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Optimizing retail systems: using big data and power business intelligence for performance insights

Huu Dang Quoc, Ha Le Viet
Faculty of Economic Information System and E-commerce, Thuongmai University, Hanoi, Vietnam

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ABSTRACT

In the rapid development of information technology, using enterprise data to support timely management decisions is crucial in helping businesses operate effectively and improve competitiveness. This study uses Microsoft power business intelligence (MPBI) to analyze data in retail systems, allowing managers to grasp the business situation in real time, track advanced sales, optimize inventory control, and analyze customer behavior and supply chain visibility. From the data generated by the business, the study uses the streaming extract transform load (ETL) model to support real-time data aggregation, then converts to the MPBI data visualization system to convert data into visual charts, helping businesses easily monitor, track, analyze, and make decisions to promote business activities. The study proposes a data structure to organize retail information storage. It proposes a system of calculation formulas and data synthesis, making integrate and convert tabular data into visual charts. Through analysis of real data from the LH83 retail system, the study shows the feasibility of implementing a data visualization system and the difficulties encountered when businesses want to deploy this model.

Corresponding Author:

Ha Le Viet
Faculty of Economic Information System and E-commerce, Thuongmai University
Hanoi, Vietnam
Email: levietha@tmu.edu.vn

1. INTRODUCTION

The rapid development and widespread deployment of digital technology are creating profound changes in many fields, and the retail industry is one of the most strongly affected. In an increasingly competitive market, the needs of customers and consumers are constantly changing, and businesses also need to adjust their products and services to better meet customer needs. Digital transformation, therefore, is not only a strategy but also a requirement for survival, especially in the retail sector, where data is generated continuously and in huge volumes.

Modern technologies allow businesses to automate work processes, optimize supply chains, and collect valuable data faster and more accurately. As a result, businesses can improve their analysis and management capabilities, from tracking financial indicators such as revenue, costs, and profits to gaining a deeper understanding of overall operational performance. One of the practical support tools for this process is Microsoft power business intelligence (MPBI) [1], a data analysis and visualization platform that helps businesses to exploit customer behavior and grasp market trends further, thereby making more informed data-based decisions. To support data processing, this study uses the streaming extract transform load (ETL) in a real-time technique in processing and converting data from different sources into a visualization environment, helping to process quickly and effectively. Unlike batch ETL, streaming ETL allows data to be processed continuously from collection and conversion to visualization and is very suitable for the characteristics of the retail industry, where transactions, inventory, and customer behavior change and arise continuously over time. This method helps synthesize data in real time, supporting analysis, monitoring, and making timely decisions.

This study also proposes a suitable database structure for storage organization, which can be linked to the enterprise's management information systems to store complete and unified data, facilitating the exploitation and processing process. To support the calculation and synthesis of data, this paper builds a set of formulas to calculate key business indicators such as costs, revenue, and profits. It applies them directly to actual data from the LH83 system. This data set contains detailed information about sales activities and is organized according to the data structures proposed in section 3. Through power business intelligence (PBI), the data is visualized in many forms to support the analysis and decision-making process in business.

The structure of the rest of the paper is as follows: section 2 presents an overview of the literature and related research works. Section 3 describes the data structure, synthesis process, and data processing method from the LH83 detailed system. Section 4 presents the application of data visualization technology to convert data into visual charts, analyze the results, and give important management implications. Finally, section 5 concludes and suggests further research directions.

2. RELATED WORKS

Currently, many data analysis technologies and processes have been deployed and supported for businesses very effectively, helping businesses specifically synthesize and process data from many different sources. MPBI is the leading solution in this field; this flexible and powerful tool allows complex data processing in real time, supporting the creation of visual data charts through charts, graphs, and interactive dashboards. This visualization tool connects tabular data in different sources and database management systems, represents them as relational data models, and then uses them for visualization. Applying MPBI helps businesses respond faster and more accurately to emerging trends and operational needs by presenting data in a clear and user-friendly format.

2.1. Business intelligence applications with Microsoft power business intelligence

2.1.1. Supply chain optimization and demand forecasting

MPBI is increasingly used in supply chain management, especially in demand monitoring and forecasting. Nabil *et al.* [1] developed a real-time dashboard based on the alternative dispute resolution (ADR) method to improve supply chain operational efficiency. This study shows that visual elements such as key performance indicators (KPIs) and interactive charts can support fast and accurate decision-making. Belghith *et al.* [2] built a pharmaceutical-specific flow forecasting model using PBI to improve sales forecasting and synchronize supply chain activities. Mohammed and Panda [3] combined artificial intelligence (AI) models with PBI to enhance predictive analytics in logistics planning. At the same time, Hosen *et al.* [4] emphasized the role of modern business intelligence (BI) tools in promoting data-driven decision-making habits, contributing to a more efficient and flexible supply chain. These studies show that PBI is a valuable tool for transforming real-time data into information that can be used immediately in practice through intuitive and accessible dashboards.

2.1.2. Visual data analysis in retail and e-commerce

In the context of the rapid development of retail and e-commerce, PBI supports businesses in making more effective strategic decisions. Murugan *et al.* [5] used PBI to analyze customer preferences and regional sales changes, helping businesses adjust their strategies to each market. Visual tools such as heat maps or bar charts have also helped improve the effectiveness of marketing campaigns and inventory management. Alqhatani *et al.* [6] present an integration approach between PBI and machine learning, providing a holistic view of retail operations and contributing to improving customer satisfaction. Similarly, Banerjee *et al.* [7] point out a PBI implementation that simplifies the analysis of sales and distribution data, supporting the development of more effective marketing strategies. Chen *et al.* [8] extend the application of PBI to predictive models, which are closely linked to the Industry 4.0 trend. Yadav *et al.* [9] evaluate PBI in e-commerce performance analysis, while Lande *et al.* [10] emphasize the ability to integrate real-time data to personalize consumer experiences. In addition, Rumhi and Sivakumar [11] utilized PBI visualizations to analyze supermarket sales data, identifying key trends in customer satisfaction, product performance, and payment methods. The study proposed targeted strategies to improve sales and enhance customer experience.

2.1.3. Real-time analytics with machine learning

With machine learning integrated into PBI, businesses can enhance real-time analytics with greater flexibility and accuracy. Mohammed and Panda [3] proposed integrating AI models into PBI dashboards to improve predictive functionality, supporting businesses in making quick decisions based on specific data. By combining visual charts and predictive algorithms, businesses can grasp market trends more accurately. Nikitha *et al.* [12] introduce a PBI-based system integrated with advanced machine learning models (autoregressive integrated moving average (ARIMA), long short-term memory (LSTM), and random forest (RF)), enabling real-time, interactive forecasting. The models achieved high accuracy and low error rates, offering actionable insights for business decision-making. Surwade *et al*. [13] also emphasized the role of advanced predictive algorithms in increasing supply chain responsiveness. Finally, James *et al*. [14] discussed the combination of PBI with big data analytics to support organizations in making more effective strategic decisions.

2.1.4. Power business intelligence with the internet of things

Integrating MPBI and the internet of things (IoT) offers new approaches to processing large volumes of data generated by sensor systems. Rai *et al*. [15] emphasize the role of PBI in visualizing big data in the IoT ecosystem, especially for real-time monitoring and decision-making. Libby *et al*. [16] also explore how PBI can be integrated into logistics operations, using IoT data to improve operational visibility and performance monitoring.

2.1.5. Applications in specialized industries

In addition to traditional data applications, MPBI can be applied to specialized sectors or industries. Seto *et al*. [17] studied integration with enterprise resource planning (ERP) systems in the mining industry to make decisions about fuel consumption and inventory replenishment. Ameer *et al*. [18] applied PBI to human resource analysis, utilizing dashboards to reduce employee turnover and improve evaluation metrics. There are studies on the application of business data visualization capabilities for online business systems. Anardani *et al*. [19] proposed using PBI to analyze sales trends for fishing gear and enhance inventory optimization and marketing. Shubho *et al*. [20] detailed its impact on small and medium enterprises (SMEs), improving operations and financial planning transparency. In addition, data visualization can be applied in several other areas. Sharma *et al*. [21] compared PBI with other BI platforms, emphasizing the superiority of visualization for complex data sets. Ruiz *et al.* [22] demonstrated the trend-forecasting capabilities of PBI in the gaming industry. Seto *et al*. [17] further developed their application in human resource analytics, highlighting predictive use cases for employee engagement and turnover.

2.2. Data warehousing

A data warehouse is a centralized data storage system designed to support analysis, reporting, and decision-making within an organization. Unlike an operational database that processes day-to-day transactions, a data warehouse stores historical data processed and integrated from various sources such as an ERP system, customer relationship management (CRM) platform, or Excel spreadsheet. Data is often organized using models such as a star or snowflake schema to facilitate efficient querying and analysis. This allows businesses to quickly consolidate information, analyze trends, evaluate performance, and generate management reports. As a core component of a BI system, a data warehouse becomes especially powerful when combined with tools like MPBI, allowing users to visualize data and make timely, data-driven decisions.

Initially, data warehouses were used to meet the need to store large amounts of data in various functions. The primary purpose of a data warehouse is to provide a structured repository that supports analytical and management functions [10]. It acts as an electronically managed data center that allows organizations to aggregate information from various sources, preprocess, and structure it in a unified manner for on-demand use, report synthesis, and data analysis [11]. For corporations operating in many fields, data warehouses help conveniently organize and store data for the entire business ecosystem, creating large, continuously emerging data warehouses. Data mining can then be applied in broader ways, such as organizing and using online analytical processing (OLAP) models and applying algorithms to predict business situations in real time [23], [24].

Data warehouses are vital in supporting BI processes in today's organizations. They facilitate pattern recognition, trend analysis, forecasting, and strategic planning across different departments. When integrated with tools like MPBI, data warehouses enable users to transform complex, multidimensional data sets into clear, actionable insights. This combination enhances an organization's responsiveness and competitiveness by helping to optimize operations, manage risks, and capture growth opportunities in an increasingly data-driven marketplace.

2.3. Streaming ETL: a real-time alternative to traditional ETL

In traditional data integration workflows, ETL has long been the dominant paradigm. ETL processes typically operate in batch mode, extracting large volumes of data at scheduled intervals (e.g., hourly and daily), transforming them through predefined rules, and loading them into a target system such as a data warehouse or data mart. While effective for many business scenarios, batch-based ETL suffers from latency and is ill-suited for environments that demand immediate visibility into data. In contrast, streaming ETL [25], [26] is a modern alternative designed for real-time or near-real-time data processing. Rather than waiting for data to accumulate into batches, streaming ETL ingests and processes each data event as it occurs. This shift from batch to stream processing significantly reduces data latency, enabling organizations to respond faster to operational changes, customer behaviors, and market dynamics. The key differences between traditional ETL and streaming ETL are outlined in Table 1.

Streaming ETL offers several advantages for businesses that need to analyze and act on time-sensitive data. For instance, in the retail industry, real-time processing allows for immediate inventory updates, dynamic pricing strategies, and personalized customer engagement based on recent activity. These capabilities are often not feasible with traditional ETL due to its inherent delays. To implement streaming ETL effectively, organizations often rely on event-driven architectures and technologies that support high-throughput, low-latency data flows. Tools such as Apache Kafka serve as the backbone for message streaming, while platforms like Apache Flink or Spark Structured Streaming perform transformations on-the-fly. Combined with analytics tools like MPBI, these pipelines enable decision-makers to monitor KPIs and derive insights in real time. While traditional ETL remains useful for many scenarios involving structured, stable datasets and periodic analysis, it is increasingly inadequate for today's dynamic, data-intensive environments. Streaming ETL fills this gap by offering a low-latency, continuous processing alternative that aligns with modern business demands for real-time insights and responsiveness. As digital transformation accelerates across industries, the adoption of streaming ETL is becoming a key enabler for data-driven agility and competitive advantage.

Table 1. Key differences between ETL and streaming ETL

Aspect	Traditional ETL	Streaming ETL
Processing mode	Batch	Real-time (event-by-event)
Latency	High (minutes to hours)	Low (milliseconds to seconds)
Data freshness	Periodic updates	Continuous updates
Use cases	Historical reporting, regulatory compliance	Real-time analytics, fraud detection, personalized offers
Infrastructure requirements	Simpler; suitable for periodic jobs	Requires a scalable, fault-tolerant streaming architecture
Tools	Talend, Informatica, SSIS	Apache Kafka, Spark Streaming, Flink, Debezium

3. MODELING AND AGGREGATING RETAIL DATA FOR DECISION SUPPORT

In a management information system, which is used in retail systems, building a good database structure plays a fundamental role in storing, managing, and exploiting data. The large and continuous volume of data from sales transactions, inventory management, debt, promotion programs, and consumer behavior requires a scientifically designed, unified storage architecture to organize and retrieve information effectively. A well-designed database structure helps ensure data consistency and integrity while facilitating data integration from many sources. This is especially important in the retail environment, where information needs to be processed quickly to make timely decisions. Organizing data according to a clear relational model also helps to minimize duplication, improve query performance, and support more stable analysis tools. Furthermore, a well-structured database is the foundation for advanced analytics applications such as demand forecasting, inventory optimization, and customer behavior analysis. When combined with BI tools such as PBI, a clear data structure helps visualize information flexibly and supports strategic decision-making at the management level.

3.1. Relational database

To meet the requirements of data storage and management in the retail system, we designed a relational database model consisting of seven core entities. These entities represent key components of business operations, playing a central role in collecting, storing, and organizing information. Each data table reflects a separate aspect of products, customers, transactions, and employees, but they are simultaneously tightly linked to ensure the data flow is connected throughout the system.

Building logical relationships between tables helps ensure data integrity while allowing for more efficient and flexible queries during information mining. This relational design also helps the system accurately reflect the actual operating processes in the retail environment, from inventory management to sales tracking and consumer behavior analysis. Thanks to this structure, data is stored systematically and ready to serve analysis, reporting, and decision support activities. Figure 1 illustrates the relationships between data entities in the system, showing how they interact and form an integrated, unified data model. This structure is the foundation for developing advanced analytical functions, thereby improving management efficiency and quickly responding to market fluctuations.

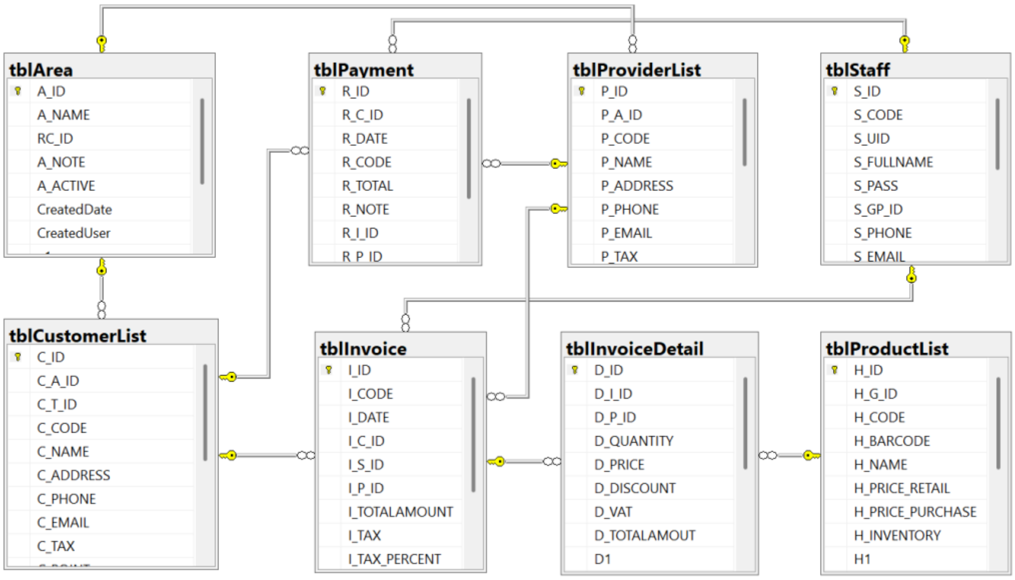

Figure 1. Relational database storing data

3.2. Formulas for data computation and aggregation

In this analysis, we propose to build mathematical formulas to calculate business results based on daily generated data, which will be rendered as input for MPBI to build visual charts. These formulas are the main constraints in implementing retail data calculation and synthesis processes. Through this, the data is guaranteed to be accurate when synthesizing and analyzing data across the entire retail system, ensuring consistency and transparency in the business operations of retail enterprises. The constraints are shown in Table 2.

Table 2. The constraints in the retail system

Formula	Description
$S^k = \sum_{i=0}^{r} S_i$	Determining the number of products listed in an invoice.
$M^k = \sum_{i=0}^{r} M_i$	Calculating the total payable amount for an invoice.
$T^k = \sum_{i=0}^{r} S_i \,.\, P_i . T_i \quad \forall Ti: \in \{0.08;0.1\}$	Computing the tax amount on an invoice, using either a 0, 5, 8, or 10%.
$D^k = \sum_{i=0}^{r} S_i \,.\, P_i . D_i \quad \forall D_i \in \mathbb{R}$	Applying a discount to the total invoice value.
$R_k = \sum_{i=n_{1,l}}^{n_2} M_l^i + T_l^i - D_l^i \quad \forall l=20$	Summing up the total revenue generated within a specified date range.
$A = \frac{\sum_{i=n_1}^{n_2} M^i}{\sum_{i=n_{1,l}}^{n_2} S^i} \quad \forall l=10$	Finding the average purchase cost of selled products.
$V = \sum_{k=n_{1,l}}^{n_2} \sum_{i=1}^{r} . A_i . s_i^k \quad \forall l=20$	Calculating the total purchase expenses associated with selled products.
$N = R - V$	Measuring the overall profit earned during a given period.

Where S_k is total number of items listed in invoice k, S_i is quantity of the product in entry i of a invoice, M_k is total payable amount for invoice k, M_i is cost associated with entry i in the invoice, P_i is unit price of the product in entry I, T_k is total tax applied to invoice k, T_i is tax amount calculated for entry i, D is total discount applied to the invoice, D_i is discount value for entry i, R is total revenue generated, l is type of transaction (l=10 for purchase, l=20 for sale), A is average purchase price of imported goods, r is number of line items in a bill, n_1, n_2 is time range used for calculation (from date n_1 to date n_2), and N is net profit earned during the period.

3.3. Data collected from the LH83 retail system

To experiment with data processing and visualization, this study collected data from the retail system of LH83, one of the large retail enterprises in the Hanoi area; the business unit's products are water filtration equipment. The collected data includes retail invoices, receipts, and import receipts for the fiscal year 2024. The customer classifies this data at a specific time; the data also shows the business performance of each sales staff member of the company. On that basis, information on import prices is also collected to calculate the profits of the company's products. Through processing with formulas and synthesizing by month, the study has synthesized the enterprise's business data in Table 3.

The data collected from the LH83 retail system is stored in an export data structure, as shown in Figure 1, then aggregated and calculated for 2024 revenue and profit. Invoices are classified by customer and period, providing a clear view of purchasing behavior throughout the year. Each transaction includes detailed information on product type, quantity, selling price, and cost price, allowing accurate revenue and profit calculations and totals by customer, product, month, quarter, and year.

Table 3. LH83's revenue dataset in 2024

Name	Month	Year	Revenue		Profit	
			Value	%/year	Value	%/year
LH83.01.24	1	2024	11,931,906,000	9.42	1,185,245,595	10.16
LH83.02.24	2	2024	6,663,160,000	5.26	655,615,165	5.62
LH83.03.24	3	2024	12,522,444,000	9.88	1,205,437,735	10.33
LH83.04.24	4	2024	10,281,690,000	8.11	888,722,475	7.62
LH83.05.24	5	2024	12,097,281,000	9.55	1,140,505,320	9.78
LH83.06.24	6	2024	10,142,084,080	8.00	863,673,775	7.40
LH83.07.24	7	2024	11,878,659,000	9.37	651,930,385	5.59
LH83.08.24	8	2024	11,096,585,480	8.76	1,119,062,425	9.59
LH83.09.24	9	2024	10,718,791,600	8.46	902,866,460	7.74
LH83.10.24	10	2024	9,479,322,000	7.48	1,022,341,480	8.76
LH83.11.24	11	2024	8,975,844,000	7.08	953,588,895	8.17
LH83.12.24	12	2024	10,931,256,000	8.63	1,075,968,860	9.22
Total			126,719,023,160	100.00	11,664,958,570	100.00

4. ANALYTICAL RESULTS AND DECISION-MAKING SUPPORT VIA VISUALIZATION

The collected data is stored in a structured database based on the proposed schema, then transformed and integrated into the MPBI system for visualization through charts and graphical reports. This process not only enhances data readability and accessibility but also helps users quickly identify trends and fluctuations in business performance. In particular, streaming ETL techniques allow data from source systems to be extracted, transformed, and continuously updated in real-time in MPBI. As a result, the visualizations and dashboards always reflect the current operational status of the business. This real-time capability is especially valuable for managers who need to monitor activities continuously and make timely decisions based on up-to-date information.

The visual elements are organized into dynamic dashboards and overview screens, which can be displayed directly within the MPBI platform or embedded into internal management software. In addition to visualizing data according to the predefined structure, MPBI also supports interactive filtering directly on charts and dashboards. This enables users to view information based on various criteria such as time, region, customer segment, or product category, thereby making business performance evaluation more comprehensive and accurate. Figure 2 illustrates an example of the business overview dashboard of the LH83 retail system, with data continuously updated and visualized through the streaming ETL process.

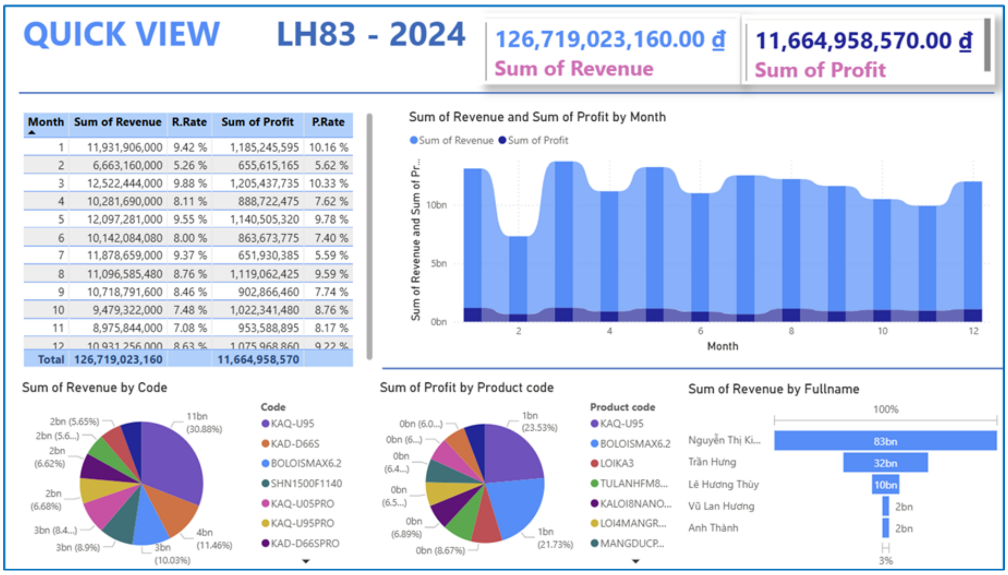

Figure 2. PBI dashboard overview

This dashboard is designed to help managers monitor the overall business situation of the LH83 retail system. In 2024, the company's total revenue reached VND 126.7 billion, bringing in a profit of VND 11.66 billion, corresponding to a profit margin of 9.21%. The intuitive interface helps managers easily observe revenue fluctuations by month. Notably, February recorded the lowest revenue, mainly due to coinciding with the Lunar New Year holiday. To get high revenue at this time, marketing campaigns must be deployed more strongly to boost demand or focus on the consumption of staple products with stable purchasing power.

Figures 3 and 4 display a list of the 10 products with the highest revenue and the 10 with the highest profit in the year, providing a basis for managers to prioritize developing effective consumption promotion programs. At the same time, the dashboard also shows a list of employees with outstanding achievements, facilitating the proposal of appropriate salary and bonus policies to encourage and maintain work performance. This visualization system gives managers a comprehensive view of LH83's business performance, making timely and realistic decisions to improve operational efficiency in the following stages.

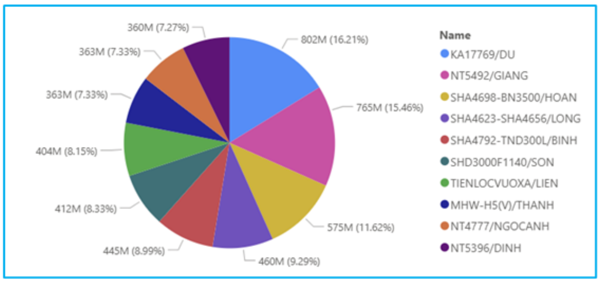

Figure 3. Top 10 customers have the highest revenue (in billion VND)

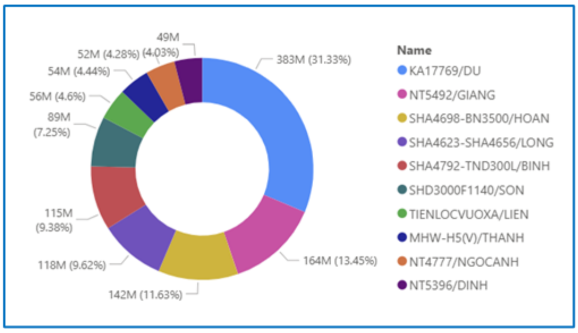

Figure 4. Top 10 customers have the highest profit (in billion VND)

In the retail sector, employees are the direct force that generates revenue and maintains customer relationships. The performance of each individual has a significant impact on business results as well as service quality. Therefore, monitoring and evaluating work performance is an important factor that helps managers identify outstanding employees, thereby building appropriate reward, training, and job arrangement policies to improve motivation and work efficiency. Figure 5 shows the top 5 employees with the highest revenue and profit for the LH83 system. These charts assist the management in visualizing each individual's contribution level, serving as a basis for making personnel decisions and implementing team development strategies, thereby improving the business efficiency of the entire system.

Deploying a data visualization system in the enterprise environment contributes to the digital transformation process and the implementation of science and technology applications, but also serves as a foundation to support effective and timely data-based decision-making. Through research and experiments in this article with retail systems, deploying standardized database applications (especially with big data), applying data constraints, and converting data into visualization reports brings excellent efficiency to the enterprise. However, when deploying, enterprises need to note the following points:

i) Prioritize real-time data updates to improve the ability to monitor and handle situations promptly

In the modern business environment, timely decision-making based on the latest data is necessary. Applying streaming ETL techniques in data visualization systems allows businesses to continuously update data in real time, helping managers quickly detect unusual revenue, inventory, or employee performance fluctuations. The ability to closely monitor operational indicators in real-time provides a significant advantage in flexibly responding to rapidly changing market situations, especially in the retail and e-commerce industries.

ii) Designing a reasonable, unified, and clear database structure is the foundation for practical analysis

A unified, clearly structured database architecture will ensure data integrity, completeness, and synchronization between departments and the business ecosystem. This helps standardize data flows throughout the system and optimizes the efficiency of data retrieval, aggregation, and visualization. Especially in retail systems, where data is continuously generated from invoices, orders, inventory, and customer transactions, building a reasonable relational data model from the beginning will be a key factor for the reporting system to operate accurately and steadily in the long term.

iii) Identify and effectively exploit loyal customer groups, as well as encourage key employees

Using data visualization helps businesses easily identify customers with high purchase frequency and employees who bring in outstanding revenue or profit. From there, managers can build customer care programs or appropriate rewards and incentives for employees to maintain and maximize the value of these key groups. This is a strategic direction that helps businesses grow in sales and increase the engagement and loyalty of customers and employees.

iv) Build a flexible dashboard that can interact with multiple analysis criteria

An effective reporting system is not just about presenting data, but also allows users to freely interact and analyze in many different dimensions, such as time, product, personnel, and geographic area. PBI provides filtering, drill-down, and real-time selection tools, allowing management and staff users to analyze data according to their perspective. Designing a hierarchical dashboard, from overview to detail, will help businesses serve strategic management and daily operational needs.

v) Data visualization must be linked to specific actions

The ultimate goal of visualization is not only to provide an overview but also to support clear action decisions. Charts and dashboards should be designed around specific management questions, such as: “Why is revenue down this month?”, “Who is exceeding targets?”, “Which products need to be promoted more?”. When data visualization is linked to KPIs and action plans, businesses will improve management efficiency while increasing their initiative in optimizing processes and exploiting growth opportunities.

Moreover, Christodoulou *et al.* [27] developing and maintaining a customer network is a crucial factor that helps businesses overcome challenges within the industry and increase their competitiveness. By building effective customer engagement strategies and maintaining sustainable relationships, businesses can leverage collected data to improve their understanding of customers, thereby developing better customer acquisition strategies and enhancing strategic decision-making. As shown in this research, the integration of technology and customer strategies can help businesses build a stronger customer network, enabling them to adapt to the rapid changes in the modern retail market.

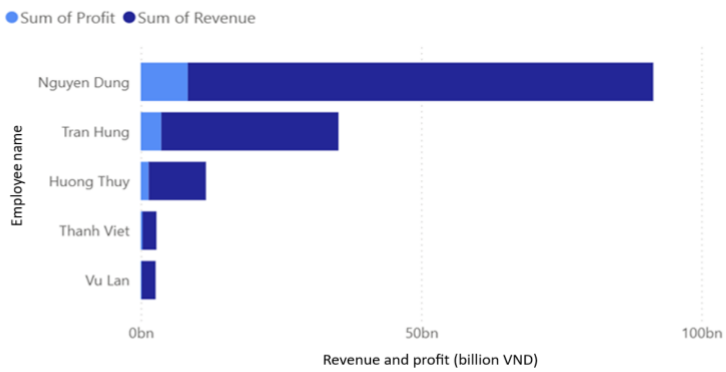

Figure 5. Top 5 employees with the highest sales revenue and profit (in billion VND)

5. CONCLUSION AND FUTURE WORKS

This paper investigates the application of MPBI in visualizing data from a management information system tailored for the retail sector. It proposes a structured data model for organizing retail information collected from operational systems, enabling smooth integration with PBI to generate interactive and insightful visual reports. Additionally, a set of mathematical formulas for data aggregation and metric computation is presented to support retail managers in extracting meaningful insights for monitoring, supervision, and strategic decision-making. The dataset utilized in this study is derived from LH83's retail operations. This data is transformed into an analytical format and integrated into PBI through a well-defined pipeline. To enhance the responsiveness and timeliness of analytics, the study also incorporates streaming ETL techniques. Unlike traditional batch processing, streaming ETL enables continuous ingestion and transformation of data as events occur, thereby ensuring that dashboards reflect near real-time business activities. This approach significantly improves decision-making capabilities by providing up-to-date insights on KPIs and operational metrics. The visual outputs, in the form of dynamic charts and dashboards, allow managers to intuitively interpret business performance and make timely adjustments. In future work, we plan to expand this framework by integrating predictive algorithms and forecasting models within the PBI environment, combining them with real-time data pipelines via streaming ETL. This will offer an even more comprehensive decision-support system to assist managers in proactively overseeing and optimizing retail operations.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Huu Dang Quoc	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ha Le Viet			✓	✓		✓	✓	✓		✓	✓	✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

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

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [HLV], upon reasonable request.

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BIOGRAPHIES OF AUTHORS

Huu Dang Quoc received a Bachelor's and M.S. degree in the School of Information Technology, Vietnam National University, Hanoi, Vietnam, in 2000 and 2015. He received a Ph.D. degree from the Military Institute of Science and Technology, Hanoi, Vietnam, in 2023. He worked at Thuong Mai University, Hanoi, Vietnam, from 2006. His research interests include AI, IoT systems, management information systems in manufacturing, software engineering, evolutionary algorithms, and optimization algorithms. He can be contacted at email: huudq@tmu.edu.vn.

Ha Le Viet graduated with a Bachelor's and Master's degree in Information Technology, Hanoi National University in 2000 and 2024, and a Ph.D. in Management Information Systems from National Economics University in 2019. She is currently working at the Thuongmai University. Her research interests include management information systems, fuzzy systems, big data analytics, machine learning, artificial intelligence, and blockchain technology applied in the fields of economics, finance, accounting, business, and science. She can be contacted at email: levietha@tmu.edu.vn.