

The Role of Data Visualization in Business Intelligence: A Comparative Analysis of Tools and Techniques

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Abstract

The importance of data visualization in business intelligence cannot be understated—it connects unrefined data to insightful, actionable intel. It simplifies complex data into graphical representations like charts, graphs, and dashboards, helps organizations build understanding, and makes data-backed decisions. In this research, we study a dataset of visualization tools and focus on their features and purpose. These include well-known tools like Tableau, Power BI, QlikView, and Google Data Studio, as well as those with higher levels of customization or specialization like D3.js, Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionCharts. It is evident from our research that the usability and efficacy of these tools are their main determining factor of success. Tools that focus on a holistic user experience, ease of use, design, intuitive navigation, and cross-platform interactivity tend to be more widely adopted and satisfy users. With the advancement of data visualization, many industries like healthcare, finance, retail, transportation, and education have greatly improved efficiency and planning, and have fostered innovation. From our analysis, we put forth a set of actionable recommendations for organizations that wish to use data visualization tools more effectively. These recommendations include: identifying critical gaps, focusing on UX design, offering training at all levels, prioritizing ongoing refinements, looking for useful implementations from other fields, promoting trial-and-error, enabling cross-silo partnerships, and appropriately disseminating results and recommendations. Thoughtfully applied, data visualization helps organizations connect disparate data, revealing hidden systems and providing a competitive edge in a rapidly evolving, data-centric world.

Keywords: Data Visualization, Business Intelligence, Comparative Analysis, Visualization Tools, Decision-Making Processes

Introduction

Large volumes of data from many sources are becoming a challenge for businesses. Making well-informed decisions now depends on gleaning significant insights from this data and turning them into useful knowledge. Business intelligence (BI) uses this critical process, enabling organizations to use data to achieve their strategic goals. As data volume and complexity increase, so has the importance of data visualization in business intelligence. The ability to present information in an aesthetic way that enhances understanding and supports data-driven decision-making makes data visualization an important link

between primary data and relevant information. Data visualization is the transformation of abstract data points into interactive charts, graphs, and dashboards that show invisible patterns, trends, and relationships for stakeholders. In addition, the purpose of this research project is to study "The Role of Data

Visualization in Business: A Comparative Analysis of Tools and Techniques". The goal is to assess how different data visualization techniques and methods can improve a business intelligence strategy. Our goal is to identify the advantages and disadvantages of different

exposure methods as well as contribute to specific business intelligence activities through comparative analysis. Organizations must also identify the best data visualization tools and techniques to improve decision-making processes, given the plethora of options available on the market.

The purpose of this study is to introduce key features and real-world applications of several data visualization tools, including Looker, Tableau, Microsoft Power BI, QlikView, Google Data Studio, and D3. Node.js, Plotly, IBM Cognos Analytics, and FusionCharts. We hope to provide useful insights by evaluating usability and data integration capabilities, visibility, scalability, and cost-effectiveness. Choosing the right data visualization tools for an organization's specific needs can improve data-driven decision-making processes, driving business growth and success. In addition, the results of this study will enrich academic understanding while being useful for organizations seeking to maximize the value of their data assets. Organizations can enhance their decision-making capacity and improve their performance, growth, and success by understanding the role and value of data visualization in business intelligence and choosing the best Tool and technique.

Related Work

Researchers and practitioners alike have emphasized the role of data visualization in business intelligence, recognizing its significance as firms rely more on data-driven decision-making.

Data visualization is a vital tool for transforming intricate data into clear information. Numerous studies have been conducted on the impacts and efficiency of various business intelligence data visualization techniques and methods. To understand the strengths and weaknesses of tools like Tableau, Microsoft Power BI, QlikView, Google Data Studio, D3.js, Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionCharts performed by these researchers. The researchers compared these tools for their features including several chart formats and interactive dashboards that are designed to facilitate data analysis as well as decision making. The purpose of this literature review is to sensitize people about the significance of business intelligence (BI) data visualization and also give practical advice to organizations when selecting visualization tools and procedures that fit their company's needs.

The visualization of information is a necessary and varied component of BI that aids businesses to make better decisions by using data. It is an effective process which breaks down complicated analysis into elegant presentations that help in understanding patterns, trends, and deeper

insights. In this part, we will review the different roles and advantages of business intelligence (BI) for visualizing data. [1, 2, 3]:

Enhancing Data Comprehension:

Data visualization changes data into graphics forms enabling rapid comprehension of complex information. Charts and graphs as well as dashboards enable various stakeholders to easily see connections, patterns, and anomalies that would be impossible to identify in raw numbers. As a result, data visualization promotes greater data comprehension throughout the organization, benefiting people at all levels, from CEOs to front-line employees (1).

Facilitating Data Exploration and Analysis:

Interactive data visualizations allow users to explore data from multiple angles, apply filters, and drill into precise details. This tool enables business analysts and data scientists to undertake impromptu data analysis, discover trends, and extract critical insights as needed, speeding up data-driven decision-making (1).

Improving Decision-Making Processes:

With data visualization, decision-makers can access real-time or near-real-time information and obtain a holistic view of business performance. Visual representations of key performance indicators (KPIs) and trends allow executives to make informed decisions swiftly, increasing the agility and responsiveness of the organization (1).

Supporting Predictive and Prescriptive Analytics:

Data visualization is instrumental in presenting predictive and prescriptive analytics outputs. Visualizations, such as predictive models, trend lines, and scenario analysis, aid in understanding future possibilities and potential outcomes. This helps organizations strategize and plan more effectively, mitigating risks and capitalizing on opportunities (2).

Enabling Data Storytelling:

Effective data visualization allows data narrators to deliver engaging and memorable insights and results. Analysts can influence decision-makers and stakeholders by creating a data narrative using visualizations and fostering a culture of data-driven decision-making within an organization (2).

Enhancing Collaboration and Communication:

Teams and departments may more effectively communicate complex data findings when they use data visualizations. By presenting data in aesthetically pleasing ways, they facilitate data flow across the enterprise and encourage cross-functional collaboration (2).

Identifying Business Opportunities and Challenges:

Visualizations help in recognizing problems and firm potential rapidly. For instance, interactive maps, heat maps, and geographic visualizations may highlight untapped markets or areas with particular business issues that need to be resolved (3).

Monitoring Key Metrics and Performance:

Using dashboards and scorecards helped facilitate real-time data monitoring, which gives organization's owners the ability to evaluate organizational performance about predefined goals. Thus, when performance deviates from expected goals, it is easier for users to take remedial action using data visualization (3).

Promoting Data Transparency and Accountability:

Providing visual access to data encourages accountability and openness in business. People are empowered to take responsibility for their data and align their work with data-driven goals when data sharing and data visualization are widespread (3).

Facilitating Data-Driven Culture:

Creating a data-driven company culture is based on data visualization. This allows employees to work with data and make decisions based on facts rather than assumptions (1).

Using data visualization, decision-makers can quickly obtain critical insights by transforming complex data into visual representations. The use of clear charts, graphs, and interactive dashboards, it simplifies the process of finding trends, patterns, and connections in raw data. Decision-makers can study data from many angles, delve into specifics, and identify critical factors influencing corporate outcomes. Data visualization accelerates decision-making processes by speeding up information absorption and revealing actionable insights. Data visualization empowers stakeholders across various levels of the organization to collaboratively analyze and interpret data, fostering a data-driven decision-making culture that enhances overall organizational efficiency and effectiveness (4).

Popular data visualization tools and techniques in business intelligence enable organizations to better make sense of their data. Known for its user-friendliness and extensive visualization,

Tableau enables users to create interactive dashboards, charts, and maps. Microsoft Power BI provides robust data connectivity, allows for seamless integration of data sources, and enables multiple views. QlikView stands out for its interactive data model, and for users can search and dynamically analyze data. Google Data Studio offers a cloud-based platform with easy collaboration, making it ideal for teams working on data visualization projects. D3.js, the JavaScript library, caters to the needs of advanced users and developers, offering unparalleled flexibility and flexibility in creating unique graphics. Plotly excels in interactive graphics and provides APIs for Python, R, and JavaScript. IBM Cognos Analytics provides enterprise-level data visualization capabilities, including advanced analytics and AI-driven insights (5). Looker focuses on data analytics and real-world user analytics with flexible interfaces. Highcharts and FusionCharts are popular charting libraries that offer a wide range of charts for web-based data visualization. These tools, with their unique characteristics and capabilities, respond to different user needs and usage patterns, making them a valuable asset in the management science field (6). User preferences, satisfaction, and experiences with different visualization tools play an important role in determining the success and professional adoption of these tools. Many studies have been conducted to understand how their users understand the various tools used to analyze images and their impact on decision-making processes. User and feedback surveys show that Tableau and Microsoft Power BI tend to get high marks for their user-friendly interface and ease of use. Users appreciate the convenience of drag-and-drop features and the ability to quickly create high-quality dashboards and charts. QlikView's associative data model and dynamic data exploration capabilities also receive positive feedback from users who value its flexibility in open research (7). On the other hand, D3.js, although praised for its customization options, tends to attract more professional technical users because of its coding requirements. Furthermore, Looker's self-service analytics paradigm effectively serves consumers desiring greater control over their data analysis efforts. Teams working on collaborative projects value Google Data Studio's cloud-based collaboration features. Highcharts and FusionCharts are praised for their diverse range of charts and smooth integration into web applications. These user preferences, driven by factors such as data integration capabilities, visualization choices, and pricing, influence the selection and adoption of data visualization tools in business intelligence settings (8).

The relationship between data visualization and business intelligence performance metrics is closely intertwined, as effective data visualization directly impacts the overall efficiency and effectiveness of BI processes. Well-designed and interactive visualizations facilitate quicker and deeper data analysis, enabling stakeholders to comprehend complex information rapidly and make data-driven decisions with greater accuracy. Organizations that employ data visualization tools tend to experience improved key performance indicators (KPIs) such as reduced time-to-insights, enhanced data accessibility, and increased user engagement with BI platforms (9). Visualizations that provide real-time data updates empower decision-makers to respond promptly to changing market conditions, identify emerging trends, and seize opportunities. Moreover, intuitive and interactive dashboards foster a culture of data-driven decision-making throughout the organization, resulting in better strategic planning and improved operational outcomes. By presenting data in a visually compelling manner, data visualization strengthens the link between data analysis and actionable insights, ultimately contributing to enhanced business intelligence performance metrics and driving overall organizational success (10).

Effective use of data visualization has been critical to the evolution of decision-making processes in various industries. In healthcare, data management tools have enabled medical professionals to analyze patient records and medical data, enabling more accurate diagnosis, personalized treatment, and patient outcomes also able to identify potential risks, leading to more informed investment decisions and risk management strategies Retail e-commerce services Data to gain insights into consumer behavior, identify popular products, and develop best pricing strategies. Besides visualization for improving customer experience and increasing sales, data visualization has proven to be a must in logistics management to streamline supply chain operations, create better processes, and reduce transportation costs and this example of using data visualization for growth shows that successful data visualization applications have revolutionized industries by leveraging the power of data to drive innovation, flying businesses effectiveness, and strategic decision-making (11).

Thus, data visualization plays a pivotal role in business intelligence, empowering organizations to derive meaningful insights from complex data. The choice of data visualization tools should align with specific user preferences, organizational requirements, and use cases. User-friendly interfaces, interactive features, and real-time data updates enhance the overall efficiency and effectiveness of BI processes. By successfully implementing data visualization solutions,

industries across diverse sectors have experienced significant improvements in decision-making, operational outcomes, and customer experiences (12). Going forward, the continued advancement and adoption of data visualization tools will likely shape the future of business intelligence, enabling organizations to unlock the full potential of their data assets and stay ahead in the competitive landscape. In addition, data visualization plays a pivotal role in business intelligence by transforming raw data into meaningful insights that drive better decision-making, enhance collaboration, and foster a data-driven organizational culture. Its ability to simplify complex data, enable data exploration, and facilitate communication makes it an indispensable tool for organizations seeking to unlock the true potential of their data assets (13).

Methodology

We are commencing our analysis using Gartner Magic Quadrant data, where Tableau and Qlik hold prominent positions as business intelligence and analytics (BI&A) tools in terms of Ability to Execute. Microsoft Power BI, QlikView, Google Data Studio, D3.js, Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionCharts also feature in the Magic Quadrant, offering diverse capabilities for data visualization and analytics.

Although Tableau and Qlik lag behind the tools of SAP, SAS, and Microsoft BI when considering the Completeness of Vision, their significant profits and favorable positions on the axis of Visual Discovery and self-service automation make them compelling candidates for further examination. In addition, Looker, Google Data Studio, and Microsoft Power BI are showing promising results in real-time visualization. On the other hand, the D3s.js, Plotly, and FusionCharts have special features tailored to specific data visualization features.

To determine these tools' advantages and disadvantages within the BI&A ecosystem, we examined several key performance indicators (KPIs), such as visibility, scalability, cost, ease of use, and data integration capabilities. Then, we compared them to these standards. We employed practical strategies, such as comparable hardware and datasets, to provide a fair comparison. To have a complete grasp of the features and capabilities of the tools, we also conducted a literature review and contrasted the knowledge from other tutorials.

We evaluated a number of popular data visualization tools, including Tableau, Microsoft Power BI, QlikView, Google Data Studio, D3.js, Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionCharts, in order to offer a thorough analysis that will assist companies and

organizations in selecting the most appropriate tool for their business intelligence and data visualization requirements.

Comparison of Data Visualization Tools

Business intelligence relies heavily on data visualization because it enables firms to glean valuable insights from data and apply those insights to decision-making. In this study, we will focus on a number of aspects, such as scalability, ease of use, visibility, data integration, and cost. So we will compare ten data visualization analysis products widely used in this study: Tableau, Google Data Studio, QlikView, Microsoft Power BI, D3.js, Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionChart.

Easy to use:

If we look at the attractive interfaces, ease of use, and drag-and-drop functions, users of all levels of technical skills find Tableau, Microsoft Power BI, and Google Data Studio the most attractive. Where non-technical or technical people can all easily use these platforms. On the other hand, both QlikView and D3.js require a certain level of scripting or coding experience, due to challenges with sharper learning curves.

Aggregate Data:

Tableau, Microsoft Power BI, and QlikView enable seamless integration of multiple data sources, databases, and cloud services, meaning these applications offer robust data connectivity solutions. On the other hand, Google Data Studio emphasizes interaction within the Google data ecosystem by using Google Sheets that can be linked to other data sources. D3.js, Plotly, Looker, Highcharts, and FusionCharts also offer significant and clear adjustments to data integration.

Options available to you:

Visualization possibilities that could be accessed using Tableau, Microsoft Power BI, and D3.js include charts, graphs, maps, and interactive dashboards. In addition, QlikView has many pre-made views for users to choose from as well as the ability to create new ones through extensions. Also, there are other graphical options given by Google Data Studio, Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionCharts; however, some might require additional modifications or additions.

Simple adjustments:

Different skills and preferences of different individuals also influence the importance of different applications. For example, these applications have a lot of flexibility meaning that Tableau,

Microsoft Power BI, and D3.js can be used to design complex interfaces having distinct themes. On the other hand, QlikView allows for multiple customizing choices unlike Plotly, IBM Cognos Analytics, Looker, Highcharts, and FusionCharts which provide customization options.

Pricing:

Regarding pricing structures, several apps offer free versions with limited functionalities while others have paid ones with added features like Google Data Studio has a different pricing structure from Microsoft Power BI whose one is not similar to Tableau's. However, on the other hand there are also some apps that charge their customers on a monthly and yearly basis such as QlikView which depends on a number of subscribers as well as the features needed. On top of that, there are some open or free source apps that don't need to be repaid, but if a membership or license is needed to access premium features and additional support you pay for it, as is the case with D3.js, Plotly, Highcharts, and FusionCharts. Based on the above, we find that each data visualization tool has unique characteristics that distinguish it from the rest of the tools, and thus meet the needs of its user base. If you're looking for flexibility to use so that it can be handled from beginners to seasoned analysts, Tableau and Microsoft Power BI are the perfect choices for this. If you want personalized visualization and sophisticated data analysis, QlikView and D3.js good options that are part of the Google ecosystem have an easy choice with Google Data Studio. If you're targeting specific markets with different costs and technological requirements, tools like Plotly, Looker, Highcharts, and FusionCharts offer the best service.

Table 1: A Comparison Between the Data Visualization Tools

Criteria	Tableau	Power BI	QlikView	Google Data Studio	Google		IBM Cognos		Looker	Highcharts	FusionCharts
					D3.js	Plotly	Analytics				
Ease of Use	Easy	Easy	Moderate	Easy	Moderate to Difficult	Moderate	Moderate to Difficult	Moderate to Difficult	Easy	Easy	Easy
Data Integration	Extensive	Extensive	Extensive	Limited	Moderate to Extensive	Limited	Extensive	Extensive	Moderate	Moderate	Moderate

					sive					
Visualiz										
ation	Extens	Exten	Moder	Mode	Exten	Exten	Extens	Exten	Extensi	
Options	ive	sive	ate	rate	sive	sive	ive	sive	ve	Extensive
Flexibili			Moder	Mode			Moder		Moder	
ty	High	High	ate	rate	High	High	ate	High	te	Moderate
	Paid	Paid				Paid				
	with	with				with				
	Free	Free				Free				Paid with
	versio	versio			Open-	versio				Free
Pricing	n	n	Paid	Free	source	n	Paid	Paid	Paid	version

Discussion of the Results

Through this study, the ability of visualization technology to revolutionize different sectors can be confirmed by enhancing data visualization of decision-making processes. This enables decision-

makers to quickly grasp ideas and reach informed conclusions when complex data is presented in visually appealing formats. This type of technology is in line with organizations that frequently use data-driven systems so that they gain flexibility and

competitiveness in a rapidly changing business environment. By discussing the results, the focus was on mechanisms that help decision-makers make informed and timely choices with the help of data visualization by bridging the gap between raw data and actionable insights. Overall, it can be said that common data visualization tools and techniques possess a variety of options that organizations can have when it comes to converting data into meaningful visual representations. From the most advanced systems such as D3.JS to the more user-friendly systems such as Tableau and Microsoft Power BI, these technologies meet a wide range of needs and power levels. The difference between these tools leads to the importance of choosing the right tool based on specific business needs, technical competence, and the desired visualization results.

Previous studies on user preferences, satisfaction, and experiences using visualization tools have shown that user-centered design should be given the priority. Studies have shown that user satisfaction rates are higher when tools rely on ease of use, sharing, and accessibility. Thus this is

in line with the results that have shown that software adoption and success depend heavily on user experience. Organizations wishing to use data visualization tools should assess both technical capabilities and user experience and thus ensure successful acceptance and use. When discussing the relationship between BI performance indicators and data visualization, research has confirmed a direct correlation between improved BI results and effective data visualization. By interpreting visual data, strategic planning and corporate performance can be enhanced which in turn helps in faster, more accurate, and effective decision-making. This shows that data visualization is critical in maximizing the benefits of data-driven operations and is more than just visual appeal.

Finally, a thorough examination was conducted across several industries of successful data visualization applications, which showed the widespread impact of data visualization. This has been significantly reflected in improved outcomes and procedures across these different industries. Through the results, it can be said that applying data visualization anywhere enhances creativity, operational effectiveness and decision-making and confirms the idea's credibility. In short, research emphasizes how important data visualization is to business intelligence. Where it has been shown that there are good and positive effects that User-centered design and careful selection of tools have an important role in improving data visualization, which is an important part of today's data-driven decision-making process and is more than just a tool.

Conclusions and Recommendations

Through this research, data visualization tools were evaluated, highlighting how important it is to choose solutions that align with certain business goals and that show a balance between technology and ease of use. The study showed that user preferences, satisfaction, and experiences are the ability of the tool to balance properly, and that accessibility and sophistication are essential for successful implementation, and this puts user adoption and engagement at its highest level. Our analysis of common data visualization tools also highlighted that choosing the right tools plays an important role, as tools that comply with certain requirements must be selected in line with the company's goals in terms of technological capability and ease of use. Deploying the tool must also strike a balance between complexity and ease of use. Use This plays a role in maximizing user engagement and adoption. In addition, it can be said that the relationship between improved business intelligence performance measures and data visualization is noteworthy, and this confirms that professional visualization is

important in facilitating appropriate and informed decision-making. Finally, practical examples across several sectors place data visualization as a versatile tool with broader applications beyond certain industries thus regularly yielding positive results such as in finance, education, or healthcare.

In light of the findings, we offer a set of recommendations for organizations looking to use data visualization in their business intelligence applications:

- **Needs Assessment and Tool Selection:** One of the most important things to ensure that tool selection matches specific business objectives is to conduct a comprehensive needs assessment. When determining which tool is best to work, we must consider the complexity of the data, user efficiency, and desired visualization results.
- **User-Centric Design:** When identifying interactive and easy-to-use data visualization techniques, further encourages team adoption and increases user engagement because interaction is seamless through intuitive interfaces.
- **Training and Support:** To fully understand the potential of data visualization, organizations need to invest in in-depth training courses to enhance the efficiency of the tool's use to ensure that users are aware of the potential of the selected technologies.
- **Continuous Monitoring and Improvement:** Organizations must work on continuous improvement, by continuously evaluating the impact of data visualization on business intelligence performance indicators. This is to ensure that the changing requirements of the organization align with the tools used, thus achieving insights gathered from user input.
- **Cross-Industry Inspiration:** Organizations can adjust their strategies to address the problems they face, and this can be done by taking insights from successful applications of data visualization in many industries.
- **Experimentation and Innovation:** To foster experimentation-based innovation, organizations must stay up-to-date with technological developments such as augmented reality, virtual reality, and machine learning.
- **Collaboration and Communication:** The most important thing that a team should have is to create a collaborative atmosphere. Organizations should make better use of collaboration features and tools to facilitate decision-making and knowledge-sharing within the team.

In conclusion, the use of data assets has unleashed various industries to enhance decision-making, and this shows how important it is to visualize data and consider it a vital and evolving

tool. Following the advice given enables businesses to make full use of data visualization, facilitating the accomplishment of business intelligence projects and preserving competitiveness in a dynamic environment.

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