known as COVID-19 (Staff, 2023). With the presence of this health contingency, a global problem arose as major suppliers located in Asian continent reduced the supply of inputs, raw materials, and components for several commercial products worldwide, causing disruptions in the supply chains of various products and services (Buenrostro, 2021). Faced with this situation, the need to focus on supply chain management, risk management, and logistics became apparent in each of the companies, with logistics being one of the most important processes to ensure that the product adds value at each echelon in a supply chain, which it is arise until up to 1,560 companies in the automotive industry, for example and according to figures from the Industria Nacional de Autopartes (INA).

The complexity of the automotive supply chain is due to the number of upstream and downstream suppliers, is more complex than other conventional supply chains, especially when it comes to projects involving modifications to operations or infrastructure, as they involve extensive uncertain aspects where not all echelons in the chain are involved or there is little control over external factors. Therefore, having best practices for successful project management on logistics and supply chain is an interesting topic to explore for Mexican industry, from learning about new applied techniques, the evolution of tools and methodologies and even successful implementation cases.

This article offers a systematic literature review through a qualitative analysis that examines different techniques and methodologies over a period of 12 years (2011 to 2023) about project management techniques with the clear purpose of identifying feasible opportunities for future proposals in the Bajío industry in Mexico. The contribution of this research reveals significant advances in the field of engineering, particularly in critical areas such as transportation, construction, and project management. This approach not only emphasizes the relevance and applicability of best practices and project management tools for improving intralogistics but also highlights how these techniques are widely adopted to streamline processes and enhance efficiency in industrial and logistics environments. These findings not only strengthen the theoretical and methodological foundation of applied engineering but also provide valuable insights for designing and implementing advanced management strategies that foster innovation and enhance competitiveness across various industries.

This document consists of five sections, starting with the "introduction" section that shows the preamble of the context to be addressed in the exploration of articles; continuing with the "background" section that shows some similar articles that have been carried out by other authors; the "methodology and classification framework" section presents the selection criteria and search process for the compilation of articles; the "classification results" section shows the findings of the qualitative analysis, and finally, “conclusions and future contributions” related to the knowledge area of this article.

2. BACKGROUND

The automotive industry demands control and improvement in internal material flows, also known as intralogistics, with the aim of optimizing related resources. There are widely used methods in the industry, such as Kaizen, Jit Kaizen, or lean manufacturing; however, these methods do not delve into project time management to ensure proper resource utilization and adequate activity planning.

The risks of disruption in supply chains projects are constant due to the involvement of several actors, such as suppliers, transportation and other service providers along the decentralized chain (Ashraf & Ali, 2023). This was evident in March 2020 when COVID-19 changed the face of many markets, including e-commerce and online businesses, creating many problems and interconnected bottlenecks to resolve, so project deliveries themselves required modern solutions (Suguna et al., 2022). That circumstances prompted the search for methods, techniques and solutions to mitigate delays in ongoing or scheduled projects, exploring the advantages and disadvantages of implementing the concept of industry 4.0 as organizational support for better decision making (Sony, 2020).

Industry 4.0 technologies are a trend in the organizational environments of Micro, Small and Medium Enterprises (MSMEs), identifying which technologies should be implemented to assist the value chain (da Silva et al., 2022), in fact, industry 4.0 revolutionizes the concept of automation and digitization within the organization, generating immense interest in academia and industry. The digitalization of an organization in terms of horizontal, vertical, and end-to-end integration would change the roles played by an employee in an organization (Sony & Mekoth, 2022). A critical analysis and discussion of the fundamental importance of learning and the central human role in collaboration in Industry 4.0, based on key ideas contributed through literature review, reveal the significance of collaboration in the current era of digitalization, along with the importance of recent approaches and technology to enable or promote collaboration (Varela et al., 2022).

In other hand, it is important to mention that multiple challenges in automotive industry led to an increased need for transparency and optimization, being the Real-Time Location Systems (RTLS) the key tool to achieve this goal, enabling smart and automated production processes. Although, existing solutions such as ultra-wideband, low energy Bluetooth, or radiofrequency identification, have drawbacks in terms of costs, range, or accuracy (Küpper, 2022) that must be perfected in a short time.

3. METHODOLOGY AND CLASSIFICATION FRAMEWORK

This qualitative analysis is conducted by a systematic literature review with the possibility that the process can be replicated in the future with similar results. Methodologically, a literature review must be systematic, explicit, and reproducible approach to identifying, evaluating, and interpreting the existing body of documents (A. Fink, 2005), it differs from traditional reviews by being systematic, clear, and easily understandable (Jairo R. Montoya-Torres & Diego A. Ortiz-Vargas, 2013). The developed classification framework for this article is detailed below, comprising three significant sections: a) data collection, b) data analysis, and c) synthesis and classification framework.

A. Data collection

The process for data collection section follows three important steps to reach a compilation of relevant and significant scientific contributions for this research.

Step 1: research questions

These types of questions arise from a natural need or interest, either independently or because of pending work, providing direction and focus to literature review and subsequent research steps. The questions for this article are the follow:

1.- Is there a trend or correlation factors used in different industries to improve their intralogistics?
2.- What has been the trend of simulation use for intralogistics improvement in Mexico?
3.- Which simulation models are most used to improve intralogistics?
4.- What is the percentage of project management methodology application in intralogistics improvements?

Step 2: search for articles

This step involves reviewing prestigious and highly reliable databases, particularly four high-impact databases (Scopus, IEEE, ScienceDirect, and Taylor & Francis). These databases were chosen for their importance in academic field, their position about the multidisciplinary extension and the broader coverage of citations and abstracts reviewed on scientific articles and books (Clarivate, 2023).

In this context, Scopus is a bibliographic database launched in 2004 by Elsevier, a leading publisher of scientific, technical, and medical content. Scopus covers over 76 million records, including journal articles, conference papers, book chapters, and patents, it indexes over 24,000 journals worldwide and provides detailed citation information with a variety of metrics to assess research impact (Somasundaram, 2023). On the other hand, the content in IEEE Xplore comprises about 300 journals, around 7,000 conference proceedings, and over 1,800 standards; it is updated daily with approximately 20,000 new documents added (Lecanda Meschede et al., 2023). In this context, ScienceDirect is a full-text database offering journal articles and book chapters from over 2,500 peer-reviewed journals and 11,000 books; it also has a good complement of materials in the social sciences and business areas (Harnegie, 2013). Based on two centuries of experience, Taylor & Francis has grown rapidly over the past two decades to become a leading international academic publisher; the group publishes over 800 journals and more than 1,800 new books each year, covering a wide variety of subject areas and incorporating the imprints of Routledge, Carfax, Spon Press, Psychology Press, Martin Dunitz, and Taylor & Francis (Ithaka, 2023).

Once the databases are selected, keywords are determined to explore each of them, taking the topics shown in Table 1 as the main themes and searching for related words to consider the spectrum of existing possibilities.

Table 1. List of keywords.

Item	Topic	Main Keyword	Related words				
1.-	Logistics	Intralogistics 4.0	Intralogistics	Warehouse Logistics	Internal Logistics	In-House Logistics	Logistics 4.0
2.-	Simulation	Simulation using software	Modelling	Computer modeling			
3.-	Project	Project Managing	Project Manager	Project Management			

From the above information, a primary search string emerges to access the selected databases, considering only articles from 2011 to 2023, in English language, with a document type related to research article or literature review, and coming of a journal. This configuration is reflected in the following string:

"(KEY ("simulation" OR "simulation using software" OR "modelling" OR "computer modelling")) AND (KEY ("project" OR "project managing" OR "project manager" OR "project management")) AND (KEY ("intralogistics" OR "intralogistics" OR "intralogistic 4.0" OR "intralogistics 4.0" OR " logistics" OR "warehouse logistics" OR "internal logistics" OR "internal logistics" OR "in house logistics" OR "logistics 4.0" OR "warehouse logistic" OR

"internal logistic" OR "in house logistic" OR "logistic" OR "logistic 4.0")) AND PUBYEAR > 2010 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English"))"

It is important to mention that modifications were made to the conjunction of keywords just in the ScienDirect database, as shown below. The other criteria were selected manually like the language, document type, and resource.

"(KEY ("simulation") AND (KEY ("project management") AND (KEY ("intralogistics" OR "warehouse logistic" OR "internal logistic" OR "in house logistic" OR "logistic")"

Step 3: classification and evaluation

A total of 134 contributions are identified without discrimination. Subsequently, a comparison was made between databases, and no duplicate articles were detected, leaving a total of 134 contributions that make up the literature collection for this article. The complete set of articles was reviewed to carry out the detailed classification described in section C, corresponding to the Synthesis and Classification section. It is important to note that in this process, 19 contributions that did not meet the established criteria related to the focus, such as contributions from computational, energy economics, mathematical modeling, and decision sciences domains were excluded. In summary, the final sample submitted for evaluation and classification consists of 115 articles, representing the definitive collection to be analyzed in this literature review.

B. Data analysis

After gathering articles from reliable data sources and identifying them with a consecutive identifier code, a data extraction template is created using a spreadsheet, facilitating the classification and processing information. This template includes specific fields to categorize articles, such as publication year, document type, application domain, technique used (Project Management Institute - PMI), project control methodology, solution methodology, country, theory construction-application, among others detailed in following section. It is essential to highlight that the information gathering process was carried out with the support of Mendeley®, a secure and efficient reference manager for analysis.

C. Synthesis and classification framework

The classification framework in this article is divided into two significant parts with the purpose of distinguishing the classification related to Project Management (PM). The first part, the elements of the general descriptive analysis are detailed, covering publication year, publication source, country of origin, document type, and application domain of the 115 articles. In the second part, the components of the specific PM descriptive analysis are described, including the PMI technique or tool used, project control methodology, solution methodology, and theory construction-application. It is important to note that, in this second part, only articles considered empirical (theory construction) and empirical (theory application) from the 115 articles are selected, resulting in 90 classified contributions. The classification framework is described as follows:

1).- Publication year, source, and country

In this classification, the aim is to identify the publication year within the defined time range of 2011 to 2023 in the 115 contributions. This is done to analyze the trend in the application of project management tools in the logistics field, additionally, the publication source and the country of origin are identified according to the author's location and evaluate the influence of scientific journals and the trend in application of internal logistics or intralogistics globally.

2).- Document type

The descriptive approach of the systematic literature review proposed by (M. M. Crossan & M. Apaydin, 2010) indicates that scientific articles can be categorized from a methodological perspective into several classes: theoretical articles, literature reviews, empirical articles that construct a theory, and empirical articles that test an existing theory. Regarding “literature reviews” are contributions that specify the number of reviewed articles to highlight trends, scientific contributions, or new applicable research directions. "Empirical contributions (theory construction)” is for cases where articles propose a framework derived from experimentation, surveys, or discussions, and this framework is validated in real environments, with case studies or scientific methods. If an article focuses only in experiments or the implementation of a technique or framework in real situations without proposing reference models, it is classified as an “empirical contribution (theory application)” because it is limited to applying existing proposals, techniques, or tools and evaluates their application. On the other hand, the classification of "theoretical" is established for articles that present only discussions on specific topics without developing a framework or model, therefore, lack validation. “Meta-analysis” research is identified using metasearch engines or metadata in the research process.

3).- Knowledge area

The contributions are divided into categories based on the knowledge area in the research. These categories include computational sciences, engineering, decision sciences, business and management, mathematics, multidisciplinary, economics and finance, materials science, environmental sciences, among others according to the classification of (ELSEVIER, 2023).

4).- Research method

For this criterion, the second part of the descriptive analysis related to PM begins. The target is to identify the research method used to validate the purposed solution, common approaches in the academic field include simulation, case study, statistical validity and experimentation. It is important to note that these are not the only methos available, leaving the possibility of classifying other approaches based on future proposals.

5).- PMI technique used

The classification is carried out according to the most recurrent topics related to PM and its application. For topics addressing the implementation of Project Management, information management, and project control methodology. Regarding topics linked to PMI techniques used (Deniyage & Palliyaguru, 2019), classification as “Risk Management and Resource Management” is proposed, considering the activity plan and its fulfillment, taking corrective actions in many cases where activities are delayed or unexpected issues arise.

6).- Solution method

In this criterion, the most innovative methodologies for resolving problems in an intralogistics environment are explored to identify the functionality of different engineering tools. This is done to determine the strategies or solutions that project management employs to address logistics challenges more efficiently, for example: Warehouse Management Systems (WMS), radio-frequency identification (RFID), Warehouse Automation, Enterprise Resource Planning (ERP) systems, lean and six sigma, traceability and data analysis, simulation and process modeling, collaborative robotics, Augmented Reality (AR) and Virtual Reality (VR), as well as fleet management and vehicle tracking. The choice of methodologies and tools will depend on the specific needs of each company and its logistics environment reflected in the article. The combination of

several of these innovations can provide a comprehensive approach to internal logistics project management, improving efficiency and competitiveness.

4. CLASSIFICATION RESULTS

In this section, the result of the classification of analyzed articles is presented with the purpose of providing relevant information that highlights the importance of project management in projects related to internal logistics or intralogistics. The results of the proposed methodological framework are detailed below.

A. General descriptive analysis

This section presents the basic results of the analyzed articles:

1) Classification results by publication year

As indicated in the Figure 1, there is an upward trend until 2022, marking this as the last peak year with the highest number of contributions (32 articles of 115). Subsequently, in 2023, the trend decreases because the information concentration was conducted in the early second semester of 2023.

According to the trend shown in Figure 1, it can be argued that in the years 2020, 2021, and 2022, the number of contributions exceeds the average, which is set at 8 articles per year. In early 2019, a significant increase of successful applications about project management was glimpsed, driven by the impact of the COVID-19 pandemic, becoming an effective tool for strategic decision-making.

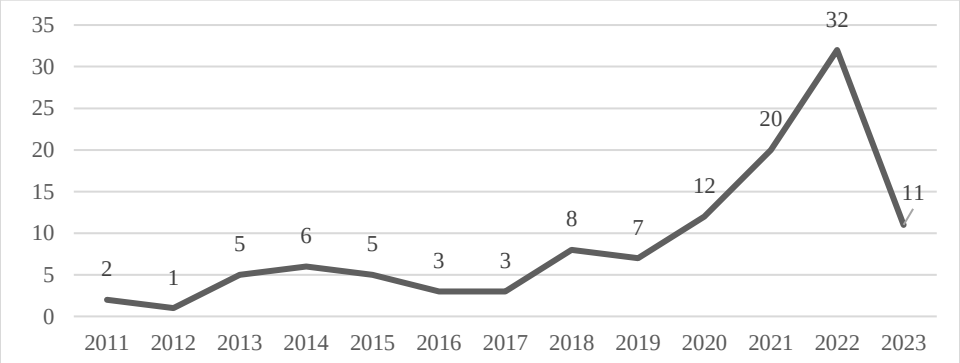

Figure 1. Trend of project management application from 2011 to 2023.

According to PricewaterhouseCoopers, in one of its globally executed research studies through a survey of 198 top-level officials in different companies on the maturity level of organizations in project management, revels 26% of companies develop more than 100 projects annually and 15% between 50 and 100 projects. Given the number of projects and investment levels, it is important to implement best practices every day to remain in business competition, starting from optimal governance of your projects that lead to organizational success and entrepreneurship, always seeking to increase positive demand for products and services focused on customers (Quitian-Tellez, 2018).

It is important to highlight that according to (Despeisse et al., 2022) manufacturers are facing increasing pressures to adapt their operations and meet production and sustainability goals, requiring the application of control and monitoring tools for compliance. In fact, technology is a crucial element for solutions, although research reveals opportunities to create and capture value in increasingly complex and connected industrial systems, additionally, digitization does not always align with sustainability, and case studies combining these two themes are still scarce.

2) Classification results by country

To highlight the relevance application about project management in different parts of the world, an analysis of the origin of the collected articles is performed to identify the country that most uses project management methodologies in intralogistics issues.

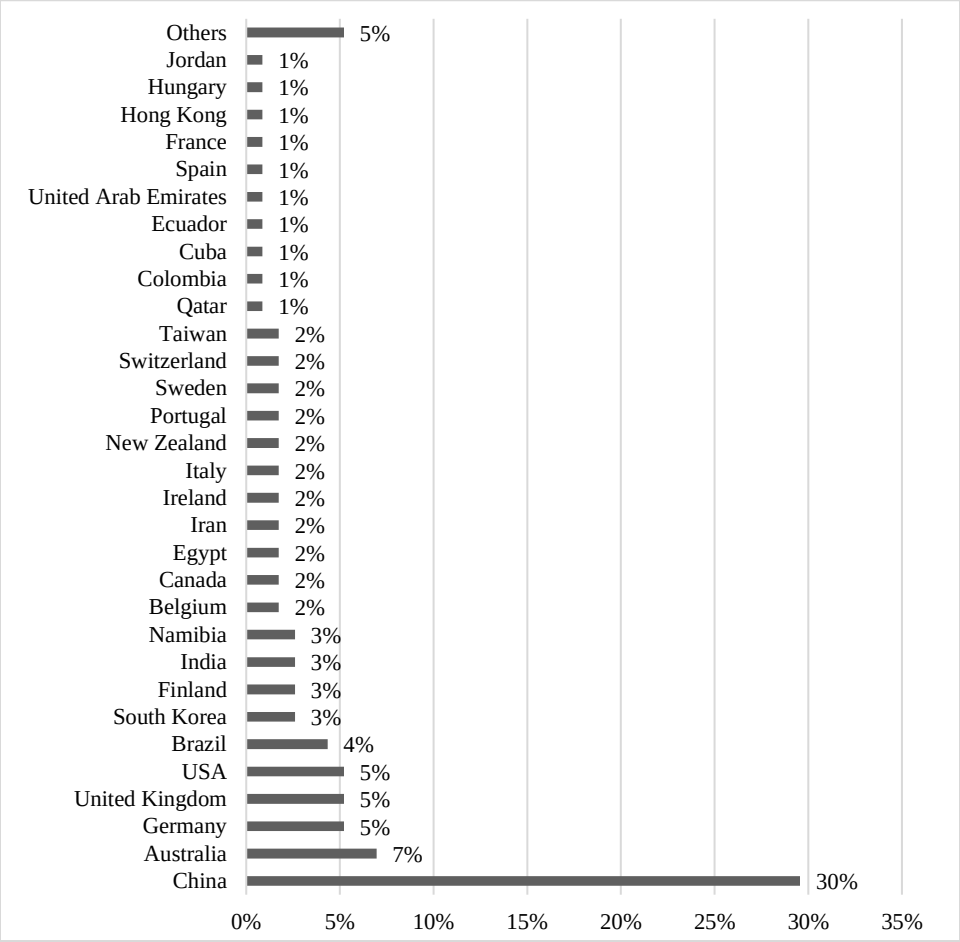

Figure 2. Percentage of participation in project management by country.

For this purpose, the Figure 2 proposes a chart representing the percentage of participation for each country where it is observed that China stands out as a leader in the application of project management techniques or tools about intralogistics activities, with a notable participation of 30%, equivalent to 34 articles of 115. Australia ranks second, contributing 8 articles and representing 7% of the total contributions. Germany and United Kingdom contribute in 5%, corresponding to 6 articles each one. The fifth position is held by the United States of America with a 5% of participation in total contributions, contributing with 6 articles to this literature review.

The Figure 2 also provides a more detailed view of the subsequent positions of the countries involved in this study, highlighting that Mexico is not listed in any position. However, more developed countries than Mexico, such as Brazil, South Korea, and Finland, do present limited contributions on this topic. It's important to highlight that some countries were grouped into the "Others" category for simplification actions, this includes Turkey, Russia, Czech Republic, Netherlands, Morocco and Kazakhstan.

3) Classification results by source

With the aim of providing a detailed overview of the main scientific journals hosting works related to the article topics, Table 2 has been prepared. In this table, the "Production & Manufacturing Research Journal" stands out as the undisputed leader, hosting a total of 18 contributions, representing a15% of the entire set of articles.

Table 2. Index of scientific journals with a higher presence in the use of project management.

Scientific source	Number of publications	Percentage
Production & Manufacturing Research Journal	18	15.7%
Tsinghua University Press (TUP)	16	13.9%
IEEE Transactions on intelligent Transportation Systems	9	7.8%
Journal of Construction Engineering and Management	4	3.5%
Automation in Construction	3	2.6%
Engineering, Construction and Architectural Management	3	2.6%
Construction Innovation	2	1.7%
International Journal of Project Management	2	1.7%
Journal of Cleaner Production	2	1.7%
Journal of Information Technology in Construction	2	1.7%
Omega - The International Journal of Management Science	2	1.7%
Safety Science	2	1.7%
Waste Management	2	1.7%
Applied Soft Computing	2	1.7%
Science of the Total Environment	1	0.9%
Other journals and/or sources	45	39.1%

However, we cannot overlook the second position, "Tsinghua University Press (TUP)," which is a high-impact journal that plays a significant role by contributing 16 articles, around 13% of the contributions in the proposed article collection.

It is important to highlight that classification labeled 'Other journals and/or sources' groups scientific journals with just one contribution of the total analyzed articles. These include titles such as “Production Planning and Control”, “Computer & Industrial Engineering”, “Construction Management and Economics”, “International Journal of Logistics Systems and Management”, among others. Also, it is important to mention that the total number of scientific journals explored in this literature review amounts to 60, reflecting the diversity of topics and approaches in the field of decision sciences, business, and administration areas where project management has found application.

4) Classification results by document type

The results of this classification are shown in Figure 3, where it can be observed that the most frequent document type is Empirical (theory building), accounting for over 63%, equivalent to 73 articles. This is because in these contributions, methodological proposals or reference models are made for specific problems in internal logistics or intralogistics, and in most cases, these proposals are tested to demonstrate the optimal performance of project management.

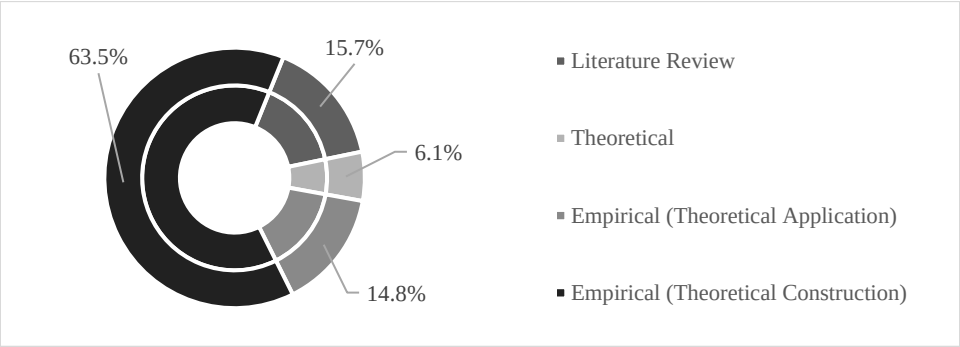

Figure 3. Percent by document type.

In this context, 17 articles were focusing on application of existing knowledge, frameworks, or previously conducted models to demonstrate solving generic problems in internal logistics. This type of document was classified as Empirical (application of theory), which is present in the collection with a participation rate exceeding 14%.

For articles with a theoretical focus, only seven were recorded with 6% of the articles analyzed. These articles discuss the use of project management in manufacturing systems, as well as the coordination and management of intralogistics activities.

Finally, 18 literature review articles were found, 11 of which focus on intralogistics problems that have been resolved with project management through planning, resource optimization, and the use of emerging technologies related to Industry 4.0. The remaining articles address topics related to software development, corporate security, environmental sustainability, and collaborative work.

5) Classification by knowledge area

The Figure 4 show that the most knowledge area addressed in the analyzed articles is engineering with 46 articles of the 115 under analysis. This indicates that project management has been extensively used to solve engineering-related issues throughout intralogistics activities.

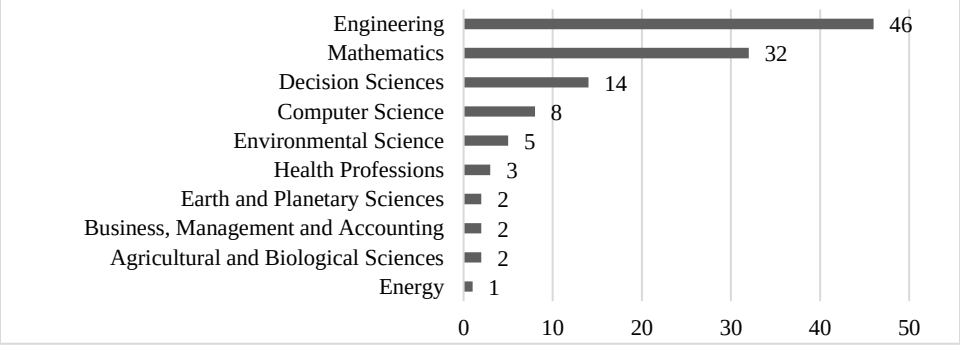

Figure 4. Number of articles by knowledge area.

Similarly, the field of mathematics is the second addressed knowledge area, with a total of 32 articles in the literature collection, in this context, project management has successfully addressed issues related to coordination and information management due to its analytical properties, decision-making based on data, and algorithm generation.

The third position is held by the field of decision sciences with 14 articles related to this area. Other knowledge areas recorded a lower application rate, with up to 1 article, which does not reflect the

inefficiency of the tool in the knowledge area but rather indicates a lack of sufficient studies related to project management focused on improving intralogistics.

B. Synthesis and discussion

The results related to the descriptive analysis of internal logistics or intralogistics using project management are presented, allowing for a discussion upon analyzing the findings. It should be emphasized that this section only applies to the descriptive analysis of internal logistics, which includes 90 articles classified as Empirical (theory construction) and Empirical (theory application).

1) Classification results by research method

In Figure 5, it can be observed that the simulation technique is the most employed by authors to validate intralogistics solutions. This is because it offers researchers a powerful tool to test and validate theories in controlled virtual environments, providing a deeper and more accurate understanding of the complex systems they are studying.

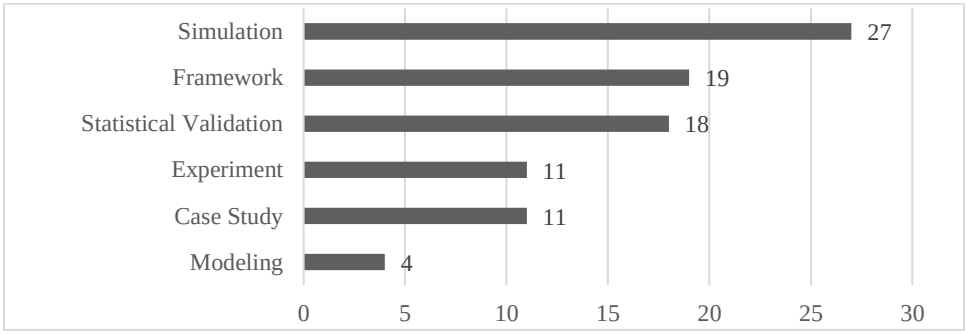

Figure 5. Number of articles by research method.

This situation can be reflected, for example, in the contribution of (Ying et al., 2021) to ensure the supply of materials in construction operations, where many industries seek to manage materials effectively by integrating logistics processes into supplier and customer logistics chains. In that case, the logistics processes are crucial for successful completion of construction projects that cannot be halted, it is because to adopt an approach with computer simulation using Flexsim® software, resulting in validation of the use of a logistics center to reduce waste in the construction project.

The second most addressed research methodology by authors is framework generation. The main function of a framework is to provide the essential conceptual structure to understand, contextualize, and effectively address a specific research problem, by integrating theories, models, concepts, and paradigms. Frameworks directs research toward a defined purpose and establishes a robust knowledge base by exploring, analyzing, and understanding complex phenomena, as exemplified by (López-Joy et al., 2020), who performs qualitative assessment using the Value Network Reference Model as a methodological tool.

On the other hand, statistical validation is carried out through statistical processes such as experimental design, linear or multiple regression, among others. For instance, (Gurmu & Ongkowijoyo, 2020) constructs a logistic regression model that can be used to estimate the productivity of building projects based on the levels of planning or implementation of human resource management practices.

In this context, experimentation in a small environment is present in 11 articles, providing a controlled and systematic means to test theories, establish causal relationships, and generate empirical evidence that contributes to the advancement of scientific knowledge, as demonstrated by (Zhao et al., 2021), who propose

a cooperative multi-stage hyperheuristic algorithm (CMS-HH) to address certain combinatorial optimization problems. The performance of the CMS-HH algorithm is evaluated on six specific combinatorial optimization problems, as such boolean satisfiability, one-dimensional packing, workflow permutation programming, staffing programming, traveling salesman and vehicle routing troubles.

The use of case studies is applied to illustrate and support the findings or conclusions found in research. Case studies provide concrete and contextualized examples that help exemplify the theories, concepts, or trends discussed in research. Additionally, they allow the researcher or readers to better understand how theoretical principles are applied in real situations, thus strengthening the validity and relevance of the arguments presented in the study. As (Kumar et al., 2018)mention in their research, it is to demonstrate how a modal shift from railways to inland water transportation led to qualitative and quantitative improvements (in terms of costs) in the supply chain.

Finally, Modeling is a crucial tool in research methodology, as it allows for the representation of phenomena or systems of study in a simplified and understandable manner. Through modeling, researchers can develop hypotheses, test theories, and simulate different scenarios to better understand the behavior of a system. Models can be mathematical, computational, physical, or conceptual, depending on the object of study and the research objectives. Modeling provides a systematic and structured way to analyze and understand complex phenomena in various fields of study, as mentioned and affirmed by (Sun, 2014), the model is very suitable for solving the problem of cost optimization of logistics for engineering projects of electrical networks, as applied in their research.

Despite multiple authors proposing different research methodologies, ultimately the choice will depend on the context and objectives of the analyst, as evidenced in the case of (Santos et al., 2023), where project control presents a crucial phase within project management. It is primary aim to ensure in an integrated manner that project objectives are met according to the plan. Earned value management, along with its various improvements, emerges as the most popular and widely adopted method for top-down project control.

2) Classification results by intralogistics problems in business sectors

The results regarding the issues in intralogistics most frequently documented during the analysis of the articles are presented in detail in Figure 6, with the clear objective of emphasizing the most common issues addressed through project management.

It can be argued that intralogistics issues are directly related to business sectors such as transportation and construction with a total of 24 articles, representing 26% each one (in total 52% of the articles in this section). For example, (Qiao et al., 2021) indicates that grouping road transport projects can significantly reduce the project's delivery cost but may have unintended consequences, such as reduced market competition in internal logistics.

The second most prevalent area, comparable to the first and with a total of 24 contributions (26%), is related to construction. This is one of the most common and confronted topics with various approaches. Project management proves highly favorable in addressing resource optimization issues, supplier localization, and defined routes. The aim is to identify how responsibilities and costs for planning, control, and execution of material, resource, and waste flows are transferred among actors by introducing a Construction Logistics System (CLS) as a product innovation in a construction project (Thunberg & Fredriksson, 2023).

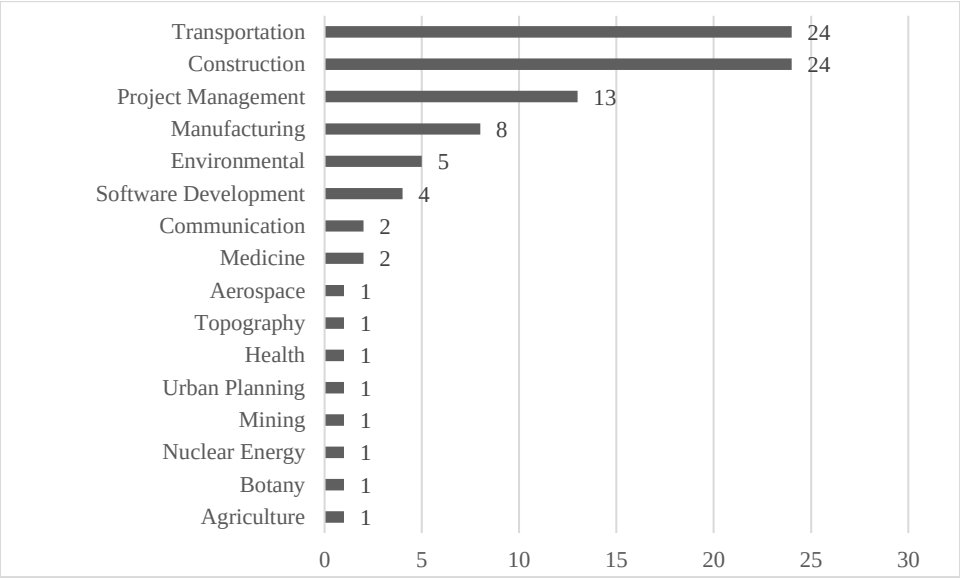

Figure 6. Incidence of internal logistics problems due to business sectors.

In other domains of intralogistics, similar situations to those described are presented, where multiple authors liken project management to problem-solving, facilitating knowledge dissemination via communication channels such as the internet to enhance processes. Most analyzed project management modules have a database or knowledge base that allows managing project learning in their tasks. Finally, according to the analyzed articles, it can be affirmed that all contributions effectively addressed the posed challenges, attributable to the distinctive characteristics of project management delineated in Section I.

3) Classification results by solution method.

Project management sometimes emerges as the sole tool to address issues related to project control and monitoring. However, at a deeper or technical level, it collaboratively complements other engineering methodologies or tools, where one resolves technical issues while the other provides support and control. Therefore, it is important to identify which technical methodologies have been most implemented in the field of internal logistics.

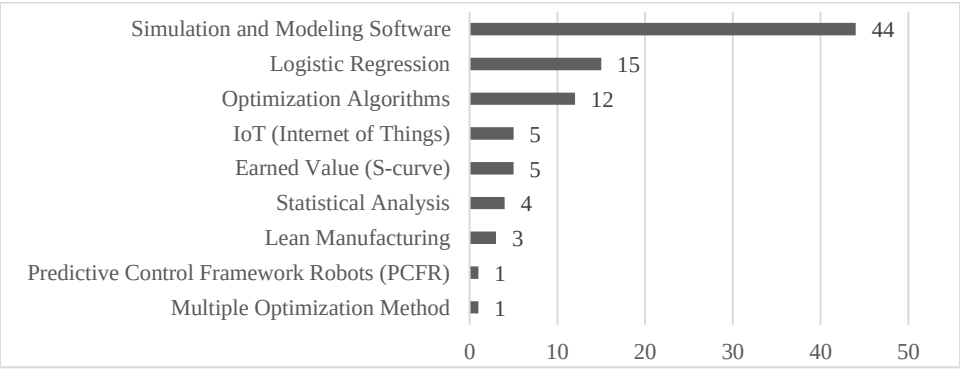

Figure 7. Number of articles by solution method.

As depicted in Figure 7, 44 authors of the analyzed articles, comprising more than 48% of the 90 contributions, utilized simulation and modeling software proposed to address issues and improve the intralogistics performance. It is worth mentioning that the exclusive use of simulation and modeling software does not diminish the success or confidence in the proposed solution. The autonomous vehicle community

increasingly uses game engines as simulation platforms to develop vehicle control systems and test environments. A key requirement for simulation-based development and verification is determinism, as a deterministic process will always produce the same result given the same initial conditions and event history. Different configurations and uses of software and hardware are explored to determine an operational domain where simulation accuracy is high enough, meaning the variation between repeated executions becomes insignificant for development and testing purposes (Chance et al., 2022).

As observed, the second most used methodology to streamline the project management solution process focused on internal or intralogistics is the logistic regression. These can include simple logistic regression, binary logistic regression, permutation, multi-stage optimization, among others. This kind of regression is present in 15 contributions, representing 16% of the articles. And it enriches the theoretical foundation of complexity in project management field, and it provides an innovative approach that helps academics and professionals to evaluate complexity levels based on the applicability of identified complexity measures (Dao et al., 2022).

The third tool with the most impact is optimization algorithms or optimization method using equations, with 13% of the analyzed articles, meaning 12 contributions. These algorithms can be used in a wide range of fields, such as data science, engineering, finance, and logistics, among others. The global economy has transformed many manufacturing companies from a single-plant production mode to a cooperative multi-plant production mode, it is because the Distributed Flexible Job Shop Scheduling Problem (DFJSP) has become a relevant research topic in the field of programming because its production is closer to reality, and one of the proposed solutions is the use of optimization algorithms (Li et al., 2022) to create harmony between multiple companies.

The Internet of Things (IoT) is another technique applied in 5% of the analyzed articles, meaning in 5 contributions. The IoT has transformed how research and theory corroboration are conducted by providing a wide range of real-time data and the ability to monitor and control devices and systems remotely. Nowadays a connected object is the key element of IoT to shift a perceptible real-world to a digital virtual world known as a cyber-physical system. In fact, a communicated device ensure performance in all productive sectors included logistics and warehouse management (Trab et al., 2017).

The Earned Value Method (EVM)is a project management technique applied in 5% of the articles as a purely solution tool, meaning in 5 contributions. The EVM is mainly used in the engineering and project management field to measure project performance in terms of cost and schedule. It is important to note that EVM has been developed mainly for engineering and management projects, and its direct application to scientific or theoretical research may not be as direct. However, adapting some related principles could provide a management and performance evaluation perspective in research projects context. EVM or project scheduling (EV/PS) systems have played a central role in project control and provide simple key performance metrics that measure deviations between planned and actual performance in terms of time and cost (Trab et al., 2017).

It is important to mention that methodologies such as statistical analysis, lean manufacturing, predictive control frameworks, robots, and multiple optimization methods together have a total of 13 articles among all these topics, equivalent to 14%. Statistical analysis is fundamental in scientific research for analyzing data, identifying patterns, relationships, and trends, it is used to infer conclusions about a population base or samples and to validate hypotheses. It can be applied in the collection and analysis of experimental data, surveys, or in validating theoretical models, as mentioned by (Ahmad et al., 2018), who based all factory to research on integrated lean tools with process/product information data from the ERP system connected to the factory workshop.

On the other hand, discrete event simulation is useful for modeling and analyzing dynamic systems where events occur at discrete moments in time. In research, it can be used to simulate the behavior of complex systems and evaluate different scenarios, for example, it could be used to optimize supply chain management. In this context, predictive control frameworks are used to predict the future behavior of systems and adjust inputs to achieve certain goals, even interacting directly with simulation schemes for more complex problems, using simulation to quantify the benefits gained from a blockchain-enabled real-time traceability system in a project-based supply chain generates multiple scenarios, estimation accuracy, and project completion time (Ahmad et al., 2018).

4) Results about techniques and approach of simulation or modeling.

Simulation or modeling techniques are widely used in the development of projects focusing on internal logistics or intralogistics to analyze, plan, and optimize multiple aspects of these.

As depicted in Figure 8, 10 authors of the analyzed articles, more than 22% of the 44 contributions that used simulation and modeling software focused on discrete event simulation (DES) to address issues and improve the performance of intralogistics. For example, (Alvanchi et al., 2021) applied the DES-based method to capture the operational details of material logistics and used a heuristic approach to overcome the combinatorial problem of options. Despite the powerful capabilities of DES models to capture the operational complexities of construction projects, they have not been previously used to optimize material logistics for road construction projects.

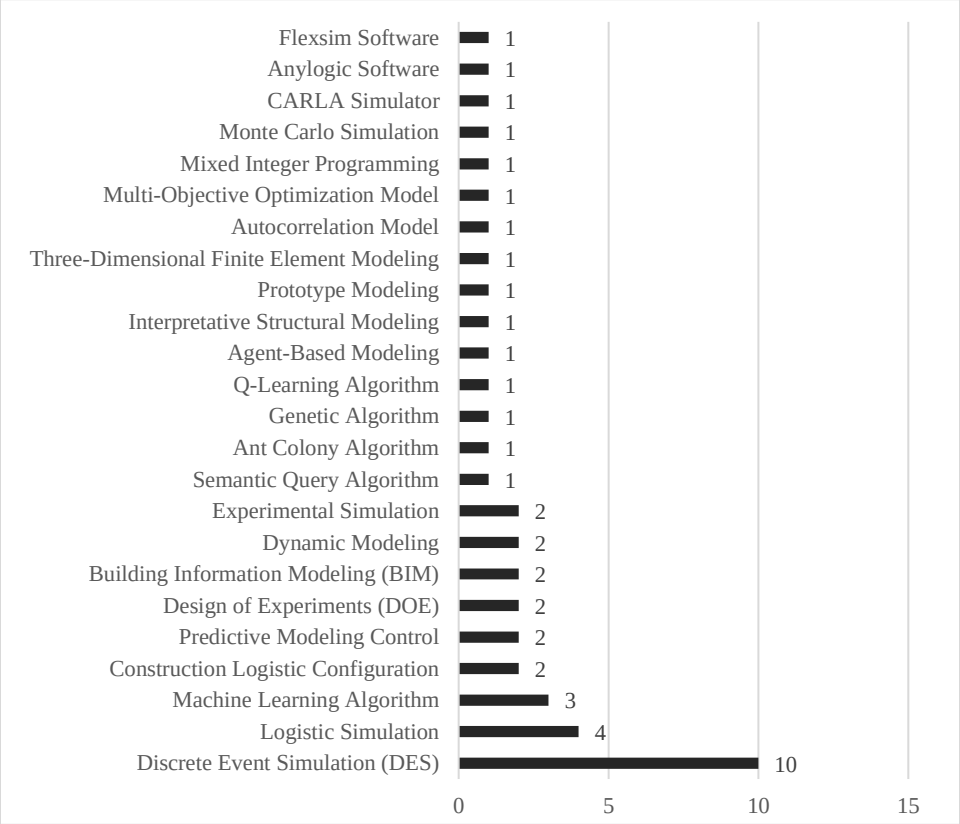

Figure 8. Techniques, approaches, and software of simulation.

Simulation and modeling in the project management of intralogistics are valuable tools for understanding, planning, and improving the efficiency of logistical processes, enabling organizations to make informed decisions and optimize their operations.

5. CONCLUSIONS AND FUTURE CONTRIBUTIONS

Academic research interest related to solving internal logistics or intralogistics problems with best project management practices is revealed through the review of 115 articles, employing a qualitative analysis from 2011 to 2023, providing a fresh perspective about the utility and scope of project management best practices as a tool for decision-making in distributed and dynamic environments

This comprehensive research on project management applied to intralogistics exposed significant findings shaping the fields of engineering and decision sciences:

Temporal growth and trends: the research has noted a steady increase in contributions from 2011 to 2023, peaking in 2022. This rise reflects growing interest and practical application of project management tools in intralogistics, driven especially by the need to adapt to post-pandemic production dynamics and sustainability. This reflects a greater trend in the probability of success in projects when using project management tools from planning to closure, which is why researchers are increasingly turning to this type of knowledge area.

Geographical application: China leads in the application of project management techniques and tools in intralogistics activities, followed by Australia, Germany, and the United Kingdom. These countries represent centers of innovation and development in the field, noted for significant contributions through case studies and empirical experimentation. This reveals application opportunities for Mexico given that it does not appear in any position, while more developed countries such as Brazil, South Korea and Finland do present limited contributions on this topic.

Document type and research methods: more than 63% of the articles analyzed focused on the construction of theoretical and empirical models, validated through methods such as simulation, case studies and statistical analysis. These approaches have enriched the theoretical basis of project management and provided practical tools for the effective implementation of optimization strategies in complex industrial environments. This reflects a latent application trend either through real applications or with the use of simulators seeking a significant improvement in the success of the project at the management level.

Knowledge areas and technological solutions: engineering predominated as the applied area, focusing on supply chain optimization and resource management. Emerging technologies such as discrete event simulation (DES), algorithm optimization, and the Internet of Things (IoT) are the most employed solution method for addressing problems in conjunction with project management best practices, irrespective of whether project management is used as the sole solution. Also, DES software is widely applied in project developments focused on optimizing internal logistics activities, providing a better option for enriching risk and resource management as it can perform different iterations or scenarios with high precision. In this sense, the use of simulation software is the most employed research method, aiding in verifying decision-making efficiency.

Project management tools: risk and resource management are among the management techniques that enhance control during the scheduled execution phase in internal logistics project management, as discussed in the analyzed articles. In this context, it is identified that both DES software and risk or resource management could benefit greatly from including the earned value technique (a technique with very low application in the analyzed articles) as support to assess and control project performance in an efficient way.

Impact on specific industrial sectors: the transportation and construction sectors benefitted most from project management applications in intralogistics, noted for improvements in route planning, resource optimization, and operational cost reduction. There are many cases of success in the implementation of project

management; however, areas with limited research are revealed. This situation is often attributed to the complexity, high specialization, or lack of knowledge of the tools, for example, fields such as energy, agriculture and biological sciences, business, management and accounting, health professions, and environmental sciences have been less frequently addressed.

The research developed above will serve as a foundation to support strategies for the application of project management tools in economic activities. Additionally, it helps to propose future research as a case study focused on improving intralogistics in the automotive industry in Mexico, supported by project management tools. This research outlines an overview to open application opportunities in other actors in the supply chain in Mexico with the growth of manufacturing in recent years.

In summary, this research contributed to the role of project management as a key enabler in the optimization of intralogistics projects, but also identified areas for future academic research or industrial implementation. The current integration of emerging technologies and adaptation to global changes will continue to be fundamental to improve competitiveness and sustainability in multiple industrial sectors.

AUTHOR CONTRIBUTION CRediT

Author responsibility statement:

José Alberto Báez Jiménez: conceptualization, investigation, data curation, writing, project administration.

José Carlos Hernández-González: conceptualization, methodology, validation, data curation, writing and supervision, project administration.

Missael Alberto Román-del-Valle: conceptualization, methodology, validation, data curation, writing and supervision.

DECLARATION OF COMPETING INTERESTS

The authors of this article declare that they have no conflicts of interest, either financial or professional, that could have influenced the results or the interpretation of the data presented. This commitment ensures the objectivity and integrity of the work, guaranteeing that the conclusions accurately and faithfully reflect the available evidence.

DATA AVAILABILITY

The datasets generated or analyzed during the current study are available from the corresponding author upon reasonable request. Interested researchers may contact to gain access to the data, which will be provided in compliance with relevant privacy and confidentiality regulations.

REFERENCES

A. Fink. (2005). Conducting research literature reviews: from the Internet to paper. 2nd Ed. Thousand Oaks, Calif.: Sage Publications.

Ahmad, R., Masse, C., Jituri, S., Doucette, J., & Mertiny, P. (2018). Alberta Learning Factory for training reconfigurable assembly process value stream mapping. Procedia Manufacturing, 23, 237–242.

Alvanchi, A., Baniassadi, F., Shahsavari, M., & Kashani, H. (2021). Improving materials logistics plan in road construction projects using discrete event simulation. Engineering, Construction and Architectural Management, 28(10), 3144–3163.

Ashraf, M., & Ali, I. (2023). Evaluation of project completion time prediction accuracy in a disrupted blockchain-enabled project-based supply chain. International Journal of Systems Science: Operations & Logistics, 10(1).

Buenrostro, A. M. (2021). COVID-19: el gran desafío para la logística en la industria. In Ciencia Amateur. Chance, G., Ghobrial, A., McAreavey, K., Lemaignan, S., Pipe, T., & Eder, K. (2022). On Determinism of Game Engines Used for Simulation-Based Autonomous Vehicle Verification. IEEE Transactions on Intelligent Transportation Systems, 23(11), 20538–20552.

Clarivate. (2023). The Emerging Sources Citation Index (ESCI).

da Silva, N. A., Abreu, J. L., Orsolin Klingenberg, C., Antunes Junior, J. A. V., & Lacerda, D. P. (2022). Industry 4.0 and micro and small enterprises: systematic literature review and analysis. Production & Manufacturing Research, 10(1), 696–726.

Dao, B., Kermanshachi, S., Shane, J., Anderson, S., & Damnjanovic, I. (2022). Developing a logistic regression model to measure project complexity. Architectural Engineering and Design Management, 18(3), 226–240.

Deniyage, C. J., & Palliyaguru, R. (2019). Conceptual framework for effective implementation of 'project management institute's standard for earned value management' in Sri Lanka. Proceedings of the 8th World Construction Symposium, 189–199.

Despeisse, M., Chari, A., González Chávez, C. A., Monteiro, H., Machado, C. G., & Johansson, B. (2022). A systematic review of empirical studies on green manufacturing: eight propositions and a research framework for digitalized sustainable manufacturing. Production & Manufacturing Research, 10(1), 727–759.

ELSEVIER. (2023). Scopus Sources. Scopus: Comprehensive, multidisciplinary, trusted abstract and citation database

Goh, C. S., Su, F., & Rowlinson, S. (2023). Exploring Economic Impacts of Sustainable Construction Projects on Stakeholders: The Role of Integrated Project Delivery. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 15(3).

Gurmu, A. T., & Ongkowijoyo, C. S. (2020). Predicting Construction Labor Productivity Based on Implementation Levels of Human Resource Management Practices. Journal of Construction Engineering and Management, 146(3).

Harnegie, M. P. (2013). SciVerse Science Direct. Journal of the Medical Library Association: JMLA, 101(2), 165–165.

Quitian-Tellez, H. A. (2018). Grado de Madurez en la Gestión de Proyectos de la Empresa de Logística Open Market de Bogotá D.C. Universidad Piloto de Colombia Especialización en Gerencia de Proyectos.

Ithaka. (2023). Taylor & Francis, Ltd. JSTOR.

Jairo R. Montoya-Torres, & Diego A. Ortiz-Vargas. (2013). Collaboration and information sharing in dyadic supply chains: A literature review over the period 2000–2012. Estud. Gerenciales, 30, 343–354.

Kumar, P., Haleem, A., Qamar, F., & Khan, U. (2018). Analysis of maiden modal shift in coal transportation supply chain using SAP-LAP technique. International Journal of Logistics Systems and Management, 30(4), 458.

Küpper, C., Rösch, J., & Winkler, H. (2022). Use of real time localization systems (RTLS) in the automotive production and the prospects of 5G – A literature review. Production & Manufacturing Research, 10(1), 840–874.

Lecanda Meschede, I., Colmenar Santos, M. P., Parrado Prieto, J. Á., & Pérez Goyanes, C. (2023). IEEE Xplore: Presentación. Biblioteca de La Universidad de Valladolid /Biblioguías.

Li, J., Gu, X., Zhang, Y., & Zhou, X. (2022). Distributed Flexible Job-Shop Scheduling Problem Based on Hybrid Chemical Reaction Optimization Algorithm. Complex System Modeling and Simulation, 2(2), 156–173.

López-Joy, T., Gómez-Acosta, M. I., Neira-Mugercia, A. N., Acevedo-Suárez, J. A., Peña-García, C., & Acevedo-Urquiaga, A. J. (2020). Medicines Value Chain Management Level in Cuban Health System. Ingenieria y Universidad, 24(1).

M. M. Crossan, & M. Apaydin. (2010). A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature. J. Manag. Stud. No. 6, 47, 1154–1191.

Qiao, Y., Labi, S., & Fricker, J. D. (2021). Does highway project bundling policy affect bidding competition? Insights from a mixed ordinal logistic model. Transportation Research Part A: Policy and Practice, 145, 228–242.

Santos, J. I., Pereda, M., Ahedo, V., & Galán, J. M. (2023). Explainable machine learning for project management control. Computers & Industrial Engineering, 180, 109261.

Somasundaram R. (2023, October 15). Scopus vs Web of Science: Which is Better? ILovePhD.

Sony, M. (2020). Pros and cons of implementing Industry 4.0 for the organizations: a review and synthesis of evidence. Production & Manufacturing Research, 8 (1), 244–272.

Sony, M., & Mekoth, N. (2022). Employee adaptability skills for Industry 4.0 success: a road map. Production & Manufacturing Research, 10(1), 24–41. https://doi.org/10.1080/21693277.2022.2035281

Suguna, M., Shah, B., Raj, S. K., & Suresh, M. (2022). A study on the influential factors of the last mile delivery projects during Covid-19 era. Operations Management Research, 15(1–2), 399–412.

Sun, W. (2014). Logistics Cost Optimization in Total Life Cycle of Power Grid Engineering Project Using Improved Ant Colony Algorithm. Journal of Information and Computational Science, 11(5), 1411–1418.

Taye, G. D., & Feleke, Y. A. (2022). Prediction of failures in the project management knowledge areas using a machine learning approach for software companies. Applied Sciences, 4(6), 165.

Thunberg, M., & Fredriksson, A. (2023). A model for visualizing cost shifts when introducing construction logistics setups. Construction Innovation, 23(4), 757–774.

Trab, S., Bajic, E., Zouinkhi, A., Thomas, A., Abdelkrim, M. N., Chekir, H., & Ltaief, R. H. (2017). A communicating object's approach for smart logistics and safety issues in warehouses. Concurrent Engineering, 25(1), 53–67.

Varela, L., Putnik, G., & Romero, F. (2022). The concept of collaborative engineering: a systematic literature review. Production & Manufacturing Research, 10(1), 784–839.

Ying, F. J., O'Sullivan, M., & Adan, I. (2021). Simulation of vehicle movements for planning construction logistics centers. Construction Innovation, 21(4), 608–624.

Zhao, F., Di, S., Cao, J., Tang, J., & Jonrinaldi. (2021). A Novel Cooperative Multi-Stage Hyper-Heuristic for Combination Optimization Problems. Complex System Modeling and Simulation, 1(2), 91–108.