Kimball data warehouse for the sales analysis process in a manufacturing business in Perú

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Article Info

ABSTRACT

The main goal of this research is to demonstrate that the use of innovative technology like business intelligence (BI) in a specific type of business significantly impacts their sales processes, enhancing decision-making, promotional strategies, and consequently customer loyalty and sales growth. The case study is a manufacturing business located in Lima, Peru. The information requirements of this business were analyzed, and a data mart model was created using the Kimball methodology. This multidimensional model enabled the comparison of client sales trends to propose new promotions and marketing strategies. The data analysis used to evaluate the results included hypothesis testing, analysis of employee responses to questionnaires to measure the impact of technology use on sales processes, and data reviews to assess sales increases both before and after the implementation of this technology. In both cases, the approval of the BI technology by the employees was satisfactory, and the increase in sales quantity was significant.

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1. INTRODUCTION

Nowadays, there is a big competition between business organizations; businesses are constantly searching for new tools and processes to improve their decision-making in order to obtain competitive advantages. Many technological advances are being developed, including different types of devices that allow data collection. Businesses recognize the use of this data as an important asset to stand out among other businesses. To analyze this data, many tools and techniques have been used, and business intelligence (BI) is a disruptive technology that allows deep data analysis, enabling businesses to make informed decisions. This causes decisions within businesses to be more accurate and precise.

In order to demonstrate the utility of BI within businesses, some research was conducted, such as [1], which aimed to improve operational optimization by implementing system dynamics (SD) based on BI to enhance operations in a Japanese company. Their findings showed that applying these technologies to core business processes can increase net profits and earnings by 25% to 48%, respectively.

It is also noted that BI positively influences decision-making. Awan *et al.* [2] analyzed the relationship between big data analysis (BDA), BI, and decision-making, collecting data from 109 Czech manufacturing firms and analyzing it using least squares structural equation modeling. The findings showed that the application of BDA and BI is associated with improved decision-making quality through data-driven insights. This

concept is corroborated in research [3], a systematic literature review (SLR) in which the authors investigate the principal benefits of BI systems. They conclude that not only is decision-making improved, but BI also contributes to understanding customer behavior, which leads to the creation of targeted client promotions.

Kasemsap [4] confirms the benefits mentioned in previous studies and also extends these benefits. The authors in their investigation assert that BI leads businesses to enhance performance and efficiency, specifically in increasing sales, boosting profit, and ensuring sustained growth over time. This increase in sales, profit, and growth is achieved through the strengthening of customer relationships. Mortezaei *et al.* [5], the authors assert that BI allows businesses to turn data into information and analytical knowledge, enabling them to know their clients and achieve a competitive advantage. These findings were obtained after an SLR was performed.

Despite all the aforementioned benefits, the implementation of BI in emerging countries, such as those in Latin America or in Peru, where the current research is being developed, still faces many barriers to widespread use. One of the principal concerns about the implementation of BI is the budget and cost of these types of projects. Du Plessis [6], the authors, after a literature review, deduce that existing traditional methodologies take a long time, mentioning specifically Imon's methodology. This lengthy methodology and its associated implementation costs are major barriers to adoption. The proposed solution is a short methodology to reduce both budget and time for implementation in an Indian company, demonstrating the viability of this approach. Also, Maurer [7], the authors claim that BI is applicable to small and medium-sized enterprises (SMEs) and demonstrate that substantial investments are not always required, making BI implementation feasible for these businesses.

Mupaikwa [8], the authors in their SLR mentioned that SMEs are motivated to implement BI systems to gain competitive advantages that strengthen customer relationships, but are easily demotivated by the lack of funding, managerial support, and expertise, which are the main barriers to implementation. The authors recommend, as principal advice, investing in training in this type of technology not only for technical areas but also for management, so they can understand and accept the future benefits BI brings to the business. Oliveira *et al.* [9] confirms that the majority of large enterprises are obtaining the benefits of BI implementations, but SMEs still have doubts about their implementation. However, the study analyzes an SME where a BI system was implemented with good results and recommends incentivizing implementation in the most common business processes as a first stage to obtain benefits sooner.

In this research, the implementation of a BI system in an SME manufacturing business is analyzed, following the recommendations explained in the above literature. The focus is first on the implementation methodology, as mentioned in [6], where the long duration of implementation increases the budget. In this case, the Kimball methodology, which facilitates the creation of data marts - specialized databases that store historical information used throughout an organization for analysis and trend identification- is applied as a base, as mentioned in [10], [11]. This methodology provides various implementation steps, including requirements integration, cost estimation, design considerations, tool utilization, and best practices [11]-[16].

The Kimball methodology was used in a modified version, including only the steps that are required and necessary for the selected business case. This reduced the time of implementation and lowered the budget (a main concern in [6]). Additionally, the processes considered for this implementation focus only on sales, aiming to enhance decision-making and promotional strategies, which addresses the recommendation in [9] by focusing only on common processes. All this is aimed at demonstrating that BI technology is suitable for implementation in SME businesses in Latin America, specifically in Peru, and to show the benefits that can be obtained in this context. Additionally, the research aims to motivate the implementation of BI and increase scientific production, taking into account that research publications on BI have not increased at the same rate as in other countries [17].

In the following sections, the selection of methodology steps, process selection, BI system construction, and results are explained to demonstrate the research's validity and how the BI system brings benefits to the organization under study.

2. METHOD

The research was conducted in an industrial enterprise located in Peru and established three specific objectives: (O1) to evaluate the relationship between marketing strategies and the use of BI technologies; (O2) to assess the impact of BI technologies on sales growth; (O3) to examine the influence of BI technologies on customer loyalty and retention. The study was carried out in three phases: the first involved the identification

of the problem and methodology selection, the second was the execution of the methodology, which included software elaboration and instrument creation, and the third phase was validation, results, conclusions, and recommendations, as observed in Figure 1. The steps are detailed in the following sections.
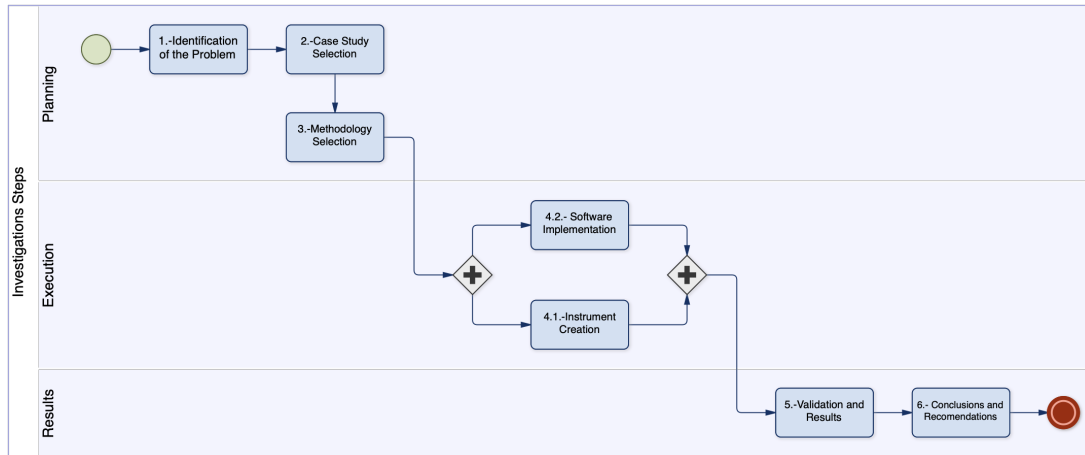

Figure 1. Methodology steps

2.1. Phase 01: identification problem and methodology selection
2.1.1. Identification problem

In order to establish the problematic situation, a literature review was conducted, and a total of 30 papers were reviewed and distributed throughout this paper. The papers reviewed demonstrate that the use of BI in SMEs is also possible, with adaptations in methodologies that minimize the budget. These methodological adaptations bring the same benefits as full implementations in larger businesses. The investigations reviewed also demonstrate that implementations were made in emerging countries like Latin America and Peru, where the implementation of this technology is not yet widespread, and there is also a lack of related literature [17].

2.1.2. Case study selection

All these findings show evidence of a problematic situation, and this research will analyze that problem in a specific context. The context is to evaluate the implementation and benefits achieved with the implementation of BI in SMEs in Latin America, which should be considered as emerging countries. The case study selected is a factory business located in Peru, chosen because it fulfills the characteristics relevant to this research.

2.1.3. Methodology selection

Investigation [6] mentions that selecting a good methodology could minimize the implementation time and associated budget, which are considered two of the main barriers to implementation in SMEs. Investigation [6] analyzes Inmon's methodology that has a top-down approach. This approach first creates a centralized data warehouse, represented by a normalized entity-relationship diagram that includes the data of the entire organization. After the data is gathered in this repository, the data marts would be created [18]. As a result, Inmon's approach can be time-consuming and resource-intensive [19]. That's the reason why in [6] the methodology was adapted. Another popular methodology used to implement BI is the Kimball methodology. The Kimball methodology focuses on creating data marts using multidimensional modeling for each process [20] with a bottom-up design. After that, these data marts will be combined to form a data warehouse [21].

This approach makes Kimball's methodology more agile and flexible than Inmon's approach, reducing implementation time and budget. For these reasons, Kimball's methodology was selected as the base methodology. As research [6] mentions, it is important to personalize the methodology to adapt the implementation process to the needs of the organization. Following the recommendations cited in many studies, four main steps were established.

Choose the process: for the creation of a data warehouse using the Kimball methodology, understanding the business requirements is a key factor, as mentioned in [22]. The importance of this step is to determine the process to create the first data mart. In this step, the development team holds meetings to determine requirements, dimensions, attributes, and metrics.

Design and create the data warehouse: Girsang *et al.* [22] mentions the importance of this stage. In this stage, data warehouse analytics and reports are developed. This stage is a critical element because the data model is constructed [23]. In this stage, the data mart is created using multidimensional modeling. The model used is the star schema, where dimensions, conformed dimensions, fact tables, and metrics are created. Additionally, tools for implementation were selected, including tools for data management, reporting, and related services. With all requirements and tools identified, the BI system is developed.

Implement the data warehouse: this stage is a technical stage. All applications, reports, and databases are published and configured in the main repositories selected in the previous stage, and all users and privileges are set [24].

Evolve the model: at this stage, the model undergoes a continuous improvement process to adjust to evolving business information needs and to establish new indicators that enhance productivity [25]. The importance of this stage is that the BI system is evaluated by the user (through questionnaire) and the performance obtained by the business to identify possible improvements and expand its use. In the case of Kimball's methodology, the creation of the data mart is carried out with the unification of future data marts in mind.

2.2. Phase 02: execution of the methodology

In this phase of the research, the proposed methodology is executed, which includes the creation of the BI system and the development of the questionnaire (instrument) to evaluate the results.

2.2.1. Software implementation

In the first stage, choosing the process, the business processes of the factory were analyzed. The main concern at the time the research was conducted was how to increase their sales, and they felt overwhelmed by the lack of information needed to make decisions. Given this scenario, the processes selected were related to increasing sales volume and amount of sales. To achieve the objectives explained in section two, improvements in marketing promotions and decision-making are necessary.

The next stage, designing and creating the data warehouse, involved dimensional modeling. The model used was the star schema [26], which employs dimension tables, fact tables, and metrics to implement the business process. In Figure 2, the star schema with the most important fields is shown. It is important to mention that this modeling uses conformed dimensions to integrate data marts [27].
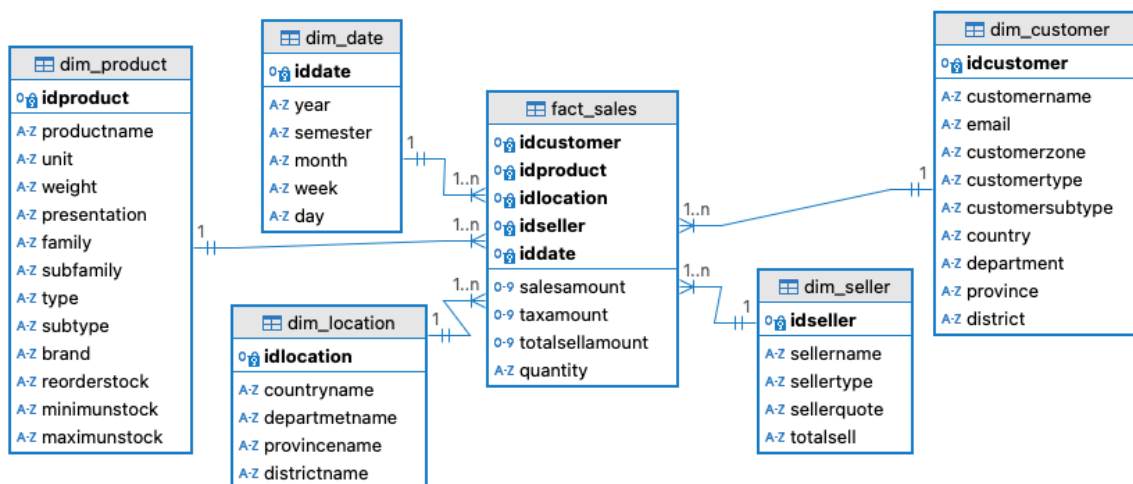

Figure 2. Start model created with Kimball methodology

This is the first process analyzed in the factory, but there is room to implement other BI systems in other processes. The conformed dimensions identified in this model are the dim_product and dim_customer

tables. Another technique used is the slowly changing dimension (SCD) to manage dimensions with many changes and improve analysis [28]. The dim_customer and dim_location were originally one single dimension, but after applying SCD type 5, they became two separate dimensions. another important concept consider in the model is hierarchies to allowing examination of data in various levels [29], as a example of one hierarchies in the model is family –> subfamily (dim_product) and year–>semester–>month–>week–>day (dim_date). It is also worth mentioning that the identified metrics, shown in the figure, do not include execution-time metrics like average sales; these types of metrics are set in reports.

After the creation of the model, the tools for implement it are chosen, the tool selected for manage databases were sql server management studio (SSMS) to implement the data mart, sql server analysis services (SSAS) to implement the information cubes, this is a multidimensional database. The tool form ETL proceses is sql server integration services (SSIS), the reporting tool selected sql server reporting services (SSRS).

The following phase is implementing the data warehouse. All the necessary meetings were carried out, centered around stakeholders whose participation was crucial in determining the requirements and selecting the right tools for implementation. With this information, the requirements were made using the selected tools. After that, tests were conducted, and the BI system was implemented.

The final phase is evolving the model, which involves evaluating the performance of the BI system. In this case, the evaluations were made using instrument creation to assess the results of system usage, as well as data analysis to evaluate the increase in sales. The process of instrument creation is explained in the next section.

2.2.2. Instrument creation

To evaluate the results of the BI implementation, a questionnaire instrument were elaborated, to realized this questionnaire an operationalization matrix [30] was elaborated, in this dimensions indicators were identified, this concepts are related to main objetives of this research. The questionnaire created, contains 25 questions, 11 questions related to BI variable, and 14 questions related to sales increase variable, each question measure the propose indicators in Table 1.

Table 1. Summarized operationalization matrix

Variables	Dimensions	Indicators
Business intelligence	Applications and technology	Business intelligence technology
		Web, desktop or mobile applications
	Information management	Quality of information
		Access to information
	Decision-making	Reliability in decision-making
		Speed of decision-making
Increase in sales	Quantity and amounts sold	Quantity and Amount sold per customer
		Quantity and Amount sold per product
	Marketing strategies	Product promotions
		Replacement time
		Average purchases
	Customer segmentation	Segmentation by type
	Period of time	Sales campaigns according to period
		Planning new campaigns
	Build customer loyalty	Increase in sales per customer due to marketing campaigns
		New customers for new marketing campaigns

After the questionnaire was created to ensure its consistency, a validity and reliability test was conducted. The Cronbach's alpha metric was used to assess reliability [31]. The indicator for BI-related questions (11) was 0.8, and the indicator for sales increase-related questions (14) was also 0.8. This indicates a high level of internal consistency [32]. To demonstrate the questionnaire's validity, content validity (using expert judgment [33]) and construct validity (using the KMO index and factor analysis [34]) were evaluated. For content validity, three experts reviewed the questionnaire and agreed that it is appropriate for measuring the proposed indicators. The KMO index (0.77 for the BI variable and 0.71 for the sales increase variable) and factor analysis represented all the dimensions (8) considered in the creation of the questionnaire.

2.3. Phase 03: results evaluation

To evaluate the result of this investigation, a hypothesis test applied to the questionnaire was selected as a tool (Chi-square test). This type of test is commonly used in quantitative research to confirm or refute hypotheses [35]. To conduct the hypothesis tests, three research hypotheses were established: H1 BI implementation improves marketing strategies, H2 BI implementation helps increase sales, and H3 BI implementation strengthens customer loyalty and segmentation. The objective of this hypothesis test is to attempt to reject the established hypotheses using their corresponding null hypotheses.

Documentary review [36] is also another technique to confirm the objectives, comparing the amount and quantity of sales before and after the implementation of the BI system. The questionnaire was applied to 200 people who work in the manufacturing business. It was implemented using Google Forms and took 30 minutes to complete. The results are explained in the following section.

3. RESULTS AND DISCUSSION

In this section, the results of the research are explained and discussed accordingly. The results are analyzing through an hypothesis validation, the Chi-squared test is commonly used [37] for that. The hypothesis presented in section 2.3 and their corresponding null hypothesis were analyzed in Table 2. Table 2 shows that all null hypotheses are rejected with high chi-squared values and low p-values. A p-value of less than 0.01 indicates a 99% confidence level and a 1% error margin, which is the cause of the null hypotheses rejection, meaning all investigation hypotheses are accepted.

Table 2. Results of hypothesis validation

Hypothesis	Null hypothesis	Chi-squared	P-value	Interpretation
BI implementation improves marketing strategies	BI implementation improves marketing don't strategies	5.5	0.0001	Null Hypothesis rejected / Hypothesis accepted
BI implementation helps increase sales	BI implementation don't helps increase sales	21.48	0.0003	Null Hypothesis rejected / Hypothesis accepted
BI implementation strengthens customer loyalty and segmentation	BI implementation don't strengthens customer loyalty and segmentation	38.59	0.0001	Null Hypothesis rejected / Hypothesis accepted

The main findings of this investigation indicate that for the first accepted hypothesis (H1), the questionnaire measured product promotions, new products, replacement time, promotions to customers, and average purchases. The results, supported by Table 2, indicate that there is a significant improvement in promotion strategies at the factory. A similar analysis was conducted for the second (H2) and third hypotheses (H3), where the questionnaire measured metrics such as quantity sold per customer, amount sold by customer, amount sold per product, reliability in decision-making, and speed in decision-making. The metrics collected by the questionnaire indicate improvement in these areas.

The document review technique supports these findings. For the review, a sales comparison was conducted; in this comparison, the years from 2015 to 2022 were evaluated, excluding 2020 and 2021 because, as pandemic years, sales were irregular. This comparison, presented in Figure 3, shows an increase in the level of sales over the years. The first three years, where the BI system was not implemented, show the lowest sales in the figure. In the last years, with the implementation of the system, sales increased and set a stable trend.

The findings align with the literature review conducted. The increase in sales is a benefit mentioned in research [1], [4], while the improvement of marketing techniques and customer relationships is supported by studies [2], [3]. This demonstrates that the implementation of BI in SMEs in emerging countries can bring benefits in sales, marketing, and client loyalty. However, the implementation of this technology needs to be carefully managed to avoid increases in budgets and timelines. To control these aspects, it is necessary to consider factors such as choosing the right methodology for implementation and adapting it to the business needs. This is important for motivating the implementation of BI systems in emerging countries in Latin America, including Peru, where there is a lack of increasing literature related to strengthening the use of this technology.
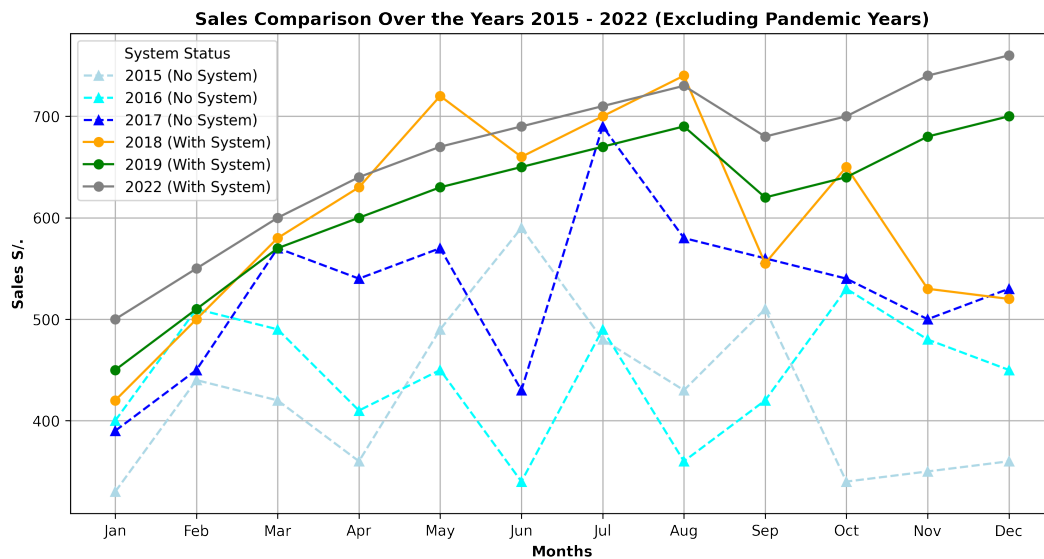
Figure 3. Sales comparison

4. CONCLUSION

The importance of this research is to demonstrate that BI technology is also relevant in emerging countries in LATAM. The case study focuses on SME factory businesses in Peru, and in this context, this research is relevant to indicate the critical factors to consider in the implementation of BI technology, such as controlling implementation time. Extended implementation processes generate additional expenses that increase the budget and demotivate stakeholders. This research recommends, based on the literature review and validated in the method and results sections, that adapted methodologies control time and expenses, allowing implementation in SME businesses and bringing identified benefits. As future work, this study should be used as a success case to motivate further BI adoption in similar businesses and regions. Ultimately, such advancements could significantly enhance the global competitiveness of SMEs in emerging markets.

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