

## **OPEN-SOURCE ERP FOR SMES: A LINK BETWEEN HUMAN RESOURCE MANAGEMENT AND INTELLIGENT LOGISTICS**

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**Abstract--** The objective of this study was to design an *open-source Enterprise Resource Planning* (ERP) system for small and medium-sized enterprises (SMEs), which account for 99% of productive units in Latin America and generate between 60% and 70% of formal employment (ECLAC, 2023). Some SMEs face technological and budgetary constraints that hinder the integration of essential processes such as human resources management and logistics, thereby reducing their operational efficiency and the quality of decision-making (Heizer, Render & Munson, 2020).

The methodology employed was based on the Protocol, Search, Appraisal, Synthesis, Analysis, and Report (PSALSAR) approach and a mixed-methods research design. This allowed for the analysis of international scientific and technological evidence, as well as the operational reality of a Mexican company in the logistics sector. Document searches, database analyses, direct observation, and the collection of qualitative and quantitative data from the personnel involved were conducted. Through the PSALSAR process, 45 initial references were narrowed down to 17 highly relevant studies, from which categories such as implemented technologies, operational KPIs, and main challenges emerged, highlighting a lack of integration, low traceability, and work overload.

Field analysis confirmed that traditional ERPs do not adapt with sufficient flexibility to the dynamic demands of last-mile logistics and human resources, which justified the design of a customized solution. The pilot phase allowed for the configuration of role-based permissions, ensuring confidentiality and traceability of information. Key functional requirements were defined to optimize routes, measure attendance, automate processes, improve data availability, and strengthen strategic decision-making.

**Keywords—**Design, business, research, transportation planning, human resources, and open-source software.

**Abstract** --The present study aimed to design an Open Source ERP for small and medium-sized enterprises (SMEs), which in Latin America represent 99% of productive units and generate between 60% and 70% of formal employment (CEPAL, 2023). Many SMEs face technological and budget constraints that hinder the integration of essential processes such as human resource management and logistics, reducing their operational efficiency and the quality of decision-making (Heizer, Render & Munson, 2020).

The methodology used was based on the Protocol, Search, Appraisal, Synthesis, Analysis, and Report (PSALSAR) approach. This enabled the analysis of international scientific and technological evidence, as well as the operational reality of a Mexican company in the logistics sector. Documentary searches, database analyses, direct observation, and the collection of qualitative and quantitative data from relevant personnel were conducted. Through the PSALSAR process, 45 initial references were narrowed down to 17 highly relevant studies, from which categories such as implemented technologies, operational KPIs, and key challenges emerged, highlighting the lack of integration, low traceability, and excessive workload.

Field analysis confirmed that traditional ERPs do not adapt flexibly enough to the dynamic demands of last-mile logistics and human resources, justifying the design of a customized solution. The pilot program enabled the configuration of role-based, differentiated permissions, ensuring confidentiality and traceability of information. Key functional requirements were defined to optimize routes, measure attendance, automate processes, improve data availability, and strengthen strategic decision-making.

**Keywords**-- Company, design, human resources, open source software, research and transportation planning.

## INTRODUCTION

The purpose of this research was to design an *open-source Enterprise Resource Planning* (ERP) system for SMEs that integrates human resources and logistics management,

customizing it for a real company and comparing it with a proprietary system using the PSALSAR methodology. The research is justified by the strategic role of SMEs in Mexico, where there are approximately 350,000 units (82.5% small and 17.5% medium) (INEGI, 2024), but which face financial constraints in adopting commercial ERP systems. Therefore, open-source systems represent a sustainable, flexible, and cost-effective alternative to improve process integration, reduce costs, and strengthen their competitiveness in globalized environments.

Based on the above, this study proposes the implementation of an *open-source* ERP system for an SME that integrates human resources management and last-mile logistics, using a robust methodology that combines the PSALSAR systematic review with a mixed-methods research approach. This methodological combination allowed for the analysis of both the scientific and technological evidence available internationally and the operational reality of a Mexican company in the sector, generating comprehensive information to adapt the ERP to its actual needs. To this end, rigorous searches were conducted in academic databases, along with document analysis, direct observation, and the collection of qualitative and quantitative data from the personnel involved.

The PSALSAR methodology was used as the primary tool, which was developed in phases that included goal definition, systematic search, critical evaluation, and literature synthesis (Camacho-Tamayo & Bernal-Ballé, 2023). These findings were organized into categories such as operational *Key Performance Indicators* (KPIs), technologies used (*Representational State Transfer*) REST API, (*Global Positioning System / Internet of Things*) GPS/IoT, machine learning, NoSQL databases, (*open-source* platforms), and key needs identified in the sector, such as lack of integration, low traceability, and scientific staff overload.

The study was conducted using a mixed-methods approach in the field, integrating quantitative data—such as delivery volumes, times, routes, and workload levels—with qualitative information obtained through interviews, direct observation, and document analysis. The convenience sample allowed for a comparison of reality with theoretical findings, confirming that traditional ERPs do not respond with sufficient flexibility to the

changing needs of the last mile, justifying the creation of a customized and adaptable ERP.

The design of the *open-source* ERP system was developed through a pilot phase which, according to Correa (2023), allows processes to be evaluated and adjusted before full implementation—a critical step for tailoring technological systems to the actual needs of each organization. This scientific approach made it possible to adapt the logistics and human resources modules specifically to the operational requirements of the company under study. The initial experimental test included four phases: the collection and refinement of information to structure context-specific databases; the design of a customized functional architecture that defined flows and relationships between modules; the migration of data and creation of *dashboards* that facilitate the analysis of key management indicators (Few, 2013); and the configuration of users, roles, and permissions in accordance with the organizational structure. The results demonstrated a highly adaptable ERP system capable of centralizing critical information, optimizing routes, and strengthening personnel management, proving that customization in *open-source* systems is an effective strategy for increasing the efficiency and competitiveness of SMEs. **JUSTIFICATION**

The contemporary business environment is being reshaped by the convergence of digital transformation and strategic information management. In this regard, SMEs in Mexico face a structural technology gap that limits their competitiveness and ability to adapt to the demands of the global market. (Pozo-Benites, Guadalupe-Sánchez, Peñarreta-Barrera & Meza-Salvatierra, 2025). Unlike large corporations, these organizations operate with limited financial and technological resources, which hinders the implementation of integrated management systems and the efficient coordination of their processes.

According to data from the Ministry of Economy (2024), in Mexico, SMEs account for approximately 4% (small) and 0.8% (medium) of the country's total economic units. Although their proportion is smaller compared to other business sizes, their role is fundamental in generating formal employment, productive diversification, and national economic dynamism.

However, these organizations continue to face financial and technological constraints that hinder the adoption of integrated management systems, affecting their operational efficiency and their ability to compete in increasingly digitalized environments. These constraints also lead to IT fragmentation which, together with the high costs of acquiring, licensing, and maintaining commercial ERP systems, contributes to widening the digital divide and limiting their competitive potential.

Given this situation, the adoption of solutions based on open-source ERP systems presents itself as a modern and essential alternative for optimizing organizational management, as these systems integrate all areas of the business into a single platform. In addition to being cost-effective, *open-source* ERP offers flexibility, scalability, and technological autonomy—elements that make it a key tool for boosting the competitiveness and sustainability of SMEs (Vargas, Cruz & Sauza, 2024).

This is why the true value of adopting such systems transcends the technological dimension: it strengthens strategic management by fostering an organizational culture based on integration, information traceability, and operational efficiency. In this context, digital transformation ceases to be a purely technical process and becomes a structural pillar of competitive positioning. Likewise, Meraz Sepúlveda (2024) emphasizes that today, corporate technology strategy is a decisive factor in generating sustainable advantages and in the evolution of organizations toward models of continuous innovation.

In light of the above, this study explored a methodology for adapting ERP functionalities to the critical processes of SMEs, avoiding the unnecessary complexity of systems designed for large corporations, with a focus on the human resources and logistics modules in order to facilitate decision-making, reduce operating costs, and improve competitiveness, since the Human Resources module improves staff selection by ensuring the hiring of more qualified and competent employees, which reduces costs associated with turnover and the constant training of inefficient employees, while the logistics module allows for the identification of best practices and advanced technologies

ensuring that resources are always available and managed efficiently, reducing wait times and increasing operational capacity (Mejía et al., 2024).

Thus, this research aims to understand how the strategic use of open technologies can minimize the digital divide and reduce the structural constraints that limit the development of SMEs, through the integration of ERP systems customized to the organization’s needs, representing an improvement in internal processes and undoubtedly a pathway to consolidating more analytical, coordinated, and resilient management models capable of transcending their traditional limitations and establishing a position of business efficiency.

Therefore, ERP systems are emerging as a solution for improving organizational management by centralizing and automating processes (Laudon & Laudon, 2022). However, their high costs limit their adoption. In this regard, open-source ERPs offer a viable and sustainable alternative by providing low cost, flexibility, and customization (Flores Campoverde, Palacios Meléndez & Bastidas Logroño, 2024; Amini & Sadat Safavi, 2013; Haddara & Elragal, 2013). Therefore, this study proposes the development of an open-source ERP system for SMEs that integrates human resources and logistics management processes using accessible digital tools. The research employs the PSALSAR methodology, which ensures a rigorous and replicable analysis (Agbehadji et al. 2023). Consequently, the proposal aims to enhance the efficiency, digital transformation, and competitiveness of SMEs in globalized environments.

**METHOD.**

The methodology used in this study integrates two complementary approaches. First, a rigorous systematic review was conducted based on the PSALSAR methodology (Figure 1), which allowed for the identification and analysis of relevant scientific and technological evidence at the international level. Second, a mixed-methods research design was developed, aimed at understanding both the operational processes of a parcel delivery company and the perceptions, experiences, and needs of the staff involved.



**Figure 1.** *Diagram of the PSALSAR methodology.*

**Source:** Author's own work (2025).

The combination of these two approaches made it possible to develop a robust methodological model, grounded in specialized literature and technological practices used in the industry, as well as in qualitative and quantitative data obtained directly from the real-world application environment, as presented in Table 1. In this way, the methodology not only underpins the design of the customized ERP but also precisely situates it within the operational dynamics of a Latin American e-commerce-linked parcel delivery company.

To contextualize the target population, data from INEGI (2024) were used as a basis, indicating that in the state of Hidalgo, 97.2% of establishments are microbusinesses, while only 2.7% are small and medium-sized enterprises (SMEs), representing approximately 3,842 SMEs in the state. Considering that the company under analysis is part of this segment and that SMEs represent a small proportion of the state's business sector, a convenience sample was chosen, focusing on an active parcel delivery company representative of this type of economic entity.

**Table 1.** *Research methods used.*

Technique	Justification	Type
Direct observation	To understand the actual workflow	Qualitative
Interviews	Gain insight into staff perceptions	Qualitative
Document analysis	Review guidelines, reports, and evidence	Non-statistical
Process review	Identify bottlenecks	Qualitative
Operational data	Times, routes, volumes	Quantitative

**Source:** Prepared by the author.

First, the *Protocol* phase of the PSALSAR methodology was carried out, during which the central purpose of the study was defined: to identify, analyze, and synthesize the most recent evidence on the integration of logistics and human resources management systems within an ERP, so as to enable the design of a customized system tailored to last-mile operations. During this phase, the research questions, search criteria, and inclusion and exclusion criteria were established, along with the methodological scope. Table 2 lists questions designed to directly address actual operational needs, including:

**Table 2.** *Research questions defined in the Protocol phase.*

No.	Question
1	What technologies enable the integration of logistics and HR in real time?
2	What are the essential KPIs in last-mile logistics?
3	What are the limitations of traditional ERP systems for parcel delivery?
4	What algorithms do leading companies use for dispatch and routing?
5	What requirements should a customized ERP include?

**Source:** *Prepared by the author.*

Based on the established protocol, the *Search* phase was carried out, involving systematic searches in academic databases such as *Redalyc*, *Google Scholar*, *SciELO*, and *Scopus*, as well as in technical repositories containing specialized literature on logistics, traceability, ERP systems, and optimization, including *MDPI*, *ResearchGate*, *IEEE Open*, and *Theseus*. Specific search strings were designed to cover topics such as last-mile logistics, HR–Logistics integration, optimal routing, heuristic algorithms, GPS-based traceability, and the development of open-source ERPs. To strengthen the human dimension within planning systems, terms related to workplace well-being, staff turnover, expired contracts, training hours, and absenteeism were also incorporated—key elements for understanding the interaction between operational performance and talent management within SMEs. The search strings included expressions such as “*last-mile logistics, ERP, and dynamic routing*,” “*human resources management and logistics integration*,” “*traceability*

and e-commerce deliveries,” and “open-source ERP and SMEs,” which enabled the identification of relevant studies in both academic and technical contexts.

In total, 45 initial records were identified, including scientific articles, systematic reviews, theses, case studies, technical reports, and technology implementation documents. Following a screening and critical evaluation process, 17 studies were selected for detailed analysis, as they met the criteria of relevance, methodological quality, and applicability to the context of SMEs engaged in last-mile logistics. Table 3 presents the three most relevant studies, selected for their significant contribution to logistics, ERP, and human capital management.

**Table 3.** *Relevant studies on logistics, ERP, and human capital management in SMEs.*

<b>Author(s) and year</b>	<b>Study title</b>	<b>Main contribution</b>	<b>Relationship to open-source ERP / logistics</b>	<b>Relationship with human resources</b>
Ruiz & Cambero (2023)	Review of impact of ERP on logistics processes of SMEs	It proposes a conceptual framework that links the adoption of open-source ERP with the integration of business processes and information management capabilities in SMEs.	Examine how ERP and systems open source integrate business processes in SMEs and facilitate logistic s logistics management through integrated information.	Although focused on overall business performance, it includes management of processes and data that affect areas such as HR in the integration of system.
Quintero Portocarrero, N. G. (2018)	Analysis of Critical Success Factors in ERP Implementations in SMEs in Latin America	Analyzes the critical success factors in the implementation of ERP in Latin American SMEs, identifying five key macro-groups and highlighting the need to adapt best practices	It demonstrates that ERP systems promote the integration and efficiency of logistics processes, a key factor for SMEs that adopt solutions ERP	Highlights training, the management change and staff participation as key factors in the success of the

		large companies to the context of SMEs.	open source due to its flexibility and lower costs.	implementation of ERP in SMEs
Jaimes Ariza & Tarazona Flores (2021)	Implementation of enterprise resource planning (ERP) systems based on open-source platforms in SMEs, Huánuco Province, 2019	It demonstrates that the implementation of open-source ERP systems optimizes the management of SMEs, improving process efficiency, productivity, and decision-making through a structured model for adoption, selection, implementation, and rollout.	Evidence that <i>open-source</i> ERP systems allow for the integration and optimize operational and logistics processes, reducing time, and improving control over operations and the efficient use of resources in SMEs in the retail and manufacturing sectors.	It highlights that the success of ERP depends on the human factor, reflected in increased staff productivity and improved decision-making. The decision-making process is critical for the successful implementation of the system.

Source: Prepared by the author.

Subsequently, during the *appraisal* phase, all preliminary documents were evaluated based on criteria such as clarity of objective, methodological consistency, relevance to last-mile operations, applicability to SMEs, availability of metrics, data reliability, technological relevance, and source credibility. This evaluation allowed us to refine the literature, retaining only studies with a score of 7 or higher out of 10, as shown in Table 4, thus forming a final set of 17 highly relevant studies.

**Table 4.** Criteria used for the evaluation of studies.

Criterion	Description	Evaluation
Clarity of the objective	The study clearly states what it analyzes	0–10
Methodological rigor	The method is well-defined and supported	0–10

Logistical relevance	The study applies to last-mile or ERP	0–10
Applicability to SMEs	Can be applied to small businesses	0–10
Data quality	Clear and verifiable data	0–10
Clear metrics	Defined KPIs	0–10
Identified limitations	The study identifies areas for improvement	0–10
Internal consistency	Method–Results–Conclusions are consistent	0–10
Credibility of the source	Reliable journal / access	0–10
Technological relevance	Technologies applicable to ERP	0–10

**Source:** *Prepared by the author.*

This refinement ensured that the theoretical framework used in the ERP design would be based solely on verified and methodologically sound evidence. According to Motwani and Argyropoulou (2007), the evaluation and selection of an Enterprise Resource Planning (ERP) system in SMEs must be closely aligned with the corporate strategy and the organization’s competitive priorities. The authors note that an ERP only generates value if it fits within the timeline, the available budget, and the actual needs of the business, and its functionality must meet the specific requirements of users and operations. From this perspective, the planning and adoption of an ERP is effective only when it is directly linked to the objectives of business growth and consolidation.

During the *Synthesis* phase, a detailed data extraction was conducted, organizing the findings into key categories: KPIs used in the industry (cycle time, failed deliveries, cost per kilometer, coverage areas, and route efficiency); predominant technologies, including REST APIs, an architectural style that enables lightweight and scalable communication between systems via web services (Fielding, 2000); GPS/IoT, technologies that enable real-time tracking, sensor data collection, and transmission within logistics operations (Gubbi et al., 2013); and NoSQL databases, used to handle large volumes of unstructured, high-speed data typical of tracking and dynamic routing systems (Sadlage & Fowler, 2012). Likewise, recurring problems in logistics companies were identified, such as a lack of

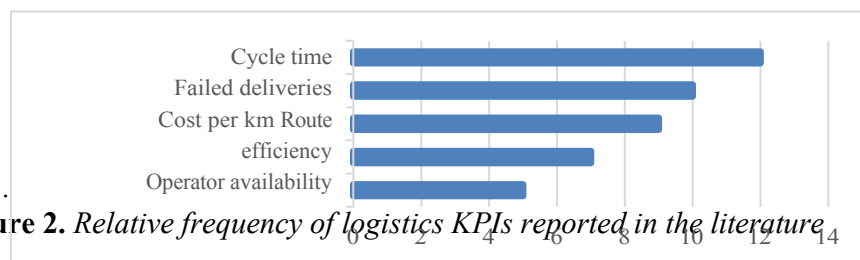
integration between departments, manual assignment, staff overload, poor traceability, and delays due to poor planning; and notable solutions were described, such as optimization through dynamic routing, real-time information availability, load forecasting, the implementation of automated KPI dashboards, and HR–Logistics integration via API. This synthesis not only consolidated the knowledge gathered but also enabled its translation into functional requirements applicable to the system design. The results, organized by category, are presented in Table 5, which shows the key elements identified during the *Synthesis* phase.

**Table 5.** *Categories and key elements identified in the Synthesis phase*

Category	Key elements
KPIs	Cycle time, missed deliveries, cost per kilometer, route efficiency, workplace well-being, staff turnover, expired contracts, training hours, absenteeism.
Technologies	<i>Open-source</i> ERP, REST API, GPS/IoT, ML, NoSQL
Challenges	Lack of HR–Log integration, poor traceability, overload
Solutions	Dynamic routing, smart assignment, KPI dashboards

**Source:** *Prepared by the author.*

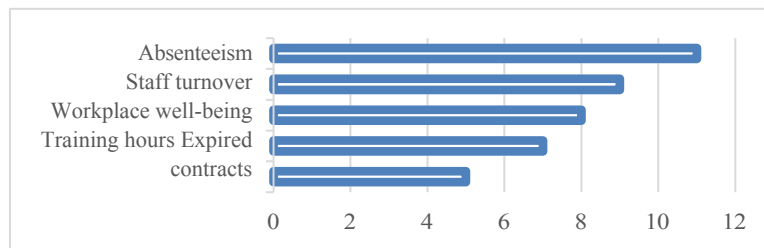
The most commonly used key performance indicators in logistics and human resource management studies were identified. In the case of logistics KPIs, the literature agrees on prioritizing metrics such as cycle time, missed deliveries, cost per kilometer, route efficiency, and operator availability, which are widely documented in recent analyses of operational performance (Marjani et al., 2017; Arango-Serna et al., 2019; Ranieri et al., 2018). Data normalization reveals a higher frequency of cycle time (frequency = 12), followed by failed deliveries (10) and cost per kilometer (9), as shown in Figure 2.



**Figure 2.** *Relative frequency of logistics KPIs reported in the literature*

**Note.** The figure shows the predominance of cycle time, followed by missed deliveries, cost per kilometer, route efficiency, and operator availability (Marjani et al., 2017; Arango-Serna et al., 2019; Ranieri et al., 2018).

Regarding Human Resources KPIs applied to logistics, studies highlight indicators such as absenteeism, staff turnover, workplace well-being, and training hours due to their impact on operational continuity (Eurofound, 2020; ILO, 2019; Sheehan, 2014). The analysis shows absenteeism as the most frequent indicator (11), followed by staff turnover (9) and workplace well-being (8), as shown in Figure 3.



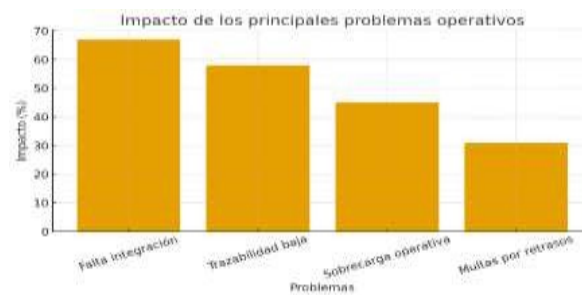
**Figure 3.** Relative frequency of Human Resources KPIs reported in logistics operations.

**Note.** The figure shows the relevance of human indicators, highlighting absenteeism, staff turnover, workplace well-being, training hours, and expired contracts (Eurofound, 2020; ILO, 2019; Sheehan, 2014).

The integration of both sets of KPIs made it possible to consolidate functional requirements that consider both operational efficiency and the human dimension within smart logistics.

During the *Analysis* phase, the findings from the literature were compared with the collected data; this analysis incorporated both quantitative and qualitative information. The quantitative data included an assessment of daily package volumes, average delivery times, service areas, and the frequency of failed deliveries. The qualitative data included staff perceptions regarding their workload, communication difficulties, operational needs not met by current systems, and expectations regarding a new ERP system. As part of the analysis, the main operational problems and their level of impact within the organization were identified. Figure 4 summarizes these findings, showing that the lack of integration is the problem with

greater perceived impact (67%), followed by poor traceability (58%), operational overload (45%), and fines for delays (31%). These results confirm the need for a platform that integrates processes, improves operational visibility, and distributes the workload effectively.

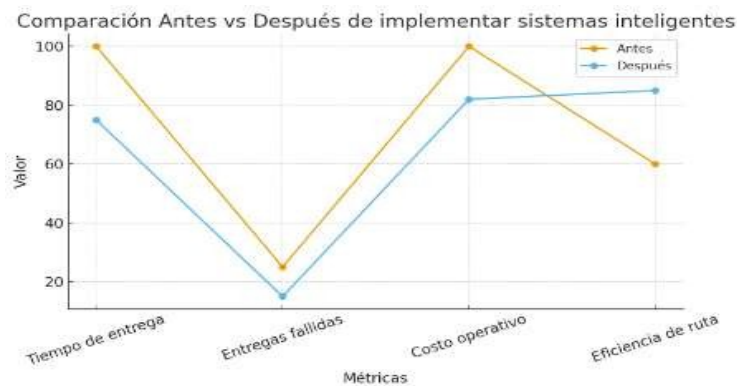


**Figure 4.** *Impact of the main operational problems*

**Note.** *Prepared by the author.*

The figure shows the percentage of impact associated with the main issues identified: lack of integration, low traceability, operational overload, and fines resulting from delays. Based on this analysis, it was concluded that last-mile delivery companies require a highly flexible system, adaptable in real time and capable of simultaneously integrating staff availability, workload, transport capacity, optimal routes, and *marketplace* constraints. This confirmed that a traditional ERP lacks the necessary capabilities to resolve the identified problems, fully justifying the development of a customized ERP.

The *Reporting* phase consisted of documenting and structuring the findings using graphs, tables, methodological flows, and explanatory narratives, ensuring transparency, reproducibility, and a coherent presentation of the information for readers, evaluators, and developers. As part of this documentation, a visual comparison of operational performance before and after implementing intelligent systems was prepared. Figure 5 presents this comparison, showing significant improvements in key metrics.



**Figure 5.** Comparison of operational performance before and after implementing smart systems.

**Source:** Author's own work.

The figure shows a significant reduction in delivery time (from 100 to 75 units) and a drastic decrease in failed deliveries (from 25 to 15 units). Additionally, there is a reduction in operating costs (from 100 to 80 units) and an increase in route efficiency (from 60 to 85 units). These results not only reflect the internal improvement observed in the case study but also align with evidence reported in the scientific literature. These findings confirm that the adoption of smart solutions optimizes critical processes and strengthens real-time decision-making.

In parallel with the PSALSAR methodology, a non-experimental, cross-sectional research design with an integrated mixed-methods approach was applied, with the aim of describing and analyzing the operation without manipulating variables. This approach allowed us to work with two complementary spheres: the objective sphere, based on quantitative data such as delivery times, load capacity, daily routes, and volumes; and the perceptual sphere, supported by qualitative information obtained through semi-structured interviews, direct observation, and document analysis. Denzin and Lincoln (2018) note that the perceptions of the actors are a valid source of knowledge for capturing meanings and attitudes, while Patton (2015) asserts that operational perceptions reveal tensions and needs that do not typically appear in administrative reports, justifying their integration into the mixed-methods approach.

Sampling was non-probabilistic and based on convenience, selecting available staff (delivery drivers, administrative staff, and route managers) and operational records spanning 30 to 90 days. This

This decision reflects the actual conditions of the business context, where full access to the population is limited by operational and confidentiality considerations. Creswell and Creswell (2018) note that this type of sampling is legitimate and widely used in applied research when the goal is to understand internal processes rather than generalize findings. Etikan, Musa, and Alkassim (2016) add that it is appropriate when participants possess privileged knowledge of the phenomenon, while Marshall (1996) emphasizes that in organizational studies, the intentional selection of key informants allows access to high-quality data.

The applied nature of the study—designing and implementing a customized ERP—led to a controlled pilot test at the analyzed company. This allowed for the validation of functionality, usability, and operational impact, ensuring pre- and post-measurements and real-time adjustments. Thus, convenience sampling was not only feasible and ethical but also the only coherent path to move from diagnosis to the implementation and effective validation of the proposed ERP.

## **DEVELOPMENT**

Subsequently, a design proposal for the ERP system was developed. The main objective of this design is to conduct a pilot study, which, according to Correa (2023), is an initial phase of testing and experimentation carried out prior to implementing a large-scale study or project. During this stage, procedures are evaluated and adjusted, potential problems are identified, and improvements are made to ensure the proper functioning and viability of the project prior to full implementation. This resulted in a preliminary version that was prepared to conduct an evaluation of the logistics and Human Resources modules; it is important to note that the design is tailored to the needs of each organization.

To validate the correct implementation of the Human Resources and logistics modules within the *open-source* ERP, a pilot study was conducted, divided into four strategic phases, as shown in Figure 6. Each phase allowed progress from the initial data collection to the actual management of users within the system, ensuring functionality, security, and alignment with the internal processes of SMEs.



**Figure 6.** Phases of piloting.

Source: Prepared by the author.

### Phase 1. Information gathering

To carry out the pilot, the first step involved creating a database in Excel spreadsheets; therefore, a detailed analysis of the Human Resources and Logistics processes was conducted, recording times, routes, and updating information in the existing manual systems. At the same time, preliminary databases were created in Excel that consolidated essential information on routes (Figure 7) and, similarly, on personnel: general data, attendance records, workplace well-being, contract end dates, training completed, and punctuality bonuses. In this regard, the databases served as an initial framework for identifying key fields, refining information, and preparing for the migration to the ERP.

**RUTAS DIARIAS CENTER PACHUCA**

LINEA	VEHICULO	TIPO	PLAZA	CONDICION	TIPO	CONDICION	TIPO	CONDICION	TIPO	CONDICION	TIPO	CONDICION	TIPO	CONDICION	TIPO	CONDICION	TIPO	CONDICION	TIPO	CONDICION
1	3010	NOVENMARE	01	OPERAHOR 1	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
2	3010	NOVENMARE	01	OPERAHOR 1	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
3	3010	NOVENMARE	01	OPERAHOR 2	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
4	3010	NOVENMARE	01	OPERAHOR 2	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
5	3010	NOVENMARE	01	OPERAHOR 3	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
6	3010	NOVENMARE	01	OPERAHOR 3	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
7	3010	NOVENMARE	01	OPERAHOR 4	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
8	3010	NOVENMARE	01	OPERAHOR 4	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
9	3010	NOVENMARE	01	OPERAHOR 5	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
10	3010	NOVENMARE	01	OPERAHOR 5	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
11	3010	NOVENMARE	01	OPERAHOR 6	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
12	3010	NOVENMARE	01	OPERAHOR 6	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
13	3010	NOVENMARE	01	OPERAHOR 7	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
14	3010	NOVENMARE	01	OPERAHOR 7	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
15	3010	NOVENMARE	01	OPERAHOR 8	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
16	3010	NOVENMARE	01	OPERAHOR 8	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
17	3010	NOVENMARE	01	OPERAHOR 9	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
18	3010	NOVENMARE	01	OPERAHOR 9	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
19	3010	NOVENMARE	01	OPERAHOR 10	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
20	3010	NOVENMARE	01	OPERAHOR 10	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
21	3010	NOVENMARE	01	OPERAHOR 11	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
22	3010	NOVENMARE	01	OPERAHOR 11	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
23	3010	NOVENMARE	01	OPERAHOR 12	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
24	3010	NOVENMARE	01	OPERAHOR 12	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
25	3010	NOVENMARE	01	OPERAHOR 13	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
26	3010	NOVENMARE	01	OPERAHOR 13	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
27	3010	NOVENMARE	01	OPERAHOR 14	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
28	3010	NOVENMARE	01	OPERAHOR 14	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
29	3010	NOVENMARE	01	OPERAHOR 15	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						
30	3010	NOVENMARE	01	OPERAHOR 15	01	AR01	PACH	NOCSAP1	06:00	07:00	020413-01	0079110	111	71						

**Figure 7.** Route registry.

Source: Prepared by the author.

### Phase 2. Architecture

In accordance with the phases established for the pilot project, the functional architecture of the modules within the ERP was designed, taking into account the KPIs defined during the PSALSAR methodology. These KPIs made it possible to identify the system’s critical control points, ensuring that the architecture meets the needs of SMEs. During this phase, the main components of the system, information flows, relationships between entities, and interrelationships with other modules—particularly between Human Resources and Logistics—were also defined.

The graphical representation provided a clear vision of how vehicle control functions would be interconnected with personnel, focusing primarily on attendance and training. Figure 8 shows the sections selected to integrate the

of the ERP: start, administration, vehicle control, logistics, and Human Resources. This structure was established to ensure clear, hierarchical, and functional navigation, where each module would perform a specific role while maintaining the necessary intercommunication for comprehensive management.



**Figure 8.** ERP Modules.

**Source:** Prepared by the author.

### Phase 3. Prototyping

Once the architecture had been defined in the previous phase, we proceeded to migrate the data stored in Excel spreadsheets to the *open-source* ERP system, which involved format conversion, record standardization, and data validation to ensure consistency and prevent duplicates. Subsequently, the first functional designs of the modules were developed in accordance with the structure defined in the ERP's overall architecture, allowing each module to be configured with required fields, validation rules, and search options to facilitate the retrieval and updating of information. Additionally, individual *dashboards* were created for each department, enabling the centralized and graphical monitoring and visualization of key data, thereby facilitating decision-making, performance analysis, and the identification of trends (Few, 2013).

These dashboards enabled the visualization of relevant information; for the Human Resources area, they are shown in Figure 9, displaying indicators such as workplace well-being, attendance rates, and absenteeism percentages. Similarly, contract status is tracked through the number of contracts nearing expiration, the number of training hours, employees on vacation, and staff turnover.



**Figure 9.** *Human Resources Dashboard.*

**Source:** *Prepared by the author.*

Following on from the previous section, to view the *dashboard* shown above, enter the data as illustrated in Figure 10, which provides an overview of the workforce. This dashboard displays metrics such as the total number of active employees, expired contracts, active vacation days, and pending leave requests. Similarly, an attendance records table is included, displaying data such as employee name, date, clock-in and clock-out times, overtime, department, position, and status. This allows for immediate monitoring of staff performance and facilitates the identification of incidents.



**Figure 10.** *Human Resources Record*

**Source:** *Prepared by the author.*

In addition, this module includes staff contract management, with a particular focus on contracts nearing expiration. Figure 11 shows the record corresponding to this section, which is designed to clearly and promptly display alerts related to contracts that are about to expire. The system also provides a general summary that includes the total number of registered contracts, as well as active, expiring, and expired contracts, offering a comprehensive view of staff contractual status. Additionally, a detailed table of

contracts nearing expiration, providing key information for deciding whether to renew, update, or terminate them.



**Figure 11.** *Contract Management.*

**Source:** *Prepared by the author.*

In the logistics area, two main processes were implemented: vehicle registration and route management. For the first, Figure 11 shows the interface used for vehicle management; this view displays an organized table that includes fields such as license plate numbers, vehicle model or type, serial number, and year of manufacture. It also incorporates advanced search functions by license plate and action buttons such as edit and delete, which allow records to be updated or purged as needed. This section plays a key role within the *open-source* ERP, showing the relationship between vehicles and assigned personnel, strengthening operational and administrative control, and verifying the relationship between the Human Resources and Logistics departments.

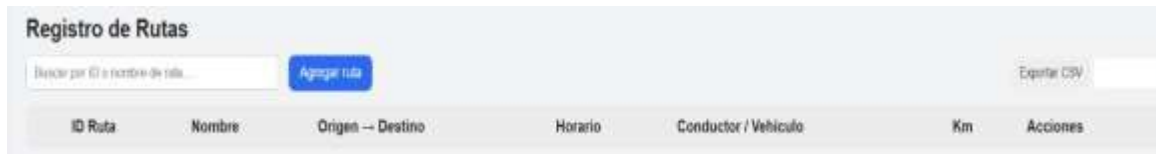
Registro de Vehículos				
Placas	Modelo/Tip	No. Económica	Año	Acciones
<input type="checkbox"/> 34J215	Rental Small Van	846512	2025	<input type="button" value="Editar"/> <input type="button" value="Eliminar"/>
<input type="checkbox"/> 35J867	Rental Electric Large Van	846508	2020	<input type="button" value="Editar"/> <input type="button" value="Eliminar"/>
<input type="checkbox"/> LF73009	Rental Small Van Electrica	846484	2020	<input type="button" value="Editar"/> <input type="button" value="Eliminar"/>

**Figure 12.** *Vehicle Registry.*

**Note:** Prepared by the author.

While the route record shown in Figure 13 includes the key fields for route management, capturing relevant data such as the route ID, route name, origin and destination, assigned driver, and the vehicle in which the route will be carried out

the starting point and the total distance required to complete the route; this information allows for proper and accurate tracking of each operation, facilitating real-time planning and monitoring of routes. Similarly, advanced search functions and an action button for adding a route have been incorporated.



**Figure 13.** *Route log.*

**Source:** Author's own work.

Similarly, Figure 14 shows the form used to add a new route, featuring fields such as route ID, route name, origin, destination, estimated distance, assigned vehicle, and responsible driver. Additionally, tabs such as Stops, Calendar/Schedule, and Documents/Photo are included, allowing users to supplement the information with relevant logistical details. The status option (scheduled) and the action buttons (Save and Cancel) facilitate secure information management, integrating the logistics module with data on the personnel involved in each operation.



**Figure 14.** *Registering new routes*

**Source:** Author's own work.

Figure 15 shows the system's initial interface, where staff enter their username and password to log in and subsequently access the system according to their profile and authorization level, ensuring information control and protection.



**Figure 15.** *Login page*

**Source:** *Prepared by the author.*

#### **Phase 4. Results**

Finally, based on the results obtained from the pilot, the ERP user system was configured, assigning specific permissions according to each employee's role. Restrictions were established to ensure the confidentiality and traceability of sensitive personnel information. Similarly, to evaluate the pre- and post-implementation metrics of an *open-source* ERP, a comparative table (Table 6) was created to compare the results obtained before and after the system's implementation, highlighting the impact: previously, to maintain records, employees entered data manually and then transferred the information to spreadsheets to generate a weekly report; with the ERP, data entry is digital and automated.

**Table 6.** *Comparison of pre- and post-implementation percentage metrics.*

<b>Variable</b>	<b>Before implementing the ERP system Open-source</b>	<b>After implementing the open source</b>	<b>Variation</b>
Average time spent on data collection (min)	120	10	-91.7%
Manual intervention	High	Discharge	↓
Accuracy of data	90%	100%	+10 pp
Average route assignment (min)	30	12	-60%
Efficiency of	68%	85%	+17 pp

vehicle capacity			
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**Source:** Author's own calculations.

The results showed that the average time spent was reduced from 2 hours to 10 minutes, representing a 91.7% improvement in processing time. Similarly, manual intervention was reduced, leading to 100% accuracy and reliability of the data. This is evidenced by the automation of the process, which eliminates errors that arose from manual data entry, ensuring that each record is accurate. Additionally, data reliability is further enhanced given the volume of information, as it is still feasible to manage it using Excel.

In addition to the above regarding logistics indicators, the implementation of the ERP system led to significant improvements in logistics management, as evidenced by a 60% reduction in route assignment time through the automation of vehicle and driver assignments. Furthermore, vehicle capacity utilization efficiency increased by 17 percentage points, rising from 68% to 85%.

## CONCLUSIONS

During the ERP system pilot, operational tests were conducted to validate its functionality, identify improvements, and ensure its adaptation to the organization's needs. One of the main outcomes of this phase was the configuration of the user system, an essential process for ensuring proper information control and secure operations. The user structure was defined based on the roles and responsibilities of each employee, allowing for the assignment of specific permissions that regulate access to the various modules and functionalities of the ERP.

This established differentiated access levels that define the information each team member can view, modify, or manage, ensuring more efficient administration aligned with the principles of organizational best practices. In addition, restrictions were implemented to protect personnel information, particularly that related to operational, labor, and administrative data. These measures enhance the traceability of actions within the system, facilitating the monitoring of activities and improving internal audit capabilities.

Furthermore, the pilot phase identified areas for improvement in the initial permissions structure, leading to adjustments in role assignments and the implementation of additional measures to prevent errors, unauthorized access, and role overlap. Taken together, these results demonstrate that the pilot phase not only evaluated the technical functionality of the ERP but also contributed to the design of a more robust and reliable internal control structure aligned with the company's operational requirements. Additionally, the pilot confirmed the benefits of implementing an *open-source* ERP in SMEs.

### **FUTURE RESEARCH DIRECTIONS**

The results of this study open up lines of research aimed at analyzing the adoption of *open-source* ERP systems in different sectors and organizational contexts, as well as their sustained impact on the integration between human resource management and logistics processes. Likewise, it is suggested to explore the incorporation of emerging technologies such as artificial intelligence, advanced analytics, and machine learning within these systems, with the aim of strengthening decision-making, operational efficiency, and staff productivity.

Finally, future research could examine the integration and configuration of new functional areas and ERP modules tailored to the specific context, capabilities, and needs of SMEs, in order to assess the systemic scope of these platforms from the perspective of sustainable adoption.

### **REFERENCES**

- Agbehadji, I. E., Mabhaudhi, T., Botai, J., & Masinde, M. (2023). A systematic review of smallholder farming systems and food security in Africa using PSALSAR methodology. *Sustainability*, 15(2), Article 1234. <https://doi.org/10.3390/su15021234>
- Amini, M., & Sadat Safavi, N. (2013). Critical success factors for ERP implementation in SMEs. *International Journal of Information Systems and Project Management*, 1(4), 33–48.
- Arango-Serna, M. D., Serna-Uran, C. A., Gómez-Montoya, R. A., & Zapata-Cortés, J. A. (2019). Optimal route for last-mile distribution in urban environments. *Ingeniare. Chilean Journal of Engineering*, 27(3), 413–426.

- Camacho-Tamayo, E., & Bernal-Ballé, A. (2023). Theoretical elements on teacher training in natural sciences with a STEAMH approach. Systematic review. *Ciencia Latina Multidisciplinary Scientific Journal*, 7(1), 1598–1618. [https://doi.org/10.37811/cl\\_rcm.v7i1.4508](https://doi.org/10.37811/cl_rcm.v7i1.4508)
- Economic Commission for Latin America and the Caribbean (ECLAC). (2023). *Economic Survey of Latin America Latin America and the Caribbean* (LC/PUB.2023/11-P). <https://www.cepal.org/es/publicaciones/81132-estudio-economico-america-latina-caribe-2023-version-accesible>
- Correa Gutiérrez, M. (2023). *Development of a protocol for identifying biopsychosocial characteristics in individuals exposed to conflict using a portable EEG device from GTEC* (Bioengineering research project). University of Antioquia.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
- Denzin, N. K., & Lincoln, Y. S. (Eds.). (2018). *The SAGE handbook of qualitative research* (5th ed.). SAGE Publications.
- Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1–4. <https://doi.org/10.11648/j.ajtas.20160501.11>
- Eurofound. (2020). *Living, working, and COVID-19*. Publications Office of the European Union.
- Few, S. (2013). *Information dashboard design: Displaying data for at-a-glance monitoring* (2nd ed.). Analytics Press.
- Fielding, R. T. (2000). *Architectural styles and the design of network-based software architectures* (Doctoral ). University of California, Irvine. [https://www.ics.uci.edu/~fielding/pubs/dissertation/rest\\_arch\\_style.htm](https://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm)
- Flores Campoverde, M. A., Palacios Meléndez, J. G., & Bastidas Logroño, D. J. (2024). Paradigms of Open Source Use in Enterprise Resource Planning in SMEs in the Province of Santa Elena, Ecuador. *PENTACIENCIAS: Peer-Reviewed Multidisciplinary Scientific Journal*, 6(6), 410–425.

- Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645–1660. <https://doi.org/10.1016/j.future.2013.01.010>
- Haddara, M., & Elragal, A. (2013). The readiness of ERP systems for the Factory of the Future. *Procedia Technology*, 9, 421–430. <https://doi.org/10.1016/j.protcy.2013.12.047>
- Heizer, J., Render, B., & Munson, C. L. (2024). *Operations management: Sustainability and supply chain management* (14th ed.). Pearson.
- National Institute of Statistics and Geography (INEGI). (2024). *2024 Economic Census*. National Institute of Statistics and Geography.
- International Labour Organization (ILO). (2019). *Work for a brighter future – Global Commission on the Future of Work*. ILO.
- Jaimes Ariza, A. G., & Tarazona Flores, R. H. (2021). *Implementation of open-source enterprise resource planning (ERP) systems in small and medium-sized enterprises (SMEs) in the province of Huánuco, 2019* (Undergraduate thesis). Hermilio Valdizán National University. <https://hdl.handle.net/20.500.13080/6581>
- Laudon, K. C., & Laudon, J. P. (2022). *Management information systems: Managing the digital firm* (17th ed.). Pearson.
- Marjani, M., Nasaruddin, F., Gani, A., Karim, A., Hashem, I. A. T., Siddiqa, A., & Yaqoob, I. (2017). A review of big data analytics in logistics and supply chain management. *Journal of Big Data*, 4, Article 39. <https://doi.org/10.1186/s40537-017-0098-5>
- Marshall, M. N. (1996). Sampling for qualitative research. *Family Practice*, 13(6), 522–525. <https://doi.org/10.1093/fampra/13.6.522>
- Mejía, M., Sánchez, J., De-La-Cruz, C., Bermejo, Y., & Rojas-Millán, R. (2024). Challenges faced by companies in terms of infrastructure, technologies, and human resources to improve their logistics management. *Bulletin of Innovation, Logistics, and Operations*, 6(2), 6–14. <https://doi.org/10.17981/bilo.6.2.2024.02>
- Meraz Sepulveda, A. (2024). Business technology strategy as a key factor for the competitiveness of MSMEs. *European Public & Social Innovation Review*, 9, 1–16. <https://doi.org/10.31637/epsir-2024-1125>

- Motwani, J., & Argyropoulou, M. (2007). ERP systems in SMEs: An integrated framework. *International Journal of Management and Enterprise Development*, 4(1), 1–18.
- Patton, M. Q. (2015). *Qualitative Research & Evaluation Methods: Integrating Theory and Practice* (4th ed.). SAGE Publications.
- Pozo-Benites, K. B., Guadalupe-Sánchez, K. W., Peñarreta-Barrera, E. E., & Meza-Salvatierra, J. K. (2025). Digital transformation of SMEs in Latin America: Barriers, opportunities, and strategies for competitiveness. *Multidisciplinary Latin American Journal*, 3(2), 236–255. <https://doi.org/10.62131/MLAJ-V3-N2-015>
- Quintero Portocarrero, N. G. (2018). *Analysis of critical success factors in ERP implementations in SMEs in Latin America* (Master's thesis). Bolívar Technological University, Cartagena, Colombia.
- Ranieri, L., Digiesi, S., Silvestri, B., & Roccotelli, M. (2018). A review of last-mile logistics innovations in a vision for reducing externalities costs. *Sustainability*, 10(3), 782. <https://doi.org/10.3390/su10030782>
- Ruiz Porras, A. R., & Cambero Pando, M. (2023). *A review of the impact of ERP on logistics processes of SMEs* (Thesis for Bachelor's degree). Private Private del North. [https://repositorio.upn.edu.pe/bitstream/handle/11537/26005/TrabajoInvestigaci%C3%B3n\\_RuizPorras%20AbilioRolando\\_CameroPando%20Mafer.pdf](https://repositorio.upn.edu.pe/bitstream/handle/11537/26005/TrabajoInvestigaci%C3%B3n_RuizPorras%20AbilioRolando_CameroPando%20Mafer.pdf)
- Sadalage, P. J., & Fowler, M. (2012). *NoSQL distilled: A brief guide to the emerging world of polyglot persistence*. Addison-Wesley.
- Sheehan, M. (2014). Human resource management and performance: Evidence from small and medium-sized firms. *International Small Business Journal*, 32(5), 545–570. <https://doi.org/10.1177/0266242612465454>
- Vargas, C., Cruz, D., & Sauza, B. (2024). ERP for inventory management in small businesses: Financial feasibility analysis. *Senpai*, 1(6), 47–64.

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