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# Dynamically Visualizing Key Performance Indicators for Informed Business Decision-Making

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**Abstract**—This study aims to enhance the usage and optimization of Key Performance Indicators (KPIs) by addressing their underutilization and lack of proper visualization in decision-making processes. Currently, KPIs are often calculated using static scripts, leading to delays and dependency on the data analysis process. To overcome this challenge, we propose a solution that involves visualizing KPIs alongside the relevant data in a dynamic manner using Tableau dashboards. The project primarily focuses on the sales domain. Furthermore, various statistical techniques have been applied to ensure data reliability by removing outliers. The comprehensive solution developed encompasses meticulous data preprocessing, accurate KPI calculation, and dynamic visualization of both the underlying data and KPIs. By implementing this approach, business stakeholders gain access to a more interactive and intuitive platform for consuming and leveraging KPIs.

**Keywords**— Key Performance Indicators, Dynamic Visualisation, Informative decision-making

## I. INTRODUCTION

In today's project-based organizations, the strategic use of Key Performance Indicators (KPIs) is vital to ensure efficient project management and successful project outcomes. Nevertheless, many companies encounter difficulties in selecting appropriate KPIs due to a lack of standardization and oversight. Consequently, ineffective project management and subpar results may arise consequently. Addressing this challenge, the research paper "Identification of Key Performance Indicators in Project-Based Organizations through the Lean Approach" [1] suggests the adoption of lean principles and techniques to identify relevant KPIs. Although this paper offers valuable insights into the significance of KPIs in project management, it does not fully explore the potential of visual management techniques.

Visual management is a method that focuses on displaying Key Performance Indicator (KPI) data in a visually attractive and easily comprehensible format. This technique facilitates quick and effective assessment of project performance. To ensure the efficient management of KPI quality, adopting the "visual management" strategy proves to be a promising remedy. This involves incorporating "KPI dashboards" into

the processes of reporting, monitoring, and controlling KPIs. These dashboards serve as interactive visual aids that provide real-time insights into performance metrics. As a result, project managers gain the ability to make well-informed decisions and take prompt actions based on the information presented.

Despite the acknowledged importance of visual management and the critical role of KPIs in obtaining valuable insights, the existing solutions fail to fully exploit the potential of KPIs in data visualization and analysis. Therefore, there is a pressing need to develop an effective and user-friendly solution that enhances the visualization of KPI data. This research aims to bridge this gap by proposing a comprehensive solution that surpasses conventional data visualization practices.

To ensure accurate analysis, the research will commence by employing robust statistical techniques such as Z-Score, Interquartile Range (IQR), and Mahalanobis Distance to detect and address outliers in the product data. Treating outliers effectively enhances the overall quality and reliability of the dataset, ensuring more accurate and insightful KPI analysis.

The proposed solution will integrate selected KPIs into an interactive Tableau dashboard, offering users dynamic data exploration options on various time scales, including quarterly, half-yearly, yearly, or custom periods. Additionally, users will have the flexibility to switch between different regions and categories, tailoring their analyses to specific needs. The dashboard will support various visualizations, enabling users to gain comprehensive insights into sales data trends and patterns.

By combining customized KPIs, effective outlier treatment, and dynamic data visualization capabilities, our solution aims to empower businesses to comprehend their data more easily. The enhanced visual management approach will facilitate better-informed decision-making processes, maximizing the benefits of data analysis. Ultimately, this research endeavors to equip project-based organizations with a powerful tool to

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optimize their KPI utilization and elevate their overall project management performance.

While both Python and Tableau are powerful tools for data analysis and visualization, Tableau may be more beneficial for visualizing KPIs data due to its user-friendly interface and interactive dashboards. Tableau allows users to create compelling worksheets and dashboards that can be easily shared and collaborated on, making it an ideal tool for presenting KPIs data to stakeholders who may not have coding skills.

Tableau also offers advanced features for data blending, data aggregation, and data filtering, making it easier to explore and analyze large datasets. Additionally, Tableau provides strong integration capabilities with various data sources, allowing users to connect to databases, spreadsheets, and other data files directly. Furthermore, Tableau's AI analytics feature allows users to integrate and dynamically visualize the results from other sources like R, Python and other extensions and integrations in Tableau which means that users can leverage the power of other programming languages while still using Tableau's user-friendly interface for data visualization.

In summary, effectively implementing Key Performance Indicators (KPIs) is crucial for successfully managing projects in project-based organizations. To overcome the existing limitations, this study suggests a solution that combines lean principles and advanced data visualization techniques. By integrating tailor-made KPIs into an interactive Tableau dashboard and applying statistical outlier treatment, our proposed solution aims to equip businesses with robust data analysis capabilities. The research endeavors to enhance the visualization of KPI data, promoting user-friendly interfaces and facilitating improved decision-making processes while maximizing the advantages of data analysis.

## II. RELATED WORKS

In January 2020, a research paper titled "Identification of Key Performance Indicators in Project-Based Organisations through the Lean Approach" emphasized the essential role of key performance indicators (KPIs) in effective project management within project-based organizations. However, these organizations often encounter challenges in selecting appropriate KPIs due to the lack of standardization and oversight in this aspect. This lack of clarity in identifying relevant KPIs can result in ineffective project management practices and suboptimal project outcomes. To tackle this issue, the author proposed the adoption of lean principles and techniques to identify KPIs in project-based organizational settings [1]. By employing such an approach, project-based organizations can streamline their KPI selection process, enhance project management practices, and ultimately improve overall project outcomes.

While the research paper contributes valuable insights into the significance of KPIs for project management, it is not without limitations. Notably, effectively managing the quality of KPIs remains a challenge. To overcome this, the paper suggests employing the "visual management" technique as an appropriate approach. This technique likely involves presenting KPI data in a visually comprehensible manner, thereby enabling swift and efficient assessment of project performance.

Furthermore, the paper recommends the adoption of "KPI dashboards" by project managers during the reporting, monitoring, and control of KPIs. These dashboards are presumably interactive visual tools that offer real-time insights into performance metrics. By utilizing KPI dashboards, project managers can enhance their decision-making capabilities and promptly act based on the data presented, leading to more informed and effective project management practices.

The application of visualization in strategic management has gained considerable recognition to enhance comprehension and decision-making processes [2]. Representing data visually facilitates a deeper understanding of intricate information, empowering individuals to make well-informed decisions. Through the presentation of data in a visual format, managers and decision-makers can readily grasp essential insights and patterns, leading to a more efficient strategic planning and implementation.

Key Performance Indicators (KPIs) hold immense importance in measuring and evaluating organizational performance. Nonetheless, effectively implementing KPIs can be a daunting task, and many organizations struggle with defining and utilizing them effectively [3]. To tackle this challenge, the concept of information flow visualization has emerged as a valuable solution. By visualizing the information flow related to KPIs, organizations can enhance their understanding of the KPI formulation process, thereby enhancing the quality and reliability of their KPIs [3]. This involves using diagrams, charts, and other visual aids to represent the entire KPI formulation process, including data sources, data handling, and the interconnections between different KPIs. Such an approach aims to offer a clearer perspective of the KPI process, leading to improved KPI quality and dependability.

Beyond just aiding decision-making, this visualization approach also facilitates communication and comprehension of KPIs among stakeholders, even those who are not technically oriented. As a result, organizational performance measurement and management processes can be significantly

improved through the use of visualization techniques in the context of KPIs.

The research paper titled "Research on Python Data Visualization Technology" [4], published in January 2021, emphasizes the significance of data visualization in decision-making across various fields. It highlights the use of Python libraries, particularly Matplotlib, for visualizing data and extracting business insights to improve financial performance.

However, the paper acknowledges that these visualization tools come with technical complexities, which can pose challenges for non-technical users in the business domain. The programming language nature of Python libraries may require a certain level of proficiency and understanding to fully utilize them for effective KPI visualization. This recognition of the technical challenges underscores the need to address these barriers and develop a more user-friendly approach to KPI visualization. Simplifying the visualization process and creating intuitive interfaces can empower non-technical users to leverage these tools and gain valuable insights from their data, enhancing decision-making processes.

When it comes to addressing the technical challenges associated with KPI visualization, Tableau stands out as a prominent and preferred solution. The World Economic Forum (WEF) has acknowledged and endorsed Tableau above other Business Intelligence tools due to its user-friendly nature and seamless integration with various applications [5]. Tableau offers the advantage of flexible connectivity, integration, and extensibility with diverse databases and files, simplifying the process of integrating it with other applications [6][7]. Its user-friendly interface, capacity to handle large datasets, customizable dashboards, integration capabilities, and robust analytics make it a powerful tool. By harnessing Tableau's comprehensive features, organizations can effectively visualize KPIs, extract meaningful insights, and enable informed decision-making.

### III. METHODOLOGY

The objective of this solution is to offer valuable insights into sales performance by creating a unified Tableau dashboard that examines the sales data of various products sold by a company. To carry out the analysis, the dataset will be sourced from Kaggle [8], a renowned platform for hosting diverse and extensive datasets. For precise and dependable analysis, the data will be processed and stored in a relational database, specifically MS SQL. Furthermore, statistical techniques from machine learning will be employed to identify and handle outliers present in the product data. The integration of these approaches aims to elevate data quality and streamline runtime for more refined analytical outcomes.

To initiate the analysis, we will download the sales data from the Kaggle platform, which may be available in various formats such as Comma Separated Values (CSV). Once obtained, the data will be saved in a relational database to facilitate further processing. MS SQL, a powerful and widely used database management system, will be employed for this purpose. Utilizing MS SQL's features, we will design efficient SQL queries and views to optimize data retrieval and manipulation, enabling smoother data processing for subsequent analysis.

As outliers can significantly impact data analysis and result interpretation, their identification and treatment are critical to ensure the accuracy and reliability of our findings. To achieve this, we will employ statistical techniques from machine learning, including Z-Score, Interquartile Range (IQR), and Mahalanobis Distance. These methods will assist in identifying abnormal data points, allowing us to address outliers effectively. By treating outliers, we aim to improve the overall quality of the dataset and ensure robust analysis of sales performance.

Once the outlier-treated data is obtained, we will preprocess it to extract meaningful insights. This involves performing calculations for Key Performance Indicators (KPIs) that are relevant to the sales domain. KPIs serve as quantitative measures to assess the company's progress towards its objectives. By calculating and incorporating KPIs [9] in our analysis, we can gain deeper insights into sales performance, identifying strengths and areas for improvement.

As illustrated in Fig. 1, the workflow of the proposed solution is shown.

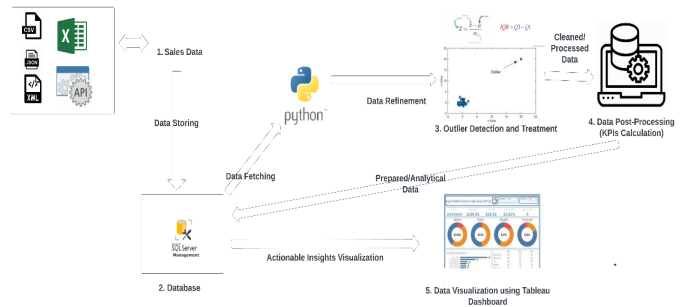


Fig. 1. Workflow of proposed solution

Our research project revolves around the development of an interactive Tableau dashboard for consuming the KPIs along with the data. Through the utilization of Tableau's robust visualization capabilities, the dashboard will dynamically and intuitively present sales data and the calculated KPIs.

This interactive interface will allow users to customize their visualizations based on specific date ranges, countries, and product categories, thus offering a comprehensive and detailed view of sales performance at varying levels of granularity. The flexibility and user-friendliness of the dashboard will empower users to extract valuable insights and make well-informed decisions based on the presented data.

Below are the key components and functionalities of the proposed solution-

- **Database Management:** For database management, we will be using MS SQL to maximize the capabilities of database tool. To effectively manage and manipulate the sales data, optimized SQL queries for better runtime and views will be utilized.
- **Data Preprocessing using Statistical Techniques:** To ensure that data used for analysis is accurate, we will be employing outlier detection techniques [10] to handle missing values and detect outliers within the available sales data. Moreover, for these techniques such as IQR (Inter Quartile Range) [11], Z-Score, and Mahalanobis Distance will be used to recognize and address outliers. By preprocessing and refining the data, we are ensuring the quality and reliability of the sales dataset for subsequent analysis.
- **Data Analysis using KPIs:** After data preprocessing, the refined sales dataset will be utilized to extract meaningful insights and calculate KPIs [9] related to sales performance.
- **Data Visualization using Tableau:** The solution will leverage Tableau's dynamic data visualization capabilities to create an interactive dashboard [5] [12]. This dashboard will not only visualize the sales data but also showcase the calculated KPIs, enabling business experts to gain deeper insights into sales trends, product performance, and market dynamics within the selected date range.

It will enable businesses to store their data in a robust database management system, refine it through outlier detection techniques to enhance reliability, extract valuable insights by analyzing the data and calculating KPIs, and finally, visualize the data and KPIs dynamically. This empowers businesses to make decisions based on comprehensive and visually appealing representations of their sales data, optimizing their decision-making process.

#### IV. RESULTS

In this research project, we harnessed the synergistic potential of Tableau's dynamic visualization capabilities in tandem with Python libraries to deliver a comprehensive and user-friendly representation of our sales data and key

performance indicators (KPIs). By integrating Tableau's powerful visualization tools with Python's data processing functionalities, we created interactive dashboards that offered a holistic view of sales performance. The seamless integration of data from various sources allowed us to explore trends, identify patterns, and gain valuable insights into our business operations. Stakeholders were empowered with real-time access to relevant KPIs, enabling them to make informed decisions and respond to dynamic market conditions effectively. The interactive nature of our presentation facilitated data exploration and empowered stakeholders to extract deeper insights, making our approach a powerful tool for driving data-driven strategies and enhancing overall business performance.

Through the Tableau dashboard, business stakeholders can gain access to real-time visualizations that depicted sales trends, product performance, and other critical KPIs. The dashboard allowed users to customize visualizations based on date ranges, countries, and product categories, empowering them to explore data at various levels of granularity. Sales managers and executives could easily monitor the performance of individual products, identify geographical sales patterns, and assess the overall progress towards sales targets.

In addition to fostering contextual awareness by presenting KPIs in the context of the underlying data, our interactive dashboards facilitated data-driven decision-making. The ability to perform 'what-if' analyses and scenario simulations empowered decision-makers to assess different strategies' potential outcomes. Moreover, the flexibility of customizability allowed each stakeholder to tailor the visualizations according to their specific needs, enhancing engagement and collaboration during discussions and meetings. By embracing dynamic visualization techniques, our research project demonstrated how businesses can leverage the power of data to gain valuable insights, optimize performance, and drive successful outcomes.

As we know, detecting outliers is an essential step in data preprocessing and analysis, as it helps in understanding the quality of the data therefore, we python libraries, matplotlib to detect any outliers as shown in Fig. 2 as these outliers can screw the KPI visualization therefore we cleaned the data before using it for KPI visualization.

After removing the outlier from input dataset, we used tableau for essential data and performed demand forecasting dashboard as shown in Fig. 3 to predict the KPI for upcoming future which provides me valuable insight related to profit and sales, so that one can take the informed decision which will not only help business to mitigate the risk moreover they can strategies their growth plan.

We extended the tableau features to create the dashboards for dynamic visualization as illustrated in Fig. 4 and 5

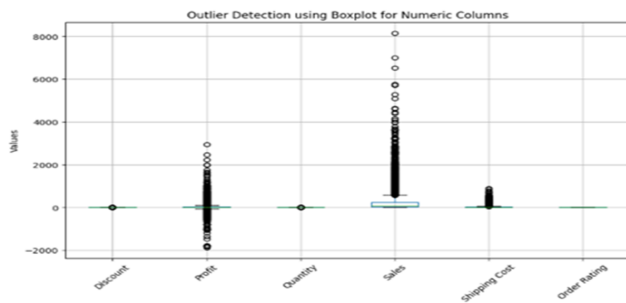


Fig. 2. Visualizing outlier detection using boxplot

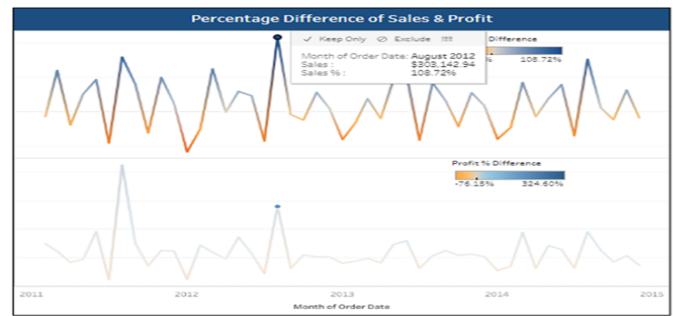


Fig. 5. Dynamic visualization of KPIs

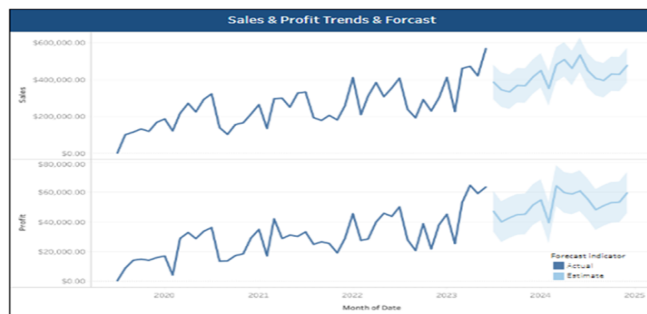


Fig. 3. Demand forecasting dashboard

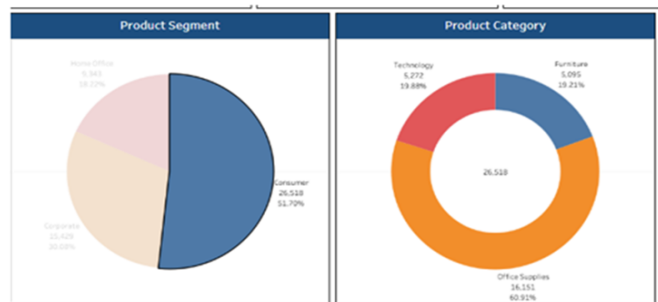


Fig. 6. Dynamic visualization of product segment and category

of the other part of information from data. This dynamic visualization adds a significant advantage to understand the KPI and other related information by providing different inputs using the above global filter options.

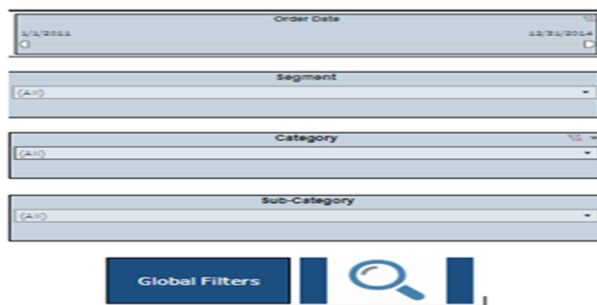


Fig. 4. Global filter for dynamic visualization

The visuals displayed as shown in Fig. 6 above clearly demonstrate the immense value of dynamic KPI visualization for businesses and project managers. By utilizing this approach, they gain a comprehensive and intuitive understanding of every aspect of their business. The dynamic nature of the visualizations allows them to explore various

segments and drill down into specific details effortlessly. It is like having a magnifying glass to examine every nook and cranny of their operations.

What's even better is that Tableau provides a user-friendly dashboard that streamlines the whole process. Compared to using Python, where one must execute multiple scripts each time to grasp the updated data, Tableau proves to be a much more convenient and efficient option. With Tableau, the dashboard is just a few clicks away, saving valuable time and effort. Business and project managers can swiftly access real-time insights without getting tangled up in complex coding and scripting. This ease of use makes Tableau an invaluable tool for making data-driven decisions and staying on top of the game in today's fast-paced business environment.

We conducted a comprehensive comparison between the results obtained using Python libraries for visualizing KPI data and the capabilities offered by dedicated visualization tools. Here are the key differences we identified:

- **Ease of Use:** Dedicated visualization tools such as Tableau, Power BI, or Google Data Studio come with user-friendly interfaces, allowing non-technical users to create interactive and visually appealing dashboards effortlessly without the need to write any code. Python offers powerful libraries like Matplotlib, Seaborn,

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and Plotly for data visualization. However, creating visualizations using code requires some programming knowledge, making it potentially more challenging for non-technical users.

- **Flexibility and Customization:** While visualization tools provide a wide range of pre-built charts and templates, they may have limitations in terms of customization beyond the tool's capabilities. Python offers complete flexibility and customization capabilities. Developers can create any type of visualization and have full control over the design, layout, and interactivity.
- **Automation and Data Integration:** Many visualization tools have built-in data connectors, enabling easy integration with various data sources and databases. They often support automated data refreshes, ensuring that the KPI dashboards remain up to date. Python can also handle data integration and automation, but it may require more effort to set up data pipelines and automate the process compared to using visualization tools.
- **Interactivity:** Many visualization tools offer interactive features like filtering, drill-down, and tooltips, which enhance the user's ability to explore the data and gain insights interactively. Interactivity can be implemented in Python visualizations as well, but it may necessitate additional coding and effort.

Our project's outcomes aligned closely with our initial expectations, demonstrating the effectiveness of our approach. The dynamic visualization of KPIs exceeded our expectations in providing a more interactive and intuitive platform for consuming and leveraging data. Visualization tools like Tableau provide ease of use and quick dashboard creation for non-technical users, while Python libraries offer greater customization and control for developers. Users found it easier to grasp complex sales metrics, leading to better decision-making processes. The integration of Python libraries for outlier detection, along with Tableau's visualizations, proved to be a robust combination. It allowed us to ensure data reliability by removing outliers and providing more accurate analyses.

## V. LIMITATIONS

- **Tableau's Emphasis on Visualization:** Tableau excels in visualization, but it may face challenges when dealing with uncleaned data. Properly cleaning and preparing the data in the underlying database is essential to avoid inaccuracies in visualizations. Lack of built-in data cleaning capabilities necessitates careful data formatting, removing duplicates, and ensuring consistency before importing into Tableau.

- **Outlier Detection Complexities:** Ensuring data accuracy is crucial, but detecting outliers presents challenges. No method is foolproof, leading to potential misinterpretation of valid data points. Combining automated techniques with human judgment during data preprocessing helps address this issue and reduces erroneous data interpretations.
- **Forecasting KPIs Complexity:** While the approach is flexible with data usage, not all data qualifies as KPI data. Accurate historical data is vital for meaningful forecasting. Lack of historical data poses significant challenges, particularly in demand forecasting, resulting in less reliable forecasts and increased errors, especially for new products. Limited historical data availability for certain products also hinders trend identification.

## VI. CONCLUSION

This research underscores the significance of dynamic visualization of KPIs and its potential to enhance overall business performance. By offering real-time insights and contextual awareness through interactive dashboards, organizations can make informed decisions and effectively adapt to changing market dynamics. The hypothesis of integrating dynamic visualization with data processing has been validated, demonstrating that this approach serves as a powerful tool for leveraging data and achieving success.

The dynamic visualization of KPIs using Tableau empowered stakeholders with real-time access to essential sales data, enabling data-driven decision-making and swift responses to be evolving market conditions. The interactive nature of the dashboards facilitated in-depth data exploration, allowing stakeholders to conduct 'what-if' analyses and scenario simulations, leading to well-informed strategic planning. Additionally, the customization options of the visualizations tailored the dashboards to suit individual stakeholders' specific requirements, promoting active engagement and collaboration during discussions and meetings.

Adopting this methodology empowers enterprises with a notable competitive advantage, enabling them to maintain agility, responsiveness, and a profound understanding of their sales strategies. In a constantly evolving market scenario, the capacity to promptly comprehend crucial insights and adjust strategies accordingly becomes pivotal for achieving lasting success.

## VII. FUTURE WORK

Building on these findings, there are several new and expanded ways of thinking about the research problem, offering innovative approaches for framing and contextualizing the issue:



- **Scalability and Big Data:** As the research project focused on the sales domain, it is essential to consider how to handle larger datasets efficiently. To enhance scalability, exploring strategies like data partitioning and summarization can be beneficial. By breaking down large datasets into smaller, manageable chunks, data processing can be accelerated, leading to faster insights. Additionally, leveraging big data technologies such as Apache Spark or cloud-based solutions can further optimize data processing and storage, ensuring the Tableau dashboard remains responsive even with massive datasets.
- **Real-time Data Integration:** Building on the dynamic visualization aspect of the Tableau dashboard, the next step is to investigate ways to integrate real-time data streams. By connecting live data feeds into the dashboard, stakeholders can monitor KPIs with minimal delay, ensuring they have up-to-the-minute information at their disposal. This capability enables businesses to react promptly to changes in sales performance, making timely decisions to address emerging trends or challenges.
- **Machine Learning for Predictive Analytics:** While the research project has initiated the integration of machine learning models for predictive analytics, further exploration can be done in this direction. By expanding the types of use cases and applying different machine learning algorithms, stakeholders can gain deeper insights into predictive KPIs and their implementation. This could involve predicting sales performance based on factors like seasonality, customer behavior, and marketing initiatives. Implementing predictive KPIs can empower stakeholders with valuable foresight into potential trends and forecasts, enabling more proactive and data-driven decision-making.

In conclusion, considering scalability and big data solutions will ensure that the Tableau dashboard can handle larger datasets efficiently, paving the way for future expansion. Integrating real-time data streams will enable stakeholders to access the most current KPI information and respond promptly to changing sales dynamics. By embracing machine learning for predictive analytics and exploring various use cases, businesses can unlock deeper insights into sales performance and make informed decisions to drive success in the competitive market landscape.

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