Survey on Data Warehouse-Based Business Intelligence (BI) Systems for Strategic Decision Making

VARUN BITKURI[1], SUNIL JACOB ENOKKAREN[2], AVINASH ATTIPALLI[3], RAGHUVARAN KENDYALA[4], JAGAN KURMA[5], JAYA VARDHANI MAMIDALA[6]

[1] Software Engineer
Stratford University
USA

[2] ADP, Solution Architect
USA

[3] Department of Computer Science
University of Bridgeport
USA

[4] Department of Computer Science
University of Illinois at Springfield
USA

[5] Computer Information Systems
Christian Brothers University
USA

[6] Department of Computer Science
University of Central Missouri
USA

Abstract: - The increase in the volume of data in the organization has led to more issues like poor consistency in data quality, disjointed analytical process, and delay in extracting insights into actionable process, which has weakened strategic decision-making in any sector. To mitigate these challenges, the current paper explores the architecture and operation of data warehouse-based Business Intelligence (BI) systems with an emphasis on the contribution of ETL processes, data integration processes, OLAP processes, as well as analytical instruments that transform unprocessed data into credible and useful information. The paper discusses the development of the BI technologies, evaluates their existing strengths and weaknesses in industries such as retail, finance, healthcare, and manufacturing. The constant issues associated with lack of scalability, low interoperability, dependence on batch-based ETL workloads, and limitations on real-time analytics are pointed out. The new research hypothesizes a Conceptual BI Evolution and Cross Industry Integration Framework, a new framework that brings together data collection and transformation, data storage, analytics, and decision-support layers in a unified and scalable framework applicable to the various industries. The framework shows the maturity of BI systems and interaction within sectors as a roadmap towards improving real-time responsiveness, adaptability and cross-industry usability. The results indicate that contemporary businesses need agile, real-time and business-friendly BI architecture to enhance operational efficiency, organizational intelligence, and strategic decision-making that is futuristic.

Key-Words: - Business Intelligence, Data Warehousing, ETL Process, OLAP, Data Mining, Predictive Analytics, BI Evolution

Received: July 13, 2025. Revised: August 16, 2025. Accepted: September 11, 2025. Published: December 11, 2025.

1 Introduction

The contemporary business environment is significantly altered by the rapid growth of digital data, and effective data handling has become an important consideration while making strategic decisions. BI has since become a business orientation among managers, coupled with a collection of a number of tools, which assist organizations to turn unstructured data into information that may be utilized [1]. The ability to make better decisions in business is made possible by BI because the information is refined, analysed and organized which ultimately results into increased overall performance of the organization. The need to have a strategy that can best leverage on data has increased tremendously in the current competitive world where the decisions are made at the right time and in the right way. Simultaneously, the volume and complexity of organizational information is growing at a very rapid pace due to the many sources, both internal and external. Such an information overload may take up unnecessary space in the decentralized databases and departments and it thus necessitates sophisticated management and analytics software so that organizations can be able to remain competitive and agile.

In an attempt to address this conundrum, data warehouses have been integrated into BI frameworks and are the main location of various data of operation [2]. The information that is stored in these warehouses is synthesized using diverse sources of information such as day-to-day operational databases, web applications and departmental systems among others where the decision-makers get one perspective of organizational knowledge [3]. The data warehouse ETL processes ensure that the information in the warehouse is correct, reputable and standardized and thus enhance the analytics foundation. BI tools rely on these highly structured repositories to generate reports, support advanced queries, support forecasting models and real-time insights which is important in managerial decision-making. Over time, it has been discovered that the synergy existing between BI and data warehousing can be described as transformative and the responsiveness and the heterogeneity of BI systems was further augmented through real time data processing [4].

The operational relationship between the BI tools and the data warehouses is particularly important to the strategic decision making. Such systems help the leaders to get timely, regular, and operational information by simplifying and analysing data supplied within the enterprise which is utilized in making tactical and long-term strategies [5]. They allow organizations to detect new trends, streamline the business, eliminate inefficiencies, and react promptly to the market dynamics. Besides, the consolidated data increases the level of stakeholder confidence since the strategic decisions made are based on valid and precise evidence. By doing so, it is possible to conclude that the data warehouse-based BI systems not only enable organizations to maintain a competitive benefit but also to generate value by integrating data-based insights with strategic purposes [6].

Even though there are benefits to BI systems, there are still major challenges. The problem of scalability is being experienced while the amount of data keeps growing exponentially, interoperability between heterogeneous sources of data hinders smooth integration and dependence on batch based ETL processes limits the real-time responsiveness. In addition, the previous study has largely concentrated on single industries, with a gap of a single framework to describe the cross-sector BI system development. To fill these gaps, this paper attempts to put forward a Conceptual BI Evolution and Cross-Industry Integration Framework, a framework that incorporates data acquisition, transformation, storage, analytics and decision-support strata within a unified and scalable model. The framework shows the maturity of the BI systems and the interactions that the systems have in the retail, healthcare, finance, and manufacturing sectors, providing a roadmap towards adaptive, real-time, and industry-sensitive BI architectures.

1.1 Paper Structure

The structure of this paper is as follows: In Section II, Business Intelligence (BI) systems, their definition, core components, benefits, and evolution. Section III discusses data warehouse-based BI with emphasis on ETL integration, role, and limitations. Section IV highlights applications in strategic decision-making. Section V provides a comprehensive literature review. The proposed framework for BI evolution is shown in Section VI. The paper's conclusion and future work directions are outlined in Section VII.

2 Business Intelligence (Bi) Systems

In order to convert information into useful insights, encourage informed decision-making, and foster organisational success, business intelligence (BI) systems incorporate technology, tools, and procedures. Core components include data

warehouses, OLAP, data mining, performance management tools, and diverse data sources [7]. BI enhances strategic decisions, competitive advantage, and stakeholder satisfaction, evolving from traditional DSS to mobile, visual, and real-time analytics for dynamic business environments.

2.1 Concept and Purpose of Business Intelligence

Business Intelligence (BI) is described as technologies, procedures, and practices that are applied to convert raw data into meaningful data that can be used in strategic, tactical, and operational decision-making. Gartner is of the view that BI entails people[8], processes and tools engaged in accessing and analyzing data to improve organizational performance and decision making.

Practically, BI incorporates data management systems, analysis applications, reporting systems and governance systems to provide insights which enhance competitiveness, efficiency and profitability[9]. The fundamental idea behind BI is to transform the reactive information environment into an active, intelligence-based ecosystem where trends are forecasted in their early stages, inefficiency is dealt with and performance is constantly watched.

BI systems streamline work processes of analysis, provide uniformity of access to timely information, and allow visibility in the organization. Finally, BI can offer tool independent analytics to evidence based decision making hence aligning the data assets with business objectives.

2.2 Core Components of BI

The core components of Business Intelligence, outlined below, provide the foundation for collecting, processing, analysing, and visualizing data, which helps businesses obtain useful insights and facilitate well-informed decision-making.

- **OLAP:** Business users can employ Online Analytics Processing (OLAP), a potent tool for data slicing and dicing that offers multidimensional, condensed perspectives for planning, analysis, modelling, and reporting. It employs data marts or warehouses made for corporate intelligence systems, which examine questions to identify trends and assess crucial factors [10]. Additional BI technologies include knowledge management, mapping, information visualisation, document warehousing, data mining, and decision support systems, and trend analysis, are used for data storage and analysis. Reporting software, on the other hand, creates aggregated views of data.
- **Data mining:** The process of automated data discovery of useful patterns in structured data that were previously unknown is referred to as data mining. It is among the essential elements of business intelligence (BI) from a data warehouse, which helps businesses to quickly and effectively provide meaningful insights [11]. A complex relationship in multiple dimensions can be detected by automated data mining significantly quicker than a manual analysis, hence it is a mandatory tool in informed decision-making.
- **Management of Corporate Performance (Dashboards, Scorecards, and Portals):** This broad genre typically offers a framework for several pieces that may be assembled to tell a narrative. One such example is a balanced scorecard that includes, for example, organisational learning and growth metrics with financial data.
- **Data Warehouse:** Business intelligence relies heavily on data warehouses, which provide integration, cleansing, aggregation, and querying on vast volumes of business documents. Also included are operational statistics for tactical decision-making [12]. Data may come from operational databases, historical data, external data, or data warehouse settings already in place. Decision support collections of topic areas are called data marts, and every department has its own programs, data, hardware, and software. BI systems provide Data mining, statistical analysis, forecasting, and online analytical processing.
- **Data Sources:** Data sources may include historical data, operational databases, information from the current data warehouse environment, or external data (for instance, via the Internet or market research firms). A data source can be any type of data format that serves the line of business applications, including relational databases. Both organised and unstructured data, including plaintext files, spreadsheets, and other multimedia data, may be found in them. They can also be stored on a variety of platforms.

Together, these elements transform data into knowledge that might be applied to create wise business choices.

2.3 Data Integration and ETL Process for BI

In order to ETL and data integration have been crucial components to ultimately provide meaningful decision-making. This paper's primary focus has been on data integration and ETL since they are the best ways to meet the goals and objectives established by upper management. Access to accurate information may help the management team with strategic planning and decision-making, consistent and dependable data [13]. In the end, the connection of both elements can effectively and usefully convey valuable information since it aids in decision-making for upper management. The Data Integration and ETL process's essential components include:

- **Extraction:** Raw data collection from many sources, including relational databases, access databases, web applications, and file systems.
- **Transformation:** Performing data cleaning, profiling, joining, filtering, sorting, and aggregation in the staging area to ensure reliability and consistency.
- **Loading:** Executing load processes to transfer the data into the designated data warehouse after it has been processed.
- **Centralized Data Warehouse:** Serving as a unified repository and acting as the single source of truth for BI and analytics.

Data Integration and ETL Business Intelligence (BI) process is depicted in Fig. 1. The ETL pipeline takes numerous heterogeneous data sources, including relational databases, Access databases and file systems. In this procedure, raw data will be extracted, cleaned, profiled and restructured in a staging area to maintain consistency and quality after which it was placed into the data warehouse. By being centralized, the data warehouse will consist of a dependable base of reporting, analysis processes, and decision making.

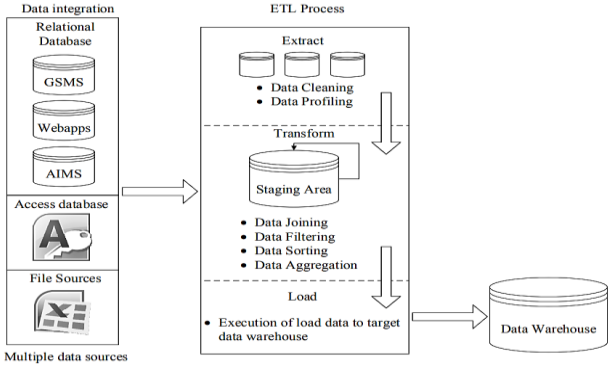

Fig. 1- Data Integration from Multiple Sources Through ETL Processes into A Data Warehouse For BI Operations[14].

2.4 Evolution and Trends in Business Intelligence

The field of business intelligence (BI) has advanced significantly since the 1980s. Operations research and management information systems were first developed into decision support systems (DSS), which offered scheduled, ad hoc, and query-based reports, usually in the form of long green bar reports. In the 1990s, the introduction of OLAP and ROLAP enabled users to analyse data through multidimensional cubes and relational databases, improving departmental data management and analytical capabilities [15]. The early 2000s brought Web-based BI, allowing real-time access, graphical reports, and predictive analysis, making data more accessible and actionable. By the late 2000s, dashboards replaced long reports, offering users clear, at-a-glance insights into business performance. In the early 2010s, BI became portable and mobile, integrating past BI tools into devices and enabling visual data discovery for casual users. Today, dashboards remain one of the most effective and widely adopted BI tools, supporting smarter, faster decision-making across organizations and helping businesses respond quickly to dynamic market conditions.

3 Data Warehouse-Based Business Intelligence Systems

A data warehouse-based BI system integrates data from multiple sources through ETL processes, providing a centralized repository for analysis and decision-making. It supports BI tools with accurate, consistent, and historical data for reporting, forecasting, and insights. Despite benefits, challenges include high costs, complex integration, limited real-time functionality, and scalability issues.

3.1 Architecture of Data Warehouse

A centralised system that houses combined data from several sources is called a data warehouse, such as operational databases and external systems, to support reporting, analytics, and decision-making. A data warehouse is intended for analysis, as opposed to transactional databases, which manage daily tasks, offering a consolidated, historical, and subject-oriented view of organizational data [16].

A typical data warehouse is three tiers as illustrated in Fig. 2. The lowest level does data extraction, transformation, and loading (ETL) and loads the processed information in the warehouse and related data marts. The intermediate level has

POLAP servers which support rapid multidimensional analysis. In the upper level, the users get access to front-end reporting, dashboards, analytics, and data mining tools. A data warehouse's primary characteristics are non-volatility, time-variance, integration, and subject-orientation that guarantee sound data support of Business Intelligence (BI) applications.

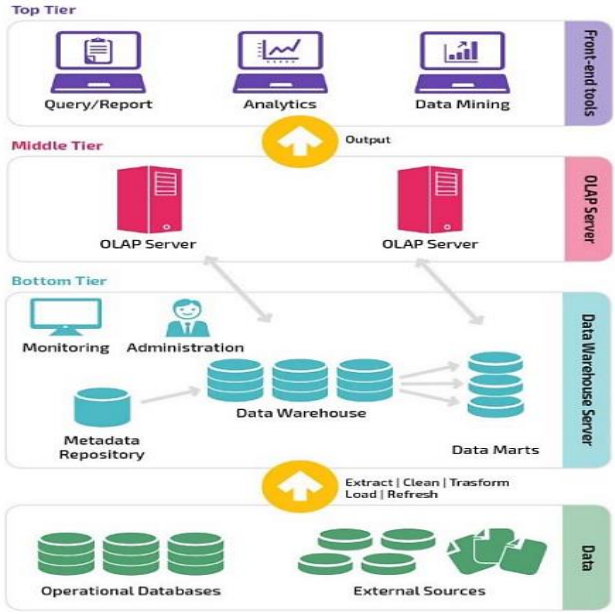

Fig. 2- Data Warehouse Architecture [17]

Contemporary BI systems have to deal with the issues of scalability and real-time needs. Conventional data warehouses are dependent on the batch ETLs that may slow down the generation of insights. To address this, streaming ETL pipelines can enable continuous data ingestion and transformation, which would enable dashboard and analytics almost in real-time[18]. Moreover, the NoSQL databases such as document, columnar, and key-value stores offer scalable storage of heterogeneous, high-volume and unstructured data. Cloud BI systems take advantage of the properties of elastic resources in order to dynamically scale processing and storage, whereas in-memory BI systems deliver much faster access to insights to support strategic decision-making. The inclusion of these technologies enhances responsiveness and efficiency of the system, which gives organizations timely, data-driven decisions.

3.2 The Role of Data Warehouses in Business Intelligence

Data warehouses are the central repositories which assemble data of numerous functioning sources, including client stimulus centres, e-business platforms and checkouts. It is this connection that ensures that organisational data is consistent, available and ready to be analysed. Information is first of all gathered out of multiple sources, followed by processing to standardise forms, rectify inconsistencies, and improvement of information and finally placed in the warehouse[19].

The consolidated data becomes the basis of Business Intelligence (BI) tools and, therefore, the development of dashboards, reports, graphs, forecasting models, off-putters, and data-mining products. Data warehouses assist in making the appropriate decision, improving operations as well as competitive advantage by transforming raw data into meaningful information.

The information of different functional systems (point-of-sale terminals, online stores, customer service centres, etc.) is directed to a central warehouse as it is shown in Fig. 3. It is then normalized and converted through the ETL process before being consumed by the BI applications in reporting, analytics and mining processes.

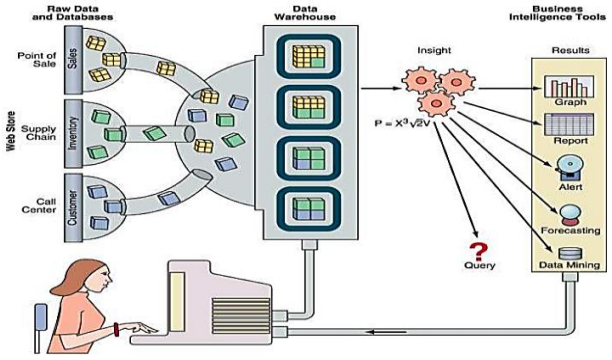

Fig. 3- Data Warehousing and Business Intelligence Process Flow[20]

3.3 Organizational Benefits of Business Intelligence

The following list of organizational values of BI is presented claiming how this tool can help to turn the data into actionable insights and make the informed decisions and improve the overall performance.

- **Effective decision:** Businesses can make better strategic and tactical decisions thanks to business intelligence (BI). It converts data into actionable data, allowing managers to make informed decisions even when there is no structure or semi-structured data [21]. By doing so, BI helps meet strategic goals and enhances the effectiveness of decisions in general.
- **Competitive advantage:** BI can be a major competitive edge as it allows accessing the necessary information promptly and proves the data-based strategies. Companies that apply BI

are better equipped to respond quicker and make smarter decisions, and have an advantage over their competitors in their respective industry.

- **Stakeholders' satisfaction:** Informed and effective decisions are beneficial to the stakeholders, such as investors, owners, and employees. BI tools are used to enhance decision-making by managers with higher levels of confidence, satisfaction, and general approval by the stakeholders.

These advantages show that Business Intelligence leads to improved decision-making, competitive advantage and satisfaction to stakeholders in organizations.

3.4 Limitations of Data Warehousing in BI

One essential part of BI is data warehousing, enabling organizations to consolidate and analyse data from multiple sources. However, despite its benefits, it comes with several limitations:

- **Costly Implementation and Maintenance:** Data warehouse setup is a costly process that consumes a lot of money in hardware, software, ETL tools, and human resources. These costs can be particularly burdensome to small and medium-sized enterprises and prevent them from using the potential of BI to the fullest.
- **Complex Data Integration:** The data ETL process, which encompasses the integration of heterogeneous data is a complex project whose purpose is to standardize, clean and reconcile data [22]. Such variations in the formats, the lack of values, or the incompatibility of the schemas can cause errors and decrease the reliability of BI insights.
- **Poor real-time functionality:** The procedure of classical data warehousing is not optimal in terms of real time analytics and the reason is that it is historically processed and batched. This poses a problem to the extent of organizations since they may not get real time insights to enable them make timely decisions.
- **Rigidity and Scalability Challenges:** The structure is being offered by premeditated schemas, at the expense of flexibility. Most new data repositories or changes in supporting analytical needs demand immense redesigning. In addition, the traditional warehouses are at times difficult and costly to expand to meet more and more data.

4 Applications in Strategic Decision Making

Business Intelligence (BI) based on the Data Warehouse is an essential tool that combines structured and semi-structured data, enabling the organisation to convert unprocessed data into actionable knowledge that can inform strategic decision-making. Any industry may employ DW-based BIs to make strategic decisions, and they can be of great benefit to both planning, forecasting and competitive positioning.

- **Enhanced Executive Decision Support:** The executives and senior management use the BI dashboards and other reports generated on data warehouses to monitor Market trends, operational metrics, and key performance indicators (KPIs). These systems provide centralised view of the organisations performance and leaders can make sound decisions on how to utilise the resources, priorities in their investments and long-term strategic plans.
- **Strategic Benchmarking and Competitive:** The DW based BI assists organisations to benchmark based on competition and industry. The external market data and internal operational data combined assist the companies in determining their performance [23]. These hints are applied in the strategic decision-making on entry into the market, diversification of products, or acquisitions and mergers.
- **Predictive and Prescriptive Analytics:** The foundation of predictive analytics is based on BI systems that are established on DW because an organization is able to estimate the future based on earlier data. By analysing patterns and correlations that are archived in the data warehouse, companies are able to know the potential demand or churn or the different opportunities available in the market. Additionally, by recommending the optimal courses of action, prescriptive analytics is a tool that helps with strategic decision-making. As an illustration, a telecommunication company can employ the predictive models in identifying the customers who are likely to move to another provider and subsequently implement retention strategies so as to reduce churn.
- State of the art BI systems using streaming ETL, notable databases, and cloud-based systems allow real time decision making across

all strategic activities. As an illustration, in-memory BI dashboards have the ability to track operational KPIs during events and therefore corrective measures are taken in the supply chains or production lines in real-time. Cloud integration provides scalable multi-location enterprise analytics and allows collaboration between departments[24]. Furthermore, the integration of real-time analytics with predictive and prescriptive models will increase responsiveness towards market changes, minimize operational risks and improve the decisions made with regard to capital allocation. With such technological developments, BI can play a more significant role in strategic and operational planning, as the gap between data collection and usability is reduced.

- **Financial Planning and Risk Management:** Data warehouse-based BI tools are useful in helping organisations to analyse the historical transactions as well as trend on cash flow and performance of investments that are used in financial decision-making [25]. Accuracy of forecasting and scenario analysis is useful in strategic financial planning, as organisations are able to reduce risks and maximise capital allocation.
- **Supply Chain Optimisation and Operational:** BI applications are supported by data warehouses that are used to provide visibility in processes and supply chains. Organisations are able to track inventory, production plans and performance of logistics and make strategic decisions geared towards reducing cost, improving efficiency and raising the quality of services. An example is the manufacturing firms that use DW-based BI to seek the bottlenecks, making production planning easier and cutting down on operational expenses.

5 Proposed Conceptual Framework for BI Evolution and Cross-Industry Integration

Business Intelligence (BI) practices have reflected a strong change in terms of analytical ecosystems that can support real-time, predictive and prescriptive decision-making, yet are out of traditional reporting systems[26]. To fill the gap that defines the current literature and with a recommendation of the reviewer, this paper proposes a Conceptual BI Evolution and Cross-Industry Integration Framework presented in Fig. 4 that integrates the most important elements of the modern BI processes in a variety of industries.

The proposed framework is a collection of five interrelated layers explaining the end-to-end BI lifecycle. The Data Acquisition Layer collects heterogeneous information across various areas in the industry, such as retail (POS transactions), healthcare (EHR and sensor data), finance (transaction records), manufacturing (logs of the IoT), and service industries (CRM systems). This multi-source data is standardized, cleansed, transformed and harmonized by the ETL and Integration Layer so that it can be consistent and of high quality[27]. The Centralized Storage Layer consists of data warehouses and data lakes that allow both structured and unstructured analytics through scalable and secure storage.

The Analytics and Intelligence Layer comprise the integration of the OLAP engines, dashboards, statistical models, machine learning algorithms, data mining tools, and extract insights and conduct trend analysis, forecasting, anomaly detection, and performance evaluation. The last Decision and Action Layer transform outputs of the analytics into industry-specific applications, including demand forecasting in retail, patient risk assessment in healthcare, financial fraud detection and predictive maintenance in manufacturing[28]. The framework therefore has outlined a holistic model that not only shows the evolution of the BI technologies, but also proves their cross-industry applicability, scalability and practicality.

Fig. 4- Conceptual BI Evolution and Cross-Industry Integration Framework

6 Literature Review

The literature shows data warehouse-based BI applications across telecom, healthcare, education, and contact centres, highlighting operational benefits but lacking generalized, cross-domain frameworks directly supporting strategic decision-making.

Ain *et al.* (2019) provide thorough understanding of the findings in the area of BI system adoption, use, and achievement. One hundred and eleven peer-reviewed studies published between 2000 and 2019 that fell into three categories—adoption, use, and success—were chosen. The examine methodology, underlying theories, and critical elements used to examine BI system acceptance, utilization, and success are included in the findings. Additionally, the assessment highlighted the areas that have received more or less attention and indicated the critical concerns pertaining to BI adoption, utilization, and success[29].

Brunello *et al.* (2019) suggest a multi-service, multi-channel contact centre decision support system for outsourcing front office business processes. The system is based on an enterprise-wide data warehouse which allows complex analysis procedures such as data mining, call-flow modelling and operator performance analysis. This provides the management and operational personnel with a platform over which they can make strategic and operational decisions that are effective in resolving the unstructured data stored in various databases in most firms [30].

Jain and Sharma (2018) discuss the long-standing purpose of BI to promote organizational development and support credibility, especially in the context of the increased level of market competition and the interest toward increased efficiency in organizational processes. The authors refer to the emergence of Data Warehousing (DW) as a crucial reporting and data analysis system which is an indispensable component of BI and the Decision Support System. They propose that the research community needs to take into account the strong impact of the BI on both big and small organizations, its offering of efficiency of the decision-making process and implementation of operations [31].

Cornejo *et al.* (2018) developed a data warehouse which mined necessary information to support decision-making in electronic medical record (EMR) administration. The warehouse is a warehouse based on a model of relationships and storing data regarding EMR in several Mexican states. The implementation and design of the warehouse were performed based on a star-dimensional structure and specification of The ETL (Extract, Transform, and Load) method in terms of the Business Event Analysis and Modelling (BEAM) method. A interactive dashboard that included a number of indicators was established to demonstrate the potential of the data warehouse [32].

Côrte-Real, Oliveira and Ruivo (2017) survey of 500 European companies and their business and IT leaders is the subject of this study. The value chain's various phases can benefit from BDA's business value, according to the findings. By using knowledge management and its effects on competitive advantage and process, BDA can foster organisational agility. Additionally, this article shows that performance (process level and competitive Agility has the ability to mediate the connection between advantage) and knowledge assets to some extent. 77.8% of the variance in competitive advantage can be explained by the model. The study's theoretical and practical ramifications, as well as its limits, are also presented in the current work [33].

Boonsiritomachai *et al.* (2016) This study suggests a SMEs' BI maturity model that highlights the elements that now impact their levels of adoption of BI and differentiates between various BI maturity levels. Multinomial logistic regression is used to evaluate survey data from 427 SMEs in order to experimentally test the suggested model. The majority of Thai SMEs are categorised as having the lowest level of BI maturity, indicating that these companies are still in the early phases of adopting BI. Competitive pressure, vendor selection, organisational resource availability, relative advantage, complexity, and owner-managers' creativity are all significant factors that affect the degrees of BI adoption. Government organisations might utilise the study's findings to create plans to accelerate SMEs' adoption of BI. The findings can also be used by IT providers to decide which SMEs to focus on [34].

Gandomi and Haider (2015) The analysis techniques used to huge data are the main focus. This work stands out in part because it focusses on unstructured data analytics, which comprise 95% of big data. In order to utilise vast amounts of diverse information in unstructured audio, video, and text formats, this study emphasises the necessity of creating suitable and effective analytical techniques. Additionally, this paper emphasises the need for creating fresh predictive analytics tools. For structured big data, see Gandomi and Haider, 2015. The practical statistical techniques were developed to draw conclusions from sample data. The enormous volume, noise, and variability of organized big data need the development of computationally effective

algorithms that may steer clear of big data hazards like spurious correlation [35].

The Table 1 provides a summarized literature overview of data warehouse-based BI system with important findings, challenges, limitations and future research of various fields.

Table 1- Summary of Studies on Data Warehouse and BI for Decision-Making

Reference	**Domain**	**Methodology**	**Key Findings**	**Challenges**	**Cross-Industry Insight**	**Future Research Direction**
Ain et al. 2019	BI Adoption, Utilization & Success (General industries)	Systematic review of 111 studies	Identifies factors influencing BI adoption + theories used	Lack of unified adoption model across industries	Adoption drivers differ by sector → need generalizable framework	Develop cross-industry BI adoption model & maturity theory
Brunello et al. 2019	Contact Centre / BPO Optimization	Enterprise DW + analytical modelling	DW enables performance monitoring & process decision-making	Requires complex modelling skills; integration issues	DW principles applicable to other real-time service industries	Multi-service BI platforms; automated modelling
Jain & Sharma 2018	Business development & market competition	Conceptual analysis	BI enhances credibility, reporting & decision efficiency	Limited empirical validation	Highlights BI value widely but lacks sectoral cases	Empirical testing across SMEs vs Enterprises
Cornejo et al. 2018	Healthcare / EMR decision support	DW + BEAM modelling + dashboard	Warehouse supports medical decision analytics	Limited scalability; needs real-time integration	Shows sector-specific clinical DW implementation	Integrate IoT/streaming data + expand framework to other health systems
Côrte Real et al. 2017	European enterprise BI agility	Survey of 500 firms + structural modelling	BDA improves competitive advantage via agility	Large firm focus — lacks SME comparison	Confirms BI agility theory transferable to supply chain, finance, retail	Comparative studies across size clusters; longitudinal trials
Boonsiritomachai et al. 2016	BI maturity in SMEs	Maturity model + regression analysis	BI adoption still early; impacted by resources, complexity	Low maturity; limited awareness	SME barriers are universal but severity differs by economy	Policies for SME capacity building; cloud BI adoption
Gandomi and Haider (2015)	Big Data Analytics methods focus	Theoretical review	Analytics need improvement to handle unstructured data	Lack of scalable algorithms for 95% unstructured data	Technical challenge spans healthcare, finance, telecom	Develop efficient big data algorithms + real-time predictive models

7 Conclusion and Future Work

Business Intelligence (BI) is now an essential part of the contemporary organization, which allows changing various and ever-increasing information into actionable insights that contribute to strategic, operational, and predictive decision-making. This paper has conducted a review of the fundamental elements of BI systems such as data warehouse

designs, ETL processes, OLAP activities, and analytical systems with reference to improving data quality, consistency and accessibility. Although cloud BI, automation, and real-time analytics are progressed, organizations continue to experience issues associated with scalability, integration of heterogeneous data, and inter-industry flexibility. Furthermore, the use of batch-based ETL processes reduces real-time responsiveness, and the BI frameworks have not been empirically verified in different organizational settings. To ensure that these gaps are addressed, this paper presented a Conceptual BI Evolution and Cross-Industry Integration Framework which offers a single framework of data acquisition, integration, storage, analytics and decision making across different industries such as retail, healthcare, finance and manufacturing. To address current shortcomings, future effort must include building on AI-based automation, to provide higher decision intelligence, deploying cloud-based and streaming ETL pipelines, to make decisions more responsive in real-time, and building industry-specific data governance models, to help achieve flexibility and interoperability. These innovations will make BI more mature, cross-sector applicable, and will make organizations capable of extracting timely, accurate, and actionable insights in their data ecosystems.

References:

[1] S. Rouhani, S. Asgari, and S. Vahid Mirhosseini, "Review Study: Business Intelligence Concepts and Approaches," *Am. J. Sci. Res. ISSN*, 2012.

[2] A. Balasubramanian, "Ai-Driven Predictive Maintenance And Process Automation In Industrial Plc Systems: A Case Study In The Oil And Gas Industry," *Int. J. Core Eng. Manag.*, vol. 5, no. 9, pp. 14–28, 2018.

[3] E. Vuka and O. Petritaj, "A Review on Traditionally ETL Process for Better Approach in Business Intelligence.," *RTA-CSIT*, pp. 17–23, 2018.

[4] D. D. Rao, "Multimedia based intelligent content networking for future internet," *EMS 2009 - UKSim 3rd Eur. Model. Symp. Comput. Model. Simul.*, pp. 55–59, 2009, doi: 10.1109/EMS.2009.108.

[5] E. B. Alhyasat and M. Al-Dalahmeh, "Data warehouse success and strategic oriented business intelligence: a theoretical framework," *arXiv Prepr. arXiv1307.7328*, 2013.

[6] F. S. Esmail, "A survey of real-time data warehouse and ETL," *Management*, vol. 9, no. 3, pp. 3–9, 2014.

[7] K. Mashingaidze and J. Backhouse, "The relationships between definitions of big data, business intelligence and business analytics: a literature review," *Int. J. Bus. Inf. Syst.*, vol. 26, no. 4, pp. 488–505, 2017.

[8] I. A. Ajah and H. F. Nweke, "Big data and business analytics: Trends, platforms, success factors and applications," 2019. doi: 10.3390/bdcc3020032.

[9] P. Marjamäki, "Evolution and trends of business intelligence systems: a systematic mapping study," 2017.

[10] P. Hawking and C. Sellitto, "Business Intelligence (BI) critical success factors," 2010.

[11] D. Bălăceanu, "Components of a Business Intelligence software solution," *Inform. Econ.*, vol. 2, no. 2, pp. 67–73, 2007.

[12] M. K. Bhetwal, "Data warehouse and business intelligence: comparative analysis of OLAP tools," 2011.

[13] A. Villar, M. T. Zarrabeitia, P. Fdez-Arroyabe, and A. Santurtún, "Integrating and analyzing medical and environmental data using ETL and Business Intelligence tools," *Int. J. Biometeorol.*, vol. 62, no. 6, pp. 1085–1095, 2018.

[14] N. A. H. M. Rodzi, M. S. Othman, and L. M. Yusuf, "Significance of data integration and ETL in business intelligence framework for higher education," *Proc. - 2015 Int. Conf. Sci. Inf. Technol. Big Data Spectr. Futur. Inf. Econ. ICSITech 2015*, pp. 181–186, 2016, doi: 10.1109/ICSITech.2015.7407800.

[15] D. S. Bataweel, "Business Intelligence: Evolution And Future Trends," 2015.

[16] S. H. A. El-Sappagh, A. M. A. Hendawi, and A. H. El Bastawissy, "A proposed model for data warehouse ETL processes," *J. King Saud Univ. Inf. Sci.*, vol. 23, no. 2, pp. 91–104, 2011.

[17] C. A. U. Hassan, R. Irfan, and M. A. Shah, "Integrated architecture of data warehouse with business intelligence technologies," in *2018 24th International Conference on Automation and Computing (ICAC)*, 2018, pp. 1–6.

[18] L. Bellatreche and S. Chakravarthy, "A special issue in extending data warehouses to big data analytics," *Distrib Parallel Databases*, vol. 37, pp. 323–327, 2019.

[19] R. Singh and K. Singh, "A Descriptive Classification of Causes of Data Quality

Problems in Data Warehousing," *IJCSI Int. J. Comput. Sci. Issues*, vol. 7, no. 2, p. 41, 2010.

[20] J. Ranjan, "Business Intelligence: Concepts, Components, Techniques and Benefits," *J. Theor. Appl. Inf. Technol.*, vol. 9, no. 1, 2009, doi: 10.2139/ssrn.2150581.

[21] S. Rouhani, A. Ashrafi, A. Zare Ravasan, and S. Afshari, "The impact model of business intelligence on decision support and organizational benefits," *J. Enterp. Inf. Manag.*, vol. 29, no. 1, pp. 19–50, 2016, doi: 10.1108/JEIM-12-2014-0126.

[22] D. Martins, C. M. Q. Ramos, J. M. F. Rodrigues, P. J. S. Cardoso, R. Lam, and F. Serra, "Challenges in building a Big data warehouse applied to the hotel business intelligence," in *Recent Researches in Applied Informatics, Proceedings of the 6th International Conference on Applied Informatics and Computing Theory (AICT'15)*, 2015, pp. 110–117.

[23] I. D. Kocakoç and S. Erdem, "Business intelligence applications in retail business: OLAP, data mining \& reporting services," *J. Inf. \& Knowl. Manag.*, vol. 9, no. 02, pp. 171–181, 2010.

[24] W. W. Eckerson, "Challenges to Operational Business Intelligence," 2007.

[25] B. Wieder and M.-L. Ossimitz, "The impact of Business Intelligence on the quality of decision making--a mediation model," *Procedia Comput. Sci.*, vol. 64, pp. 1163–1171, 2015.

[26] M. Alnoukari, "Integration of business intelligence with corporate strategic management," *J. Intell. Stud. Bus.*, vol. 7, no. 2, pp. 5–16, 2017, doi: 10.37380/jisib.v7i2.235.

[27] N. Caseiro and A. Coelho, "The influence of Business Intelligence capacity, network learning and innovativeness on startups performance," *J. Innov. Knowl.*, vol. 4, 2018, doi: 10.1016/j.jik.2018.03.009.

[28] P. Mikalef, M. Boura, G. Lekakos, and J. Krogstie, "Big data analytics and firm performance: Findings from a mixed-method approach," *J. Bus. Res.*, vol. 98, pp. 261–276, 2019, doi: https://doi.org/10.1016/j.jbusres.2019.01.044.

[29] N. Ain, G. Vaia, W. H. DeLone, and M. Waheed, "Two decades of research on business intelligence system adoption, utilization and success – A systematic literature review," *Decis. Support Syst.*, vol. 125, p. 113113, Oct. 2019, doi: 10.1016/j.dss.2019.113113.

[30] A. Brunello, P. Gallo, E. Marzano, A. Montanari, and N. Vitacolonna, "An event-based data warehouse to support decisions in multi-channel, multi-service contact centers," *J. Cases Inf. Technol.*, vol. 21, no. 1, pp. 33–51, 2019.

[31] S. Jain and S. Sharma, "Application of Data Warehouse in Decision Support and Business Intelligence System," in *2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT)*, 2018, pp. 231–234. doi: 10.1109/ICGCIoT.2018.8753082.

[32] S. G. Cornejo, K. Caro, L.-F. Rodriguez, R. A. A.1, C. B. Perez, and Luis A. Castro, "Design and Implementation of a Data Warehouse to Support Decision-Making in a Health Environment," 2018.

[33] N. Côrte-Real, T. Oliveira, and P. Ruivo, "Assessing business value of Big Data Analytics in European firms," *J. Bus. Res.*, vol. 70, pp. 379–390, 2017, doi: https://doi.org/10.1016/j.jbusres.2016.08.011.

[34] W. Boonsiritomachai *et al.*, "Exploring business intelligence and its depth ofmaturity in Thai SMEs," *Cogent Bus. Manag.*, vol. 3, 2016, doi: 10.1080/23311975.2016.1220663.

[35] A. Gandomi and M. Haider, "Beyond the hype: Big data concepts, methods, and analytics," *Int. J. Inf. Manage.*, 2015, doi: 10.1016/j.ijinfomgt.2014.10.007.