Research Article

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Development of a Data Visualization Model for Optimizing Warehouse Operations with Power BI and R.

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***Abstract*—** Data driven and decision making in warehouses is crucial to improve operational efficiency. However, many companies have difficulties when analyze large amounts of data in real time. Therefore, this research proposes the development and the implementation of dynamic dashboards using Power BI and R Script, which will analyze key metrics in five warehouses at a confectionery company located in Ciudad Juárez, Chihuahua, allowing for clear real time visualization of the warehouses for the logistical performance. The methodology used involves the integration of information from multiple and centralized sources, while R will be used for advanced data cleansing and analysis for the automation of the reports in Power BI. As a result, logistics processes of the warehouses were easily optimized, the analysis time was reduced, the decision-making accuracy was improved, and a better distribution of staff activities was achieved on the manufacture company.

Keywords: data analysis, digital transformation, report automation, r Script in “power bi”, warehouse management.

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I. INTRODUCTION

Today, with the arrival of Industry 4.0, we are entering a new era in the organization and management of value chain in the companies throughout the entire life cycle of the product. This industrial revolution is materializing through the application of technologies, specifically the Internet of Things (IoT), which integrate an "IoT" model into the industrial environment [1]. Industry 4.0 leverages a range of technological tools to enhance the efficiency, productivity, and decision-making. Among the most common used tools are big data, data analysis, cloud computing, artificial intelligence, and machine learning, etc. These tools have become indispensable pillars of the industry 4.0 technological ecosystem and are used in companies to adapt to an increasingly digitized and competitive business environment [2].

On the other hand, the analysis of key performance indicators, better known in the business world as "KPIs" (Key Performance Indicators). In warehouses, they are essential for optimizing the logistics processes and improving the operational efficiency, as they allow organizations to evaluate the performance of their processes and the human resources to facilitate the identification of areas for new improvements and informed decision-making [3]. The implementation of KPIs in warehouse management offers multiple benefits, as measuring with key indicators is the first step in understanding and improving the warehouse operations. Furthermore, by analyzing indicators, such as "material shortages, WIP, or exports," companies can identify inefficiencies and apply many strategies to reduce costs and increase productivity [4]. That is why the absence of tools for visualizing and analyzing logistics data represents a significant challenge for supply chain management. This shortcoming in companies leads to inadequate planning and inefficient inventory management, including distribution problems, which negatively affect operational efficiency in the companies [5].

The management of Logistics process is a complex activity with a multi criteria approach, as it is becoming increasingly complicated for companies due to the intervention of multiple factors of decision [6]. The missing of adequate tools for the data visualization and management makes it difficult to measure and analyze warehouse process performance, which creates gaps in the information needed for the decision-making [7]. In addition, it should be noted that the growing complexity of logistics chains has increased the need for mathematical techniques and models to help companies make correct decisions. However, the missing of advanced tools for visualizing information makes it difficult to interpret these models, which limits their applicability in real manufacturer environments [8]. For this need, the integration of programming languages with tools for creating dynamic dashboards, such as R Scripts with Power BI, allows for expanded analytical capabilities, as scripts that perform and reach advanced statistical analyses along with predictive and generative models are incorporated directly into the reports created [9]. In addition, this set of tools facilitates the consolidation of the data from multiple sources together with the application of ETL (Extract, Transform, Load) processes, since, once the data is integrated into Power BI, R libraries can be used to enrich the analysis, generating more customized visualizations in the interactive dashboards, which will enable top management to make strategic decisions in real time for the Company [10].

In end, bringing together R with a Power BI increases how accurate forecasts get plus even makes it easier to notice strange behavior in data. This method also means there is less need to use old analytical tools which makes for a more complete and automatic analysis setting that leads to higher efficiency with warehouse controls [11]. The study comes up to visualize data that mixes analytical and data changing of R with the view in Power BI. The purpose is filter and show different sources of the information to make the dashboard visuals that can measure how are performing the five warehouses of a food manufacturing business in Ciudad Juárez, Chihuahua. This system is looking for a less time spent for the employees on the analysis, making it simpler to spot when results are deviating on a forum, and build the company community that is focused on always getting better. What is contributed by this investigation is solution that works in practice and can be expanded for the digital warehouse control, giving an adjustable model for different cases useful for next studies and new technology projects with view of improving logistics on the companies.

II. LITERATURE REVIEW

a. Dynamic dashboard creation in Power BI using R

The integration of R Script into Power BI has enabled the creation of dashboard more dynamics that combine statistical analysis with interactive tools of friendly visualization. The synergy of these two tools gives us a better data driven and decision-making in various business and industrial contexts [12]. Power BI was developed by Microsoft, is a business intelligence tool that enables interactive and practical data visualization. The language of programming R is used for advanced statistical analysis and data science. The combination of this both tools allow the users to run R scripts within Power BI, applying advanced analytical and visualization capabilities within the platform [13]. This integration facilitates the complex analysis of data and the generation of custom visualizations that are not natively available in Power BI [14]. With the incorporation of R into Power BI, it is possibly creating a dynamic dashboard for update in real time and offer interactivity to the user. It possible to make performs to data transformations using R scripts, also is possible apply statistical models, and generate comprehensive visualizations. These dashboards provide an deepest understanding of the data and facilitate the identification of patterns and trends relevant to decision-making [15].

b. SharePoint for cloud file storage

SharePoint, that also was developed by Microsoft, is a cloud system for different type of companies, helping with managing files, sharing them and working together in a team place at same time. It can join with storage in the cloud, which has changed how businesses save and control the files [16]. The move of SharePoint to cloud made organizations use the pluses of online storage, including scaling up and accessing files from any location inside the company. With SharePoint and cloud joining, companies may deal with big data masses well, guaranteeing information is safe and ready to use when needed [17]. Also, this joining makes possible many users to collaborate on documents or change them at same time in real time [18].

c. Integration of Excel and Power BI for Key Performance Indicator Management

The combination of both tools allows:

- Power BI connect directly to Excel workbooks, enabling efficient data import and updates [22].
- Power BI offers interactive dashboards that make it easier to interpret trends and patterns [23].
- Power BI enables automatic report updates; this reduces the time spent on manual tasks and minimizing human error [24].

Now, if combine the use of Excel and Power BI for managing KPIs can be carried out with the next steps:

1. Relevant datasets are inserted and set up inside Excel spreadsheets to confirm data has quality and looks consistent [25].
2. Information from Excel can get loaded into Power BI, and this helps to connect both so they can update data at real time [26].
3. In Power BI, there is the chance to build interactive visuals showing selected KPIs for easier understanding about performance and analysis [27].
4. By taking Power BI's sharing attributes, dashboards are sent to stakeholders and they will access updated and related data always [28].

III. METHODOLOGY

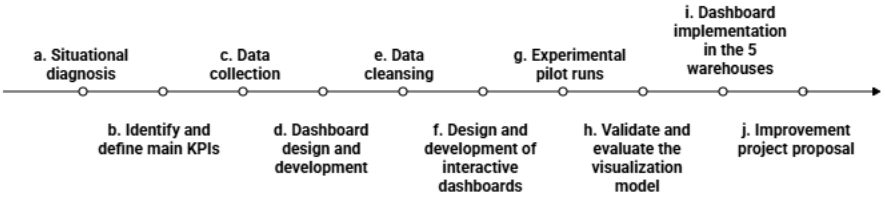

Fig. 1: Phase flow of the experimental method.

a. Situational diagnosis of the manufacturing company

This study takes place in a confectionery production company that is based in Ciudad Juárez, Chihuahua, Mexico and does making and co-making items for major international business in food industry. This factory belongs to food sector and its operations are big and increasing year by year, containing many logistics activities in storing and producing. The infrastructure holds five chief storages with names Norte, Sur, Este, Becket and Jerónimo. There is also an external logistics services partner (3PL) that allows efficient moving of both finished products and the raw materials from Mexico towards the United States. A very wide selection of operations is managed by the company, comprising raw resources, inventory-in-progress (WIP), and finished goods, which are kept and delivered precisely, so flow of operation is always steady.

Pallets are used for materials which are placed in racks and tracked with inventory system following FIFO (First In, First Out) method, which is very important to guaranteeing all food fresh and keeps SQF safety rules. But, one of most major problems faced each day is, in fact, to measure this system closely and also to deal with material shortages and hit targets for time in moving material between sites. The work environment is very dynamic, where items are always moving around from one warehouse to another warehouse and to production, a really accurate as well as visible real-time arrangement between warehouses is required. Yet, there is almost no automatic operation in any warehouse, so most depends on manual checklists, Excel files or even physical checks. Especially, to gather and put together needed data for keeping track of main KPIs, Excel files are used, which turns out to be a big time and effort investment. This fact negatively affects how well analysis and quick decisions work.

Just as an example, operation start-up meetings daily in warehouses take at least one hour; management meetings every week for viewing KPIs might even go for one and a half hours, since all information is checked by hand and there are often mismatches in data to fix. The main system used by company for registration of operations and data is BAAN ERP, but it lacks advanced displays or a higher level of automation.

b. Identification and definition of the main KPIs used to evaluate operational efficiency in inventory and warehouse management

A correct measuring operational performance in all warehouses requires reliable and an accurate indicator aligned with the organization's strategic objectives. In this study, the main Key Performance Indicators (KPIs) used were identified and defined to provide a comprehensive evaluation of operational efficiency in warehouse management within the company.

The selection of KPIs was based on four fundamental criteria established in 2023:

- Operational and strategic relevance.
- Direct impact on decision-making within the warehouse area.

TABLE I
SELECTED KPIS, DEFINITION, OBJECTIVE, AND ANALYSIS FREQUENCY.

KPI	Description and objective	Measurement frequency
Exports completed	Total number of completed and dispatched exports.	Daily
Export registration	Tracks the timely and accurate recording of each export in the system.	Daily
Glucose tanker unloading time	Measures the time from arrival to full unloading of glucose tankers.	Daily
Open Replenishment	Number of open or unattended replenishment requests.	Daily
Inter-plant transfers and WIP moved	Evaluates the number of WIP movements between warehouses and their completion.	Daily

Material shortages	Incidents where required material was not supplied on time.	Daily
WIP requirements	Record of materials needed to keep production lines running.	Daily
Forklift availability	Percentage of available forklifts relative to the total fleet.	Daily
Yard capacity	Measures the occupancy percentage of trailer or container in the yards.	Daily
Headcount	Number of personnel available for logistics activities.	Daily
Aging Finished Good	Time finished products remain in storage without being dispatched.	Weekly
Inventory accuracy	Compares physical inventory with system-recorded inventory.	Weekly

Therefore, a proper identification of the KPIs provides a solid basis for building the visualization model in Power BI. It also enables a continuous monitoring of the operations, the timely detection of the deviations, and data driven for decision-making. All of these indicators working together offer a comprehensive view of the logistics performance across all the warehouses of the company while supporting the digitalization process and continuous improvement on the effort of the company.

c. *Data collection*

The data collection was carried out with the main objective of obtaining an accurate and representative information about the logistics operations within the different warehouses of the confectionery manufacturing company. The data used in this study were obtained from three main sources:

- ERP System "BAAN": Historical and actual records related to the material movements, inventory, and the relevant logistics events were extracted. This source of data provides transactional information of the material that is essential for KPI analysis.
- Spreadsheet records (Excel): All the Key Performance Indicators was manually typed by the personnel of the warehouse in different Excel files. These documents contained a lot of consolidated information on metrics as forklift availability, headcount, material shortages, WIP, tanker load/unloading times, exports, etc.
- Observations and operational meetings: The information was complemented through direct observation of the operations with the help of the warehouse personnel, as well as by following inf a daily and weekly basis Keep Performance Indicators review meetings better known as operations kickoff meetings. These sessions, which typically lasted between one hour and one hour and half hour, helped to identify the discrepancies in data entry on the different sources, operational bottlenecks, and opportunities for improvement in the reporting processes.

The data collected cover a period from January 2023 to March 2025, including historical and actual information. To facilitate its use in subsequent analyses, an extract, transform, and load (ETL) process was designed to standardize formats, clean inconsistencies, and prepare the data for visualization in Power BI using R programming. The use of multiple data from different sources ensures a comprehensive view of the logistics system, at the same time, allows validation of data accuracy and consistency. This stage is crucial for building a visualization and analysis model that supports data driven decision-making within the warehouse environment.

d. Design and development of a dashboard connected to multiple data sources in Excel and BAAN

As an initial step toward the digitalization and automation of logistics KPIs, the first visualization solution was developed using Microsoft Excel. The purpose of this stage was validating the structure of the indicators, test calculation formulas, and ensure the integration of data from different sources. For this reason, the development of the first dashboards in Excel was carried out using a modular approach, centralizing the information into a single main control sheet connected to multiple external files.

These files included:

- Excel files manually generated by representatives from each warehouse (daily data entry).
- Reports exported from the ERP system (BAAN).
- Internal tracking files, such as forklift reports, headcount records, and finished goods aging reports and others.

1. Integration of multiple sources

The connection between the files was achieved for the usage of formulas such as VLOOKUP, INDEX-MATCH, INDIRECT, and pivot tables. In addition, Power Query of Excel was used to automate the loading of the data and the transformation. This allowed the dashboards to update a semi-automatically by replacing the source files with updated versions.

2. Visual design and structure

The dashboards were designed with a clear interface, organized by date and the "KPI" categories. Also to provide a clear visualization for each plant, were structured in a individual way to see the daily and weekly indicators.

3. Basic automation through macros

VBA macros were incorporated to automate repetitive tasks such as updating tables, cleaning formats, generating consolidated reports, and managing version control.

4. Advantages and limitations of the approach of excel

For a flexible implementation was allowed the usage of Excel, which was suitable for an environment with a low level of automation, such as the current operation of the warehouse company. However, were identified a lot of limitations, including dependence on local file, risk of manual capture errors, and difficulty in consolidating of the data in real time. These limitations justified why the later migration of the model to a more robust and scalable platform such as Power BI, integrated with R for automated data transformation processes.

5. Data cleansing using R prior to Power BI implementation

A data cleansing and a stage of transformation was carried out before the implementation of the model data using the R Script programming language. The phase objective is ensuring the quality, the consistency, and the structure of the data obtained from the multiple sources, allowing for an accurate interpretation and visual analysis in Power BI platform.

- ***Justification for using R for data cleansing***

The usage of R responds to the need to provide automate repetitive cleaning tasks, also integrate the multiple files with heterogeneous structures, detect common human errors during the entry of the data, and the data exported from BAAN ERP System standardize. R, use a robust ecosystem of data manipulation packages (such as dplyr, tidyr, readxl, and data. table), enables for transformations of complex data to be performed in a reproducible and scalable way.

- ***Data cleansing process using R Script***

A modular script is developed in R that allows the following bullet points:

a) Import Excel and .csv type files from different folders and sources.
b) Standardize variable names.
c) Remove duplicate records.
d) Impute or eliminate missing data.
e) Standardize dates, units, and categories to ensure compatibility.
f) Audit changes by generating cleaning logs to maintain traceability.

Through this approach, the process encapsulates the necessary steps, for this reason it can be executed periodically with a single command, facilitating integration with Power BI.

- ***Advantages of pre-cleaning data with R***

The performing data cleansing in R language offers several important benefits:

a) Significant reduction in data loading and processing time in Power BI.
b) Prevention of data model overload in Power BI, maintaining a lighter and more efficient structure.
c) Greater control and traceability over the transformations performed.
d) Automation of processing tasks, with the possibility of scheduling future executions through R scripts.

- ***Data output for Power BI***

Once a time cleaned the information, the data are exported from R in .xlsx or .csv format, using a clean and structured tabular layout ready for direct connection to Power BI without more inefficient movements. This output is stored in a SharePoint location, allowing Power BI to update the information dynamically with minimal manual intervention eight times per day. This stage is essential to ensure the reliability of the visualization model and to establish the foundation steps for a scalable, automated system oriented toward a continuous improvement of the data driven decision-making.

6. Design and development of interactive dashboards in Power BI

Once the data have been cleaned and structured using R packages, the process moves forward to the next step: the design and the implementation of interactive dashboards in Power BI. The purpose of this stage is transforming large volumes of operational data of the warehouses into dynamic, accessible, and practical visualizations that support the decision-making in warehouse management.

- ***Objective of the interactive dashboard***

At this stage, the main goal is to develop a visualization tool that allows:

a) Daily and weekly monitoring of the defined KPI.
b) Easier detection of deviations and opportunities for improvement.
c) Replacement of manual Excel based information consolidation processes.
d) Reduction of analysis time during operational and managerial meetings.

- ***Design principles used***

The dashboard design is based on effective data visualization principles, that includes:

a) Use of simple and easy-to-understand visuals such as bar charts, line charts, cards, and tables.
b) Critical KPIs are placed at the top, while complementary information is displayed in lower sections.
c) Unified use of colors, filters, and formats across all pages.
d) Use of slicers and filters that allow users to explore the data by warehouse, date, or KPI.

- ***Interactive dashboard functionalities***

The dashboards include the following key features to facilitate exploratory analysis by users:

a) Dynamic slicers with filters by warehouse, date, or KPI.
b) Summary cards with quick visualization of key figures.
c) Visual alerts with use of traffic light color indicators to highlight deviations from targets.
d) Comparative charts with visualization of historical performance versus averages or targets.
e) Thematic page navigation with dashboards organized into separate sections by topic.

- ***Publishing and updating***

The dashboard created is published in the Power BI cloud service of the company, allowing users to access it through web browsers or mobile devices using his company credentials. An eight time per day scheduled refresh is configured using the files previously processed in R and stored in SharePoint or shared folders. This eliminates the need for the consolidation of the data in a manual way and ensures updated information for each operational meeting.

- ***User validation***

Before launching the pilot version of the dashboard, is necessary a validation session with end users. Based on their feedback, the adjustments are made to improve usability and functionality to make each time more friendly for the personnel.

This phase represents the transition toward from a manual data entry to a data driven culture supported by accessible, reliable, and real time information, this is aligned with the organization's goals of efficiency, digitalization, and evidence based on decision-making within logistics operations to a continuous improvement culture.

7. Experimental pilot run of the interactive dashboard in Becket and Oeste warehouses

To can evaluate functionality, the operational usefulness, and the adaptability of the visualization model developed in Power BI system, was carried out a controlled experimental pilot run in two of the five company's warehouses: Becket and Oeste. The purpose of this phase was to analyze the performance of the system in a real operating environment and collect qualitative and quantitative information before to a full-scale implementation.

- ***Justification for selection***

Becket and Oeste warehouses were selected strategically to represent different operating conditions within the company's logistics network:

a) They are characterized by relatively stable and small operations.
b) They have fewer personnel and a lower operational load talking about trucks movements and productions pallets per day, which makes experimentation easier to conduct without significantly affecting in the daily activities.

The selection of these warehouses allowed the comparison of the dashboard's behavior across different operational contexts, because one of them move allergen product that it need to have a special movement.

- ***Pilot test configuration***

Historical and real time data from two pilot warehouses were loaded using the data that was cleansing script developed in R in the last steps, generating clean and structured files. These data sources were connected on Power BI model previously configured, showing only the records corresponding of these two warehouses. Also, the access was granted to operational personnel and supervisors from Becket and Oeste warehouses through the Power BI cloud platform, with an only one daily scheduled refresh and specific filters configured for each warehouse for this practical case.

- ***Metrics observed during the pilot test***

During the experimental run, the following aspects were monitored:

a) Dashboard loading and response time.
b) Accuracy of the displayed KPIs, compared with records from Excel and BAAN.
c) Ease of use as reported by users.
d) Reduction in the time required to prepare information for operational meetings.
e) Staff reactions to visual deviation alerts.

- ***User interaction***

Were conducted a brief training sessions to explain the use of filters with all the personnel of each warehouse, the tab navigation, KPI interpretation, and graphic visualization. Over a period of one month on a probe period, the users were invited to utilize the dashboard, employing it as the primary tool during daily meetings and routines. During this time, surveys and informal interviews for each person were conducted to evaluate the following things:

a) Visual clarity of the charts.
b) Practical usefulness in decision-making.
c) Suggestions for improvement or necessary adjustments.

- ***Expected results of the pilot phase***

a) Verification of the system's operational functionality under real conditions.
b) Acceptance by end users as a critical success factor.
c) Adaptability of the visualization model to different types of warehouse operations.

The findings and feedback obtained from Becket and Oeste allowed for technical and design adjustments before extending the regular implementation to the five warehouses, this, contributing to a gradual, sustainable, and a culture of digitalization strategy.

8. Validation and evaluation of the visualization model

Carried out a validation and evaluation of the visualization model developed in Power BI with R Scripts, the model system representing a critical phase within the methodological process, to determinate the system's effectiveness, reliability, and practical usefulness in the real warehouse operational environment. The purpose of this phase is to ensure that the generated Power BI dashboards are not focused only on the technically functional, but also, the relevance and aligned with the needs of end users to bring a continuous improvement culture.

- ***Validation objectives***

a) To verify that the data displayed in Power BI are the same with the original records from BAAN and Excel.
b) To ensure that users can easily detect operational deviations.
c) To confirm that the model reduces meeting times and supporting data driven decision-making.

- ***Validation criteria***

The following technical and functional criteria are defined to assess the effectiveness of the model:

TABLE II
TECHNICAL AND FUNCTIONAL VALIDATION CRITERIA.

Criteria	Description
Accuracy	Verification that the values displayed match the original data sources.
Consistency	Uniformity in the presentation of KPIs across different periods and warehouses
Visual clarity	Ease with which users interpret the visualizations.
Interactivity	Responsiveness of filters, slicers, and navigation.
Practical usefulness	Real application of the dashboard during meetings and operational decision-making.
Time reduction	Decrease in the time required to consolidate and analyze data.

- ***Techniques used for the evaluation***

a) Cross-validation data tests: Records displayed in Power BI are compared with the original data sources (Excel and BAAN) to ensure accuracy.
b) Direct observation during the use of the dashboard in daily and weekly operational meetings.
c) User perception surveys applied to supervisors, warehouse leaders and operational personnel.
d) The average time required to prepare KPIs and the duration of the meetings before and after implementation of the model.

- ***Participating users***

The operational and administrative users from the two pilot warehouses participated in the validation process. Previously they had used manual spreadsheets for KPI analysis. The experience of the personnel made it possible evaluate the transition from non-visual Excel sheet to a visual and interactive platform, gathering qualitative and quantitative feedback.

- ***Expected validation results***

a) The interactive dashboard is technically robust.
b) It is functional and adaptable.
c) It is well received by users who report greater clarity

TABLE III
EXPERIMENTAL PILOT VALIDATION CRITERIO

Validation Criterion	Description	Evaluation Indicator	Expected Result	Observed Result
Data accuracy	The KPIs displayed in Power BI match the actual figures from BAAN / Excel.	% match between dashboard and original source	≥ 95%	
Visual consistency	The model maintains coherence across pages, formats, and colors.	Number of visual errors detected	0 errors	
Interpretation clarity	Ease with which users understand and interpret the visualizations.	User survey rating (1 to 5)	≥ 4.0	
Functional interactivity	Filters and slicers respond correctly and update visuals.	Response time when applying filters	< 3 seconds	
Analysis time reduction	Reduction in the time required to prepare and analyze information.	Duration of meetings before vs. after	Reduction ≥ 30%	
Decision-making support	The dashboard supports operational decisions and helps prevent deviations.	# of decisions made based on the dashboard	≥ 1 per week	
General usability	Overall acceptance and ease of use of the dashboard.	% of users who would recommend the dashboard	≥ 80%	
Automated updates	The model updates with new data without manual intervention.	Correct update frequency	Daily without errors	

9. Implementation of the dashboards across the five warehouses

Once the visualization model was successfully validated in the pilot warehouses on the experimental period, was carried out across the companies in the five operational warehouses the full implementation: Norte, Sur, and Jerónimo without forget Becket and Oeste that was piloted in the experimental phase. This step represents the formal deployment on all the company the interactive visual system developed in Power BI using R Scripts with the main objective of establishing a unified and automated monitoring of the Key Performance Indicators throughout the company's logistics network, this allows to the top management see the performance of their warehouses operations in real time.

- ***Implementation objective***

The main purpose of the stage is achieve operational visualization model across all storage centers, standardizing the way that are reported the logistics KPIs, interpreted, and analyze. This includes:

a) Replacing manual reports and scattered spreadsheets.
b) Improving communication between warehouses.
c) Facilitating coordinated decision-making at the managerial level.

- ***Deployment strategies***

The implementation is carried out in a gradual and controlled way, following this steps process:

a) Data and dashboards are filtered.
b) Automatic paths are established to import cleaned data from R and stored in SharePoint.
c) Access profiles are defined within the Power BI cloud service.
d) Induction sessions are conducted for operators, supervisors, and managers.
e) During the first weeks, technical support and usage monitoring are provided, collecting feedback for minor adjustments.

- ***Specific adaptations by warehouse***

Custom adjustments are made according to the particular operational conditions of each warehouse adapting the system to KPI used per plant.

- ***Implementation success indicators***

During this phase, the following aspects are monitored to validate the effectiveness of the process:

a) Level of dashboard adoption on the operational meetings.
b) Reduction in the time required for manual KPI consolidation.
c) Increased consistency in reported data.
d) Improved early detection of operational deviations.
e) User satisfaction level measured through internal surveys.

- ***Expected results***

The implementation allows the organization the transition to a data-driven culture, strengthen coordination among all the warehouses, consolidate a logistics analysis model that is replicable and scalable for future initiatives with a view to a culture of continuous improvement.

10. Improvement project proposal

The development of the interactive visualization dashboard model in Power BI was the result of the diagnostic analysis and the implementation across the five warehouses of the company and established a comprehensive operational improvement proposal for the decision making. This proposal is aimed at strengthening a real time and updated data for a analysis culture in the company to reducing manual activities and increase the logistics efficiency through automation, data driven and decision-making based on reliable information

IV. RESULTS

14 Key Performance Indicators were defined and grouped into four logistic strategic areas: exports, operations, inventory, and processes. These indicators were selected based on their relevance on the operation, from the historical data and deviation tendences, their direct impact on decision-making, and their alignment with a continuous improvement culture strategy focused on logistics efficiency.

a) Exports: Total completed and dispatched export shipments.
b) Operations: Forklift availability, yard capacity, and headcount.
c) Inventory: Inventory accuracy, finished goods aging, material shortages, and WIP shortages.
d) Processes: Export registration, glucose unloading time, inter-plant trailer inventory, and WIP trailer inventory.

- ***Initial design in Excel***

On the preliminary stage, an initial dashboard prototype in Excel was developed to centralize and organize the main information of the warehouse. This Excel prototype was structured around three main functions:

1) Were created connections from multiple sources and files using formulas and Power Query.
2) Was created and structured, organized interface by date and categories
3) Visual Basic for Applications, specifically macros were developed to execute repetitive tasks.

This approach made it possible concentrate the information in a single and centralized Excel sheet, this improves the flow of each query and facilitating data analysis from multiple sources. As a result of this phase, the duration of follow-up meetings was reduced from two hours to 45 minutes, this represents a 62% improvement.

PLANTA JERONIMO	SEMANAL	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11
	Actual	15	29	44	45	50	64	61	81	71	30	81
	Target	18	30	52	52	52	52	52	52	52	40	56
Exportaciones Realizadas	*% Cumplimiento*	83%	97%	86%	87%	98%	122%	116%	154%	142%	105%	145%
	En tiempo	17	24	23	24	28	50	57	40	47	25	40
	En destiempo	-2	5	21	21	21	14	10	41	24	17	41
Registro de exportaciones	*% Cumplimiento*	117%	80%	46%	52%	54%	77%	97%	52%	68%	48%	51%
	Actual	10	10	9	13	18	16	14	21	19	18	29
	Target	0	9	10	14	19	18	13	18	19	13	27
Registro de PIPAS	*% Cumplimiento*	0%	103%	88%	95%	100%	89%	107%	116%	100%	106%	113%
Descarga de PIPAS (Tiempo promedio)	*Actual*	14:04:07	8:54:29	11:24:51	9:46:35	9:45:29	17:55:23	10:05:54	7:58:26	7:21:26	2:43:59	2:55:11
	Target	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00
	Actual	0	1	4	1	0	1	1	0	2	0	4
Open Replenishments	*Target*	0	0	0	0	0	0	0	0	0	0	0
	Actual	10	3	8	4	3	5	8	4	4	7	9
Equipos interplantas cargados	*Target*	3	3	3	3	3	3	3	3	3	3	3
	Actual	1	1	2	2	2	0	2	5	1	0	4
Equipos WIP cargados	*Target*	1	1	1	1	1	1	1	1	1	1	1
	Actual	15	21	23	16	66	1311	1231	55	40	179	142
	Target	15	39	42	40	41	34	53	60	43	46	31
Cortos de material	*% Cumplimiento*	100%	51%	52%	46%	209%	5335%	3756%	91%	97%	811%	896%
	Actual	0	4	6	3	9	7	0	0	0	1	4
	Target	0	8	16	3	21	11	0	0	0	1	10
Requerimientos WIP	*% Cumplimiento*	0%	25%	31%	100%	41%	43%	-	-	-	100%	43%
	Actual	0	0	5.00	5	5	5	6	6	7	7	7
Disponibilidad de montacargas	*Target*	0	10	10	10	10	10	10	10	10	10	10
	% Cumplimiento	0%	0%	50%	50%	50%	50%	60%	60%	70%	70%	70%
	Actual	0	0	51	57	47	54	0%	55	48	60	62
Capacidad de patios	*Target*	85	85	85	85	85	85	85	85	85	85	85
	% Cumplimiento	0%	0%	55%	71%	66%	55%	55%	64%	56%	0%	73%
Headcount	*Actual*	0	56	56	56	57	56	56	54	54	54	54
	Target	82	82	82	82	82	82	82	82	82	82	82
Aging Finished good	*Actual*	5	56	56	25	3	23	4	4	4	3	3
	Target	0	0	0	0	0	0	0	0	0	0	0
Veracidad de inventarios	*Actual*	-	77%	95%	89%	88%	80%	88%	85%	91%	90%	86%
	Target	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%

Fig. 2: KPIs prior to the implementation of the initial Excel design at Jerónimo plant.

PLANTA NORTE	SEMANAL	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11
	Actual	0	41	28	29	34	33	13	40	40	47	22
	Target	0	41	27	30	30	26	13	32	43	46	27
Exportaciones Realizadas	*% Cumplimiento*	117%	100%	97%	97%	113%	123%	100%	126%	94%	87%	51%
	En tiempo	0	41	28	26	34	33	13	40	40	40	22
	En destiempo	0	0	0	3	0	6	0	0	0	0	0
Registro de exportaciones	*% Cumplimiento*	0%	100%	100%	80%	100%	71%	100%	100%	100%	93%	100%
	Actual	0	14	13	20	28	18	22	22	13	9	17
	Target	0	8	18	13	17	10	14	14	13	11	15
Registro de PIPAS	*% Cumplimiento*	0%	133%	83%	115%	207%	152%	158%	158%	100%	81%	120%
Descarga de PIPAS (Tiempo promedio)	*Actual*	0:00:00	2:02:20	3:19:03	14:59:09	1:17:59	22:03:06	5:41:51	5:41:51	5:48:25	1:58:48	2:18:24
	Target	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00	12:00:00
	Actual	0	0	8	0	0	0	1	1	0	3	0
Open Replenishments	*Target*	0	0	0	0	0	0	0	0	0	0	0
	Actual	0	4	6	5	8	0	5	3	6	5	4
Equipos interplantas cargados	*Target*	3	3	3	3	3	3	3	3	3	3	3
	Actual	0	0	0	1	0	0	0	0	1	0	0
Equipos WIP cargados	*Target*	1	1	1	1	1	1	1	1	1	1	1
	Actual			251	66	129	1936	1843	109	108	293	265
	Target			100	75	86	90	100	75	107	118	89
Cortos de material	*% Cumplimiento*	-	-	290%	85%	167%	3917%	2186%	168%	99%	415%	392%
	Actual	155	217	227	221	217	217	219	235	211	45	50
	Target	0	9	10	4	0	0	4	20	31	30	17
Requerimientos WIP	*% Cumplimiento*	100%	100%	100%	100%	100%	100%	3150%	1757%	916%	190%	384%
	Actual	0	10	10	14	14	14	14	14	14	15	14
Disponibilidad de montacargas	*Target*	0	15	15	15	15	15	0	14	15	15	15
	% Cumplimiento	0%	67%	67%	93%	93%	93%	93%	93%	93%	93%	93%
	Actual	0	23	23	19	27	21	27	31	25	21	0
Capacidad de patios	*Target*	32	32	32	32	32	32	34	32	32	32	32
	% Cumplimiento	0%	58%	79%	66%	84%	66%	64%	80%	58%	66%	0%
Headcount	*Actual*	0	25	25	25	25	25	25	25	25	54	25
	Target	25	25	25	25	25	25	25	25	25	25	25
Aging Finished good	*Actual*	0	0	0	0	0	0	0	0	79	50	50
	Target	0	0	0	0	0	0	0	0	0	0	0
Veracidad de inventarios	*Actual*	-	98%	98%	96%	99%	99%	99%	94%	98%	98%	98%
	Target	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%

Fig. 3: KPIs prior to the implementation of the initial Excel design at Norte plant.

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Analyzing the performance prior to the implementation of the initial Excel design, was possible to identify differences among the plants, as shown in Figures 2 and 3. At Jerónimo plant, 9 out of the 14 key indicators were outside of the established target during week 11, reflecting multiple areas of opportunity. In contrast, Norte plant had 3 out of the 14 KPIs outside the target range.

PLANTA JERONIMO	SEMANAL	WEEK 12	WEEK 13	WEEK 14	WEEK 15
Exportaciones Realizadas	*Actual*	65	71	68	74
	Target	56	56	52	56
	% Cumplimiento	116%	127%	126%	118%
Registro de exportaciones	*En tiempo*	40	43	53	48
	En destiempo	25	28	15	19
	% Cumplimiento	60%	62%	83%	75%
Registro de PIPAS	*Actual*	18	19	21	17
	Target	16	17	20	16
	% Cumplimiento	109%	125%	107%	110%
Descarga de PIPAS (Tiempo promedio)	*Actual*	3:58:42	2:38:59	3:24:56	2:32:04
	Target	12:00:00	12:00:00	12:00:00	12:00:00
Open Replenishments	*Actual*	0	0	4	1
	Target	0	0	0	0
Equipos interplantas cargados	*Actual*	0	9	10	5
	Target	3	3	3	3
Equipos WIP cargados	*Actual*	2	0	0	0
	Target	1	1	1	1
Cortos de material	*Actual*	136	43	192	64
	Target	34	43	33	66
	% Cumplimiento	265%	100%	516%	97%
Requerimientos WIP	*Actual*	3	4	2	9
	Target	6	18	10	9
	% Cumplimiento	83%	18%	40%	100%
Disponibilidad de montacargas	*Actual*	7	7	7	7
	Target	10	10	10	13
	% Cumplimiento	70%	70%	70%	54%
Capacidad de patios	*Actual*	68	71	55	59
	Target	85	85	85	85
	% Cumplimiento	80%	84%	65%	69%
Headcount	*Actual*	54	54	54	61
	Target	82	82	82	82
Aging Finished good	*Actual*	110	108	110	0
	Target	0	0	0	0
Veracidad de inventarios	*Actual*	86%	85%	85%	91%
	Target	98%	98%	98%	98%

Fig. 4: KPIs after the implementation of the initial Excel design at Jerónimo plant.

PLANTA NORTE	SEMANAL	11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
Exportaciones Realizadas	*Actual*		29	37	37	29
	Target		24	33	36	25
	% Cumplimiento		121%	62%	103%	100%
Registro de exportaciones	*En tiempo*		29	37	37	29
	En destiempo		0	0	2	0
	% Cumplimiento		100%	100%	100%	100%
Registro de PIPAS	*Actual*		5	8	11	19
	Target		5	9	8	14
	% Cumplimiento		100%	100%	138%	118%
Descarga de PIPAS (Tiempo promedio)	*Actual*	4	1:35:15	1:20:10	1:26:19	1:24:22
	Target	0	12:00:00	12:00:00	12:00:00	12:00:00
Open Replenishments	*Actual*		0	0	0	0
	Target		0	0	0	0
Equipos interplantas cargados	*Actual*		9	0	6	3
	Target		3	3	3	3
Equipos WIP cargados	*Actual*		1	0	0	0
	Target		1	1	1	1
Cortos de material	*Actual*		249	415	116	188
	Target		83	115	116	102
	% Cumplimiento		574%	350%	100%	169%
Requerimientos WIP	*Actual*		47	35	43	22
	Target		12	0	7	1
	% Cumplimiento		250%	-	425%	400%
Disponibilidad de montacargas	*Actual*		11	11	11	10
	Target		14	13	13	14
	% Cumplimiento		79%	85%	85%	71%
Capacidad de patios	*Actual*		26	31	29	23
	Target		32	32	32	32
	% Cumplimiento		81%	97%	91%	72%
Headcount	*Actual*		25	25	25	25
	Target		25	25	25	25
Aging Finished good	*Actual*		40	21	21	1
	Target		0	0	0	0
Veracidad de inventarios	*Actual*		99%	96%	99%	98%
	Target		98%	98%	98%	98%

Fig. 5: KPIs after the implementation of the initial Excel design at Norte plant.

Once the initial Excel-based design was implemented, allowing for a more centralized control of information, was observed a noticeable improvement in KPI performance in the two previously mentioned plants. At Jerónimo plant, the number of KPIs outside the target range decreased from 9 to 6 out of the 14 measurable indicators by week 15. Meanwhile, Norte plant, being a more stable operation, maintained its 3 KPIs outside the target range. The overall results obtained from these two plants show that the design helps standardize warehouse operations. The number of KPIs outside the target range was reduced, this creates a more solid basis for data analysis. Also, the positive impact of centralizing data from multiple sources, improving visual structure becomes evident.

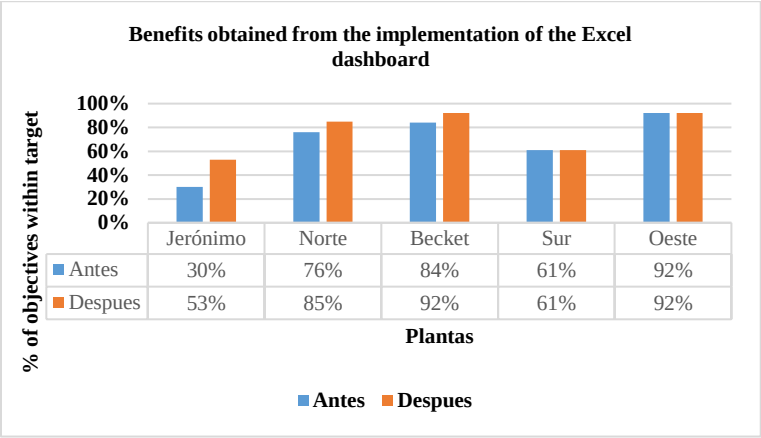


Fig. 6: Benefits obtained after the implementation of the initial Excel design.

The implementation of the initial Excel-based design resulted in a visible improvement in KPIs across each plant.
As shown in the plant-level analysis presented in Figure 6, the following results were observed:

- Jerónimo plant increased from 30% to 53% KPI compliance, representing a 23% improvement, confirming the effectiveness of the model in one of the plants with the greatest initial gaps.
- Norte plant improved from 76% to 85%.
- Becket plant increased from 84% to 92%.
- Sur plant remained stable at 61%, indicating the need for additional strategies to support and strengthen KPI monitoring.
- Oeste plant maintained its current performance, remaining at 92% both before and after the implementation.

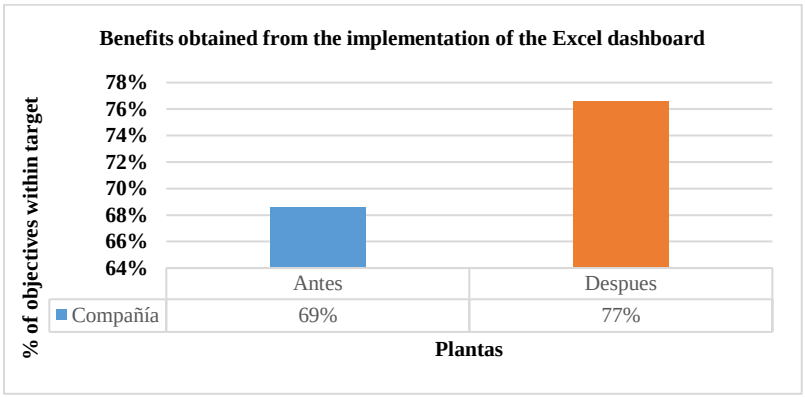


Fig. 7: Overall benefits obtained after the implementation of the initial Excel design.

On the other hand, as shown in Figure 7, the company presented an overall improvement, increasing from 69% to 77% in average global KPI compliance. This represents an 8% increase in overall operational efficiency, mainly driven by the plants that initially had the largest performance gaps. These results confirm that the initial Excel design helped standardize the KPI management, generated a improvement on overall operations, and centralized information.

- Pilot run in the development of Power BI with R in Oeste and Becket plants.

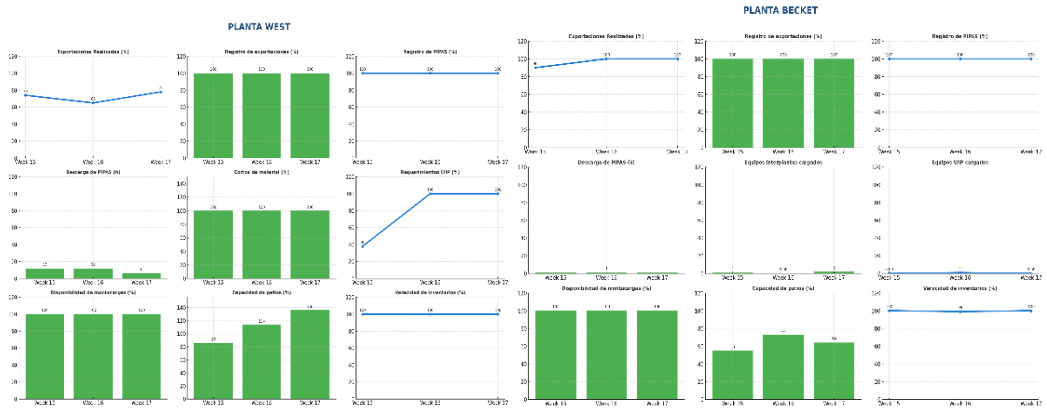


Fig. 8: Power BI pilot run at Oeste and Becket plants.

In the experimental pilot only the Oeste and Becket plants through the integration of data processing using R and dynamic visualization in Power BI. The objective was validating the effectiveness of the model compared with the initial Excel design, allowing the evaluation of accuracy, speed, and clarity in the visualization of KPIs.

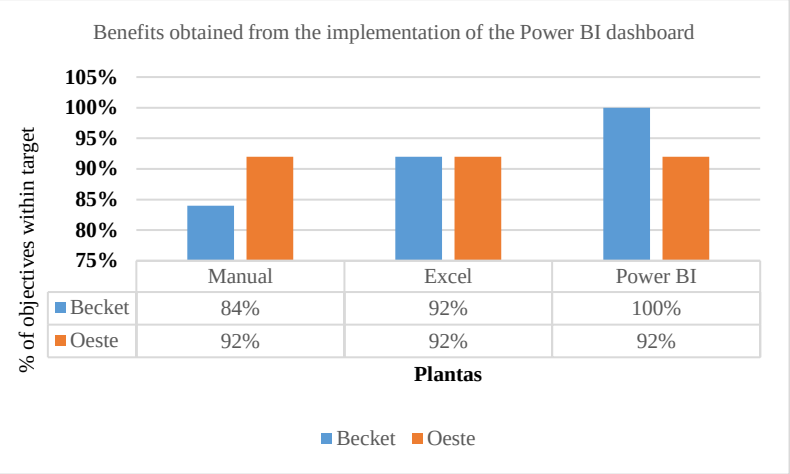


Fig. 9: Benefits obtained after the implementation of Power BI.

In Figure 9, is observed a positive impact achieved after the implementation of Power BI with R in comparison to the manual method and the Excel design (Two first phases). Becket plant reached 100% KPI compliance with Power BI, reflecting a significant improvement. Meanwhile, Oeste plant maintained the 92% compliance throughout the three development stages.

TABLE IV
VALIDATION RESULTS IN PILOT-RUN PLANTS.

Criteria	Description	Expected Result	Obtained Result
Accuracy	Match with original data sources	≥ 95%	98%
Visual consistency	Coherence across pages and formats	0 errors	1 error
Clarity	Ease of interpretation	Rating ≥ 4.0/5.0	4.3
Time reduction	Duration of meetings before vs. after	Reduction ≥ 30%	75%
Usability	Recommendation by users	≥ 80%	94%

To confirm the successful of the experimental run using Power BI with R in terms of reliability and practical on the warehouses, was carried out a validation of the model based on five principal criteria: accuracy, visual consistency, clarity, time reduction, and usability. The validation of the results confirmed that the model met expectations in the big part of the evaluated criteria, also, this reinforces its value as a reliable tool for monitoring and timely optimization of warehouse processes.

Fig. 10: KPIs used on Power BI.

Fig. 11: KPIs Graphics used on Power BI.

Once the Power BI validation was completed in two plants with positive results and a reduction of KPI outs of target were obtained from the experimental run using R Script and Power BI, after that was deployed across all five warehouses the interactive dashboards.

Was developed a new design of the Power BI dashboard following the same structural logic as the initial Excel design prototype but more functional and visual friendly. Among the main following improvements:

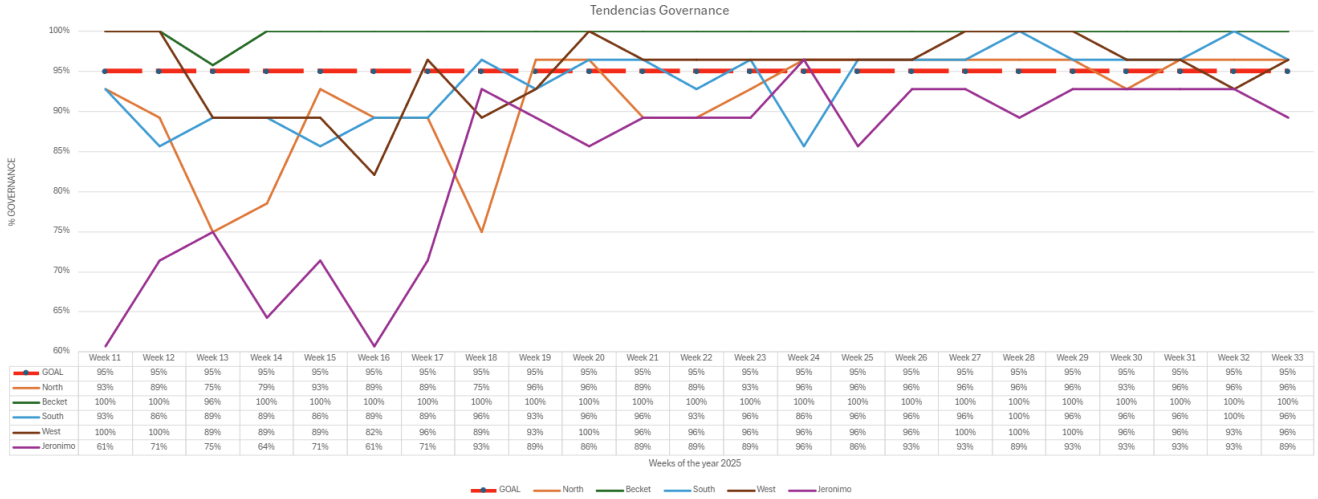
1) Information can be filtered by plant, week, or a specific period.
2) All key performance indicators were centralized in a single dashboard.
3) The information is directly connected to the data sources.
4) The model can be easily replicated in other plants and allows the addition of new KPIs without redesign the entire structure.

This implementation allowed warehouse managers and senior management of the company to monitor goal compliance in real time and observe the evolution of each KPI during the day. It also made it easier to identify deviations and errors to support corrective decision-making. Additionally, the interface improved the communication between different personnel levels during meetings and strengthened reporting by presenting structured and centralized information.

- Creation of governance for KPI compliance

	Norte		Becket		Sur		Oeste		Jerónimo		
	Reporte lleno	KPI Target	Reporte lleno	KPI Target	Reporte lleno	KPI Target	Reporte lleno	KPI Target	Reporte lleno	KPI Target	TOTAL
Exportaciones realizadas	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Registro de exportaciones	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Registro de PIPAS	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Descarga de PIPAS	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Open Replenishment	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐	80%
Equipos Interplantas Cargados	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐	80%
Equipos WIP Cargados	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	80%
Cortos de Material	☑	☑			☑	☑	☑	☑	☑	☑	100%
Requerimientos WIP	☑	☑			☑	☑	☑	☑	☑	☑	100%
Disponibilidad de Montacargas	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	80%
Capacidad de patios	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Headcount	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Aging	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	100%
Veracidad de Inventarios	☑	☑	☑	☑	☑	☐	☑	☑	☑	☐	60%
TOTAL	96%		100%		96%		96%		89%		96%

Fig. 12: Governance tracking of results by plant.



	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17	Week 18	Week 19	Week 20	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33
GOAL	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
North	93%	89%	75%	79%	93%	89%	89%	75%	96%	96%	89%	89%	93%	96%	96%	96%	96%	96%	96%	93%	96%	96%	96%
Becket	100%	100%	96%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
South	93%	86%	89%	89%	86%	89%	89%	96%	93%	96%	96%	93%	96%	86%	96%	96%	96%	100%	96%	96%	96%	100%	96%
West	100%	100%	89%	89%	89%	82%	96%	89%	93%	100%	96%	96%	96%	96%	96%	96%	100%	100%	100%	96%	96%	93%	96%
Jeronimo	61%	71%	75%	64%	71%	61%	71%	93%	89%	86%	89%	89%	89%	96%	86%	93%	93%	89%	93%	93%	93%	93%	89%

Fig. 13: Governance trends 2025.

A governance system was established as a final phase of the implementation to monitor KPI compliance across the five warehouses. The objective of this governance structure is to ensure standardization in measurement to permit comparison between plants, and track progress toward the annual target set at 95%. As shown in Figure 12, the level of compliance achieved by each plant is reflected with a 96% of global average, exceeding the established target of 95%. This result represents an improvement compared with the initial situation prior to the Excel design, when there were performance gaps and limited KPI management.

Finally, Figure 13 shows the governance performance trend from week 11 to week 33 of 2025. These highlights show the positive progression across all plants in one week, showing how those had compliance levels below the target at the beginning of the implementation and gradually improved, and in most cases surpassed the 95% global objective. These results confirm the efficiency of the tools developed in Excel, followed for the Power BI, R, and the governance system allow for real time monitoring of the KPI.

V. CONCLUSIONS

The implementation of a visualization model that is supported by data from Excel, R, and Power BI like an strategy for optimizing the warehouses management was successfully, because the model made it possible the reduction in a significant way the data analysis time, improvement the accuracy of the KPI tracking, and also establish a solid real time system to monitoring that supported more effective the strategic decision-making. The main goal at the beginning of the year implemented by the company corporative was 95% in a global average of the KPI compliance; however, the final goal after the implementation reached 96% surpassing the annual target, this is a clear improvement compared with the previous situation of the warehouses.

In addition, the governance system implemented to helped to standardization across the plants to promote a excellence organizational culture focuses on continuous improvement. These confirm that the process of the digitalization through interactive dashboards generate a strategic impact in the operation of logistics process aligned with the company´s corporate objectives. Finally, it can be concluded that the model in Power BI using R Scripts represents a replicable and scalable solution for the industries that can be applied in different type of environmental operations. By other side, a recommendation for a future improvement is to expand the scope of the system with the use and integration of IoT sensors, APIs, computational vision, digital twins, and predictive analytics techniques. This Allowing to convert the system in a intelligent warehouse management system capable of anticipating operational need and creating a highly sustainable competitive advantages to migrate to AI process.

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