Data Analytics and Business Intelligence

Data Analytics and Business Intelligence:

AI-Driven Solutions and Energy Applications

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Cambridge Scholars
Publishing

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This book first published 2026

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-6238-3
ISBN (Ebook): 978-1-0364-6239-0

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CHAPTER 1

INTRODUCTION TO DATA ANALYTICS AND BUSINESS INTELLIGENCE

ADEOLUWA EWEJE

1.1 Definitions and Key Concepts

Data analytics and business intelligence, or BI, are closely linked. They have changed how decisions are made in today's businesses (Ramakrishnan e al., 2020). Data analytics is all about looking at raw data. This helps find patterns and trends that can guide actions. There are different ways to analyze data, like understanding what happened before, why it happened, predicting what might happen next, and suggesting what to do about it. Business intelligence, on the other hand, is about the tools and strategies companies use to analyze data and create reports. This helps them run their operations better and make smart decisions.

The key concepts in data analytics and BI is shown in figure 1.1.

1.1.1 Big Data

Big Data is all about huge and complicated sets of data. These are more than what regular tools can handle. There are three main things to know about it: volume, velocity, and variety volume (Salamkar, 2021). First, volume is about the massive amount of data that comes from places like social media and smart devices. For example, Twitter users send around 500 million tweets every day! Next is velocity. This is how fast data is created and processed. It's important because some data needs to be looked at right away. Lastly, variety refers to all the different types of data. This can be anything from text to pictures to videos. By 2025, experts say the global amount of data could reach 175 zettabytes. That's a lot! Big Data helps companies understand what customers want, improve operations, and spot

market trends. It really helps with making smart decisions and driving new ideas.

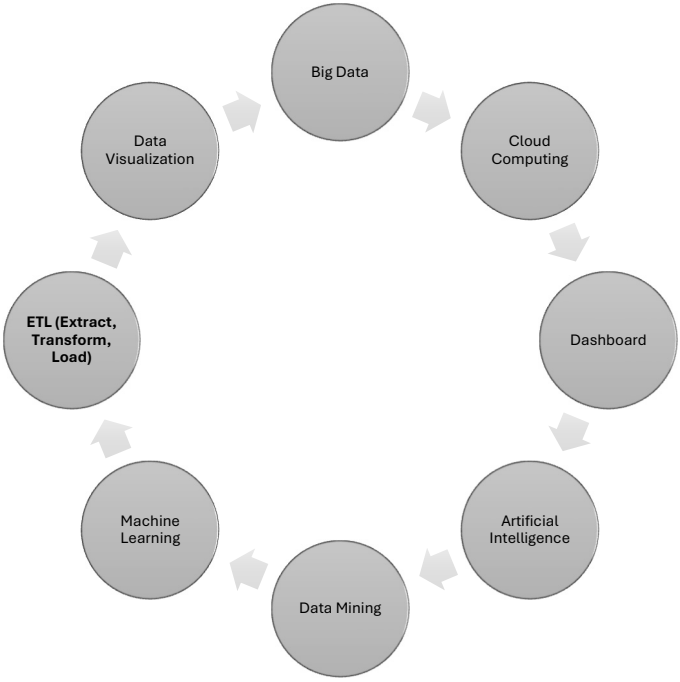

Figure 1.1. Key concepts in data analytics and BI

1.1.2 Data Visualization

Data visualization is a way to show data in pictures or graphs. It makes it easier to see important information. You can use charts, graphs, heatmaps, and dashboards to show data clearly. This helps spot trends and unusual data (Deekshith, 2020). It also makes decisions easier because the info is simpler to understand. Research shows that organizations using visual tools find information faster. They are 28% more likely to get timely data than those who stick to old reporting methods. Some popular tools are Tableau, Power BI, and matplotlib. These tools let you make interactive and custom visuals.

1.1.3 Machine Learning (ML)

Machine Learning, or ML, is a part of artificial intelligence that helps computers learn from data. It gets better over time without needing a lot of programming. There are many ways ML is used. For example, Predictive Analytics looks at past data to guess what might happen next. Natural Language Processing, or NLP, helps computers understand human language (Munagandla *et al*., 2022). Computer Vision lets computers analyze images to find patterns and make choices. A report by McKinsey says ML could boost the global economy by up to $6 trillion each year. People use tools like TensorFlow, Scikit-learn, and PyTorch to develop ML systems. These tools are making big changes in areas like healthcare, finance, and self-driving cars.

1.1.4 Data Mining

Data mining is all about finding patterns and connections in big sets of data. It uses some key methods. First, classification sorts data into groups. Second, clustering gathers similar data points. Lastly, association rule mining looks for relationships between different variables. Experts say that by 2025, data mining in areas like retail and finance will grow by over 30%. Businesses use data mining for things like fraud detection, analyzing shopping habits, and understanding customers better. They use special algorithms to turn data into useful insights (Javaid *et al*., 2020).

1.1.5 ETL (Extract, Transform, Load)

ETL stands for Extract, Transform, Load. It’s a key part of getting data ready for analysis and helps move data between systems smoothly. First, you extract data. This means pulling it from different places like databases, APIs, and even cloud storage. The idea is to gather the raw data without changing anything. The data can be in different formats: some are structured, others are not. The faster and better the extraction, the less it affects the source systems. Next is the transformation step. Here, you clean and organize the data so that it's ready to use. This might mean fixing errors, standardizing formats, summarizing info, or even adding more details. This step is super important because data often comes in different forms. Transforming it makes sure everything can work together for analysis later. The last step is loading the now-ready data into a storage system, like a data warehouse. This makes it easier for people to access the data when they need it. A good loading process is quick, so the data can be available right

away or at set times, depending on what the business needs. ETL is essential. It helps organizations gather and store data that's reliable and easy to work with. This data helps businesses make informed decisions. According to Forrester, companies that use automated ETL can cut their data prep time by 40%. Tools like Informatica, Talend, and Apache Nifi help ensure the data is good quality and easy to access.

1.1.6 Artificial Intelligence (AI)

Artificial Intelligence simulates human intelligence in machines, enabling them to perform tasks such as speech recognition, decision-making, and translation. Key aspects of AI are shown in figure 1.2.

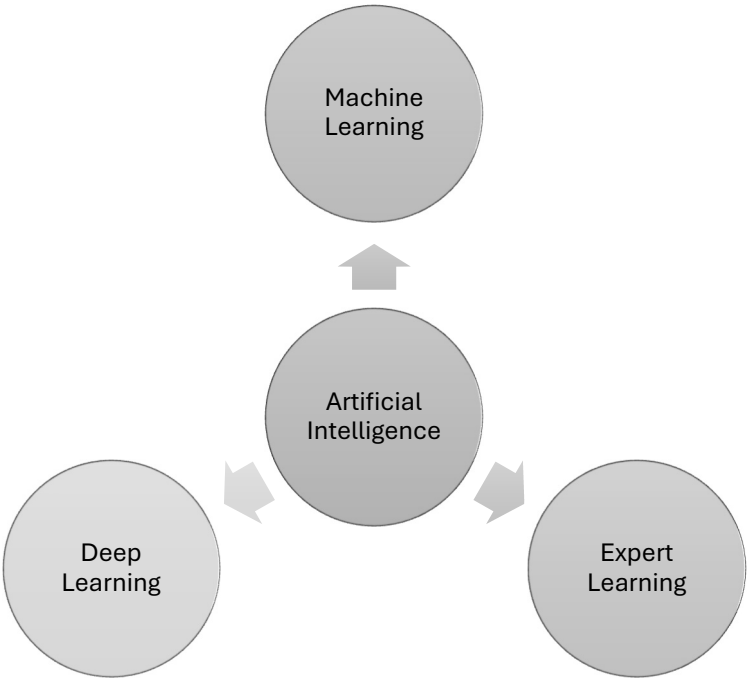

Figure 1.2. Schematic of Artificial Intelligence Aspects

1. **Machine Learning (ML)**: ML is a part of AI. It teaches computers to learn from data and get better over time. Instead of being programmed for every task, ML uses big sets of data. It finds patterns and makes predictions on its own. You see ML in things like recommendation systems,

predicting trends, and spotting fraud. It's great for tricky decisions and recognizing patterns.

2. **Expert Systems**: These systems act like a human expert. They follow set rules and use a database of knowledge. When they get data, they use logic to come up with conclusions or decisions. You can find expert systems in places like healthcare, tech support, and customer service. They provide solutions to specific problems based on rules.

3. **Deep Learning**: This is a part of ML that uses artificial neural networks. These networks try to mimic how humans think. They help in recognizing patterns, understanding speech, and analyzing images. The networks have many layers to process data, allowing them to pick up on complex features. Deep learning has improved AI in areas like image classification and self-driving cars. It can handle messy data and understand big ideas. AI is changing many industries. It allows machines to do tasks that only people did before. With ML, expert systems, and deep learning, AI keeps getting better. It opens up new ways for automation and creativity in fields like healthcare and finance. As AI grows, it will be part of our daily lives, helping with decision-making and making things run smoothly.

AI is used in many fields. It helps create chatbots, self-driving cars, and tools to fix things before they break (Vermesan *et al*., 2022). A report says AI might add $15.7 trillion to the world economy by 2030.

1.1.7 Cloud Computing

Cloud computing is when you use servers on the internet to store, manage, and process data. This makes it easier and more affordable for businesses.

One big plus of cloud computing is that you don't need to spend a lot on physical servers and equipment. With the usual setup, companies have to buy expensive hardware and pay for maintenance and IT workers. But with cloud services, businesses only pay for what they actually use. This helps save money, especially for smaller companies. Plus, cloud providers take care of maintenance and upgrades, so that's one less worry for businesses.

Another great thing about the cloud is how easy it is to scale up or down based on what you need. Unlike traditional setups that make you get more than you need to handle busy times, cloud services let you adjust resources quickly. This is super helpful for companies that have busy seasons or

changing workloads. They can avoid the cost of paying for unused resources while still keeping up during rush times.

Cloud computing also makes teamwork a lot easier. It allows teams to access and work on the same documents or apps from different places. This means better communication and productivity. Tools like Google Drive and Microsoft 365 let everyone stay synced, so they're always working with the latest info.

Overall, cloud computing has changed how businesses deal with data. It brings savings, flexibility, and better teamwork. As more companies use cloud services, they can adapt faster, save on IT costs, and keep innovating.

Experts expect the cloud computing market to grow to $947.3 billion by 2026. More businesses are starting to use cloud-based analytics, and big players like AWS, Microsoft Azure, and Google Cloud offer a wide range of services.

1.1.8 Dashboards

Dashboards are tools that show important business info at a glance. They bring together key numbers and data in one spot. This makes it easy for leaders to see how the business is doing without digging through tons of raw data. You can see sales numbers, customer feedback, growth stats, and how well things are running using graphs, charts, and gauges. This quick access to critical info helps businesses stay on their toes and adapt to changes in the market. Dashboards are great for spotting trends and issues. By looking at past and present data, users can find patterns that might show new chances or problems. For example, a sales dashboard might highlight a drop in sales or a rise in customer complaints. Catching these trends early helps businesses take action and avoid risks. Not only do dashboards give a summary, but they also let users dig deeper into specific numbers. With a click, decision-makers can find detailed insights and understand why certain trends or issues are happening. This helps users make smart choices based on what's really going on. In fact, a survey shows that companies using dashboards for decisions see a 27% boost in efficiency. Dashboards are a key part of business intelligence tools. They offer customizable views that align with company goals. Features like real-time updates and interactive elements make them useful for planning ahead (Quynh, 2023). Overall, dashboards help businesses make smart, data-driven decisions, improving efficiency and keeping them competitive.

1.2 The Role of Data in Decision-Making

Today, data plays a huge part in making decisions for businesses, governments, and groups. It helps them make smart choices and tackle problems. With data analytics, these groups can spot trends, improve how they work, and come up with new ideas. This review looks at why data is so important in decision-making. We'll cover six main points: finding chances and risks, making things run smoother, boosting customer experiences, forecasting results, encouraging innovation, and improving accountability.

1.2.1 Identifying Opportunities and Risks

Analyzing market trends with data helps businesses find growth spots and reduce risks. Companies can keep an eye on key performance indicators (KPIs) and market stats to spot trends that show what consumers want or where there are new opportunities. For example, data from online shops can show when certain products are suddenly in high demand. This helps businesses decide when to invest in making more or marketing them. Data is also key for managing risks. Take banks, for instance. They use credit risk models to check if borrowers are trustworthy. This helps them avoid losing money if someone can't pay back a loan. Predictive analytics lets companies see possible problems ahead, like cybersecurity issues or supply chain hiccups. This way, they can take steps to avoid them. In short, data acts like a map and a compass. It helps leaders make smart decisions and sidestep mistakes. Figure 1.3 shows what data-driven decision-making looks like (Kalusivalingam *et al*., 2022).

1.2.2 Improving Efficiency

Efficiency is key to running a successful operation. Data is really helpful in making things work better and getting resources to where they need to be. When companies use data, they can see how well they are doing. They can spot problems and improve their processes. For example, in manufacturing, businesses often use IoT sensors. These sensors keep an eye on machines in real time. This helps them predict when machines need maintenance. So, they can fix issues before they cause downtime, making the whole operation more productive. Logistics companies also use data. They look at route information to plan better delivery schedules. This helps them save fuel and time (Chen et al., 2021). In healthcare, data analytics is super useful too. It helps ensure that doctors and medical tools are available where they are

most needed. By using real data to make choices, organizations can save money and run more efficiently.

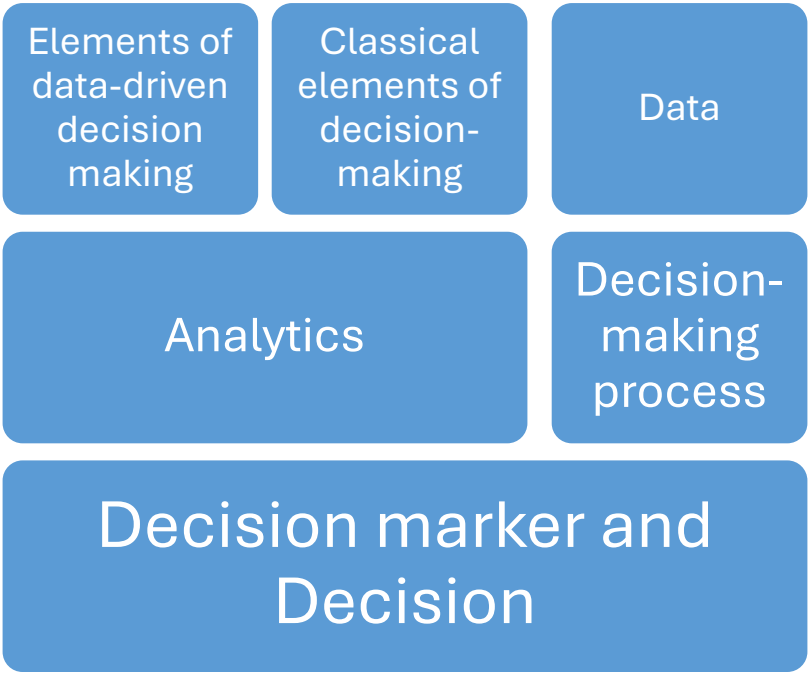

Figure 1.3: The elements of data-driven decision making

1.2.3 Enhancing Customer Experiences

Getting to know what customers like and how they behave is really important. This helps businesses create products and services that fit what people need. Data is a great tool for learning about customer habits and what they think. For instance, Netflix uses data to suggest shows based on what you've watched before. This makes your viewing experience feel special and keeps you coming back. Retail stores also use customer info to make promotions that grab attention and improve shopping fun (Verma, 2022). They might even look at how people feel about their brand to quickly fix any issues and keep a good image. When companies focus on what their customers want, they build better connections and keep people happy.

1.2.4 Predicting Outcomes

Predictive analytics uses data to help organizations make better decisions. It allows them to see trends and possible outcomes. By looking at past and current data, businesses can plan for what might happen next. In the energy sector, it helps predict changes in demand. This way, they can adjust how much energy they produce and share. In finance, special programs look at market data to guess how stocks will do. This helps guide smart investments. Retailers also get a boost. They can forecast sales, which helps with managing inventory and planning sales offers. Using predictive analytics helps companies lower risks and stay ahead of competition in fast-changing markets (Conboy *et al*., 2020).

1.2.5 Supporting Innovation

Innovation starts with data. Data helps companies create products and services that meet real needs. It sparks new ideas by showing what people want and allowing them to test these ideas safely. Take the car industry, for example. They use data from tests on self-driving cars to make safety features better. Tech companies look at how users act to improve their apps. Drug companies rely on trial data to speed up developing new medicines. Collecting and using data helps make sure that new ideas are useful and work well (Cai *et al*., 2203). By using data, companies can stay relevant in fast-changing markets.

1.2.6 Enhancing Accountability

Using data to make decisions helps everyone be clear and responsible. When groups base their choices on facts, they can show why they do what they do. This keeps things fair and not just based on opinions. In government, when data is open to the public, people can see how decisions are made. This helps build trust (Hartanto *et al*., 2021). For example, open data lets people check how the government spends money and how it handles health and the environment. In businesses, data dashboards give everyone up-to-date information about how well the company is doing, which helps hold people accountable. Now, data isn't just about looking back at what happened. It's also about using current and future data to make quick decisions. This shift encourages a culture of making choices based on solid information instead of guessing. Organizations can find new chances, avoid risks, run smoother, improve customer experiences, predict results, and support new ideas. As technology gets better, using advanced data tools

will help companies and communities make even smarter choices. Choosing a data-driven method is not just smart but necessary to succeed in today's tough market (Perera and Iqbal, 2021).

1.3 Evolution of Business Intelligence and Analytics

Business environments are getting more complicated. Companies need quick insights to keep up. That's why being flexible in analytics is so important. Let's look at how business intelligence (BI) has changed over the years. It has gone through four main stages:

1. In the 1960s to 1980s, businesses relied on reporting and decision-support systems.
2. In the 1990s, BI tools came onto the scene.
3. The 2000s saw the rise of advanced analytics.
4. From the 2010s to now, we've entered the age of modern BI and data analytics. You can see this change in figure 1.4.

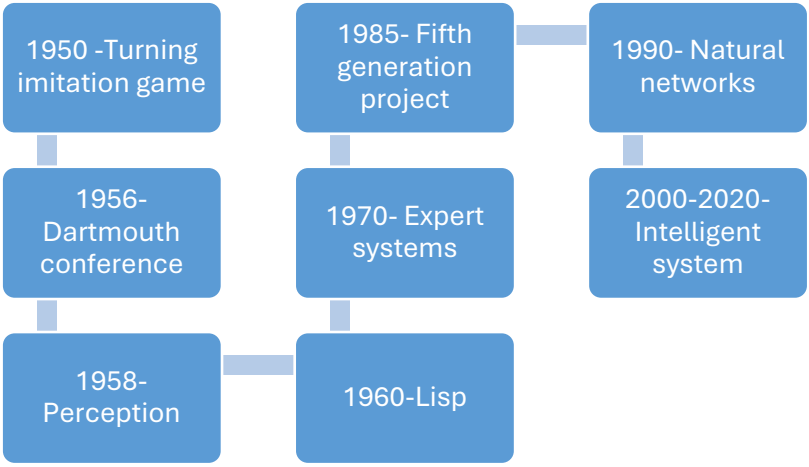

Figure 1.4: Evolution of Business Intelligence and Analytics

1.3.1 Initial Reporting and Decision Support Systems (1960s-1980s)

Business intelligence started with simple reporting systems and decision-support systems, also known as DSS. Back then, businesses mostly used structured data from their own databases. This included things like transaction records and financial information. Reporting systems produced regular reports. These reports showed how the business had performed in the past and how well it was running. DSS was a big step forward. It gave managers tools to help them make better decisions based on data. These systems used rules and mathematical models to look at the data. While DSS was important for improving decisions, it mainly focused on internal data. They weren't built to connect with outside data sources or help with long-term planning (Gupta *et al*., 2022).

1.3.2 Emergence of BI Tools (1990s)

In the 1990s, business intelligence (BI) really took off. New tools like Online Analytical Processing, or OLAP, changed the game. OLAP helped users look at data in many ways. They could sort it by time, location, or product. This made business analysis much clearer. Another big change was the rise of data warehouses. These are places where companies store lots of data from different sources. With a data warehouse, businesses could see all their information in one spot. This made it easier for them to report and analyze their performance. Back then, BI shifted from just operational reports to helping with big decisions. Dashboards and scorecards became popular. They gave leaders quick views of key performance indicators, or KPIs (Zingde and Shroff, 2020). The 1990s laid the groundwork for using BI as a key tool for strategy, not just daily tasks.

1.3.3 The Rise of Advanced Analytics (2000s)

In the early 2000s, analytics took a big leap forward. It changed how businesses made decisions. Predictive analytics became really important. It helped companies see future trends by looking at past data. Then there was prescriptive analytics. This one suggested specific actions to get good results. Big data was everywhere during this time. Tools like Hadoop and Spark made it easier to handle huge sets of data. This included messy data from places like social media and sensors. Businesses started to move away from only using organized data. They began tapping into new insights. Open-source tools also became popular. They made it easier for more

people to use analytics and create new ideas. Mixing machine learning with business intelligence improved analysis. Companies could better understand their customers and spot fraud. The 2000s really changed the game. Data analytics became a must-have for planning and staying ahead of the competition.

1.3.4 Modern BI and Data Analytics (2010s-Present)

Today, business intelligence (BI) and analytics are changing fast thanks to new tech. Cloud computing is a big part of this. It makes storing and processing data much easier and cheaper. Businesses can now look at huge amounts of data right away. This helps them make quick decisions. Self-service BI tools, like Tableau and Power BI, let regular users dig into data without needing a tech expert. These tools are easy to use, with drag-and-drop features and customizable dashboards. Because of this, more people in a company can understand and use data. It also means businesses rely less on IT teams. Real-time data processing is super important, especially in finance, healthcare, and e-commerce. With streaming data, companies can quickly change their plans based on what's happening right now. Another cool development is augmented analytics (Hassan and Mhmood, 2021). Here, AI helps with data analysis. It uses natural language processing and machine learning to spot trends and make suggestions. This takes some of the pressure off analysts and speeds up decisions. The way we use BI and analytics has come a long way. From basic reporting in the 1960s to powerful AI tools now, each step has made BI better. As more companies depend on immediate insights and smart analytics, BI's role will keep growing. New tech, like quantum computing and improved AI, could take BI to new heights (Eboigbe *et al*., 2023). For businesses to succeed, keeping up with changes in BI and analytics is essential.

1.4 Overview of Tools and Technologies

Today, businesses really need Data Analytics and Business Intelligence tools. They help turn big data into useful information. This way, companies can make smart choices, improve how they work, and push their goals forward. There are many Data Analytics and BI tools out there. Some are programming languages like Python and R. Others are visual tools like Tableau and Power BI. Figure 1.5 shows some of these tools.

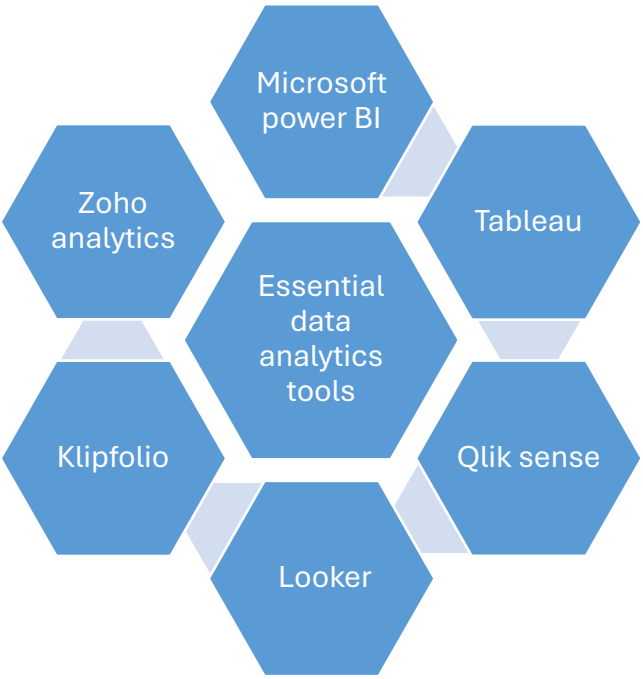

Figure 1.5: Overview of tools and technologies

1.4. 1 Data Analytics Tools

Python and R are two popular programming languages for data work. People love them because they're easy to use and have plenty of tools for handling data, analyzing it, and doing machine learning. Python is known for its simple syntax. It has a lot of helpful libraries like Pandas, NumPy, and Matplotlib. These tools let data scientists clean data, explore it, visualize it, and build models. Plus, Python works well with machine learning tools like Scikit-learn and TensorFlow, making it great for predicting outcomes and AI projects. It also easily connects with other tools like databases and cloud services (Soppin et al., 2021).

On the other hand, R is great for statistics and making charts. It has strong packages like ggplot2 for visuals, dplyr for data manipulation, and caret for machine learning. R shines when it comes to statistical tasks and creating detailed graphs. This makes it a favorite in research and schools. It works

best for things like hypothesis testing and analyzing trends over time (Cerqueira et al., 2020).

Both Python and R are key tools in data work. They help with exploring data, machine learning, and creating visuals.

Tableau and Power BI are two popular tools for business and data visualization. They help users create cool reports and dashboards that look good and are easy to understand.

Tableau is great for its strong visual features. You can make detailed reports without needing to be a tech expert. It works with lots of data sources like spreadsheets and cloud databases. Plus, you can just drag and drop things to create dashboards. Tableau handles large datasets really well and lets you see data changes in real time (Akhtar et al., 2020). This helps people spot trends easily.

Power BI comes from Microsoft and is also a strong tool for visuals. It's perfect for anyone who already uses Microsoft software. It works well with Excel and other Microsoft apps, making it easy for users. Power BI has a simple interface, so making reports and dashboards is a breeze. It also supports cloud analytics and real-time data, which helps businesses make quick decisions based on current data (Dineva and Atanasova, 2022).

Apache Hadoop and Spark are open-source tools for big data. They help people manage and analyze large data sets.

Hadoop is a framework that lets you store and process big data across many computers. It has two main parts: the Hadoop Distributed File System (HDFS) for storage and MapReduce for processing. With Hadoop, businesses can keep a lot of different types of data. It's great for industries like healthcare, retail, and finance. Plus, more computers can be added to handle even more data.

Apache Spark is built on Hadoop and is faster because it processes data in memory. It can handle both large batches of data and real-time data streams. This makes it a good choice for real-time analytics, machine learning, and other advanced data tasks (Tang et al., 2020; Pala, 2021). Spark works quickly and efficiently, making it a strong option for big data needs.

1.4.2 Business Intelligence Tools

SAP BusinessObjects is a popular tool for business reporting and data analysis. It has many features for reporting, querying, and creating dashboards. It works well with different data sources, like databases and cloud apps.

Many companies use SAP BusinessObjects because it helps them manage complex data reporting. Microsoft SQL Server Reporting Services, or SSRS, is another strong reporting tool (Gole and Shiralkar, 2020).

It's part of Microsoft's SQL Server package. SSRS helps businesses create and manage reports using data from SQL Server databases. You can make different types of reports, from interactive ones to mobile-friendly formats. It's also great for quick reports and scheduled automation. Many companies like it since it fits well with other Microsoft products (Deckler et al., 2022).

QlikView and Qlik Sense are tools that allow users to work with data and get insights without needing special skills.

QlikView is the older version and helps users see how data connects across different sources. It allows for reporting and data analysis.

Qlik Sense is the newer one, focusing on being user-friendly. It has drag-and-drop features that help users make interactive visuals and dashboards easily. It works with many data sources and offers good governance, which helps businesses share data analysis across the organization (Sharma, 2020).

1.4.3 Emerging Technologies

Artificial Intelligence (AI) and Machine Learning (ML) are changing how we look at data analytics. They help systems learn from data and make predictions. These algorithms can spot patterns and make forecasts that would be hard for people to find on their own. They’re great for things like predicting trends and personalizing recommendations (Shrestha et al., 2021).

Natural Language Processing (NLP) is another part of AI. It helps machines understand and use human language (Zucco et al.., 2020). With NLP, businesses can analyze customer feedback and social media posts. This helps them see what customers think about their products.

Then there's Blockchain. It's a secure way to record transactions. It keeps data safe and trustworthy. That's really important for industries like finance and healthcare. Blockchain helps create reliable records that can be checked.

The Internet of Things (IoT) connects physical devices to the internet. These devices gather data all the time. This helps businesses make quick decisions based on real-time information from things like smart meters and machinery.

Augmented Analytics is a new trend. It uses AI and ML to make data analysis easier. It helps prepare data and generate insights without needing experts (Ikegwu et al., 2022). This way, organizations can understand data better and faster by using AI-driven suggestions.

Today's tools for Data Analytics and Business Intelligence are getting better all the time. From basic tools like Python and R to advanced ones like Tableau and Power BI, they help companies pull out insights, spot trends, and make smart choices. With the rise of AI, ML, and IoT, data analytics is becoming more accurate and efficient. As new tools come out, businesses can use them to stay ahead and keep innovating.

Summary

Data analytics and business intelligence are super important in today's world. They help companies collect and understand a lot of data. This helps them make better choices and grow their businesses.

Tools like Python, R, Tableau, Power BI, and Apache Hadoop have changed the way we look at data. They make it easier to analyze and find solutions for tricky business problems. These tools do more than just regular data work. They also help businesses use things like predictive analytics and real-time data.

Business intelligence tools like SAP BusinessObjects, QlikView, and Microsoft SSRS help organizations work better. They give decision-makers easy-to-use ways to see and report on data. When you combine BI with new tech like AI, machine learning, and the Internet of Things, it helps businesses automate tasks and get better insights. This keeps them competitive as the market changes.

Also, new tools are making it easier for anyone, not just tech experts, to use data in their work. As companies lean more on data for their plans, knowing

data analytics and business intelligence is a must. This connection will stay at the heart of how businesses innovate and grow in the future.

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