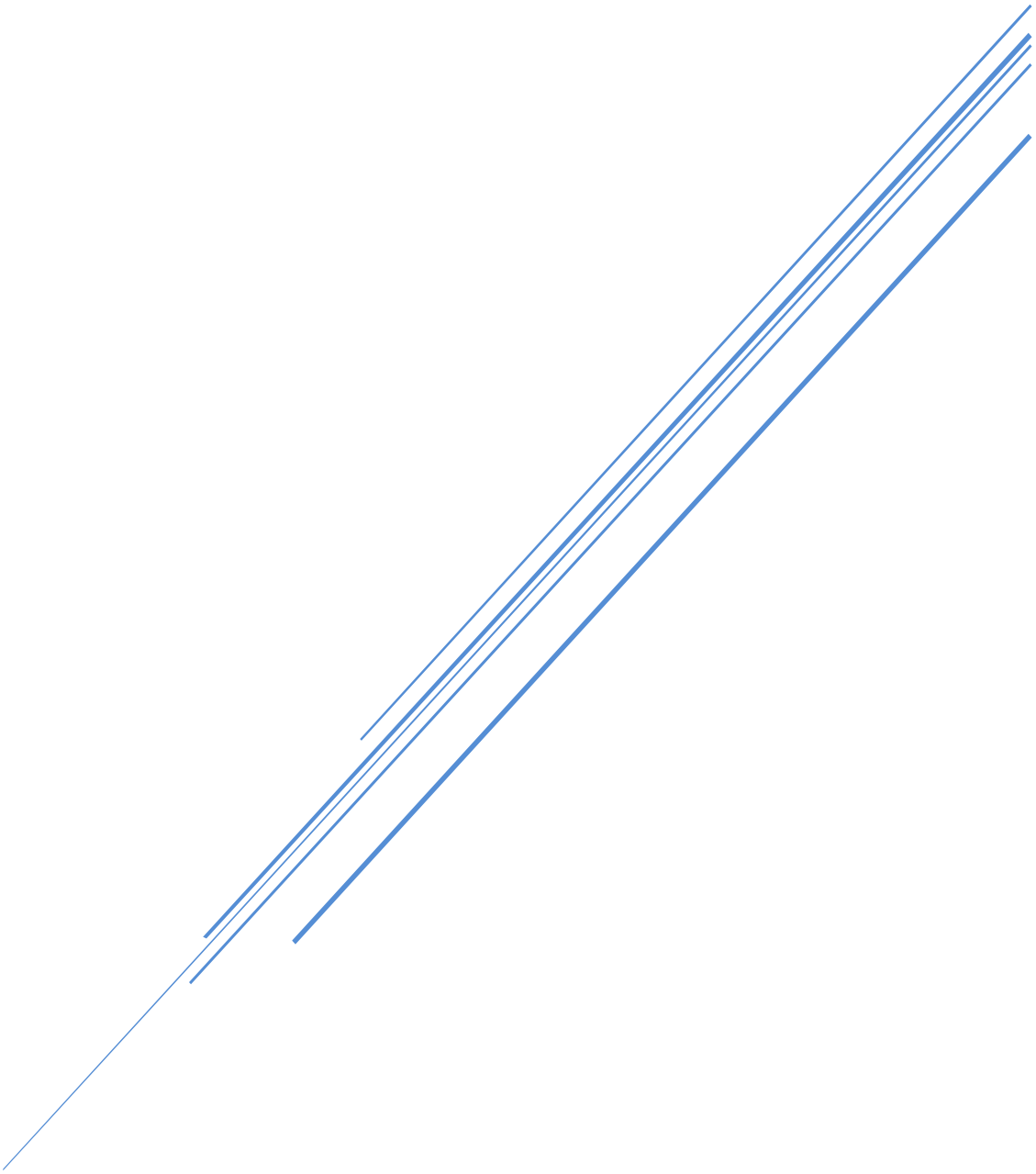
BUSINESS AND CHALLENGES IN 2024



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Data visualization in business contexts: an empirical research on tools and profieciency

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Abstract: In the era of Big Data, effective data visualization has become essential for transforming complex datasets into actionable insights. This study explores the foundational principles, tools, and techniques that underpin data visualization practices within contemporary enterprises. Through a primary research conducted in 2021, involving 511 responses, this research examines the adoption and proficiency levels of key visualization tools, including Excel, Power BI, and PowerPoint, across various industries and demographics. A central focus of the analysis is on the distribution of visualization skills within organizations, highlighting trends in knowledge levels across sectors and by gender. Furthermore, the study emphasizes the role of specific visualization techniques in presenting nuanced data insights. The findings underscore the need for a balanced approach to data visualization that combines clarity, accuracy, and aesthetic appeal, facilitating informed decision-making and effective communication.

Keywords data visualization, dashboard, infographic, visual analysis, visualization tools
JEL code: C88, D81, D83, M15

Introduction

We live in a period of popularity of data visualization. There is a proliferation of data graphics in our daily lives, which is partially attributable to the increased availability of data today. You could call it the era of Big Data. Edward Rolph Tufte, one of the pioneers of modern data visualization, explained this phenomenon by saying that modern data graphics can do much more than simply replace statistical tables. A well-designed data graphic can be the most effective and at the same time the most powerful way to communicate the analysis of statistical information. In his view, visual representation is an essential tool for human thinking, understanding and learning (Tufte, 1986).

1. Literature review

The visualization of data, its tools and the exploitation of its potential are the subject of numerous literatures and researchers. Among the classic works is the work of the economist William Playfair - The Commercial and Political Atlas (1801), which depicted economic data in graphic form. Jacques Bertin's Sémiologie Graphique (1967), which analyzed the relationships between visual elements and sought to define a formal language for data visualization. Tufte's work on The Visual Display of Quantitative Information (1983) became a standard work discussing the aesthetic and functional principles of data visualization. He gave many examples of good and bad representation, set general rules for creating and evaluating graphs. These works are considered standard works of university education today. Most contemporary authors, such as (Cairo, 2016), (Kirk, 2019), (Knaflic and Madden, 2020) or (Camm et al., 2021), have also followed in the footsteps of their predecessors, while scientifically disputing individual rules and their validity. The history of the depictions used today goes back hundreds of years. The visualization has been constantly evolving. From the creation of the first maps and graphs to modern digital data visualizations such as dashboards, business intelligence (BI) tools made possible by the computing revolution.
Playfair was the first to use bar, pie, and line charts to represent economic data in 1786, before the term statistics began to be used in English. Many types of charts, such as histograms, time series diagrams, and scatter diagrams, were also invented during this period. A new type of pie

chart, the polar chart, was introduced by an English nurse, Florence Nightingale, in 1857 to convince Queen Victoria to improve conditions in military hospitals. In 1861, French architect Charles Joseph Minard created the forerunner of today's linear distorted cartogram map, depicting Napoleon's campaign in Russia. James Joseph Sylvester created the first mathematical graphs, and the term graph itself was first used in 1878.

Different types of diagrams and graphs quickly found their way into textbooks, business and science, which is why today it is said that the field of data visualization originated from research in human-computer interaction, graphics, visual design, psychology and business methods. Due to the ever-improving development of computers, we can now store and display an increasing amount of data with quick and easy visualizations. Among others, Microsoft Excel, the most widely used spreadsheet application today, was introduced in the 1980s. Today, there are countless data visualization applications, and the number of software for data analysis is constantly growing. For example, in business intelligence and data visualization, QlikView or Qlik Sense appeared in 1994, Tableau in 2003, and Power BI developed by Microsoft in 2011, which are now typically used for business reports and dasbhoards, enabling interactive visualizations and comprehensive data processing. Data visualization is also beginning to gain prominence in programming languages, as many tools already have separate data visualization packages, for example, Matplotlib, Seaborn, or Plotly in Python are visualization libraries that offer great flexibility and data management capacity, in R ggplot2, which is both a statistical programming language and a graphics package, and is quite widespread in academic and research circles, or D3.js, which enables JavaScript-based, complex, and interactive web visualizations. Thanks to digital development, various data visualization tools are nowadays used as one of the most important elements in business decision-making, data mining or scientific research.

The definitions of data visualisation, as derived from modern authors, can be succinctly summarised as follows. Andy (Kirk, 2019 p.15) says in his textbook that data visualization is „the visual representation and presentation of data to facilitate understanding", according to Cairo, an umbrella term, „any kind of visual representation of information designed to enable communication, analysis, discovery, exploration, etc" (Cairo, 2016 p. 41). According to Wilke's approach, it is part art and part science When we visualize data, we transform data values in a systematic and logical way into the visual elements that make up the final graphic (Wilke, 2019). It is characterized by using different techniques to visually communicate data analysis, allowing users to perceive patterns and relationships within the data (Feigenbaum and Alamalhodaei, 2020; Kirk, 2019) helps summarize large datasets, making information clearer and more engaging (Wexler et al., 2017). From a theoretical point of view, it is usually understood as mapping numerical data to graphical elements (Friendly and Denis, 2005). (Kirk, 2019; Knaflic, 2019), data visualization is an interdisciplinary field that deals with the graphical representation of information and data and aims to make complex data more understandable and accessible.

The study defines data visualization *as a method of visually representing data through the use of various techniques, an interdisciplinary field that combines art and science, aiming to make information and big data easier to understand and analyze, supporting data-based interpretation and decision-making.*

It has several areas, such as information graphics / infographics, which focus on visualizingunstructured or semi-structured data in order to understand complex relationships. This is one of the effective tools of mass communication. Another area is geovisualization, where the focus is on understanding spatial relationships. Geographical data is typically represented on maps and interactive surfaces. Representation for scientific research purposes is also a separate area, specifically, scientific visualisation, where the goal is typically to illustrate numerical data for the deepest possible understanding. We can also talk about network

visualization, where the focus is on examining networks of relationships (e.g. social networks), depicting nodes and relationships, and there is also interactive visualization, where the use of interactive tools enables dynamic discovery and deeper understanding of data.

1.1. Tools and techniques of visualization

Data can be visualized in many ways, each discipline has its own data visualization techniques. Illustration varies fundamentally from discipline to discipline, but its basic function is to make the connections behind the data easier to understand. Visual formats used in data visualization include tables, charts, graphs, geospatial maps, figures, correlation matrices, which can sometimes be combined into a dashboard. Using these data visualization tools provides an accessible way to view and understand trends, outliers, and patterns in your data.

1.1.1. Maps

The power of maps lies mostly in connecting data to our physical world, precise positioning, geographical connections. Various methods of map representation have become widespread, such as the Cartograph, where coloring indicates the size of the given pointer, or the Cartochart, where charts, in this case pie charts, are placed at different points on the map to illustrate the size of the pointer. This group also includes the Point Map, which is a kind of density indicator, i.e. the amount of points indicates the magnitude of the indicator (Závoti, 2010). This includes symbol maps, koropleth maps, isopleth maps and heat maps. Known programs used in map editing include ArcGIS, Carto, GRASS GIS, MapInfo Professional, Google Earth Pro or QGIS.

1.1.2. Diagram

There are also many types of charts and graphs in groups, such as pie charts, bar charts, line charts, area charts, histograms, waterfall charts, funnel charts, scatter charts, and so on. There are many charting tools to visualize your data efficiently and spectacularly. These include Microsoft Excel, Google Sheets, Tableau, Power BI, Datawrapper, Plotly, D3.js, Infogram, Chart.js, R (ggplot2), Adobe Illustrator, Flourish, Canva. Charts usually allow you to map dimensions in data, using colors, dimensions, positions, geometric shapes. Microsoft Excel is ubiquitous in business and beyond, and is one of the most popular tools for creating data visualizations in the world. The interface for creating charts is based on a gallery of chart types, but you can create many types of charts, some that are not part of the gallery offered by Excel. Excel chart output is mainly static, but because it's a flexible tool, it can also be used to create interactive charts and dashboards.

1.1.3. Infographics

If you look at it, today individual charts are not limited to static indicators, but can also be dynamic, interactive and even animated. For example, the term infographic originally came from the term informational graphics, since infographics were the term used to produce graphics for newspapers and magazines. Today, however, the use of the word infographic also contains a new definition, which means a larger graphic design, combining data visualizations, illustrations, text, and images into a format that tells a complete story (Krum, 2013). The well-known tools for creating infographics are Canva, Piktochart, Infogram, Venngage, Visme, Adobe Illustrator, Easel.ly, Crello, Snappa, Biteable, Animaker, Mind the Graph, Genially, Adobe Spark.

1.1.4. Dashboard

The phrase dashboard frequently arises in the context of data presentation. According to Stephen Few, a dasboard is „a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance" (Few, 2006 p. 26). In more concise terms, „one or more visual elements that tell a story about related data" (Kusleika, 2021 p.5) and the emphasis is on the story and what the really important information is. In other sources, we can find that a dashboard is a one-page real-time user interface that, like a photo, presents the current status of the key performance indicators of the given organization with a graphical display, thus enabling immediate decision-making based on information. Wexler et al. in their work *The big book of dashboards* The short term dashboard is a visual representation of data that is used to facilitate understanding. Based on this, the Wexlers consider many things to be dashboards, such as an interactive display, a pdf presenting the most important actions, or even a large wall-mounted display that displays statistics about a company detail in real time (Wexler et al., 2017). According to Knaflic, a dashboard is a useful tool in the process of exploring data that helps you regularly monitor whether data is in line with expectations and identify unexpected or interesting phenomena. Once these interesting things are found, we need to extract the data from the dashboard and turn it into an explanatory story using learned methods (Knaflic and Madden, 2020).
Today, this area is developing extremely quickly and continuously, more and more self-service business intelligence (BI) tools appear that already include this function, that is, tell a story or allow users to find the meaning of data themselves. Table 1 below presents dashboard types and their characteristics, based on relevant literature sources that discuss the role and potential uses of strategic, tactical and operational dashboard types in enterprise environments. The types of dashboards formulated in the literature all have different purposes and functions. Strategic dashboards provide a high-level overview for senior executives that enables you to pursue your organization's long-term goals. These are reviewed monthly or quarterly, such as a dashboard based on a balanced scorecard. Tactical dashboards are important for business leaders and offer detailed analysis to optimize processes and monitor projects. It can have different subtypes, we can talk about analytical, predictive dashboards tracking the work of KPI, HR Markeing, IT, Finance and other parts.
Operational dashboards reflect the current state with real-time updates. These operating units are intended for weekly, daily, or hourly monitoring as they allow immediate intervention. Its goal may be to prevent problems or mitigate risks, for example to monitor the operation of a call center or server, or it may even aim to stimulate and motivate employee efficiency, where it can be used to follow the benchmarking of individual and group-level metrics against goals.

Table1: Dashboard types characteristics

Aspect	Strategic	Tactical	Operative
Target	Measure and monitor long-term strategic goals	Fine-tune and granular analysis of business processes	Optimization of daily operation, fast intervention
Scope	Enterprise level	Business or middle management level	Operational, operational level
User	Senior managers, strategic decision-makers	Managers, business unit managers	Operational staff, direct managers
Activity	Overview, performance measurement	Analysis, examination of trends and impacts	Quick action and daily intervention
Focus	Future goals and long-term plans	Historical data and trend analysis	Current data
Data refresh	Less common, monthly or quarterly	On a frequent, daily or weekly basis	Real-time or multiple daily updates
Information	High-level summary	In-depth analysis and summary data	Very detailed, operational data
Architecture	Scorecard system, Excel and data market based	Data warehouse and BI systems	Real-time update based on core systems
Metric	Strategic result indicators	Detailed indicators for drivers and KPIs	Operational level drivers
Appearance	Scorecard structure, comprehensive views	Metric portal, Analysis tools	Real-time dashboard displays

Source: own compilation (Eckerson, 2010), (Few, 2006, 2012)

2.1. Principles of visualization

In today's economic environment, businesses, from micro-enterprises to large corporations, collect and store more and more data, the use of which is the task of management in decision-making. However, extracting relevant information from raw data can be challenging (Davenport & Harris, 2007). Business Intelligence (BI) tools and processes therefore serve to transform data into information, often in the form of dashboards, making it easier for decision-makers to analyze quickly and robustly. Microsoft has also made significant improvements to Excel BI tools, integrating the Power BI family of tools to expand data visualization and expand the range of chart types available. In Hungary, companies widely use Microsoft Excel and Microsoft Power BI tools, as well as the built-in pivot and reporting modules of Tableau Desktop and various ERP systems to support data visualization. In addition, there are many additional software and tools available on the market to meet the advanced visualization needs of BI systems.

The widespread use of business intelligence tools and dashboards shows that data alone is not sufficient for effective decision-making. The visual presentation of data should be based on principles that ensure that the information reaches the user accurately and comprehensibly. According to McCandless, four key elements are needed for a "good" visualization, or at least one that works properly. It emphasizes aspects such as cleanliness, accuracy, aesthetics, and storytelling. The right combination of these elements ensures that data visualization is not only

informative, but also visually appealing and easy to understand for the audience (McCandless, 2014). According to Wilke, the challenge of data visualization is that first and foremost, you need to convey data accurately. It should not mislead or distort, but at the same time it should be aesthetically beautiful (Wilke, 2019).

The most important golden rule for data visualization professionals is to find the right balance between precise data volume and design. If there are too many illustrations, the information may be lost, but if there is too much data, the reader will find it difficult to interpret what theyare seeing, and the very purpose of the illustration will be lost. Choosing the right graph or chart is a key step in data visualization, as a well-chosen visualization helps your audience understand and interpret your data. To help you choose the right chart, you can use the visual vocabulary tool, developed by the Financial Times and related data visualization experts, to categorize and organize the various graphic elements used to visualize your data. This toolkit helps data visualizers choose the most appropriate graphical representation to visualize data relationships and patterns. The basic question of the concept is: which data connection is most important for our story? Depending on the answer, different visual representations can be selected:

- Categorical
- Comparison
- Composition
- Deviation
- Distribution
- Flow (process)
- Hierarchical
- Quantity
- Ranking
- Relationship (Correlation)
- Relationship (Part-Whole)
- Spatial
- Temporary

The Figure 1 can help in determining which data links to highlight and which chart design schemes are most efficient for presenting information. The diagram provides examples corresponding to each aspect. This collection was compiled from numerous sources.

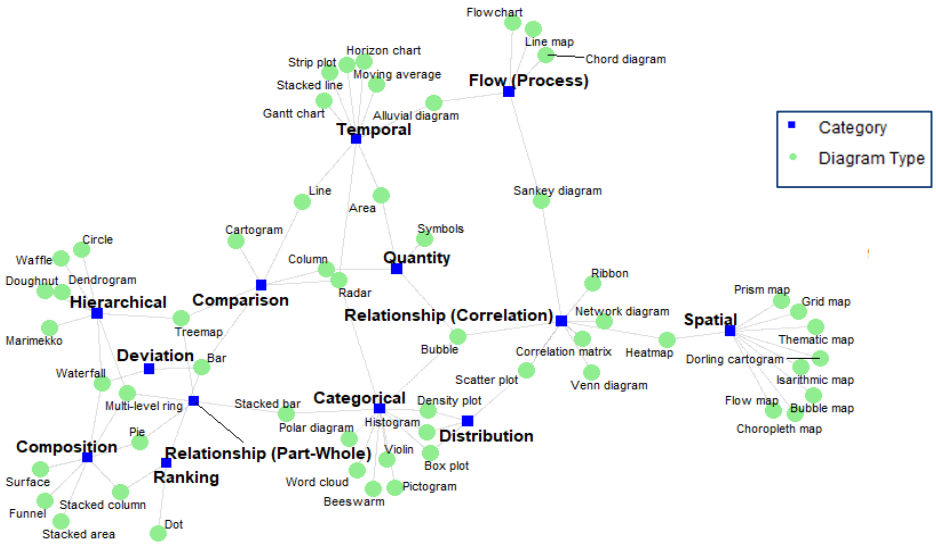

Figure 1: Diagram types by category of application
Source: own compilation and editing

Flow visualization shows how data moves or flows, allowing you to track movement patterns of information, resources, people, or other items. *Spatial visualization* visualizes geographic or on-premises data that is mapped. This is particularly useful for presenting regional, location-specific data. In *hierarchical* representation, elements are arranged according to their relationship of subordination to each other. Its advantage is that it makes complex systems more transparent, as it allows easy visualization of the relationships between individual elements. They also make it easy to recognize relationships, such as which items belong to the same group or category, or how an element is positioned in the overall system. *Deviation* visualization shows how some data or values deviate from a norm, average, or expected value. This is especially useful when discrepancies or outliers are important to the analysis. *Categorical* data visualizations are designed to show the differences and similarities between different categories. These figures support easy comparison and distribution of grouped data by category. The *relationship (correlation)* plot shows the relationship between two or more variables, giving us the opportunity to investigate patterns or dependencies. This is particularly important in cases where correlations between two sets of data are sought. Correlation visualizations are used to show the strength and direction of relationships between data when exploring relationships between variables. This helps determine whether an increase or decrease in one variable affects the behavior of another variable. The presentation of the *relationship (part-whole)* serves to explain the contribution of each part to a whole, illustrating the relative importance of each component in relation to the whole. *Tempora*l changes over time helps you discover trends and patterns over time, allowing you to analyze longer periods and understand patterns over time. The *ranking* category shows how each category or item compares to each other. This is useful when your analytics goal is to identify the best and worst performers.
Distribution charts show the dispersion, frequency, or distribution of data, allowing analysts to identify outliers, densities, and patterns. The *quantitative* plot shows the absolute magnitude of the values, allowing quantitative comparisons of data. Quantitative visualizations are used to represent data that represents absolute or relative values, especially when the goal is to show the size or volume of data. *Comparison* visuals are designed to clearly represent differences and similarities between datasets. This allows direct and easily understandable comparisons between different elements. Visualizations to show *composition* are used when we want to show the structure of an entire data set and the proportions of its individual components. This will help you understand and evaluate parts of the overall result.

2. Methodology

The article shows some result from a primary research which were created in 2021 at an enterprise and focused on the analysis and evaluation of data management and data analysis tools, as well as practices commonly employed within companies. The primary objective was to gain insights into corporate approaches to handling and analyzing data, identifying trends, and understanding the challenges and preferences of organizations in this domain. To achieve this, a structured online questionnaire was developed and distributed, targeting a convenience sample of respondents. The findings, based on 511 valid responses, provide valuable perspectives on current practices and tools utilized in business contexts, while acknowledging the study's non-representative nature. This research cannot be considered representative, used a non-probability convenience sampling technique, meaning participants were selected based on their accessibility and willingness to respond. This approach limits the generalizability of the findings but allows for practical insights within the scope of the sample. The questionnaire was distributed online, leveraging digital platforms to maximize reach and ease of access for participants. The questionnaire predominantly included closed-ended questions to facilitate standardized responses and efficient data analysis. Specifically, the questions were structured

as follows demographic questions (Figure 2), most questions utilized a Likert to measure attitudes, perceptions, and preference, binary (Yes/No) and multiple-choice questions. This methodology aligns with standard practices in survey-based research and emphasizes practical data collection while recognizing its inherent constraints. The demographic dashboard provides an overview of the sample characteristics based on company size, gender, position, and industry sector (TEAOR). The majority of respondents (47.6%) work in large companies with over 250 employees. Female respondents make up a higher percentage (58.3%) than male respondents (41.7%), indicating a slightly female-majority sample. The figures presented in this article were created using R Studio and the ggplot2 package.

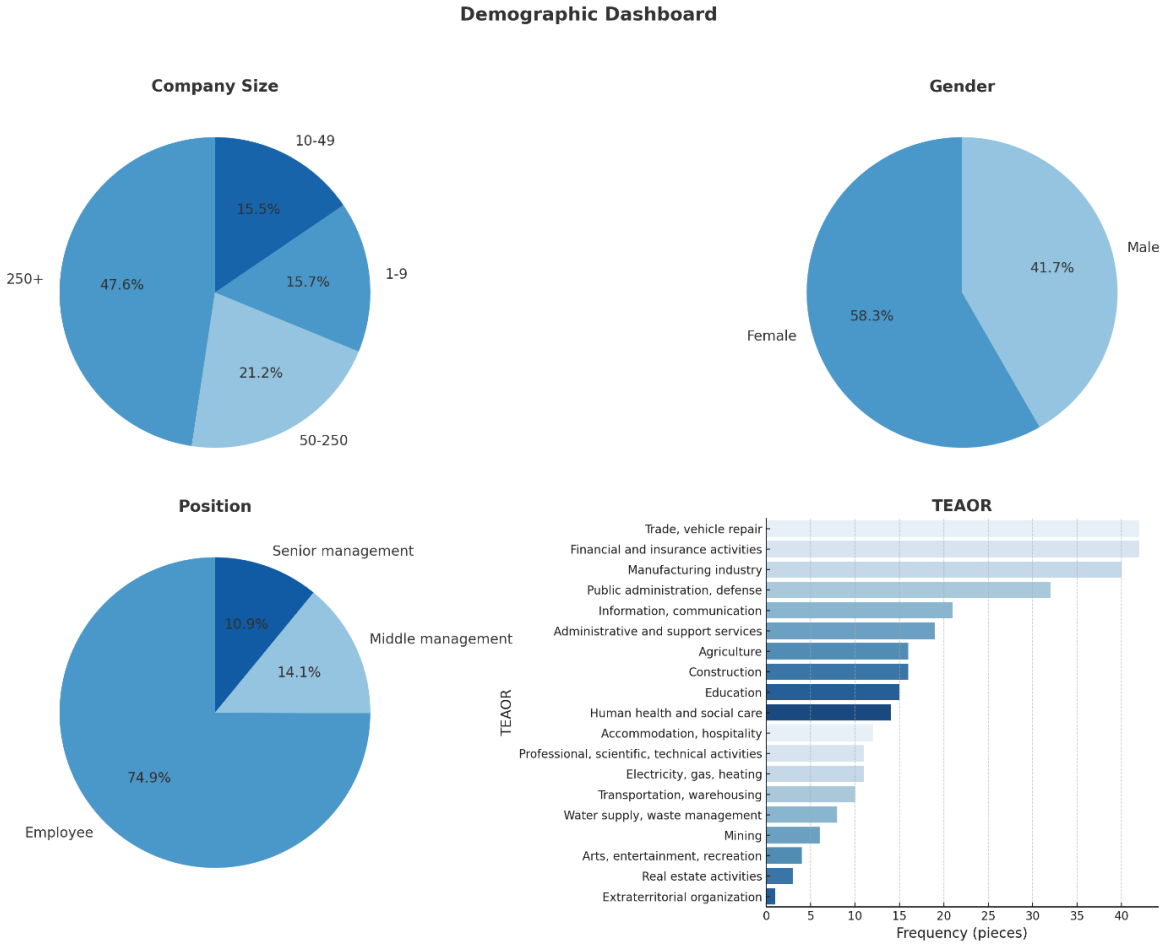

Figure 2: Demogprahic Dashboard
Source: own research, N= 511, N (TEAOR)= 375

Most respondents are in employee positions (74.9%), with fewer in middle management (14.1%) and senior management (10.9%), suggesting that the sample includes a broader base of general employees rather than managerial roles. The distribution by sector shows that the most represented industries include „Trade, vehicle repair," „Financial and insurance activities," and „Manufacturing industry," each with a relatively high frequency. Other sectors such as „Public administration, defense" and „Information, communication" also have notable representation, whereas sectors like „Real estate activities ", „Mining," and „Extraterritorial organizations" are less represented.

3. Results

In this research, the various data tools were examined that companies use. The study is focusing specifically on those directly related to data visualization. The upcoming chart (Figure 3) presents the distribution and usage rates of these specific tools within the surveyed companies, providing a clearer picture of the current trends and preferences in data visualization practices. The figure illustrates the distribution of tools used in companies. As it can be seen Microsoft Office holds a substantial share at 75.4%, suggesting that many organizations rely on Excel and similar Office tools for data visualization and analysis due to their accessibility and familiarity among users. Power BI is the next most utilized tool, representing 13.2% of usage. This reflects a growing trend toward specialized data visualization software, as Power BI provides advanced analytical features tailored to business intelligence needs. Microsoft Visio, accounting for 7.2%, is also used for visualization, particularly for creating flowcharts and process diagrams, which are valuable in operational planning and process management. Mapping applications make up 4.2% of tool usage. These are critical for industries requiring spatial data visualization, although their limited share suggests that only specific sectors prioritize or require geographic data insights.

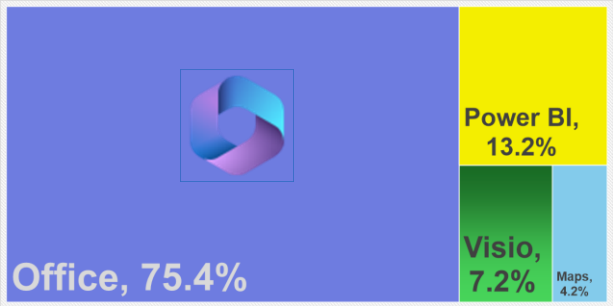

Figure 3: Data Visualization Tools Usage in Companies by Treemap
Source: own research, N= 511

The next chart is a Sankey diagram, which is often used to represent the flow and distribution of elements between categories. Figure 4 illustrates visually the use of two Excel tools - Diagram (blue) and Pivot (yellow) -across different business departments within a company. The Diagram tool in Excel is widely used across various departments. It shows a strong flow from Finance and Accounting, Administration, Corporate Management, Manufacturing and Production, HR, and Project Management departments. This suggests that many departments rely on Diagram tools for visual representation, reporting, and analysis, making it a common tool for presenting data insights visually across the organization.
The Pivot tool (Table/Charts), used for data summarization and analysis within Excel, has a more selective flow, indicating it is less widely utilized but important for numerous departments. Major users include Finance and Accounting, Logistics, Supply and Maintenance, Controlling, and IT departments. This distribution reflects that Pivot tables are highly useful in areas that require detailed data breakdowns and advanced data manipulation, such as finance for budgeting, logistics for tracking inventory, and IT for technical analysis.

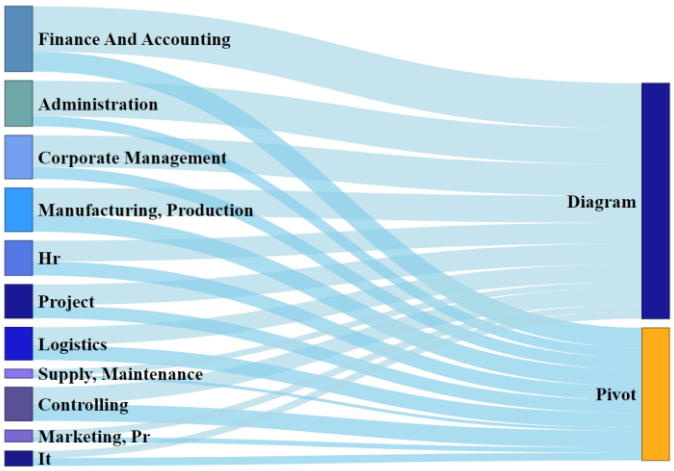

Figure 4: Departmental usage of Excel tools (Diagram and Pivot) by Sankey diagram
Source: own research, N= 511

In this research, I explored the level of knowledge as well that respondents had with various tools (Excel, Power BI, Infographics, and PowerPoint) within their organizations. The analysis aimed to identify if there were notable differences in tool knowledge based on company size, gender, or employee position. The results (Figure 5) revealed no significant differences in knowledge levels across these categories, the most deviation was shown in TEAOR activites. I visualised it by heatmaps that displays the self-reported knowledge levels of different applications (Excel, Power BI, PowerPoint, and Infographics) across various industry sectors (coded by TEAOR). Respondents rated their knowledge on a scale from „Not at all" to „Advanced", allowing for an analysis of proficiency across industries. Each heatmap reflects the distribution of knowledge levels for one specific application, showing which sectors have higher or lower familiarity with each tool. Excel proficiency is relatively high across most sectors, with significant portions of respondents in sectors like Transportation and Warehousing, Trade and Vehicle Repair, Financial and Insurance Activities, and Manufacturing indicating „Above Average" to „Advanced" levels of knowledge. Lower levels of proficiency are seen in Construction and Real Estate Activities, where a noticeable proportion of respondents report only basic or moderate knowledge. The knowledge of Power BI is less widespread compared to Excel, with sectors like Financial and Insurance Activities and Professional, Scientific, Technical Activities showing higher familiarity.
PowerPoint is well-known across a range of sectors, with high knowledge levels especially in Financial and Insurance Activities, Human Health and Social Care, and Public Administration, Defense. Sectors such as Mining and Agriculture tend to report lower proficiency in PowerPoint, suggesting these industries might have less frequent use for presentation software. Knowledge of infographic creation tools varies considerably, with Professional, Scientific, Technical Activities and Information, Communication sectors showing higher levels of expertise.

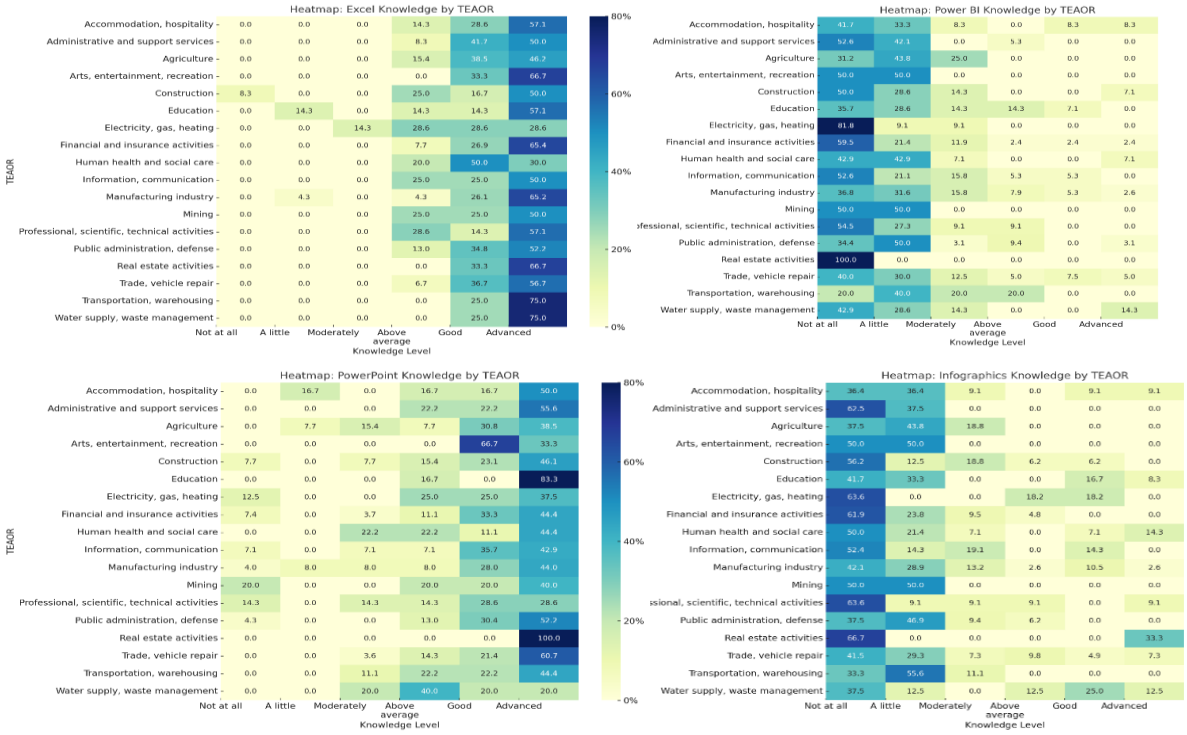

Figure 5: Knowledge levels of different applications by TEAOR Sectors

Source: own research, N= 375

Even if there isn't a significant difference between genders in terms of skill levels for each tool, using detailed illustrations like violin plots (Figure 6) still adds value to research presentations. Violin plots provide a clear and visually engaging way to display distributions, emphasizing both the central tendency and the spread of data. They show the probability density of the data at different levels. This is helpful to observe the spread and concentration of data points within each category.The violin plot below illustrates the knowledge levels of employees in three digital tools -Excel, Power BI, and PowerPoint stratified by gender. Both Female and Male distributions indicate a higher concentration at the "good" and "advanced" knowledge levels, showing that employees generally have strong proficiency in Excel. For both genders, the distribution is skewed towards lower proficiency levels, with a notable portion of responses in the "not at all" and "a little" categories.This suggests that Power BI is less familiar to employees compared to Excel, as the majority do not report advanced skills. Both Female and Male employees display a moderate level of knowledge, with a distribution concentrated around "good" and "above average" categories.

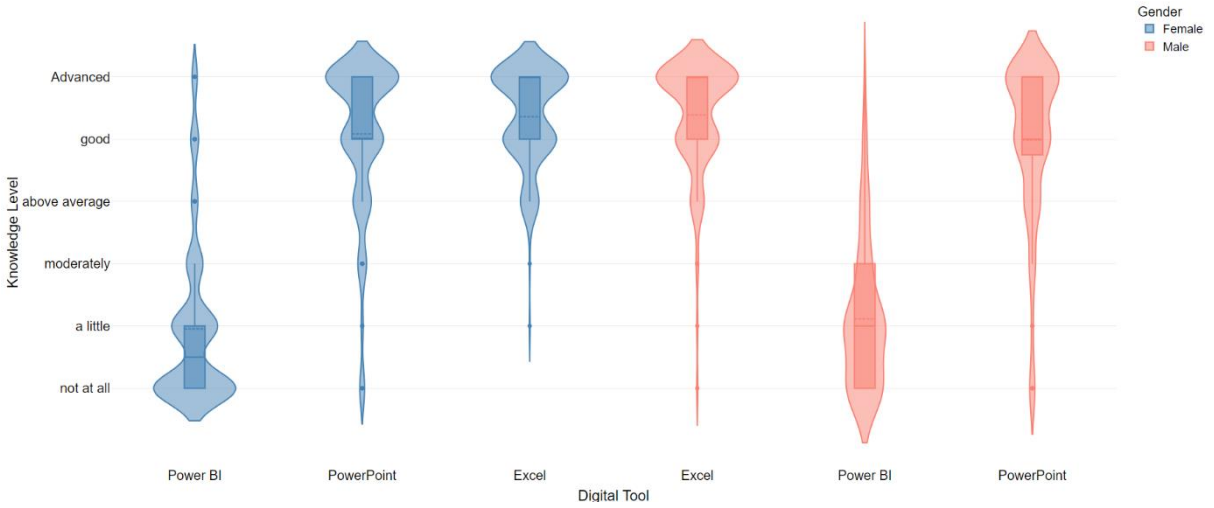

Figure 6: Violin plot of knowledge levels across tools by gender
Source: own research, N= 375

4. Limitations

The research acknowledges that non-representative nature of primer research due to the sampling method and the online data collection approach, which might exclude individuals without internet access or technological proficiency. As such, the results are indicative of trends within the surveyed group rather than the general population.

5. Conclusion

Data visualization has solidified its role as a cornerstone of data-driven decision-making in the digital age. This study provides insights into the prevalence and proficiency of visualization tools across industries, revealing trends and patterns in knowledge levels within organizations. Excel remains a dominant tool due to its accessibility and versatility, while Power BI and PowerPoint are also widely adopted for specialized visualization and presentation needs. The analysis highlights that while there are no significant differences in knowledge levels between genders, visualization practices and tool familiarity vary significantly across sectors. Understanding the principles of data visualization is fundamental to modern analysts creating reliable and valuable representations. Moreover, this article illustrates the value of diverse visualization techniques, such as violin plots and heatmaps, in research reporting, as these formats enable the representation of complex data distributions and inter-industry comparisons with clarity. As organizations have been collecting and analyzing large datasets, adopting effective visualization strategies will be critical for enabling clear, accurate, and impactful data interpretation.

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