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Appling Power BI for improved retail business analytics and decision-making

Abstract

In the rapidly evolving retail industry, data-driven decision making is critical to maintaining competitive advantage and operational efficiency. This paper explores the diverse applications of Microsoft Power BI (MPBI) in retail, highlighting its impact on real-time data management, sales analysis, inventory optimization, customer insights, and supply chain performance. By synthesizing findings from recent studies and presenting empirical data from case studies, we demonstrate how Power BI's advanced analytics and visualization capabilities can transform raw data into actionable insights. Our research underscores the importance of integrating disparate data sources into a unified platform, facilitating comprehensive data analysis, and fostering a culture of data literacy across retail organizations. We also discuss the challenges and best practices for implementing Power BI across retail functions, highlighting its role in driving innovation and adapting to emerging market trends. The results of this study provide practical insights for retailers seeking to leverage data analytics for strategic decision-making and operational excellence.

1. INTRODUCTION

The rapid global evolution and adoption of new technologies has had a significant impact on various industries, including retail. As a result, businesses must adapt their operations and customer engagement strategies to remain competitive. Digital transformation has become an essential and inevitable aspect of modern business practices, particularly in the retail industry, where data is constantly generated and evolving. By integrating new technologies, business leaders can streamline management, automate processes, and collect valuable data more efficiently. As a result, managers can gain quick and accurate insights into sales, profits, and overall business performance. A powerful tool that supports these needs is MPBI, a data analysis and reporting platform that helps executives better understand consumer trends and customer behavior, enabling them to make informed, data-driven decisions.

In this paper, we have developed formulas for calculating key metrics such as cost, revenue, and profit, and synthesized visual data using various methods within MPBI. By using data visualization, reports become more intuitive, powerful, and effective for analysis, making complex data easier to interpret. Data visualization reveals trends, relationships, and patterns, enabling business leaders to extract actionable insights and make decisions based on data analysis. The primary contribution of this research is the development of a database model that facilitates data analysis in management activities, which in turn optimizes business operations and improves data management. In addition, this paper offers practical implications for managers navigating the era of digital transformation.

The research paper is organized as follows: Part 2 reviews previous studies and relevant information related to the research topic. Part 3 outlines the data structure, retail data synthesis, and methodology used to compile the retail system data. Part 4 presents the results of the data analysis through Power BI visual reports, along with recommendations based on these findings. Finally, Part 5 concludes with a summary and suggestions for future research directions.

2. LITERATURE REVIEW

Rapidadvances in data analytics and business intelligence (BI) technologies have enabled organizations to harness vast amounts of data to improve decision making and operational efficiency. Among these tools, MPBI has emerged as a versatile platform capable of processing complex data sets in real time and transforming raw data into meaningful visualizations such as charts and dashboards. These visualizations play a critical role in making data more accessible, allowing users to easily monitor, analyze, and derive actionable insights. By transforming complex data sets into intuitive graphical formats, Power BI empowers organizations to make informed decisions with greater speed and accuracy. The workflow for MPBI is shown in Figure 1. In addition, MPBI can be seamlessly integrated with web applications to enhance data synthesis, analysis, and visualization. The integration process is shown in Figure 2.

The integration of MPBI into supply chain management has changed the way organizations visualize and forecast demand. Nabil et al. (2023) developed a real-time MPBI dashboard tailored to optimize supply chain performance using the ADR methodology. Their study highlights how dynamic visualizations, such as interactive charts and KPIs, improve operational efficiency and support timely decision making. Belghith et al. (2024) advanced these capabilities by creating a rolling forecasting framework specific to the pharmaceutical industry, using Power BI to improve sales forecasting and streamline supply chain coordination. Mohammed and Panda (2024) discussed the integration of MPBI with AI to enhance predictive capabilities in supply chain management. Hosen et al. (2024) highlighted the role of advanced BI tools in modernizing supply chains by fostering a data-driven culture and operational efficiency. These applications demonstrate how Power BI facilitates actionable insights by combining real-time data processing with accessible, visually appealing dashboards.

The retail and e-commerce industries have benefited greatly from Power BI's ability to process and visualize sales data. Murugan et al. (2024) used MPBI to uncover customer behavior trends and regional sales patterns, enabling companies to make strategic, data-driven decisions. The tool's ability to produce clear visualizations, such as heat maps and bar charts, allowed retailers to optimize inventory management and marketing strategies. Alqhatani et al. (2022) presented a hybrid analytics model that integrates machine learning with Power BI to provide a comprehensive view of retail operations and improve customer satisfaction. Similarly, [7]Banerjee et al. (2023) illustrated how Power BI dashboards support marketing strategy development by visualizing complex sales and distribution data. Yadav et al. (2024) extended these findings by exploring the role of Power BI in e-commerce performance tracking. Seyi-Lande et al. (2024) focused on integrating Power BI with real-time data for personalized customer insights in e-commerce. These studies underscore the transformative potential of Power BI to create competitive advantage for retail organizations through intuitive visualizations and real-time analytics.

The fusion of machine learning (ML) with Power BI has opened new avenues for real-time data analysis. Mohammed and Panda (2024) explored the embedding of AI-driven models into Power BI dashboards to enhance predictive analytics, enabling organizations to make informed decisions quickly. By integrating ML algorithms into visual dashboards, organizations were able to forecast trends and identify opportunities through predictive models and performance metrics. Al Rumhi and Sivakumar (2023) proposed a hybrid approach combining BI and ML, demonstrating how Power BI's interactive dashboards can deliver resource-efficient business insights. Surwade et al. (2024) extended these capabilities by incorporating advanced predictive algorithms into Power BI dashboards, highlighting their role in supply chain optimization. Afikah et al. (2022) highlighted the use of ML models within Power BI to analyze COVID-19 data, demonstrating its versatility in public health contexts. James et al. (2024) discussed the integration of Power BI with big data analytics to improve organizational decision-making processes using predictive tools.

The intersection of Power BI and IoT has introduced innovative ways to process and visualize massive datasets generated by connected devices. Arora and Rani (2018) highlighted Power BI's ability to process large IoT datasets in real time, enabling rapid data manipulation and informed decision making. Through the use of charts and sensor-driven dashboards, organizations were able to efficiently monitor IoT data and quickly respond to emerging trends. Rai et al. (2024) explored the role of big data visualization in IoT, demonstrating how Power BI addresses the challenges of presenting real-time insights and improving operational efficiency. Libby et al. (2022) explored IoT data integration with Power BI for better operational tracking in logistics. Allam (2017) discussed the challenges of big data visualization in IoT, highlighting how Power BI addresses scalability issues. These studies illustrate the tool's potential in industries such as healthcare, agriculture, and logistics, where IoT-generated data requires advanced visualization techniques for strategic planning.

Beyond mainstream industries, Power BI has proven effective in addressing unique challenges within specialized sectors. Seto et al. (2023) used Power BI to support replenishment decisions in the mining industry, integrating with ERP systems to provide actionable insights into biofuel consumption and inventory management. By visualizing consumption patterns through dashboards, the mining company was able to effectively reduce operational inefficiencies. Ameer et al. (2020) applied Power BI to human resources analytics, using its dashboards to address employee churn and improve performance evaluation processes. Anardani et al. (2023) demonstrated Power BI's ability to analyze sales trends for online fishing stores to optimize inventory and marketing strategies. Shubho et al. (2022) discussed using Power BI to improve SMB operations by visualizing sales and financial data. Ali et al. (2016) highlighted the role of Power BI in addressing visualization challenges in human resources and workforce management. These examples illustrate how Power BI's customizable dashboards and interactive features can be adapted to meet the unique needs of niche industries, improving both operational and strategic outcomes.

Power BI's contribution to the evolution of data visualization has been widely recognized, with researchers highlighting its role in fostering better business decisions. Simon (2014) describes how advanced visualization techniques supported by Power BI enable organizations to intuitively explore data trends, leading to improved strategic outcomes. The use of interactive graphs and trend lines was found to be particularly beneficial in simplifying complex data sets. Mutlu et al. (2016) introduced VizRec, a visualization recommendation tool that advances the field of personalized data presentation. Sharma et al. (2021) compared Power BI with other BI tools and highlighted its advantages in visualizing complex data sets. Palma-Ruiz et al. (2022) demonstrated the use of Power BI to predict trends in the gaming industry. Ameer et al. (2020) highlighted the application of Power BI in HR analytics, focusing on employee performance and churn prediction. Seto et al. (2023) discussed the integration of Power BI for visualizing financial data in the mining industry. These studies highlight the potential for Power BI to continue to evolve as an important tool for data visualization, especially as organizations adopt emerging technologies such as edge computing and blockchain.

ETL (Extract, Transform, Load) is a process commonly used in data integration and management. It involves extracting data from different sources, transforming it into a desired format or structure, and then loading the transformed data into a target system, such as a data warehouse or database. The ETL process is critical to ensuring the consistency, accuracy, and usability of data within a system, particularly for analysis and reporting purposes.

The ETL process has three key steps: Extraction, Transformation, and Loading.

Extraction: This is the initial phase of the ETL process where raw data is retrieved from various source systems. These sources can include databases, files, CRM systems, APIs, and other platforms. The data can be structured, semi-structured, or unstructured. During extraction, it is critical to collect the relevant data and prepare it for the subsequent transformation steps.

Transformation: Once the raw data is extracted, it typically needs to be cleaned, restructured, and enriched before it is ready for analysis. This phase involves a number of operations, including:

- Data cleaning: Remove duplicates, handle missing values, and correct errors.
- Restructure the data: Reformatting data, such as converting dates or currency values to a standard format.
- Filtering: Remove irrelevant data or outliers.
- Aggregation: Summarizing data to provide higher-level insights.
- Data enrichment: Adding additional information to enhance the data set.
- Standardization: Converting data to a common schema or structure that matches the target system.

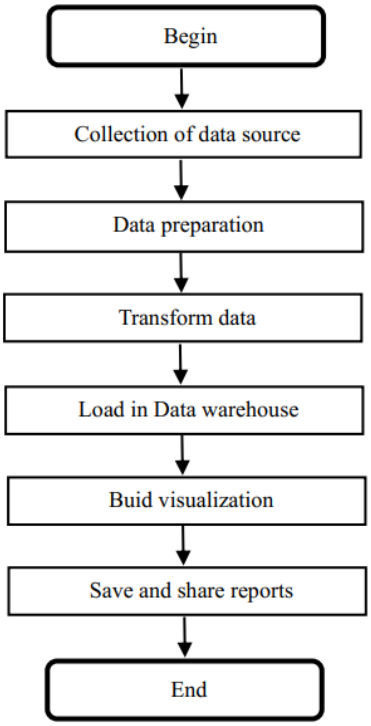

Fig. 1. Operation diagram of Power BI

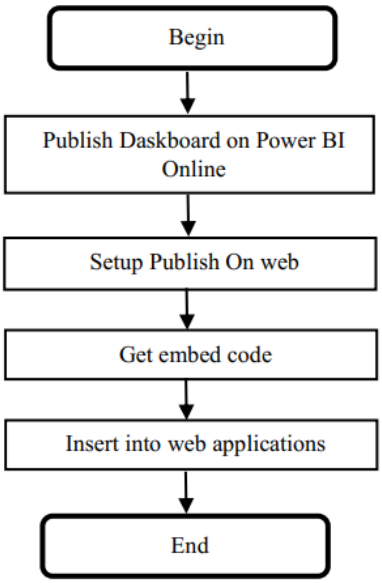

Fig. 2. Power BI intergration diagram with other applications

The transformation phase may also include defining the granularity of fact tables, designing dimension tables, and applying data warehouse schemas (such as star or snowflake schemas). It includes processes such as dealing with slowly changing dimensions, defining derived facts, and dealing with factless fact tables.

Loading: After the data has been extracted and transformed, it is loaded into the target system, such as a data warehouse, data mart, or database. The load process involves writing the transformed data to the target in a way that optimizes performance for query and analysis. Depending on the target system, the load process can be batch or real-time.

3. DATA ANALYSIS MODEL AND AGGREGATION METHODOLOGY

The database should be designed with a unified structure that ensures consistent, comprehensive, and synchronized storage across the system. This approach allows for seamless integration and easy access to data, facilitating efficient organization, consolidation, and analysis of information across the retail network. A well-structured database is critical to maintaining data integrity, enabling accurate reporting, timely decision making, and smooth coordination between different departments within the organization. By ensuring data consistency and synchronization, the system supports better forecasting, performance tracking, and overall business management.

3.1. The database structure of the retail system

For the retail system, we have proposed seven key entities to store data and integrate with the MIS database. These entities are essential tables that enable managers to efficiently and effectively monitor and control business information. Each of these data tables is interrelated to ensure a seamless flow of data and to meet the operational constraints of the trading system. By structuring the database with these relationships, the system can support efficient data management, accurate reporting, and better decision making. Figure 3 illustrates the relationships between these data objects and how they are bound together to form a cohesive and functional data model.

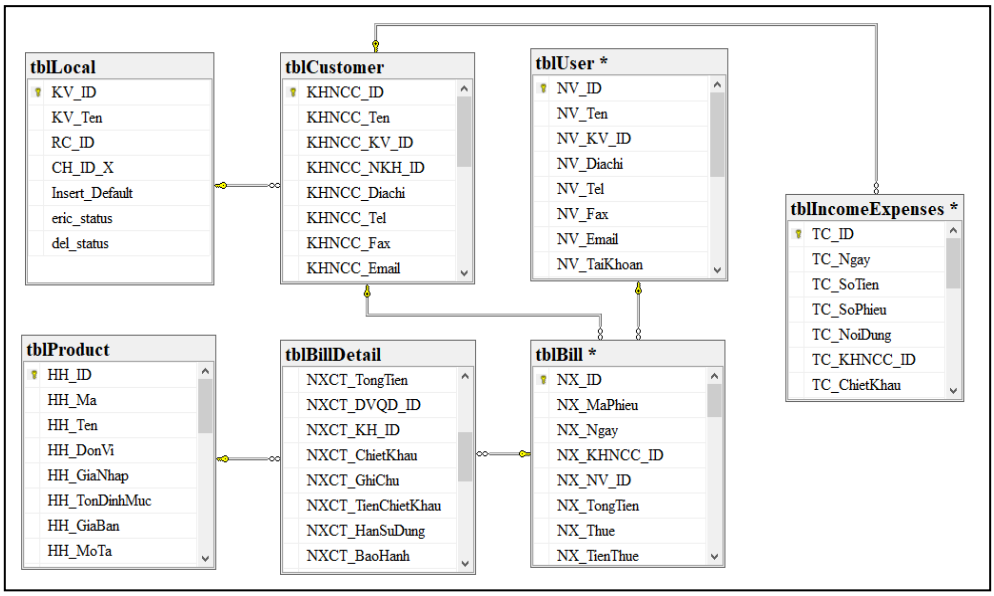

Fig. 3. Relationship between data tables

3.2. Calculation and data aggregation formulas

In this study, we have provided several calculation formulas to clarify the results calculated and used in Power BI. These formulas are essential for accurately aggregating and analyzing data within the retail system. By using these formulas, we ensure that the data is processed consistently and reflects true business performance. Table 1 outlines the specific formulas used for data aggregation, providing a clear reference for how data is transformed and interpreted within the system. This transparency helps stakeholders better understand the methodology behind the data analysis and supports more informed decision making.

Tab. 1. The formulas

Formulas		Description
$S^k = \sum_{i=0}^{r} S_i$	(1)	Calculating the total product of a bill
$M^k = \sum_{i=0}^{r} M_i$	(2)	Calculating the total money of a bill
$T^k = \sum_{i=0}^{r} S_i \,.\, P_i \,.\, T_i \quad \forall\, T_i : \in \{0.08;0.1\}$	(3)	Calculating the amount of tax on a bill, with a tax rate on each bill is 8% or 10%
$D^k = \sum_{i=0}^{r} S_i \,.\, P_i \,.\, D_i \quad \forall\, D_i \in \mathbb{R}$	(4)	Discount money for a bill
$R^k = \sum_{i=n_{1,l}}^{n_2} M_l^i + T_l^i - D_l^i \quad \forall\, l=20$	(5)	Calculating the revenue total between 2 dates
$A = \frac{\sum_{i=n_1}^{n_2} M^i}{\sum_{i=n_{1,l}}^{n_2} S^i} \quad \forall\, l=10$	(6)	Calculating average product purchase price
$V = \sum_{k=n_{1,l}}^{n_2} \sum_{i=1}^{r} A_i \,.\, s_i^k \quad \forall\, l=20$	(7)	Calculating total purchase money for the sales products
$N = R-V$	(8)	Calculating profit

Where: Sk: The total products of the k bill; S_i: The quantity of product in the i record in a bill; Mk: Total money of the k bill; M_i: The total money of a record i in a bill; P_i: The product price of the record i in a bill; Tk: Tax of the k bill; T_i: Tax at the record i in a bill; D: Discount; D_i: Discount at the record i in a bill; R: Revenue total; l: type of the bill/invoice, l = 10: purchase invoice from the provider, l = 20: sale invoice for the customer; A: Average purchase price of product; r: Number of record in a bill; n1, n2: Calculating value from date 1 to date 2; N: Profit.

3.3. Data collected from the TTC retail system

To support this research, the article collected data from the retail system of TTC, one of the leading retail companies in northern Vietnam. The data collected includes detailed retail invoices from 2023, categorized by individual customers and time periods, providing a comprehensive view of customers' purchasing patterns throughout the year. In addition, data on the cost price of products in 2023 was collected and analyzed to accurately calculate profits. Tables 2 and 3 below provide an overview of the revenue and profit of TTC's retail system in 2023, providing insight into the trends and fluctuations in the company's business performance during this period.

Tab. 2. TTC's revenue dataset in 2023

Name	Month	Year	Revenue	%/year
TTC.DT.01.23	1	2023	54,057,462,750	8.32
TTC.DT.02.23	2	2023	57,506,815,690	8.85
TTC.DT.03.23	3	2023	51,758,685,010	7.97
TTC.DT.04.23	4	2023	45,742,878,870	7.04
TTC.DT.05.23	5	2023	58,636,621,600	9.03
TTC.DT.06.23	6	2023	47,842,661,400	7.36
TTC.DT.07.23	7	2023	41,368,171,230	6.37
TTC.DT.08.23	8	2023	52,179,414,270	8.03
TTC.DT.09.23	9	2023	57,005,882,310	8.78
TTC.DT.10.23	10	2023	61,801,736,950	9.51
TTC.DT.11.23	11	2023	57,633,161,150	8.87
TTC.DT.12.23	12	2023	54,057,462,750	9.86
		Total:	649,604,537,200	100.00

The revenue is calculated by summing the sales invoices for all products by month, this data is calculated from the tblBill entity, the data field is TotalAmout with invoices of type = 20. This calculation is done through SQL queries to the database and according to formula (5) in Table 1.

Tab. 3. TTC's profit dataset in 2023

Name	Month	Year	Profit	%/year
TTC.LL.01.23	1	2023	2,971,966,170	8.29
TTC.LL.02.23	2	2023	3,055,332,770	8.52
TTC.LL.03.23	3	2023	2,812,179,520	7.84
TTC.LL.04.23	4	2023	2,476,015,260	6.91
TTC.LL.05.23	5	2023	3,290,849,180	9.18
TTC.LL.06.23	6	2023	2,642,202,790	7.37
TTC.LL.07.23	7	2023	2,360,820,760	6.59
TTC.LL.08.23	8	2023	2,903,841,560	8.10
TTC.LL.09.23	9	2023	3,174,956,320	8.86
TTC.LL.10.23	10	2023	3,453,363,890	9.63
TTC.LL.11.23	11	2023	3,177,677,390	8.86
TTC.LL.12.23	12	2023	3,527,701,910	9.84
		Total:	35,846,907,520	100.00

Profit is calculated on a monthly basis using data stored in the tblBill table (as shown in Figure 3). It is determined by subtracting the total amount of products from the total revenue, where the revenue is derived from invoices with type = 20. The cost of goods is calculated based on the import price recorded in table tblBill with type = 10. After retrieving the data from the database, the profit is finalized using formula (8) in Table 1.

The revenue and profit data for 2023 collected from TTC's retail system has been organized and stored in detail according to the proposed structure. Retail invoices are categorized by individual customers and time periods, providing an accurate reflection of customer purchasing trends throughout the year. Each transaction is recorded with complete information about the product, quantity, selling price, and cost price, enabling accurate revenue and profit calculations on a monthly, quarterly, and annual basis. This data structure streamlines data retrieval and analysis, ensuring consistency and accuracy of information. Data tables are clearly summarized, allowing managers to easily track and evaluate business performance and make informed decisions to improve retail operations in future periods.

4. DATA VISUALIZATION RESULTS AND MANAGEMENT RECOMMENDATIONS

Once the data is aggregated and processed, it is visualized using the Power BI analytics tool. By viewing the real-time dashboard, managers can quickly assess the current state of the business and make accurate and timely decisions. The dashboard presents detailed charts in a visually intuitive format, allowing users to easily

access specific figures and reports. Figure 4 provides an overview of the performance report, highlighting the TTC company's retail situation.

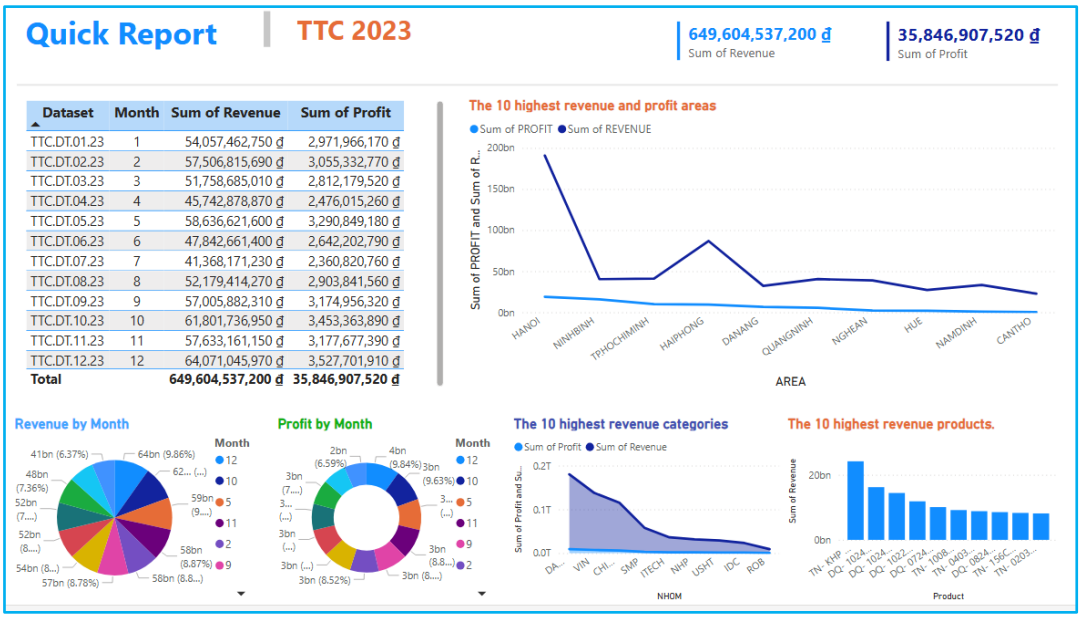

Fig. 4. Power BI dashboard overview

The 2023 dashboard provided a comprehensive and detailed view of TTC's business performance. By focusing on key metrics such as revenue, profit, customer count, and real-time updates, it provided valuable insight into TTC's business trends. Reports highlighting the top performing employees, regions and products focused on the most influential factors driving sales. This enabled TTC to pinpoint the critical elements contributing to its success. Leveraging the insights from this dashboard to inform a development strategy will be critical to optimizing business operations and building a sustainable long-term growth plan.

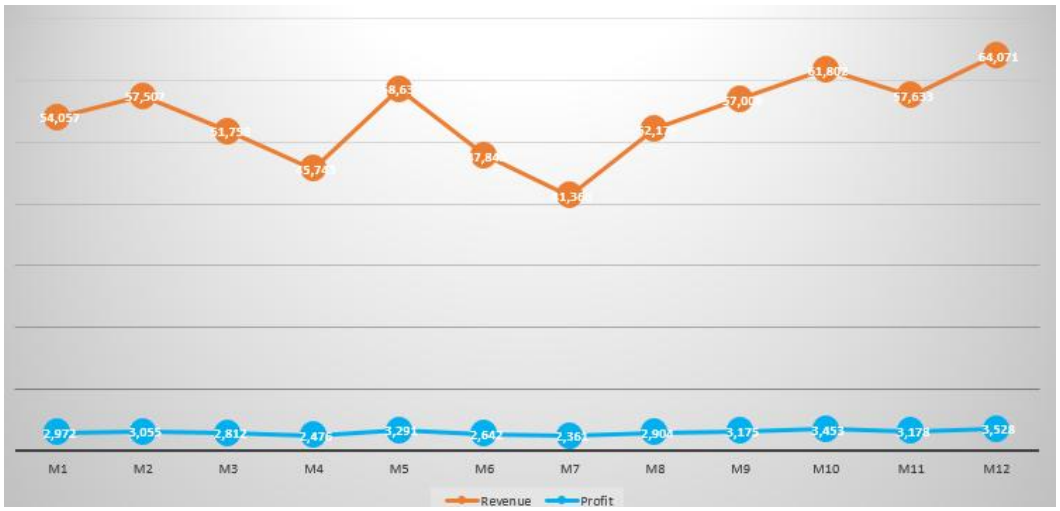

Fig. 5. Revenue and profit by month (in million vnđ)

Figure 5 shows the monthly revenue and profit of TTC shops throughout 2023. Notably, there was a significant spike in revenue toward the end of the year, starting in October, with revenue peaking at nearly VND 649.6 billion and profit at VND 35.84 billion (5.51%) in December. There were also notable fluctuations in revenue throughout the year, especially between February and June, when TTC shops had relatively low sales.

Figures 6.a and 6.b show the sales and profit of the top 10 retail areas within the TTC network. Notably, sales and profit from the Hanoi area account for 29% of the total, indicating strong demand for TTC's products in this market. To maintain and expand its market share in Hanoi, TTC should intensify its business activities,

including strengthening marketing strategies, optimizing distribution channels, expanding the retail network, and improving the quality of customer service. In addition, focusing on promotional programs, special events, and strategic partnerships will help increase brand awareness. Implementing these strategies will not only maintain strong consumption, but also drive sustainable profits for TTC in the Hanoi market.

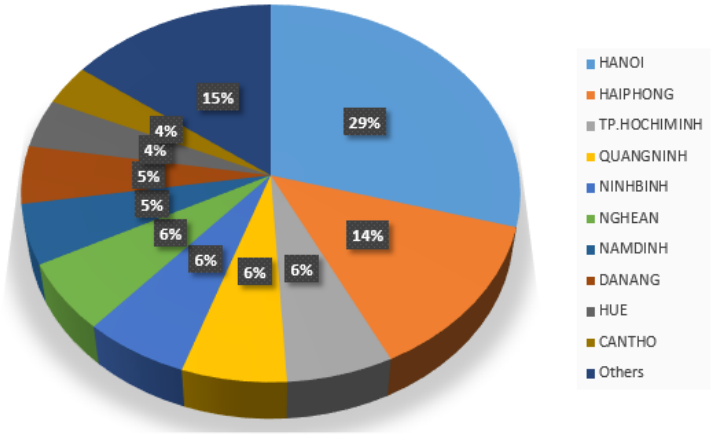

Fig. 6a. Top 10 regions with highest revenue

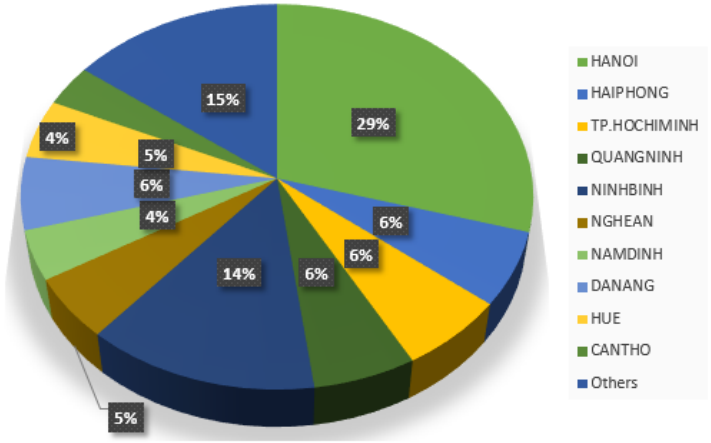

Fig. 6b. Top 10 regions with highest profit

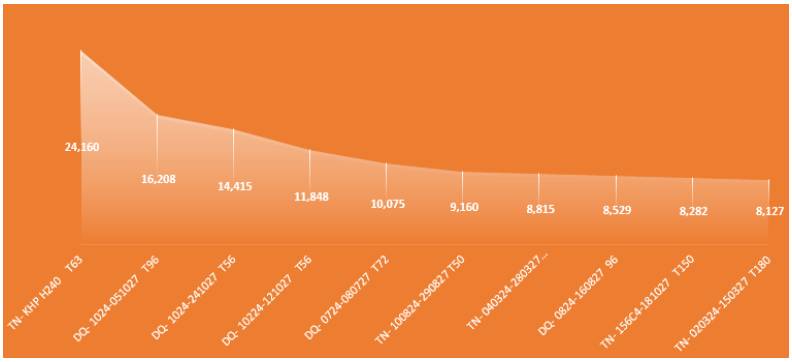

Fig. 7. Top 10 best selling products (in million vnđ)

The Top 10 Best Selling Products chart in Figure 7 provides valuable insight for TTC stores by highlighting the popularity and potential of each product in their portfolio. This graphical report serves as a basis for evaluating sales performance, developing marketing strategies, and optimizing inventory management to take advantage of top-performing products. Among these products, "TN-KHP H240 T63" stands out as the top-selling product with sales revenue of over VND24.16 billion, far surpassing all other products.

The implementation of MPBI significantly improves management efficiency by enabling fast and accurate data analysis and real-time situational awareness. Based on these findings, the article provides the following recommendations for managers to improve operational effectiveness:

- Drive digital transformation: Companies should focus on synchronizing and standardizing their data structures, especially for retail operations. Clear and consistent data structures facilitate easy integration with other applications and support more efficient use of data.
- Use business intelligence tools: Using business intelligence tools to visualize data allows managers to quickly and accurately monitor key business metrics. This improves decision-making by providing actionable insights for better retail management.
- Leverage data visualization tools: Organizations should invest in tools like MPBI that enable effective data visualization. These tools streamline analysis and observation, empowering managers to make informed, data-driven decisions.

5. CONCLUSION AND FUTURE WORKS

This article discusses the use of MPBI to visualize data from a retail MIS system. It proposes a data structure for storing retail data collected from retail systems, which can then be integrated into MPBI to generate graphical reports. The article also suggests mathematical formulas for data aggregation and calculations that will assist managers in extracting meaningful data for monitoring, control, and decision making.

The article aggregates data from the TTC company's retail system and converts it into appropriate data structures, which are then loaded into MPBI to create visual reports in the form of charts. These visual reports enable managers to easily assess and analyze their company's business situation and make timely management decisions.

In the future, we will continue to explore the application of predictive algorithms and business forecasts combined with visual reports to better assist managers in overseeing operations within the company.

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Conflicts of Interest

The author declare that there are no conflicts of interest regarding the publication of this paper.

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