Applied Decision Analytics

Journal homepage: www.ada-journal.org
ISSN: 3104-2945

Comparative Analysis of MS Excel and Power BI Tools for Business Reporting

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ARTICLE INFO

Article history:
Received 20 October 2025
Received in revised form 11 December 2025
Accepted 20 February 2026
Available online 25 March 2026

Keywords:
Business analytics, Business reporting, Power BI, MS Excel

ABSTRACT

The modern business environment is characterized by the need to make decisions based on data, and this is precisely the basis for achieving and maintaining a competitive advantage. The increasing amount and complexity of data impose the need for advanced business analytics tools that enable efficient processing, transformation, and interpretation of data. Among the most used tools are Power BI, Tableau, Qlik Sense, IBM Cognos Analytics, MS Excel, and others. Comparative analyses of the most widespread solutions in this area are often found in the literature. Despite their widespread use, direct comparative analyses of Power BI and Excel, as two Microsoft tools, are rare in the literature. The goal of this paper is to identify the advantages and disadvantages of both solutions based on a review of relevant sources and practical research; in order to determine in which business contexts their application can contribute to more effective decision-making and the improvement of business intelligence.

1. Introduction

For companies to achieve and then maintain a competitive advantage, it is necessary to measure the achieved results, that is, performance. Insight into performance is achieved by processing and transforming available data. Processed and transformed data becomes information that is an indicator of business success.

The common problem of almost all business systems that operate today is the management of a large amount of data. A large amount of data requires complex processes of organization, processing, storage, and then preparation, transformation and data analysis. Instead of performing the necessary data manipulations manually, which would be a demanding and long process, today there are various programming languages and tools.

The amount of data and the complexity of the calculations required to obtain certain information have led to an increase in the demand for data analysis tools. By applying these tools, companies can improve, facilitate, accelerate and automate the analysis, planning and decision-making processes.

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https://doi.org/10.66972/ada21202622

Depending on the nature and area of business, companies have at their disposal many different solutions from this area. Among the most famous tools for business intelligence can be found Power BI, Tableau, Qlik Sense, IBM Cognos Analytics and others [1]. There are statistical and analytical environments where R, Python, SPSS, MATLAB and others stand out [2, 3]. Microsoft Excel can be said to be a hybrid and can belong to both groups.

Due to the large number of solutions available, many of the companies face the problem of "Which of the solutions is suitable for the given industry, type of data and business goals?". Among the existing literature, one can find comparative analyses of different tools, based on a wide range of criteria. However, it was noted that some tools are not directly compared but are used in identical business contexts. Precisely because of this, this paper will investigate the relevant literature on the application, advantages and disadvantages of the Microsoft Excel and Power BI tools. The focus will be on a comparative analysis of their functionalities and application possibilities in the context of business analytics. The goal of the research is to, based on the analysis of relevant literature and practical research, determine the advantages and disadvantages of each of the tools, to recognize and better understand which tool and in which situations it is necessary to use it so that the results obtained contribute to effective business decision-making.

2. Methodology

The analysis is based on a detailed review of available literature and practical research. Due to the nature of the topic, professional and scientific literature was used in the form of books, articles, conference papers and websites. All literature, except web pages, was found using the Google Scholar and Kobson databases. The literature search was performed by searching for keywords and expressions previously mentioned in the Abstract chapter. In addition to keywords and expressions, the actuality of the literature is also included as a search criterion. Literature published in the previous five years was mostly used. In the case of notions, concepts and terms that have been present in the literature for a long time, somewhat older references were used. Practical research involves simulating the creation of reports in both tools. Two reports were created based on the same data, which enabled an objective comparison of the phases of this process, the analyses obtained and results.

The theoretical background of the research is covered in the second, third, fourth and fifth chapters of the paper. The second chapter of the paper is dedicated to the basics of business analytics and intelligence, their characteristics and differences, as well as current solutions in this area. In the third and fourth chapters, the history, descriptions of the main functionalities and modules and areas of application of the selected tools, MS Excel and Power BI are given. The fifth chapter provides a comparative analysis of the advantages and disadvantages of both tools. The research contribution is presented through the remaining five chapters, where the sixth chapter is dedicated to the life cycle model of report creation; the seventh and eighth chapters describe the process of creating reports in both tools, according to defined phases. The ninth chapter is devoted to observations of practical research, while the tenth chapter summarizes the conclusions of the theoretical and practical part of the work.

3. Literature Review

3.1 Business Analytics

For companies to operate successfully, they need to have insight into their performance [4]. Performance insight is achieved by processing and transforming available data. Processed and

transformed data becomes information that is an indicator of business success. The volume and complexity of calculations that are necessary to obtain certain information led to the need to introduce certain tools. Currently, there are many tools on the market that can facilitate, speed up and improve the process of analysis and business decision-making.

Any process that is based on data and provides certain business insights can be defined as analytics. Reporting can be based on historical data, but it can also predict future events. In any case, the goal is the same – to transform data into information that adds value [5]. The most common forms of analytics are [5]:

i. Reporting - summarizing historical data,
ii. Trend identification - observing patterns of behavior in time series of data,
iii. Segmentation – dividing data based on identified similarities among data,
iv. Predictive modeling - predicting future events using historical data.

These enumerated examples have certain common characteristics [5]:

i. Each is data-driven,
ii. A variety of mathematical and statistical techniques are applied to transform and summarize data,
iii. They add value to raw data by transforming it into knowledge.

Today, analytics play an important role in almost every business environment. Business analytics and business intelligence are increasingly in demand by senior management in a wide variety of businesses for visualization, analysis and strategic planning preparation [6]. The reason for this is their contribution to management and business decision-making [7].

Intelligence (BI) appeared as an official term in the 1990s, while business analytics appeared in the 2000s, to highlight the importance of analytics in business intelligence [8]. In today's literature, these two terms very often appear as synonyms. Some authors also use the unified term " Business Intelligence & Analytics - BI&A " [7,8].

Business analytics is the creation of data-driven insights to create value. It uses all types of analytics to achieve business results, and it is this difference that is key. Business analytics differs from classical analytics by leveraging business knowledge, using actionable insights, and measuring performance and value. In addition, another important feature is the distinction between relevant and irrelevant knowledge, considering strategic objectives. Therefore, business analytics analyzes whether the obtained information and insights are contextually relevant and whether they bring real value [5].

This type of analytics involves the use of data, information technology, statistical analysis, quantitative methods, computer-based mathematical models, and visualization to enable decision makers to better understand stakeholders, such as customers, suppliers, and others [9].

Business analysis and information management play an important role in achieving the goals of current and future projects by supporting the process of making business decisions and improving business operations. Business analytics is closely related to information management in the context of activities and tasks related to the adequate collection, manipulation and processing of information [10]. It can be divided into four types of analytics:

i. Descriptive analytics,
ii. Predictive analytics,
iii. Diagnostic analytics,
iv. Prescriptive analytics.

Business analytics is a process of sequential application of all four types of analytics in order to generate new, unique and valuable information, which can lead to improvement of measurable business performance [5].

3.1.1 Descriptive analytics

Descriptive analytics is the most used type of business analytics. It is the simplest to implement precisely because it shows and describes the existing state of the data, without complex calculations [9]. Using key metrics and measures, descriptive analytics demonstrate what happened in different areas of the business. It quantifies the relationship between independent variables, which affect the performance of the organization, with the main goal of classifying certain parameters [11]. It can be used to understand historical data, discover the reasons behind successful or unsuccessful events, and thus make fact-based business decisions [9, 11].

3.1.2 Predictive analytics

Predictive analytics is a more advanced form of analytics and is the application of advanced statistics, information software and operational research methods to identify predictive variables and develop predictive models [12]. The main goal is to predict future states. It is possible to predict which event could happen, estimate the time when that event could happen or the value of an unknown variable in the developed predictive model [11]. Future performance can be predicted by examining historical data, noticing connections and patterns of behavior among them, and extrapolating those patterns to create a forecast of possible events. Unlike descriptive analytics, it can predict risk and, using statistical modeling, data mining and other advanced techniques, identify hidden connections and patterns [9].

3.1.3 Diagnostics analytics

Diagnostic analytics deals with the analysis of historical data to identify the causes of certain events. By using advanced tools, investigating why something happened builds on and complements descriptive analytics [11, 12]. The main features of diagnostic analytics are data discovery, data mining, drill-down and correlation. Diagnostic analytics can provide deep insight into a particular problem, which can be helpful for future events [11].

3.1.4 Prescriptive Analytics

Prescriptive analytics uses the power of decision theory, management, and operational research methodologies to use available resources in an optimal way [12]. The question that prescriptive analytics answers is what outcome is optimal and provides recommendations for action plans [9]. For each of the expected outcomes, it can provide recommendations for action plans. In the last few decades, the effectiveness of prescriptive analytics has been significantly improved thanks to the development of artificial intelligence and Big Data management [11].

3.2 Business Intelligence

The emergence of business intelligence (BI) brings a change in the way organizations use data for insights, making informed decisions and maintaining a competitive advantage [13]. BI is a very important aspect that both business managers and IT managers must be aware of to use it as a source of competitive advantage [13].

There are different definitions of business intelligence in literature that have changed over time. Some of the most interesting definitions available in the literature will be given below.

Miller *et al.* [15] say that business intelligence can be defined as providing the right information to the right people at the right time. BI highlights the entire process required to transform data to turn it into knowledge, so that it is reliable and used for more efficient business decision-making. An "intelligent company", one that uses BI in its business, can more easily predict how future economic and market changes will affect the business and therefore more easily adapt and progress in the new conditions.

Qaffas *et al.* [16] and Maghsoudi and Nezafati [17] argue that business intelligence includes processes, technologies and tools that enable organizations to analyze data for informed decision-making and strategic planning. It facilitates the transformation of raw data into actionable insights, thereby providing organizations with a competitive advantage in dynamic environments.

Skyrius [18] defines business intelligence as a business practice that connects and combines people, processes and technology for the systematic collection, processing and use of complex business data. BI's goal is to provide timely and valuable insights to managers and other decision makers.

Azvine *et al.* [19] say that business intelligence deals with ways of collecting, accessing, understanding, analyzing and transforming one of the most valuable resources of the company, raw data, into applicable information, with the aim of improving business performance.

From the above definitions, it can be concluded that business intelligence represents a simultaneous technological solution for reporting, methodology, business practice, but also a process, i.e. a set of interconnected components.

3.3 Solutions for Business Reporting

There is a wide range of business reporting solutions on the market. Using and choosing the right tool can be critical to an organization's success. However, many of them encounter difficulties in choosing the appropriate solution [20]. Business intelligence tools ensure data validation and their transformation into a coherent set of information adapted to the company's profile and its needs [21].

Some solutions are very similar, while some differ significantly. Certain solutions are created strictly for data visualization, while other solutions have more advanced functionalities that are based on machine learning and artificial intelligence. Each of the companies should choose the solution that best suits the industry in which it operates, the nature of the business, the size of the company and finally, the reporting needs themselves. The solutions are most often grouped according to different types of analytics or application domain, and within these groups they are often compared with each other.

It should be borne in mind that the implementation of BI platforms requires additional efforts. The implementation of a new solution often requires the employment of suitable qualified personnel, changes in the organizational structure due to their employment, the application of new regulatory standards and the planning of new work procedures [20].

Among the most used business reporting solutions are Power BI, Tableau, Qlik Sense, Google Looker, SAP BusinessObjects, MS Excel and others. The three most common tools have been around for years:

i. Power BI is a solution from Microsoft. The goal is to provide users with a simple interface for interactive viewing of reports and dashboards. In addition to the desktop interface, Power BI also offers cloud services known as Power BI Service. Interactive dashboards, modern visuals, the ability to prepare and transform data are just some of the available functionalities [22].

ii. Tableau is a very popular solution that has been around since 2003. This tool was created to make data analysis accessible to users with varying levels of knowledge and experience, such as analysts who do not have programming or technical skills. Among the features that set Tableau apart are quick calculations, interactive reports, the absence of manual calculations, and the ability to work with large data sets. [23, 24].
iii. Qlik Sense is a modern solution developed by QlikTech for data visualization and business intelligence. Unlike traditional reporting tools, by quickly generating key insights and enabling agile decision-making, Qlik Sense allows users to manage data according to their own needs [25]. It facilitates easier data processing and understanding thanks to a cognitive engine based on machine learning and artificial intelligence [26].

3.4 Microsoft Excel

The first spreadsheet application, VisiCalc, appeared in 1979. Designed for the Apple II personal computer, the application was created to perform repetitive accounting calculations. This invention increased the value of personal computers on the market and led to their growing popularity in practical use. The owners of VisiCalc sold the rights to Lotus Development, which developed the Lotus 1-2-3 application for IBM computers of the time. This application introduced database and graphics functionalities and became one of the most popular applications of the 1980s. Over time, other spreadsheet applications emerged, including: SuperCalc, Multiplan, PlanPerfect, Quattro Pro, VP-PLANNER, AsEasyAs, and others. The next spreadsheet application to achieve significant success was Microsoft Excel.

Microsoft Excel, a spreadsheet program, officially appeared in 1987. With its appearance, what could previously be done exclusively with software and high-capacity computers, becomes available to the common man on a desktop computer [27]. Nowadays, nearly all business systems face large volumes of data that require serious organization and processing. Instead of performing the necessary data manipulation manually, various programming languages, spreadsheets, or other software tools can be used [28]. This is precisely why spreadsheet applications play an important role in business modelling, data analysis, and decision-making [29]. Although it is quite “old,” Excel has remained one of the most popular and widely used spreadsheet tools for data storage and manipulation for years [27, 30]. While the activities that can be performed in Excel are also possible in other applications, what sets Excel apart is its extremely simple and intuitive interface that anyone can use. Anyone with basic computer skills can quickly become familiar with the various features in Excel, with minimal investment of time and effort [28].

One of the main reasons for Excel 's popularity is precisely the versatility of the tool. Although it is known for working with numbers and numerical calculations, Excel is also useful for working with data that is not necessarily numerical [31]. Microsoft Excel enables users to enter, organize and store data, analyze it, transform it and visualize it, as well as automate certain processes using macros created in the Visual Basic for Applications (VBA) programming language [28]. It is highly customizable and easy to program, making it an excellent choice for creating spreadsheet-based applications [32]. With it, the entire process of data manipulation and processing can be automated and optimized, which is especially important when working with large databases.

Some of the most common applications of Excel are [30, 31]:

i. Working with numbers - creating budgets, cost records and similar financial analyses,
ii. Creating charts and visuals,
iii. Creation of lists or tables - data organization using columns and rows enables effective storage and management of lists or tables,

iv. Processing of text and numerical data - cleaning, preparation and transformation of numerical or non-numerical data,
v. Access to other data - based on the possibility of connecting data from different sources,
vi. Creating dashboards – condensing a large amount of data into an overview and clear format,
vii. Automation of complex tasks - automation of repetitive and manual tasks.

What further sets Excel apart from the sea of other tools of the same or similar purpose is its ease of use and user-friendly interface. Data is organized into rows and columns. The basic layout of Excel consists of the following units (Figure 1) [30,31]:

i. Quick Access Toolbar,
ii. Ribbon that contains various tabs and menus within them,
iii. Name tab that references the selected cell,
iv. Formula bar,
v. Worksheet with row numbers and column letters,
vi. Cards with worksheets available,
vii. Status bar, preview, zoom and navigation options.

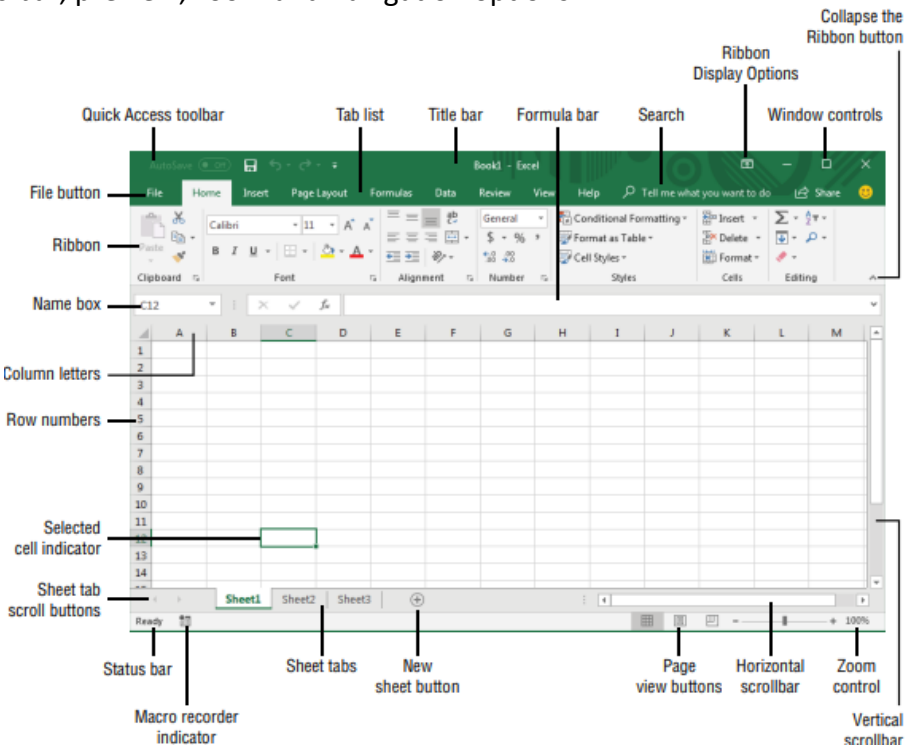

Fig. 1. Excel layout (Adapted from [30, 31])

Each newly created Excel file represents a workbook in which different worksheets can be created. Each worksheet is made up of individual cells. Each cell can contain a number, formula, or text. The worksheet, in addition to cells, also has a graphics layer that is used for images, graphs and diagrams. These objects are not part of the cells themselves, but are located above them, unlike numbers or formulas that are entered directly into the cells [30, 31].

What makes Excel particularly attractive to advanced users are the following features [30, 31, 32]:

i. A programming language that enables the creation of complex programs directly in Excel - VBA ,
ii. Custom dialog windows - professional dialog windows can be easily created using custom forms,

iii. Custom functions in worksheets - VBA can be used to create functions that facilitate formulas and calculations,
iv. Customize the user interface by changing the ribbon and shortcut options,
v. Powerful options for data analysis: Pivot Table and Power Query,
vi. Microsoft Query provides access to important data directly from the Excel environment. Data can come from databases, text files or web pages,
vii. Possibility of automation via VBA,
viii. The possibility of creating "compiled" add-ins,
ix. Various data protection options and more.

It can be observed that VBA frequently appears among the previously listed features. Visual Basic was originally a macro language used in databases. Later on, it became an open programming tool applied in applications and for connecting them. Excel was the first application to include VBA, enabling programming within it. Over time, VBA has evolved and can now be used across all Microsoft Office applications [33].

Over the years, Excel has been constantly developed by adding new functionalities (Table 1). When it comes to functionalities that are most important for data manipulation, transformation, as well as analytics of any kind, the following stand out:

Table 1
Functionality of Excel (Adapted from [23])

Tool	Functionality	Description
Power Query	Get and Transform Data	Allows connection to databases, text files, workbooks and Internet services.
	Query Editor	It enables data transformation and cleaning.
	Power Query Formula Language	M language/code is the functional language for Power BI and Excel. Enables complex data manipulations in the Power Query editor.
Power Pivot Tab	Diagram View	It allows users to view, create and manage connections in a graphical format, making it easier to understand the structure of the data model.
	Power Pivot	It enables quick data summarization and creation of graphics and visuals.
Advanced Filter	Filtering	It offers more sophisticated filtering options allowing users to define complex criteria for extracting data from a dataset.
	Slicing	It allows performing analyzes on smaller units of data.
Power Map Tab	Power Map	It enables displaying data on maps, visualizing trends, patterns and connections and consequently gaining insight into geographic datasets.
Data Tab	Data Analysis ToolPak	Basic data analysis tool. It contains a number of statistical and analytical tools.
	Solver	It allows performing linear and non-linear optimization.
	Advanced Solver/XLMiner	XLMiner helps with various data analysis and predictive modeling tasks, including regression analysis, classification, clustering, decision trees, forecasting, and more.
Developer Tab	VBA	It enables the automation of processes and the creation of custom functions and procedures.
Programming	Python	Excel Python Custom enables advanced data analysis, visualization and automation using Python libraries within the Excel environment, by integrating Python directly into Excel.

3.5 Power BI

Traditional BI projects usually include centralized data warehouses where there is a wide variety of data that has been previously loaded, sorted and then moved to an OLAP (OLAP - Online Analytical Processing) database for reporting and analysis purposes. While there are certain advantages to

having a centralized data warehouse, there are also certain disadvantages. The biggest drawback is precisely the implementation of changes in the form of adding new fields or metrics at the level of the entire organization to the existing data warehouse. The implementation of such changes is a complex and long process that requires the involvement of various experts. Thus, the need arose for a solution that enables agile data analysis without relying on IT experts and formalized processes. For those needs, Excel has been used for years, in which Pivot tables and other ad hoc analyzes were created. However, even that approach did not prove to be ideal. There were problems in the form of isolated Excel files, data silos, data security and others. On the one hand, there was a solution in the form of a too rigid centralized data warehouse, and on the other, a too flexible solution in the form of Excel. The compromise solution is Power BI. It does not replace the centralized data warehouse but complements it and thus enables agile data analysis. It can be used to pull data from a central repository, expand with other sources, create metrics, and analyze data [35].

Power BI was created when the growing demand for advanced analytics and visualization tools was recognized. Add-ins for Excel - Power Query, Power Pivot and Power View, have evolved into a new, independent platform called Power BI [36, 37]. This business intelligence tool was introduced by Microsoft in 2013. Microsoft describes the emerging platform as "a business analytics solution that enables data visualization and insight sharing across the organization" [38]. Today, it is one of the most popular tools for BI analytics, with a large community of users and constant development of functionality.

The tool is user-friendly, simple and intuitive, so it is an excellent solution for advanced users, as well as for those who are not. It is a comprehensive solution that BI engineers can use to model various problems and complex data [6, 39].

Power BI supports the entire process of extracting, transforming and loading data. With it, users can [40]:

i. Search and import data from different sources,
ii. Transform and manage data,
iii. Create connections, measurements and calculations,
iv. They create visuals and reports,
v. They store, publish and share reports.

Figure 2 shows the Power BI architecture, which includes the key components and processes in the Power BI environment.

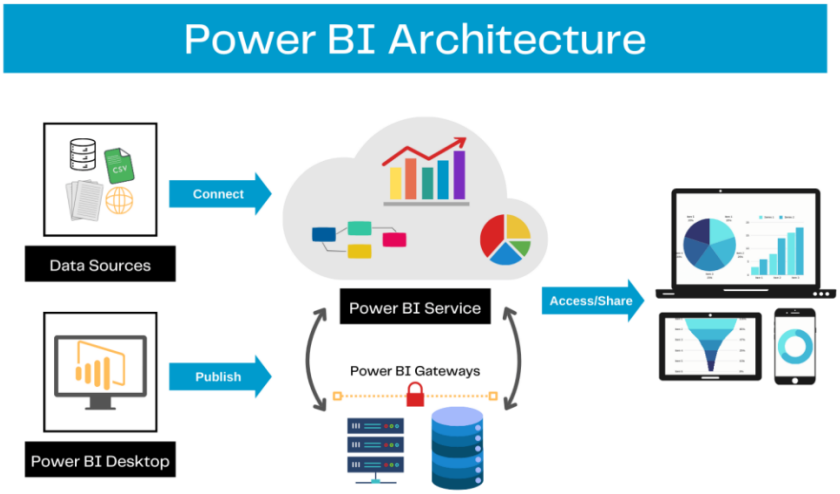

Fig. 2. Power BI Architecture (Adapted from [41])

This solution includes various components. Each of the components has its own specific purpose and in combination with the rest makes Power BI a complete platform. The basic components are (Figure 3) [42]:

i. Power Query enables connection to various data sources such as Excel files, databases, websites or cloud services. Using this option, cleaning, preparation, transformation of data is also performed,
ii. Power View allows you to create visuals and reports based on drag and drop. In this module, different types of graphics are available with different options for formatting, filtering and editing visuals,
iii. Power Pivot is a built-in component that ensures working with large data sets. Allows creation of data models. Thanks to this component, powerful and complex reports can be created without slowing down the tool,
iv. The Power Map component is used to visualize geographic and location data. Allows creation of 3D maps,
v. Power Q&A is based on smart algorithms that understand human speech and based on a simple verbal request can provide answers in the form of visuals,
vi. Power BI Desktop is the main component where the most important part of the process takes place. This is where all functionalities like Power Query, Power Pivot and Power View are combined. In translation, data cleaning and preparation, their modeling and finally visualization are done here. This component allows offline development and preparation of reports before publication and sharing,
vii. Power BI Service/Website is a cloud component for publishing and sharing reports. In this way, the report can be accessed from different devices using a browser,
viii. The Power BI Mobile App is a phone application that allows access to reports anytime, anywhere.

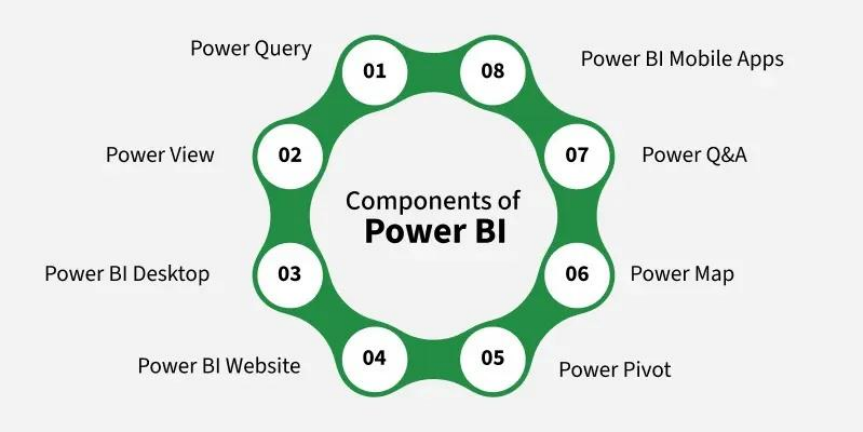

Fig. 3. Power BI components (Adapted from [42])

3.6 Comparative Analysis

Although Power BI was created as an extension of add-ins for Excel, today it is a tool. The fact is that both tools have certain functionalities in common and therefore may appear similar at first glance, significant differences still exist. First, each of them has a different application domain and therefore has its own advantages and disadvantages [43].

Most comparative analyzes available in the literature and on the Internet recommend using Power BI rather than MS Excel. However, MS Excel is still one of the most used tools in practice. The

reasons can be different: from simplicity and accessibility, flexibility, habits, all the way to data that is often stored in Excel formats.

Many users and companies use both tools in parallel: Excel for data manipulation and ad hoc analysis, and Power BI for visualizations and reports for larger datasets. It is this approach that uses the best of both tools, leading to more efficient data analysis (Table 2) [44].

Table 2
Comparative analysis of MS Excel and Power BI (Adapted from [43, 44, 45, 46])

Criteria	Business reporting solution	
	MS Excel	**Power BI**
Domain	Versatile.	Data analysis, visualization, indicators, dashboards.
Interactivity	It is necessary to create additional tables, connect them manually. The result is less responsive visuals.	Easily create interactive reports with cross-filtering based on automatically linked charts.
Dataset size	Up to a million rows.	Up to a hundred million rows.
Updating data	The refresh is manual or automated using additional tools and scripts.	Automatic refresh and access to new data in real time.
Security	Possibility of protection by restricting access and passwords.	Detailed access control by assigned rights.
Sharing and collaboration	Manual sharing. Ability to collaborate in real time.	Extensive sharing options with the ability to collaborate with multiple users at the same time.
Mobile application	Limited and uncustomized application.	Optimized application with full interactivity.
Connecting to data sources	Basic connection to data sources.	Basic connection to data sources, but also connection to cloud services, advanced databases and more.
User interface	Familiar, intuitive and similar to other Microsoft solutions.	Modern and rich interface.
Learning curve	A large number of companies and users are already familiar with the tool. Due to the large number of functionalities, mastering the tool can be somewhat more demanding for new users.	The basics are very easy to master, especially because of the similarity with Excel. However, more advanced functionalities like the DAX language and automation may require more time to master.
Price	Many users have access to the tool within the Microsoft Office suite. The price depends on whether users already have a license for the package or need to purchase it separately. Excel in the Microsoft 365 Personal package costs $7-10 per month.	A free version is available, but all functionality is only available with a paid subscription. Power BI Pro is available for $9.99 per month.
Data model types	Supports relational models.	Supports relational models.
Data model limitations and storage	Limited to worksheet rows or local data model. Users cannot access the model if it is outside the file.	There are no restrictions in DirectQuery mode . By publishing models to the Power BI service, a true client-server architecture is enabled, making the models available to other clients.
Functional logic	DAX and M-code	DAX and M-code

3.6.1 Advantages and disadvantages of MS Excel

When it comes to the advantages of Excel , they stand out [47]:

i. Fast calculations - it is almost impossible to beat the ease and speed of calculations, operations and creation of formulas;
ii. Wide application - Excel is not only a tool for data manipulation and processing, quite the opposite. A large number of companies use Excel in a wide variety of areas such as accounting, human resources, operational management, business analytics and more. In those areas, the use of tools for the purpose of collecting and entering data is more common;
iii. The possibility of fully adapting the application to work needs;
iv. Excellent first of all tabular and then visual reports;
v. Advanced spreadsheets - by combining functions, formulas, conditional formatting and other functionalities, users can automatically perform complex calculations, which improves the efficiency and reliability of the calculations themselves;
vi. Ability to protect content - in Excel there is an option to protect cells, worksheets and entire files. This can be achieved by restricting access or introducing a password.

As for the disadvantages, they can be singled out [47]:

i. Data set size limit – Excel supports up to a million rows of data;
ii. Difficulty collaborating - in order for multiple people to work in parallel on one file, that file must be saved in the cloud or manually shared and saved. In support, there is a chance that the implemented changes will be lost;
iii. Outdated graphics and visuals with a lack of interactivity.

3.6.2 Advantages and disadvantages of Power BI

In the case of Power BI the advantages are [47]:

i. Visuals - the visuals available in Power BI are intuitive, interactive, and modern. They support detailed analysis like drill-up, drill-down and drill through analysis. In addition to the available ones, users can import other visuals,
ii. Good collaboration – multiple users can change the file at the same time without losing changes,
iii. Ability to connect to various data sources,
iv. Integration with Excel,
v. Automatic update of reports from local data sources via Personal Gateway , without moving data to the cloud,
vi. It supports large data sets – up to one hundred million rows,
vii. The ability to embed Power BI directly into applications and sites, so that reports can be used without leaving the current environment.

Among the disadvantages can be found [47]:

i. Inability to work with complex tables and their connections. Power BI must clearly and unambiguously recognize relationships between tables. In the absence of unique identifiers, errors may occur,
ii. Visually overloaded user interface - due to a large number of visuals, configurations and other functionalities,
iii. Challenging work with DAX formulas - unintuitive syntax and rules,

iv. The platform is Closed -source code platform - users do not have access and cannot change and adapt the program as needed.

4. Report Creation

Depending on the type of tool and reporting area, the approach to report creation may differ. However, the overall process contains several key stages. Based on the literature, the following life cycle model of report creation is proposed [48, 49, 50, 51, 52]:

i. Collecting requests for reporting and defining the goal of reporting,
ii. Identification of data sources and data collection,
iii. Data preparation,
iv. Data modeling,
v. Data visualization,
vi. Testing and validation of reports,
vii. Publication and sharing reports.

The second half of the paper describes the practical research conducted in both tools. Practical research involves the creation of two reports, where the implemented phases of the life cycle model are described. Both reports are created using the same data, with the goal of obtaining identical results.

The data used was taken from the company's internal learning platform. The input data is delivered in eleven different text format files (CSV – Comma Separated Values), where each file represents one table:

i. Customer_Accounts.csv
ii. Customer_Contacts.csv
iii. Customer_Feedback.csv
iv. Orders.csv
v. Product_Subcategory.csv
vi. Products.csv
vii. Regions.csv
viii. Sales_Q1
ix. Sales_Q2
x. Sales_Q3
xi. Sales_Q4.

CSV is a format for storing tabular data and is often used to exchange data between different systems. It is very simple and supported by most tools. What is characteristic of this format is that each line of the file represents one row of the table, and values from different columns are separated by a separator. This format does not contain metadata, that is, information about data such as cell formats, colors, fonts, formulas, and more.

The data used covers several areas of one business, with the focus on sales. All sales transactions and accompanying data are recorded in four files: Sales_Q1, Sales_Q2, Sales_Q3 and Sales_Q4 . These four tables will later be combined into one table that represents the main fact table of this data set. The tables Customer_Feedback and Orders are two additional fact tables. Customer_Feedback contains a record of all customer comments, satisfaction ratings, response times, and more. The Orders table is a record of orders, with their dates and statuses.

The Customer_Accounts and Customer_Contacts tables contain detailed customer data such as phone numbers, email addresses, customer regions, and more. These two tables represent dimensional tables and allow for a more detailed analysis of customers. The Products and Product_Subcategory tables contain more detailed information about available and sold products.

They contain data for things like product names, categories, subcategories, product prices, and more. These two tables are also dimension tables. The Region table is another dimensional table, which, in addition to the ID of the region, also contains its name.

4.1 Creating Report in Power BI

The stages of the life cycle of a report created in Power BI will be described in the continuation of the work. As the report was created exclusively for work purposes, not all the previously listed phases will be described, but only those implemented.

4.1.1 Collecting requirements and defining the reporting objective

In a real business environment, the first phase of the report creation lifecycle is dedicated to gathering reporting requirements. In that phase, in cooperation with interested parties, the desired reporting requirements and goals are defined.

As the available data relates to sales, the aim of this report is to show the key aspects of the business through three dimensions: sales performance, product performance and customer satisfaction. By analyzing these three groups of data, the report should enable data-based decision-making, identification of trends and business opportunities, and timely response to potential challenges.

4.1.2 Identification of data sources and data collection

In the second phase of the report creation life cycle, it is necessary to identify the necessary sources for data collection, then identify the way to access the sources and download the data. For the purposes of this paper, the data available in the eleven Excel files described in the previous chapter were used.

Get Data option was used and then the Text/CSV option (Figure 4), where it was necessary to select the desired file in the File Explorer window.

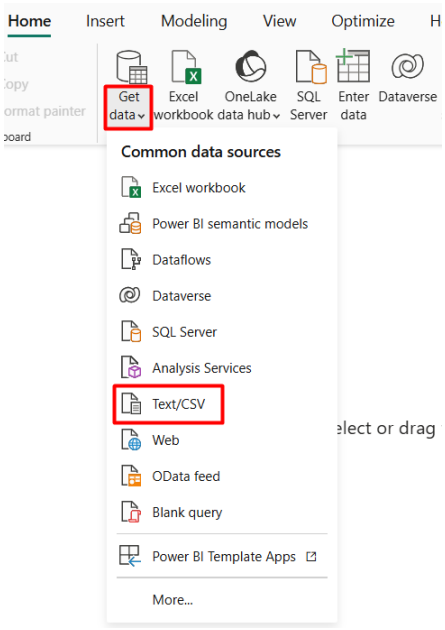

Fig. 4. Option to import data from files

After opening the window with the displayed loaded data, the Load option is selected (Figure 5). The procedure was repeated for each of the files.

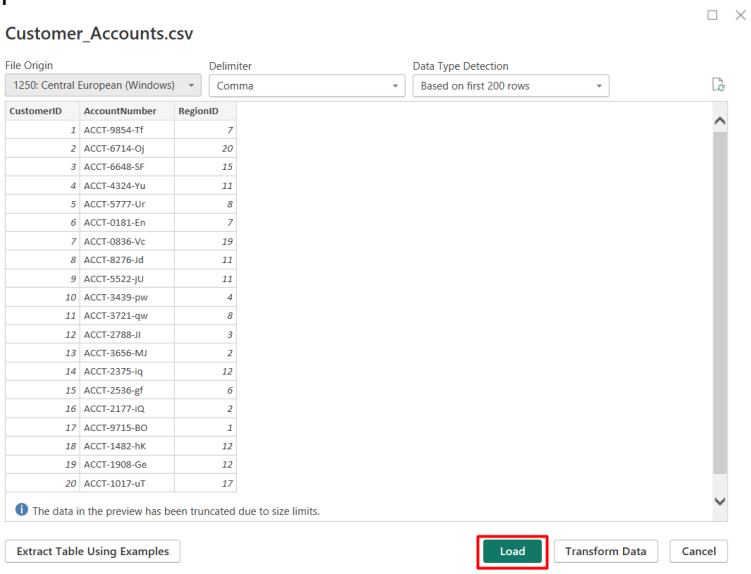

Fig. 5. Pop-up window for importing data from files

As for the sales related files (Sales_Q1.csv, Sales_Q2.csv, Sales_Q3.csv and Sales_Q4.csv), they are given separately for each quarter, but have the same data structure. To avoid manual merging of these four files in Power BI itself, a folder with these four files was created. This enables folder import as a data source where Power BI loads all available files and treats them as one set. In addition to the automatic merging of files, the dynamic import of new data has also been achieved. In case it is necessary to add data from the next quarter, it would be enough to add a new file to the folder with existing sales data, where Power BI would automatically recognize that file and include it in the report during the next data update.

To import data, it is necessary to select the Get Data option located in the ribbon bar in the Home section. Clicking Get Data brings up a drop-down list of available import options. Among them is the More option, which must be selected, and which launches the window shown in Figure 6. From the available list, the Folder option must be selected.

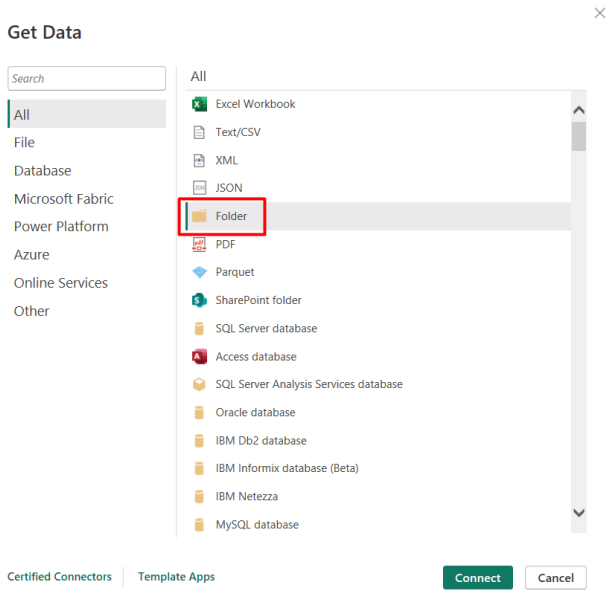

Fig. 1 Option to import data from a folder

After that, you need to enter the path to the desired folder or directly select it via the Browse option. After selecting the desired folder, the following window appears, shown in Figure 7, where the Combine & Transform Data option is selected. Selecting this option opens the Power Query Editor directly.

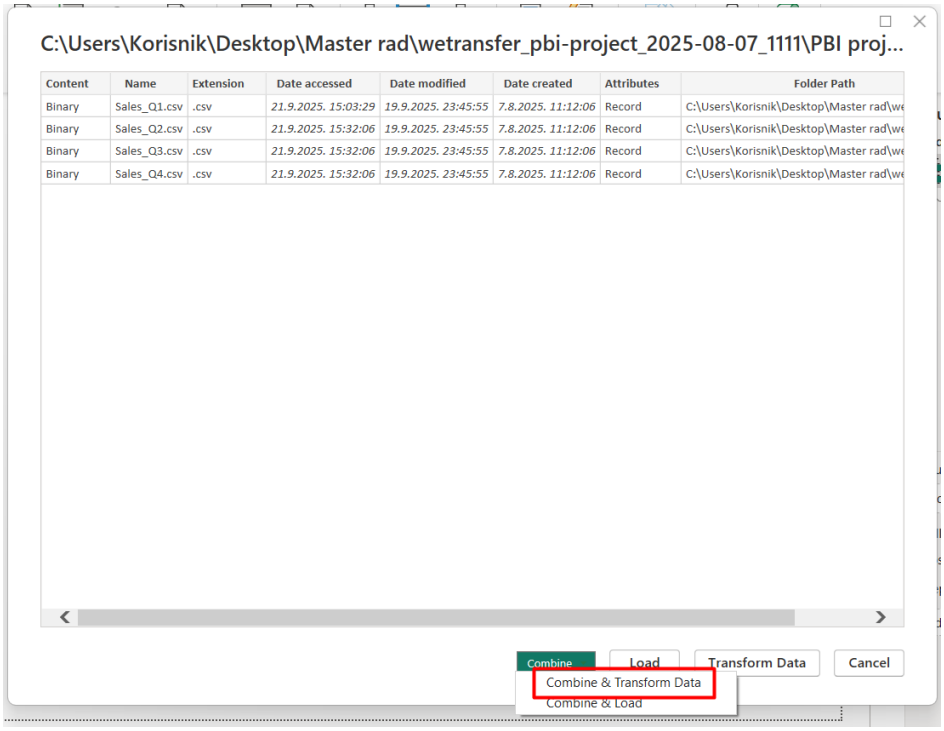

Fig. 7. Pop-up window for importing data from a folder

4.1.3 Data preparation

When it comes to data preparation, each of the tables was analyzed separately. This phase is carried out in the Power Query editor, which can be launched after loading the last desired file or from the Home section via the Transform Data option.

4.1.1.1 Management of duplicates and missing values

Tables can be fact or dimension tables. Fact tables store transactions or events, so they can contain multiple rows with the same primary key. In the example used, one customer can have several transactions, i.e. orders. Therefore, duplicates in the Customer_ID column are expected in the Sales Whole Year_Folder table, while the Order_ID must be unique. On the other hand, dimension tables store attributes about entities. In this example, the entities are customers, products, regions, and more. In dimension tables, an entity appears only once, so duplicates are not allowed [38]. Duplicates were deleted in the following cases:

i. Orders table: Order ID.
ii. Table Product_Subcategory : Subcategory ID.
iii. Table Regions: Region_ID.

Remove Duplicates option was used to delete duplicates (Figure 8). In the case that it is necessary to delete duplicates where the entire record is the same, it is necessary to mark all columns, while in the case that the duplicate is defined according to one column, it is necessary to select only that one. The option is located in the ribbon in the Home section, where you need to click on the drop-down menu for the Remove Rows option and select Remove Duplicates.

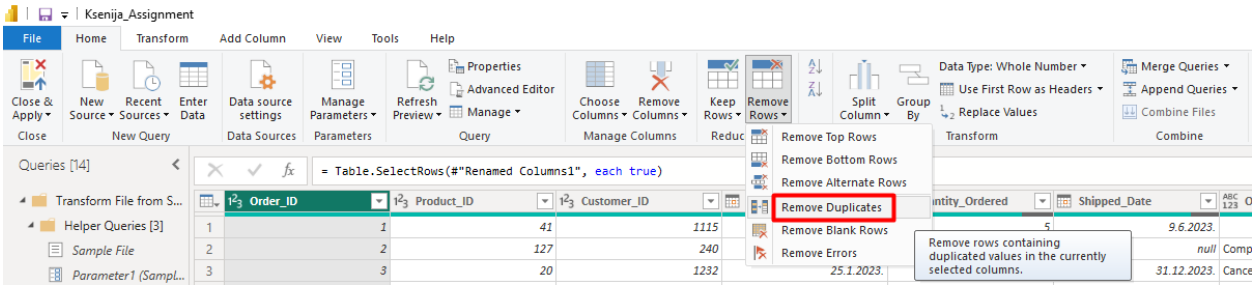

Fig. 2 Remove Duplicates option

When it comes to missing values, they can be allowed or not allowed. In cases where they are not allowed, and a pattern of data behavior could not be established based on which that data could be added, such records were deleted and excluded from further analysis. In cases of sufficient missing values, non-standardized values such as blank, non, nan, none, unknown, n/a, and others appeared, which were replaced by a null value through the Replace Values option, which will be described later.

4.1.4 Standardization and data types

Standardization and data types included checking whether the data was entered correctly and declared consistently. It was analyzed whether the number was entered with letters or numbers, whether the dates were formatted the same, what separator was used, whether an uppercase or lowercase letter was used somewhere, an abbreviated name, whether the same column type was used for related data, whether the column names were consistent, and more. The data is arranged in the following examples, as well as those similar to them:

i. Table Customer_Feedback: Standardization by replacing textual values with numerical ones in the Satisfaction column (two – 2, very bad – 1, excellent – 5);
ii. Table Product_Subcategory : Replace 999 value in column Subcategory_ID with value 13 and SubCat_#ERROR changed to SubCat_9, because column next to contains part related to ID;
iii. Tables Customer_Feedback, Orders, Customer_Accounts, Customer_Contacts: Standardization of column names by renaming Customer id, Customer ID, Customerid, CustomerID and similar names to Customer_ID.
iv. Data types are standardized in all tables: columns with dates are formatted as Date type, columns with ID values and ordered quantity as integer values and others.

The data in the given examples is sorted using the following options:

i. Replace Values: This option can be called in several ways, one of them is to right-click on the desired column and start the Replace Values option, after which a window appears where you need to enter which value needs to be replaced and the value by which it is changed (Figure 9).
ii. Change type: It is necessary to mark the column where the data type needs to be changed and right-click to select the Change type option, after which a drop-down list with available types appears (Figure 10).
iii. Rename Column*:* Renaming columns can also be done in several ways. The simplest way is to double-click on the desired column to turn on the text editing option.

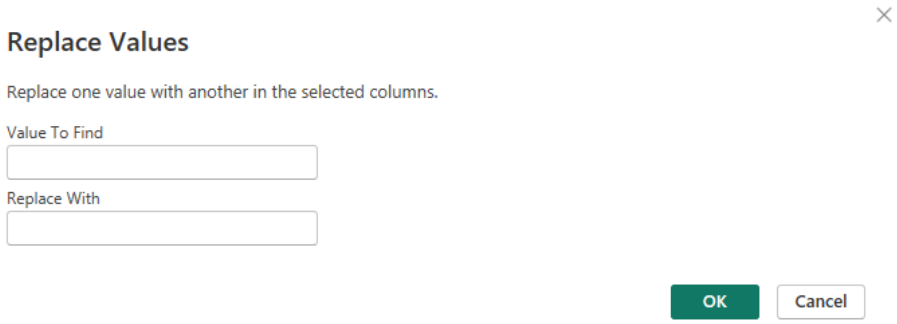

Fig. 3 Replace Values option

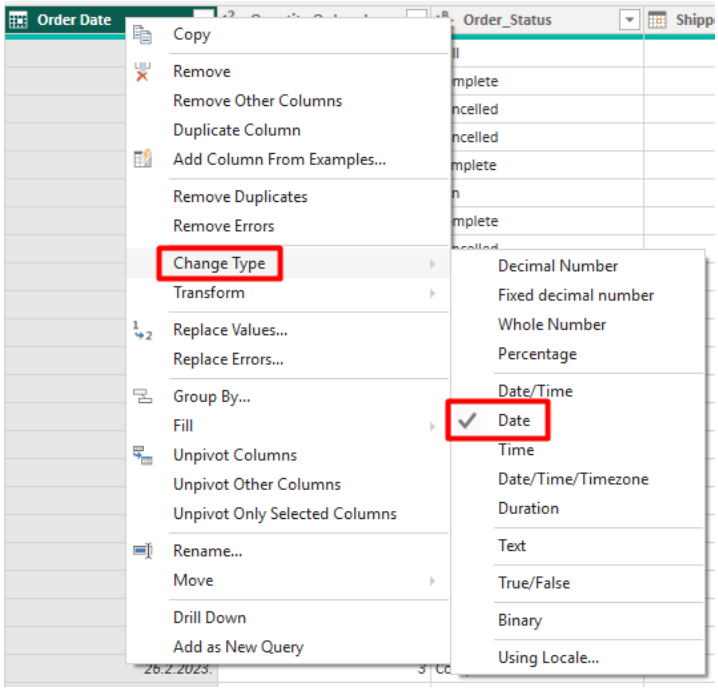

Fig. 4 Change Type option

4.1.5 Data modeling

Data modeling allows connections to multiple data sources/tables through different types of relationships. In this way, it is possible to create a data model. The data model consists of dimensional and fact tables. A good data model is the basis for subsequent data visualization, filtering and analysis [15, 20, 35].

Creating a calendar table

When it comes to data modeling, first a calendar table is created. A calendar table represents a dimension table with the goal of providing a complete and consistent time context for analysis. Using the calendar table, it is possible to create hierarchies of dates (year, quarter, month, day) and their application in all visuals and analyzes with a time dimension, i.e. drill-up and drill-down analysis. It is also necessary for using time-intelligence functions in DAX, functions for calculating cumulative values (YTD - Year-To-Date, QTD - Quartal-To-Date, MTD - Month-To-Date), comparison with previous periods and others. In the case of using only dates from fact tables, analyses are often incomplete because these data do not include every date in continuity (e.g. days without sales). Only a separate

calendar table can guarantee that calculations will be correct and consistent [53, 54]. The recommended practice by Microsoft [53] is to create calendar tables using the following DAX code:

```
Calendar_Table =
VAR MinDate = MIN('Sales Whole Year_Folder'[Sale_Date])
VAR MaxDate = MAX('Sales Whole Year_Folder'[Sale_Date])
RETURN
ADDCOLUMNS(
   CALENDAR(MinDate, MaxDate),
   "Year", YEAR([Date]),
   "Month Number", MONTH([Date]),
   "Month", FORMAT([Date], "MMMM"),
   "Year-Month", FORMAT([Date], "YYYY-MM"),
   "Quarter", "Q" & FORMAT([Date], "Q"),
   "Day", DAY([Date]),
   "Weekday", FORMAT([Date], "dddd"),
   "Weekday Number", WEEKDAY([Date], 2)
)
```

Creating a measures table

The measures table is a separate table for the centralization of all created measures. The measures table is useful for organizational and visual reasons and makes the model neat, transparent and sustainable. Practice has shown that it is always better to create your own measures, as known as explicit measures, instead of using implicit ones. The reason for this is that the measures created are part of the model, can be used in multiple visuals, have format control, can be used in other measures and more [55, 56].

To create the measures table, it is necessary to start the Enter data option from the ribbon bar in the Home section. You need to rename the table to the desired name and then click the Load button, after which an empty table appears. After that, you need to create the desired measures using the DAX code. The DAX formulas for the three selected measures will be shown below:

i. ModeSatisfaction measure – serves to calculate the most common satisfaction rating based on the Satisfaction column from the Customer_Feedback table.

ii.

```
ModeSatisfaction =
VAR OceneSaBrojem =
    ADDCOLUMNS(
        VALUES(Customer_Feedback[Satisfaction]),
        "Broj", CALCULATE(COUNTROWS(Customer_Feedback))
    )
RETURN
    MAXX(
        TOPN(1, OceneSaBrojem, [Broj], DESC),
        [Satisfaction]
    )
```

iii. TopProduct measure – serves to calculate the best-selling product based on the Quantity_Ordered column from the table Sales Whole Year_Folder and returns the product name as output.

```
TopProduct =
VAR SummaryTable =
    ADDCOLUMNS (
        SUMMARIZE (
            'Sales Whole Year_Folder',
            'Sales Whole Year_Folder'[Product_ID]
        ),
             "TotalQuantity", SUM ( 'Sales Whole
Year_Folder'[Quantity_Ordered] )
    )
VAR TopProductID =
    TOPN (
        1,
        SummaryTable,
        [TotalQuantity],
        DESC
    )
RETURN
    CALCULATE (
        MAX ( Products[Product_Name] ),
        FILTER (
            Products,
              Products[Product_ID] IN SELECTCOLUMNS (
TopProductID, "Product_ID", [Product_ID] )
        )
    )
```

iv. AvgQuantityOrdered – a measure that calculates the total average ordered quantity based on the Quantity_Ordered column from the table Sales Whole Year_Folder.

```
AvgQuantityOrdered =
AVERAGEX(
    SUMMARIZE(
        'Sales Whole Year_Folder',
         'Sales Whole Year_Folder'[Customer_ID],
          "CustomerTotalQuantity",
                                SUM('Sales     Whole
Year_Folder'[Quantity_Ordered])),
    [CustomerTotalQuantity]
       )
```

Creating a data model

When it comes to the data model itself, Power BI automatically recognizes most relationships based on primary keys and uniform column names. The model is of the extended star type scheme (Figure 11), where all relations are one-to-many from dimension tables to fact tables. The model contains three fact tables: Sales Whole Year_Folder, Orders and Customer_Feedback; then the

following dimension tables: Customer_Contacts, Customer_Accounts, Regions, Products, Product_Subcategory. Measure_table cannot be characterized either as a fact table or as a dimension table, but is an auxiliary table. The table that represents an exception is the Product_Mapping table. This table was created as a bridge table that enabled the connection of Products and Product_Subcategory, due to their non-conforming categories and thus provides a corresponding relationship.

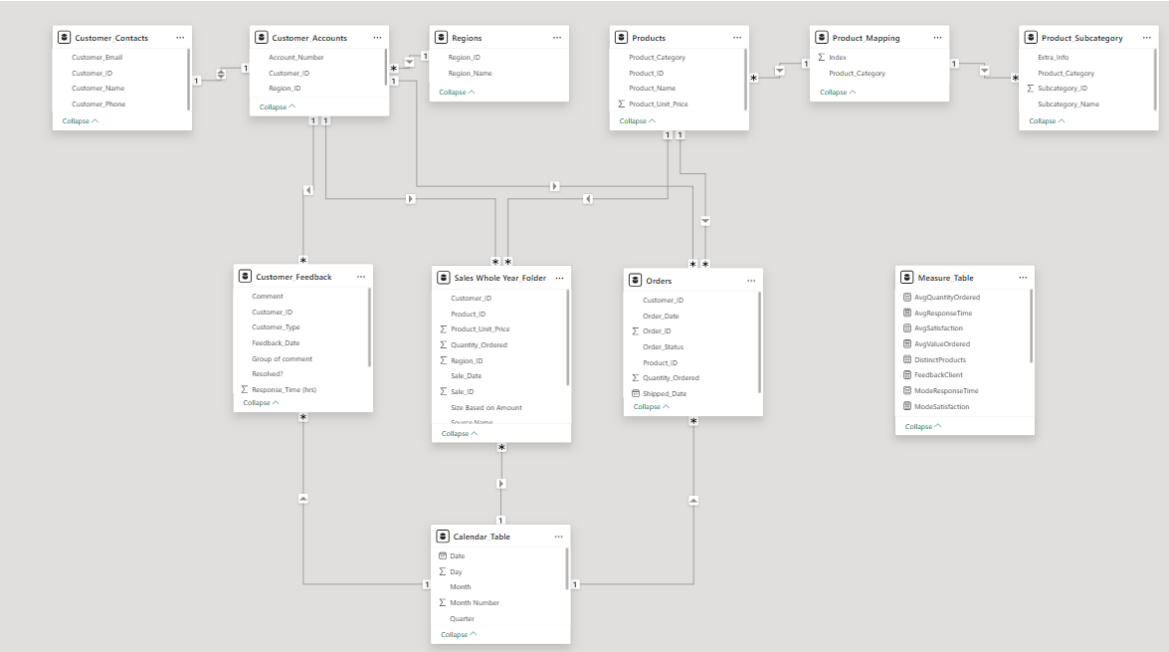

Fig. 5 Created data model

4.1.6 Visualization

Visualization is a very important step in creating reports because it should enable easier understanding and faster review of existing information. Compared to text or large and unreadable tables, visuals should enable faster analysis and understanding of data.

There are many options for creating visuals, choosing their type, design and functionality, and it can be said that there is no universal solution that is applicable for every type of report or data. However, what can be considered when creating the report are best practice tips. Different authors suggest different tips, some of which include the following [57, 58, 59]:

i. Always have a defined audience and visualization goal,
ii. Key information must be easily visible and highlighted,
iii. Practice simple design and use a minimalist approach,
iv. Well-aligned elements make the visualization more transparent and professional,
v. Consistency in colors, fonts and styles increases readability,
vi. Titles, legends and labels should be unambiguous and understandable,
vii. Avoid visuals that are difficult to read and understand - eg. 3D visuals,
viii. Do not display numbers with more than three or four digits, e.g. It is easier to read $3.4M instead of $3 400 000, remove other unnecessary data from the visual,
ix. Use appropriate graphs for the desired display - use bar and column graphs to compare values; asks for graphs when there are fewer than eight categories and when the relationships of parts to the whole need to be shown; measurement charts are great for showing current status in the context of goal achievement,
x. Use filters and slicers for more detailed analysis and more.

Areas of analysis in the report

The report is divided into three pages. Each page is dedicated to a different area: Sales Overview, Product Performance and Customer Feedback. Each of the pages is created so that it shows cards with relevant indicators at the top, then visuals in the middle of the page and finally a table for a more detailed overview of the information. The layout of the mentioned pages is given below:

i. Sales Overview: This page provides a comprehensive overview of sales performance. The displayed visuals should facilitate the understanding of the achieved results and sales trends (Figure 12).

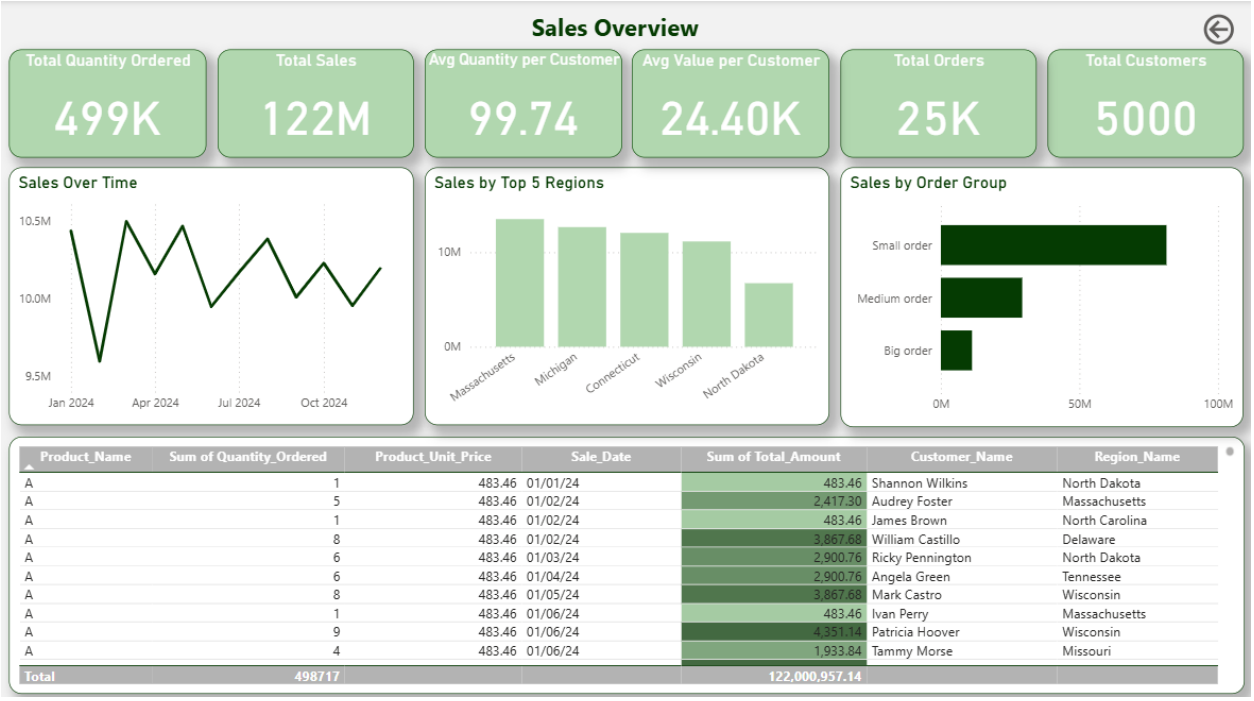

Fig. 6 Sales Overview page

ii. Product Performance: This page tracks key product metrics. The focus is on the ordered quantity, analysis of the most popular products and their categories (Figure 13).

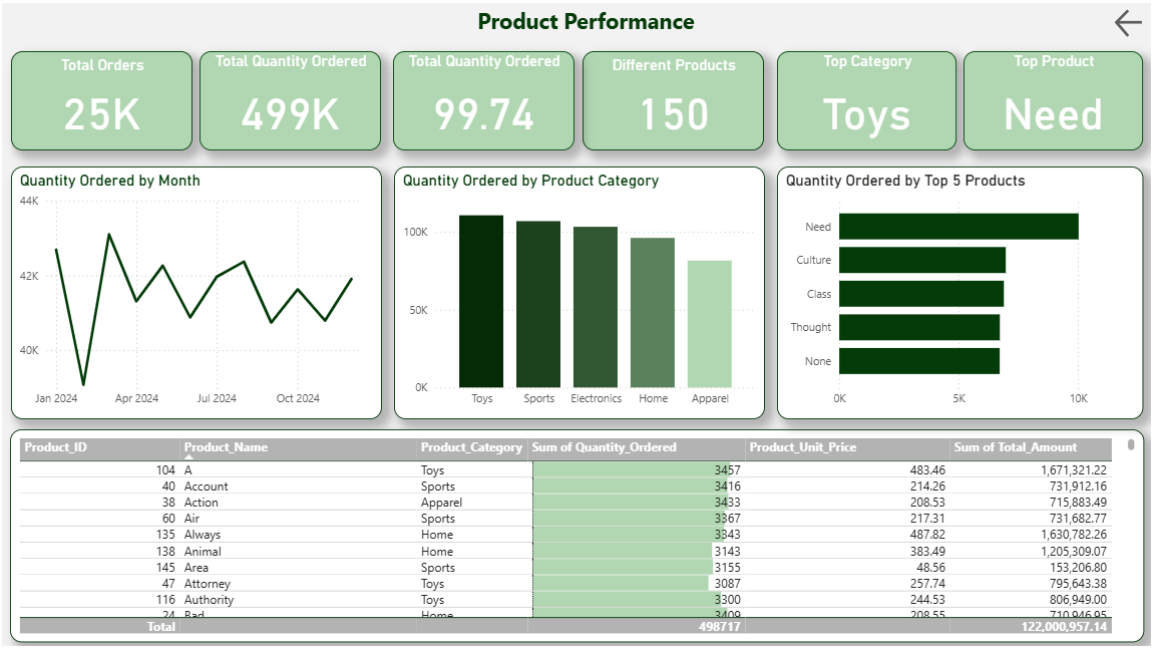

Fig. 7 Product Performance page

iii. Customer Feedback: This page provides a comprehensive overview of customer feedback such as satisfaction ratings, response times, number of comments, and the like. The displayed visuals should facilitate the understanding of customer satisfaction, as well as the reasons for their dissatisfaction (Figure 14).

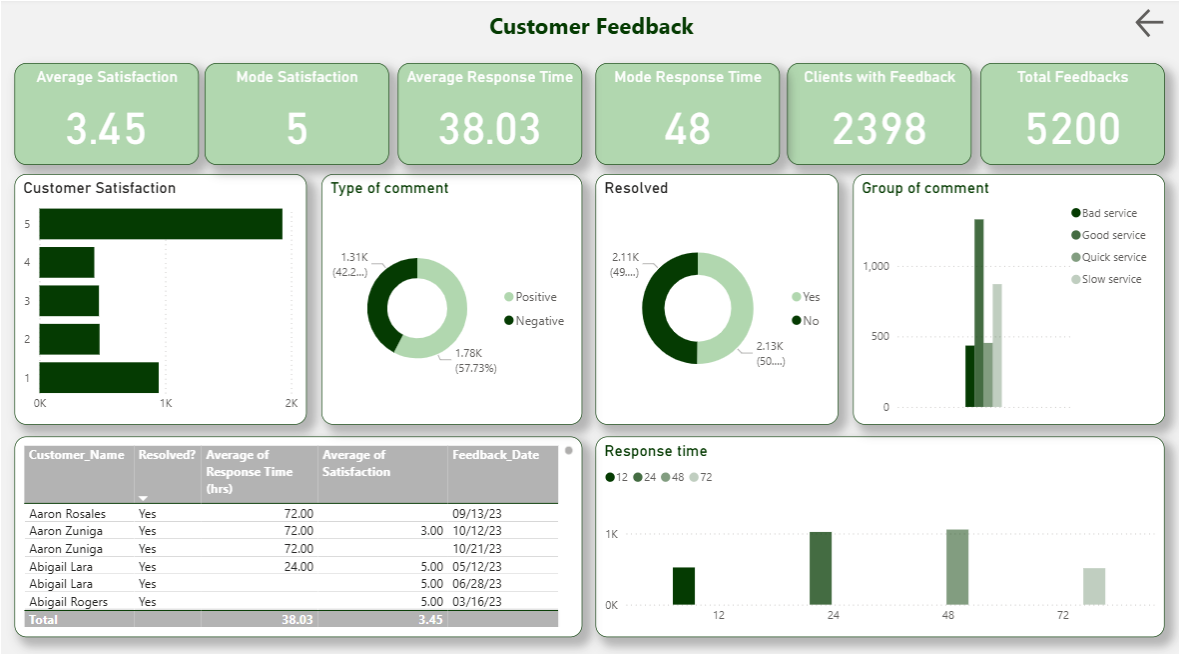

Fig. 8 Customer Feedback page

Visuals

Given that all three sides have identical visuals, the process of creating each of them will be described below:

i. A card is a simple visual that can only display one piece of information. To create this visual, you need to select a specific type of visual in the Visualisations section and then drag the desired column from the Data section to the Fields section (Figure 15). By right-clicking on the name of the selected measure in the Fields section , various options for display in the tab appear.

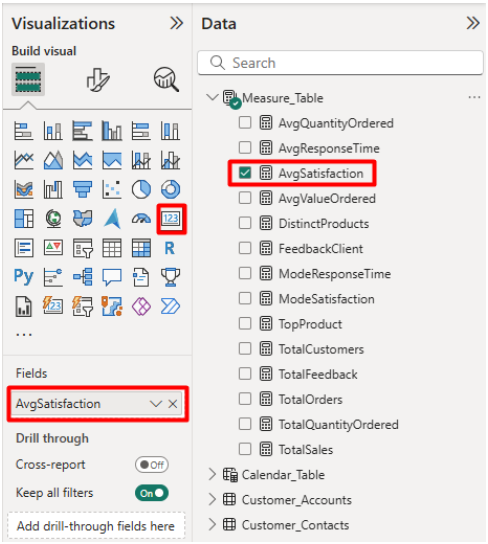

Fig. 15. Creating a card visual

ii. A bar/column chart or a line chart are the types of visuals most often used to compare values. As in the previous example, it is necessary to select this type of visual from the Visualisations section and then drag the desired data from the Data section into the X, Y axis and legend fields if necessary (Figure 16).

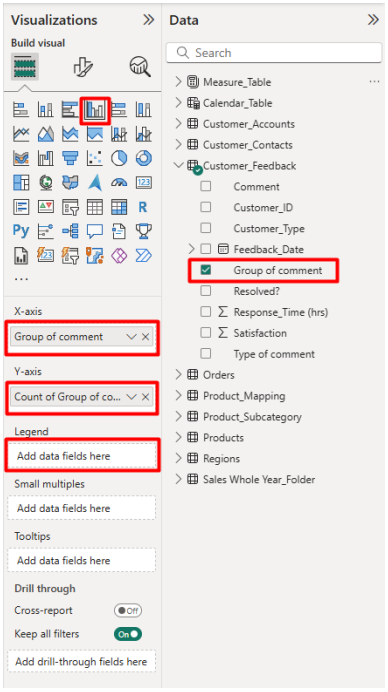

Fig. 16. Creating a bar/column chart

iii. A donut/pie chart is a visual that is most often used when it is necessary to show the relationship of parts to the whole. The procedure for adding data is the same as in the previous examples (Figure 17).

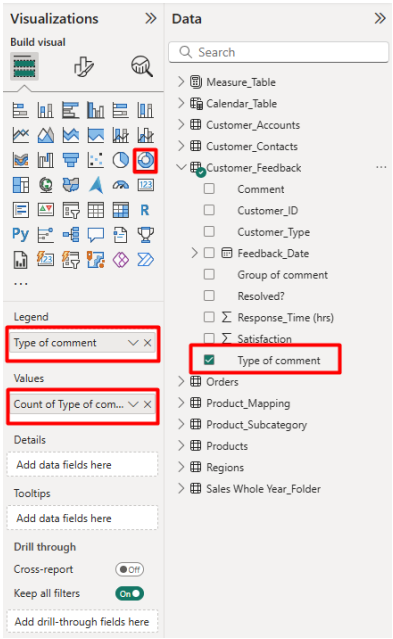

Fig. 17. Creating a donut visual

iv. Table visuals, although they may seem overwhelming, are a common practice for enriching reports. What is the main difference is that only the desired columns can be displayed in the desired order in this visual. This allows the user a more detailed analysis and insight into what the visuals themselves convey. The procedure for adding data is similar to the previous examples (Figure 18).

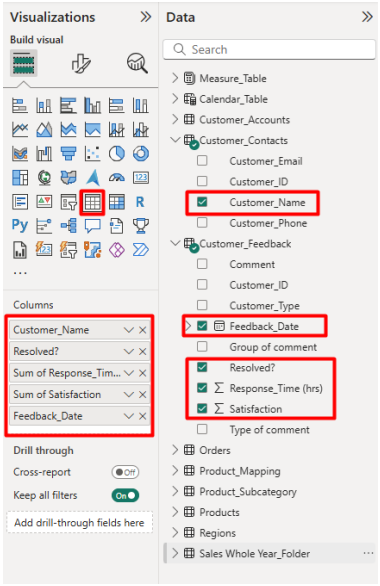

Fig. 18. Creating table visuals

Each of the created visuals, as well as the pages and titles themselves, are modified using the options available in the Visualizations panel in the Format your visual section. All changes concern colors, fonts, frames, titles and legends of visuals, as well as data display.

Slicer panel

For more detailed analysis and interactive insight into the data, the report contains slicers. Slicer in this report is an interactive element located on the report page itself. In this example, a pop-up panel is created. It is created using the bookmark option, a rectangle as a background, the desired slicers and a show/hide button. First, the background is created, slicers are placed over it, and then these elements are grouped. Then, a bookmark is created for the created group of elements when the group is visible. After creating a bookmark for a group of elements when they are visible, it is necessary to create a bookmark when they are not visible. Then buttons are created to which actions are assigned. One action will be the display action of the grouped elements, and the other will be the hide action. In this way, the effect of a pop-up slicer panel is achieved.

Selected slicers for the Customer Feedback page are shown on the right side of Figure 19. They allow users to filter the displayed data. The displayed slicers are in the form of a drop-down list and concern: Customer_Name, Customer_Type, Year, Month, Group of comment, Resolved, Response Time. Selecting one or more values from one or more slicers affects all visuals available on a given page.

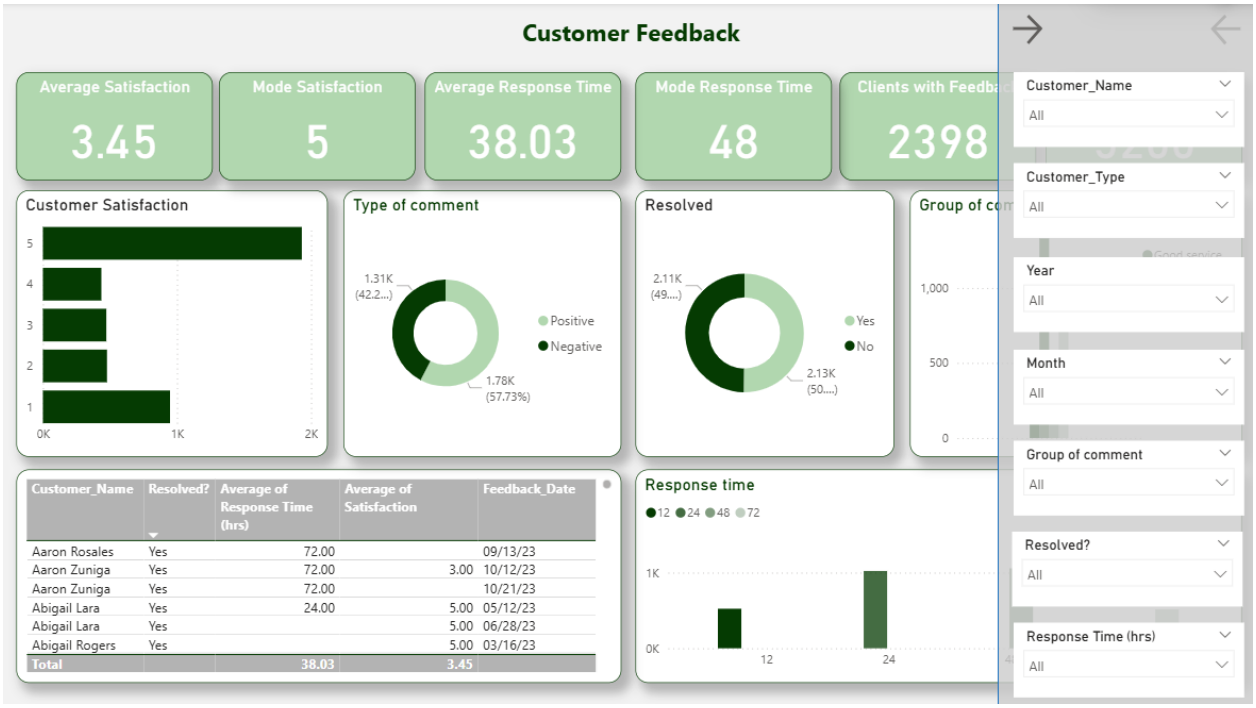

Fig. 19. Interactive slicer panel

Drill-up/drill-down

In addition to available slicers, due to the existence of Calendar_Table drill-up/drill-down analysis is enabled in visuals that display data with a time dimension. This type of analysis is activated on the visual shown in Figure 20. After activating this option, different time hierarchies such as day, month, quarter and year can be displayed using the remaining arrows.

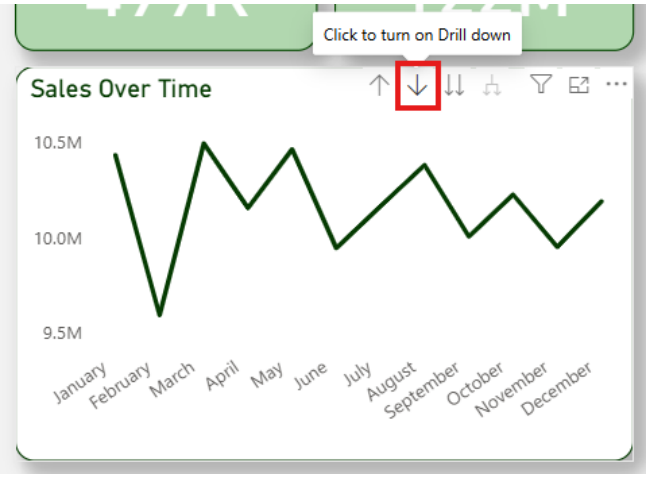

Fig. 20. Activating drill-up/drill-down analysis

The display of the effect of this option is shown in Figure 21. Therefore, on the left side of the figure, the data is shown at the monthly level, while the next one shows the data at the quarterly level.

Fig. 21. Effect of drill-up analysis

4.2 Creating Report in MS Excel

In the continuation of the work, the stages of the life cycle of a report created in MS Excel will be described. The stage "Collecting requirements and defining the reporting objective" will not be dealt with separately, since it is already described in detail in the previous chapter.

4.2.1 Identification of data sources and data collection

The process of identifying data sources and collecting data does not differ much from the process described in the Power BI part of the paper. To create reports in MS Excel, the same data was used as in the case of reports in Power BI. The files were imported via the Get Data and From File options available in the Data section. In this case, the sales data were also imported via the From Folder option (Figure 22).

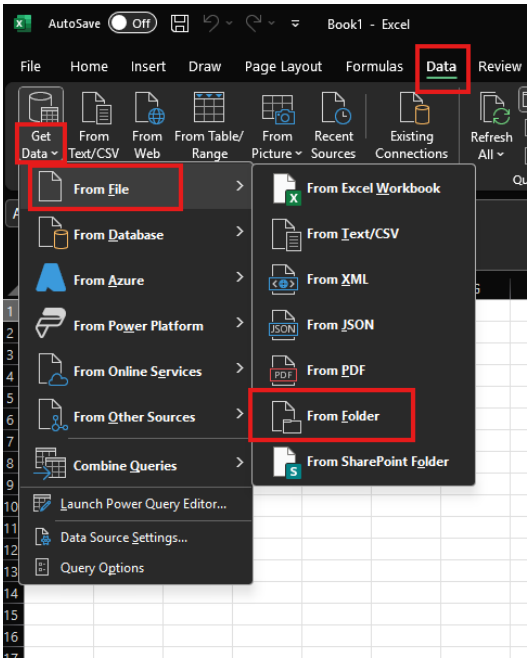

Fig. 22. Option to import data from a folder

The remaining steps are identical to those in Power BI. A window with the identified files in the folder appears again, where you need to select one of the options available in the Combine drop-down list: Combine & Load or the Combine & Transform Data option (Figure 23).

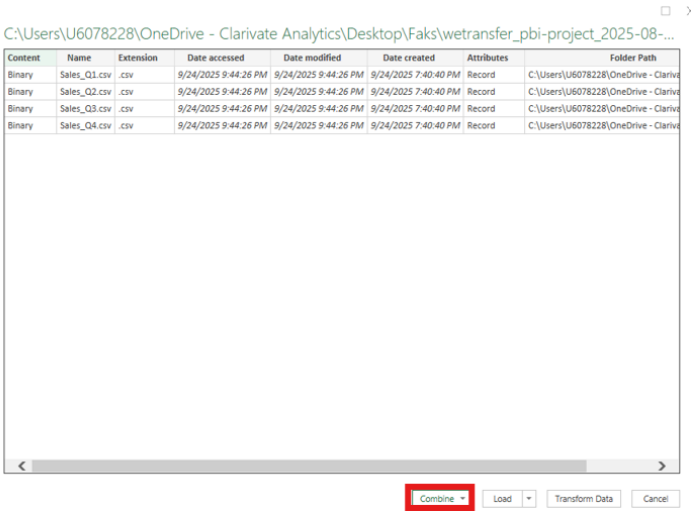

Fig. 23. Pop-up window for importing data from a folder

The remaining seven CSV files were imported via the From Text/CSV option also available in the Data section (Figure 24). After starting the option, it is necessary to select the desired file in the File Explorer window and repeat the procedure for each of the files.

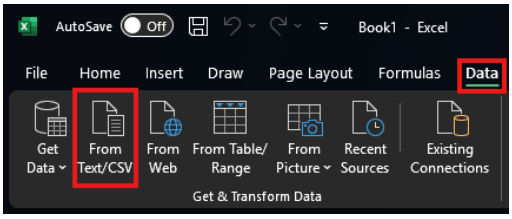

Fig. 24. Option to import data from files

4.2.2 Data preparation

Each of the tables was analyzed separately. Like Power BI, this phase is carried out in the Power Query editor, which can be launched via the previously used Get Data option by selecting Launch Power Query Editor (Figure 25).

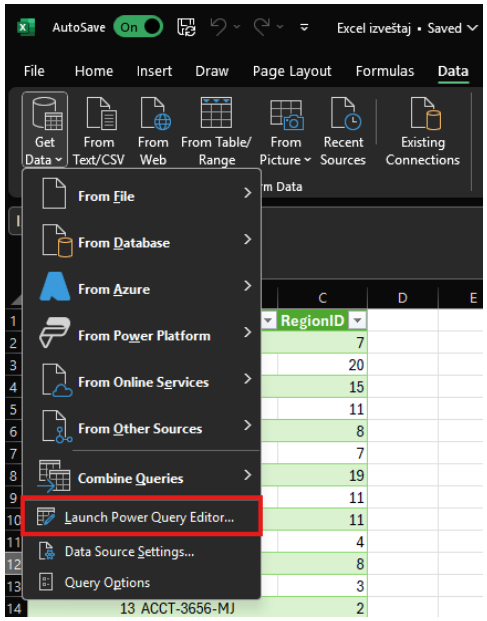

Fig. 25. Power Query editor startup procedure

As the Power Query editor is a common component of both tools, the data preparation procedure is identical to the procedure implemented in Power BI (Figure 26). The data underwent exactly the same transformations.

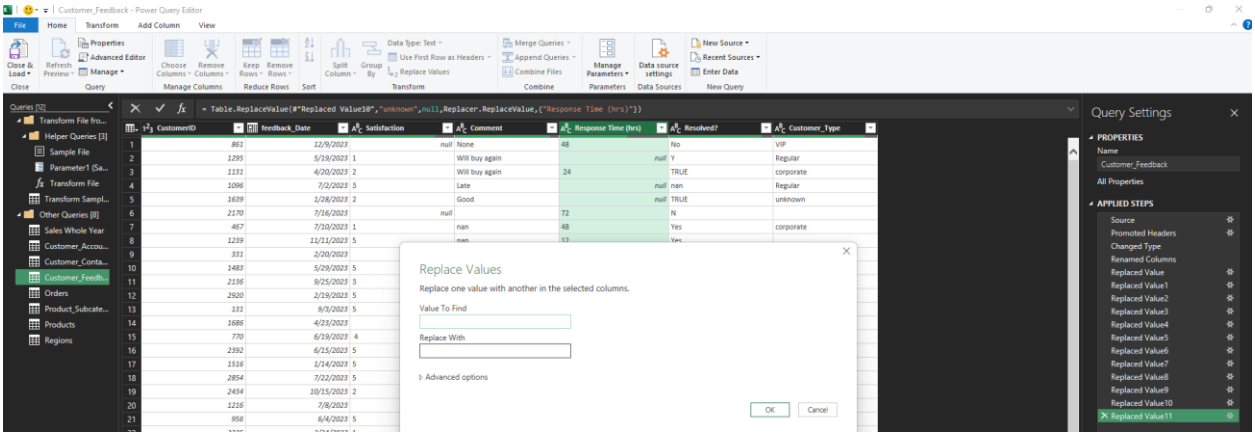

Fig. 26. Layout of the Power Query editor in Excel

4.2.3 Data modeling

Although the previous three phases are almost completely identical to the phases implemented in Power BI, the data modeling phase showed significant differences. Data modeling takes place in the Power Pivot editor. However, in order for transformed and prepared tables to be visible in this editor, they need to be imported. Tables can be imported by marking the desired table in the Queries section, then starting the Close & Load drop-down list and selecting the Close & Load To option (Figure 27).

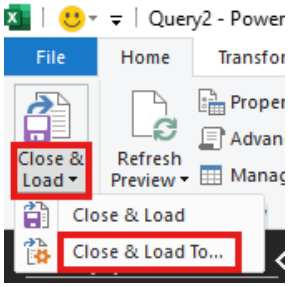

Fig. 27. Close & Load option for importing tables into the Power Pivot editor

Selecting this option brings up the Import Data pop-up window. In the displayed window, it is necessary to check the Only Create Connection and Add this data to the Data Model options. The procedure must be repeated for each table individually (Figure 28).

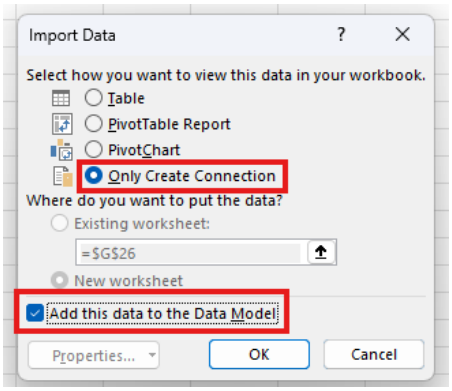

Fig. 28. Pop-up window for importing tables into the Power Pivot editor

The effect of table import can be seen by starting the Power Pivot editor. Figure 29 shows all imported tables.

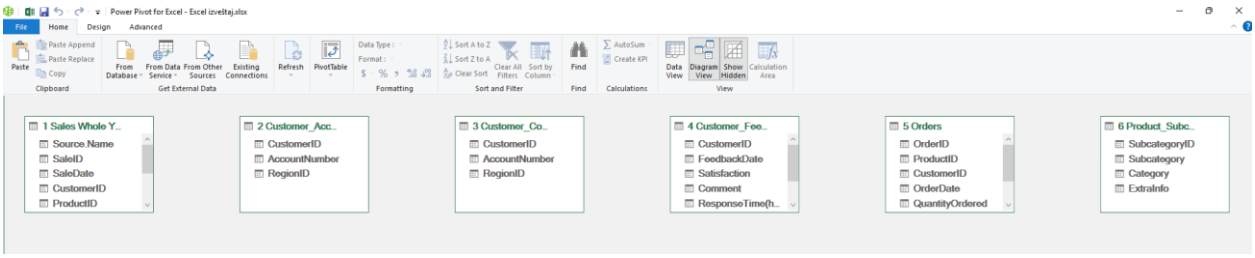

Fig. 29. Appearance of the Power Pivot editor after importing the desired tables

Creating a calendar table

Creating a calendar table is a fairly simple process in the case of Excel, compared to the case in Power BI, where it is necessary to create it using DAX code. In the Design part, it is necessary to select the New option available in the Date Table drop-down list (Figure 30).

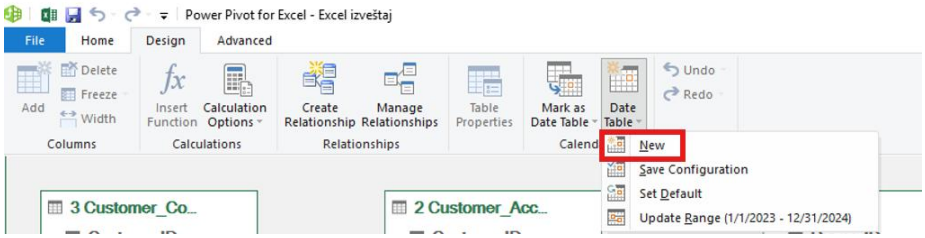

Fig. 9 Option to automatically create a calendar table

It can be seen that the creation of the calendar table is automated. By selecting this option, a calendar table with the columns shown in Figure 31 is created.

Sal...	Year	Month Number	Month	MMM-YYYY	Day Of Week Number	Day Of Week
1/1/2023 ...	2023	1	January	Jan-2023	1	Sunday
1/2/2023 ...	2023	1	January	Jan-2023	2	Monday
1/3/2023 ...	2023	1	January	Jan-2023	3	Tuesday
1/4/2023 ...	2023	1	January	Jan-2023	4	Wednesday
1/5/2023 ...	2023	1	January	Jan-2023	5	Thursday
1/6/2023 ...	2023	1	January	Jan-2023	6	Friday
1/7/2023 ...	2023	1	January	Jan-2023	7	Saturday
1/8/2023 ...	2023	1	January	Jan-2023	1	Sunday
1/9/2023 ...	2023	1	January	Jan-2023	2	Monday
1/10/2023...	2023	1	January	Jan-2023	3	Tuesday
1/11/2023...	2023	1	January	Jan-2023	4	Wednesday
1/12/2023...	2023	1	January	Jan-2023	5	Thursday
1/13/2023...	2023	1	January	Jan-2023	6	Friday
1/14/2023...	2023	1	January	Jan-2023	7	Saturday
1/15/2023...	2023	1	January	Jan-2023	1	Sunday
1/16/2023...	2023	1	January	Jan-2023	2	Monday
1/17/2023...	2023	1	January	Jan-2023	3	Tuesday
1/18/2023...	2023	1	January	Jan-2023	4	Wednesday
1/19/2023...	2023	1	January	Jan-2023	5	Thursday
1/20/2023...	2023	1	January	Jan-2023	6	Friday

Fig. 10 Appearance of the automatically created calendar table

Creating a measure table

Creating a measure table, the way it was done in Power BI, is not possible. In the previous example, it was not necessary to connect this table with the rest of the model, but it existed independently. It contained measures related to all fact tables. Creating this table in Excel requires a

longer and significantly more complex process, where you first need to create an empty table, import it into the Power Pivot editor, then create all the necessary measures and finally create relations with all the necessary fact tables. Due to the complexity and length of the process of creating the measures table, measures are created within Pivot tables, which will be discussed below.

Creating a data model

Unlike Power BI, which can automatically identify primary keys and relationship types, this is not the case in Excel. It is necessary to manually create a data model through the Create Relationship option in the Design section (Figure 32).

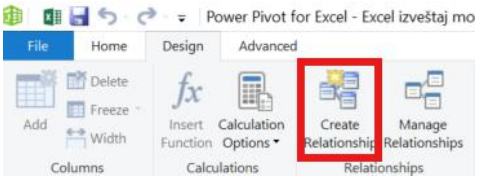

Fig. 32. Create Relationship option

By running the aforementioned option, a window appears with a suggested table for creating a connection. The desired tables for creating relations must be selected from the available drop-down lists and then, when the overview of the tables appears, mark the primary key (Figure 33).

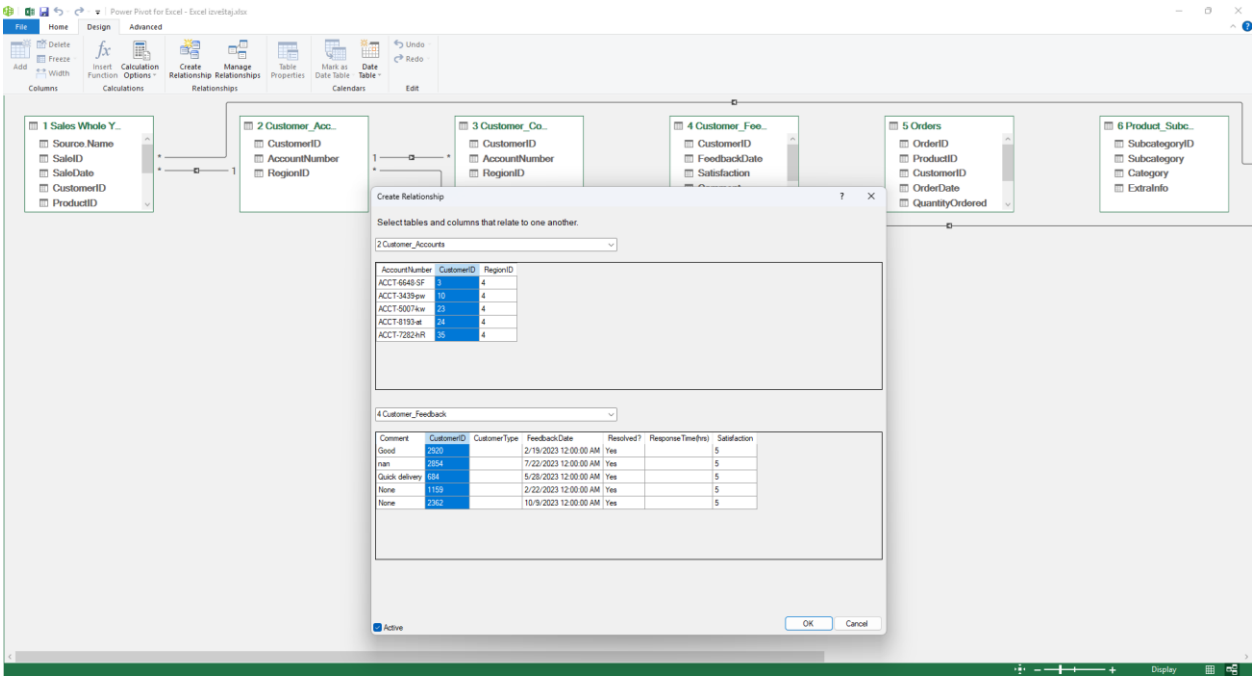

Fig. 11 Pop-up window for creating relations between tables

After defining all the necessary connections, the created model has the following structure (Figure 34):

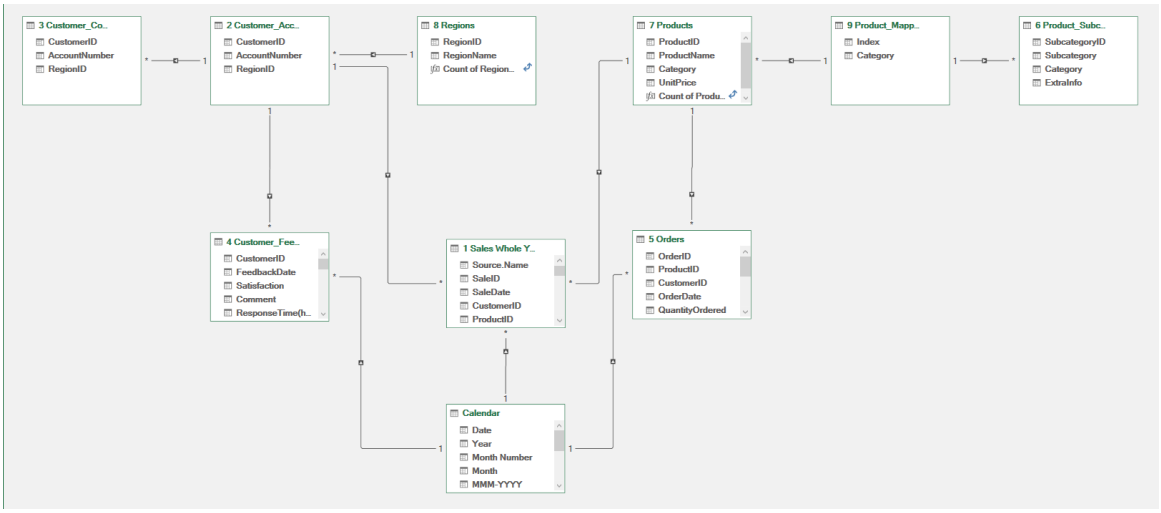

Fig. 12 Created data model

4.2.4 Visualization

To directly compare this phase as well, an attempt was made to recreate the report from Power BI. Power BI enables simpler and more intuitive creation of visualizations compared to Excel. Almost the entire visualization process is reduced to the drag-and-drop option, while in the case of Excel it is necessary to create Pivot Tables for each of the desired visuals. The process of creating some of the visuals will be presented below.

Areas of analysis in the report

The report is also divided into three pages in this example. Each page is dedicated to a different area: Sales Overview, Product Performance and Customer Feedback. Each of the pages of the report is designed to contain tabs with relevant indicators at the top, while visuals are displayed on the rest of the page. The layout of the created pages is shown below:

i. Sales Overview: Compared to the same page in Power BI, the table has been removed, and visuals such as Sales by Top 5 Categories, Sales by Top 5 Products and Sales by Order Status have been added (Figure 35).

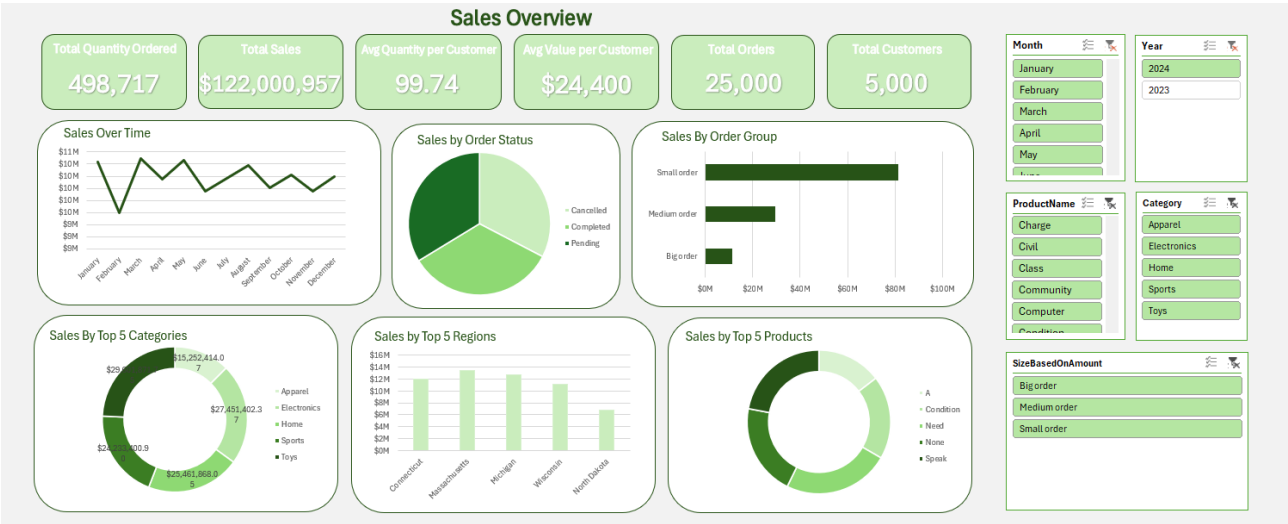

Fig. 35. Sales Overview page

ii. Product Performance: Compared to the same page in Power BI, the table has been removed, and visuals such as Quantity VS Value by Month and Number of Orders by Month have been added (Figure 36).

iii.

Fig. 36. Product Performance page

iv. Customer Feedback: Compared to the same page in Power BI, the table has been removed, and the Feedbacks Over Time visual has been added (Figure 37).

v.

Fig. 37. Customer Feedback page

Visuals

As previously mentioned, creating visuals is a somewhat more complex process when it comes to Excel. The most significantly observed differences concern the absence of indirect relations, visuals in the form of a table, as well as the creation of a Pivot table for each of the visuals individually.

The absence of indirect relationships leads to limited flexibility in data modeling. An indirect relationship can be described in the example of the existence of three tables: Table 1, Table 2 and Table 3. If there are defined relationships between Table 1 and Table 2, as well as between Table 2 and Table 3 - Table 1 and Table 3 are "connected" by an indirect relationship using a common relationship with Table 2. This functionality enables filtering related values, returning related values, and using them in different measures.

A visual table is omitted on each page of the report because Excel does not offer the ability to create such a view of the data. As an alternative, a Pivot table could have been used, but the effect would not have been the same due to the absence of certain functionalities such as indirect links, display of values without aggregation functions and others.

Pivot Tables were previously created and formatted. For each available page in the report, auxiliary worksheets containing only Pivot tables are created and they are named: PivotiSalesOverview, PivotiProductPerformance and PivotiCustomerFeedback. Visuals were created in auxiliary worksheets, from where they were moved to the official pages of the report.

All three sides have identical visuals, and the process of creating each type will be described below:

i. The tab, although a very simple and practical visual, does not exist as such in Excel. In order to recreate an identical type of visual, it is necessary to use some of the shapes and a simple Text Box that is referenced to the desired field in the Pivot table (Figure 38).

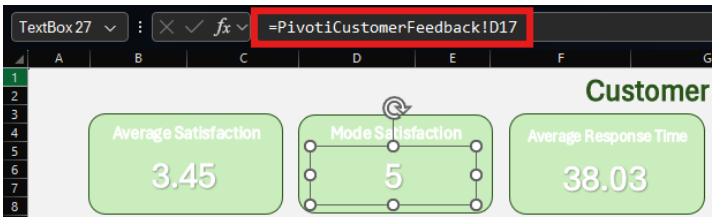

Fig. 38. Creating a card visual

ii. A bar/column chart or a line chart are the types of visuals most often used to compare values. In order to create a visual, you need to create a Pivot table with the desired axis values, then you need to mark the table and select the desired chart via the Recommended Charts option in the Insert section (Figure 39).

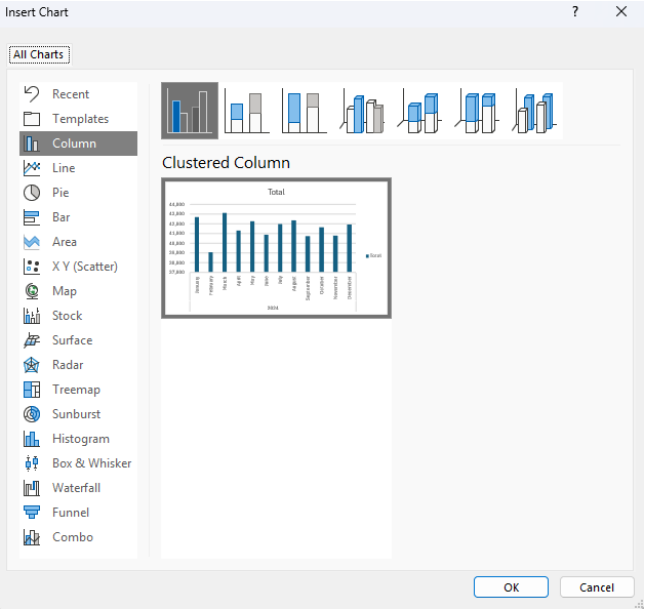

Fig. 39. Creating a bar/column chart

iii. A donut/pie chart is created in the same way as the previously described charts. The only difference is that this visual requires less data, that is, categorical data.

The created visuals are modified using the options available in the Format Shape section, where changes are implemented regarding the colors, font, frame, background, data, title and legend of the visual.

Slicer panel

For more detailed analysis and interactive insight into the data, the report contains slicers. The slicer creation process is more complex and longer compared to the Power BI process. The main reason lies in the capabilities of the data model and the absence of indirect connections. Slicer in Excel cannot guess by itself which Pivot Tables it needs to control. To create a slicer, you need to mark the desired Pivot table, select the Insert Slicer option available in the PivotTable Analyze section and select the desired criteria in the pop-up window (Figure 40).

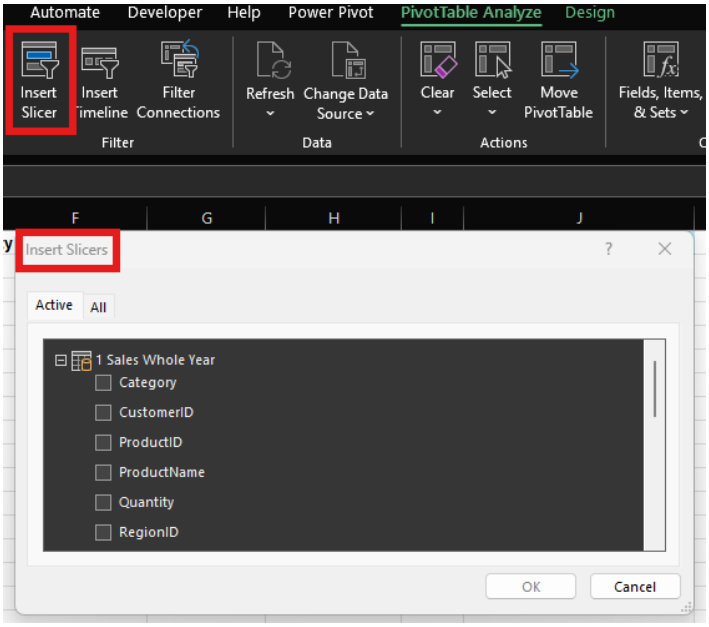

Fig. 40. Slicer creation procedure

After creating the slicer, it is necessary to manually define the connections with the remaining Pivot tables that he should control. Connections can be defined via the Report Connections option, which is available in the drop-down list opened by right-clicking. In the open window, it is necessary to mark all the desired tables for the given slicer (Figure 41). As slicers were also created in the help pages for Pivot Tables, they were eventually moved to the official report pages.

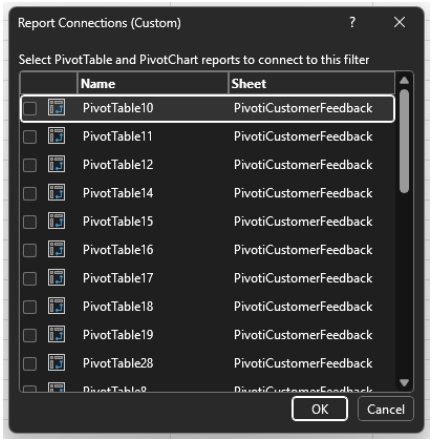

Fig. 13 Option to create slicer relations with tables

Drill-up/drill-down

Drill-up/drill-down analysis is also available in Excel. The condition for this is the existence of a hierarchy in the data model and the use of Pivot visuals. As the automatically created hierarchy for the calendar table does not contain quarters, the month-year drill-up analysis is shown. The analysis is activated by right-clicking on the desired axis, within the Drill-up/Drill-down option (Figure 42).

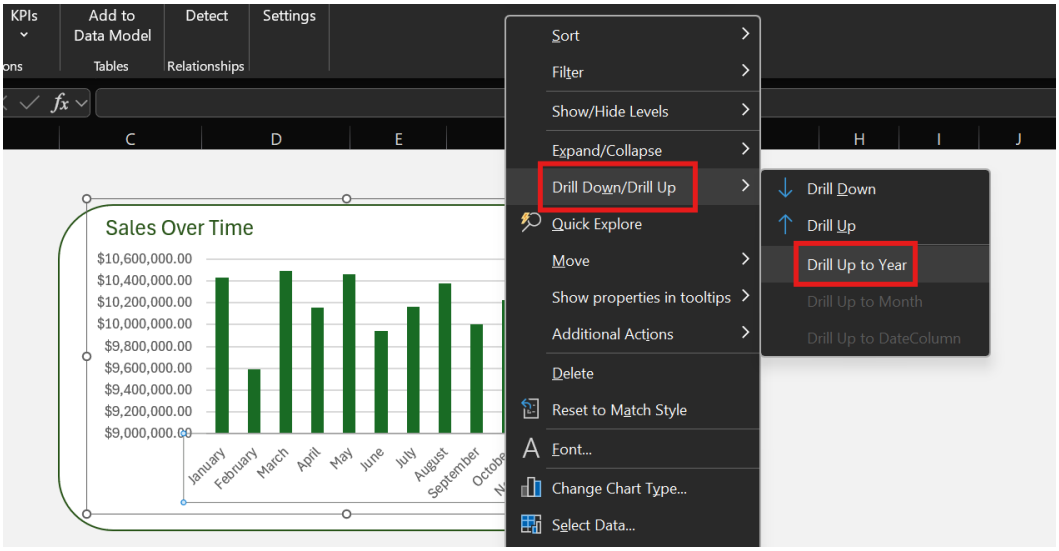

Fig. 42. Activating drill-up/drill-down analysis

The display of the effect of this option is shown in Figure 43. The left side of the image represents a visual with data at the monthly level, while the right side represents a visual with grouped data at the year level.

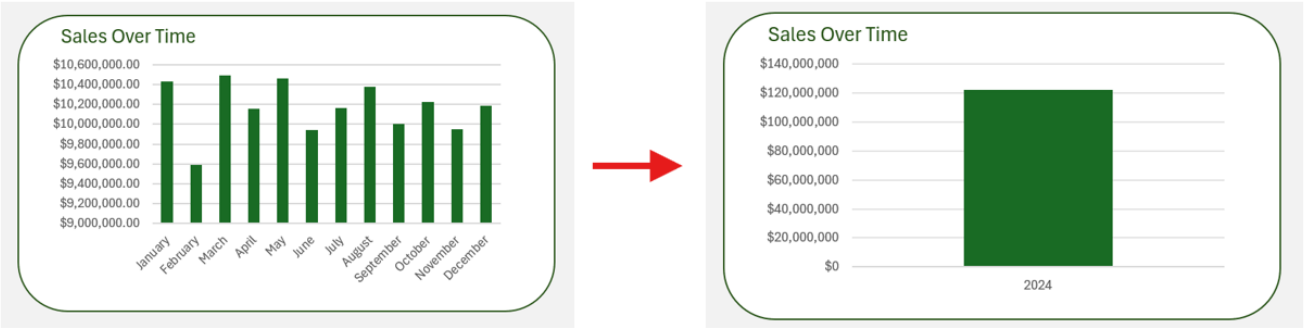

Fig. 43. Effect of drill-up analysis

5. Results of Comparative Analysis

This chapter describes the conclusions derived from practical research by creating reports in both tools. Below will be a table with tool ratings for each of the stages. The following Table 3 presents the tool ratings for each phase.

Table 1
Evaluation of the tool after practical research (Source: Author)

Phase	Subphase	Business reporting solution	
		Power BI	**MS Excel**
Identification of data sources and data collection	Data import	+	+
Data preparation	Management of duplicates and missing values	+	+
Data preparation	Standardization and data types	+	+
Data modeling	Creating a calendar table		+
Data modeling	Creating a measures table	+	
Data modeling	Creating a data model	+	
Visualization	Visuals	+	
Visualization	Slicer panel	+	
Visualization	Drill-up/drill-down analysis	+	
	Result:	**8/9**	**4/9**

As two identical reports were created for the purposes of practical research, identical phases were carried out. Therefore, the phases are directly comparable. The general conclusion that emerged from this research is that Power BI is a tool that is narrowly specialized in the creation of the lifecycle model and therefore a tool that has a compelling advantage. On the other hand, it is undeniable that MS Excel can be used for reporting, but it is still a versatile tool, with wide applications, so it lacks certain functionalities that make reporting faster and simpler.

The entire report creation process took less time in the case of Power BI, and in addition, the available functionalities are far more advanced, and the visuals are more beautifully designed. In Excel, a similar effect was achieved when it comes to appearance, but the creation process is longer and more demanding. In the stages in which the add-ins available in both tools are used, the steps performed are almost completely the same. The only thing where Excel has an advantage over Power BI is the creation of the calendar table, which is relatively automated. The creation of a data model, which is the basis for later creation of visuals, slicer and drill-up/drill-down analysis, as well as the data model itself, are far more advanced and intuitive than in Excel.

6. Conclusion

Although Power BI was created as an extension of Excel 's add-ins, it can be said that there is still a significant difference between these two tools. The main difference is reflected in the areas of application, where Power BI is a tool that is narrowly specialized for business reporting, while Excel is nevertheless a versatile tool of wide application. The tools are not mutually exclusive, on the contrary. Certain modules and functionalities in Excel can serve as supplements to reports and analyses created in Power BI.

MS Excel has been one of the most popular and important tools when it comes to data manipulation. Continuous development, ease of use, many functionalities, wide application and many other features have allowed this tool to be one of the most popular for years. It can be said that it was this great popularity of Excel that led to the development of Power BI, which arose because of the great interest in Excel 's add-ins. In addition to it, other narrowly specialized reporting tools appear with the development of technology. Today, Power BI is a comprehensive and modern tool that enables agile data analysis. It is one of the most popular tools, with a large community of users and constant development of functionality.

Practical research, conducted in the form of creating two identical reports in these two tools, produced similar results. The specialization of Power BI enabled the development of advanced functionalities, automation of individual steps, modern visuals and intuitive options. The entire process of creating a report is much shorter and simpler compared to Excel, which required more steps and more complex settings. The main differences between these tools are reflected in:

i. Creating data models, which is almost automated in the case of Power BI;
ii. The existence of indirect relations, unlike Excel;
iii. Creating a calendar table, which is almost automated in the case of Excel;
iv. Creating a measures table, which is more complex in the case of Excel;
v. Creating visuals, where in Power BI this phase is reduced to the drag-and-drop principle, while in Excel it is necessary to create a Pivot table for each visual individually;
vi. Slicers, which need to be manually connected to the desired Pivot tables, unlike Power BI, which does it automatically.

Therefore, the conclusion that arises in response to the question "Which of the solutions is appropriate for the given industry, type of data and business objectives?" is Power BI, when it comes to strict business reporting based on historical data, i.e. prescriptive and diagnostic analytics. On the other hand, supplementary analysis with predictive analytics is reserved for Excel. The combined use of both tools would definitely bring the best results, given their complementarity.

Acknowledgement
This research was not funded by any grant.

Conflicts of Interest
The authors declare no conflicts of interest.

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