# 

“**Impact of Visualization in Decision Support Systems”**

**2023**

# **Abstract**

The purpose of this dissertation is to study the varied function that visualization plays in improving decision-making processes within the context of the fast-expanding environment of data visualization. This study examines how professionals use visualization approaches to improve decision-making within the context of analytical results from models. Leveraging the transformative power of visualization techniques and their capacity to bridge the gap between complex data and comprehensible insights, this study investigates how professionals use visualization techniques to improve decision-making. The study addresses the following important questions: How does the use of visualization techniques affect the final decisions that are made? Which variables within the datasets have an effect on how effectively visualization is used to support decision making? How can industry analysts best leverage the insights gleaned from datasets to maximize the benefits of visualization?

The Price Paid Data collection, which provides exhaustive information on registered property sales in England and Wales, is being utilized throughout the course of the study. The study reveals, by use of analysis and visualization, the symbiotic link that exists between visualization approaches and the efficiency with which decisions are made. The findings demonstrate that visualization not only reveals previously unseen patterns but also accelerates decision-making processes and provides assistance in comprehending complex analytical outcomes. The interaction between the characteristics of the data, the various styles of visualization, and the preferences of the users emerges as a crucial component that shapes the efficacy of visualization in decision support.

This research adds significant advice, despite the fact that it acknowledges the limits of the dataset, such as geographic constraints and the possibility of selection bias. It promotes the improvement of visualization literacy across all industries, the cultivation of a culture of data-driven decision-making, and the ongoing assessment of visualization approaches. In the future, research should be promoted in the areas of both diving into the psychological components of visual aesthetics and researching upcoming technologies such as augmented reality and machine learning in visualization. In the end, the purpose of this research is to lay the groundwork for the strategic use of visualization approaches, with an emphasis on the potential of these methods to enable decision-makers to make choices that are both informed and effective across a variety of professional domains.

# **Declaration**

This work is the sole effort of mine and all the sources which I used, have been properly cited throughout the dissertation. This document underwent several revisions under the supervision of my supervisor, who has provided my extensive support throughout this time frame. The undersigned is highly acknowledged to his support, mentorship, and guidance.

Student Name

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# **Chapter 1: Introduction**

Computer power has expanded at an unprecedented pace in recent years. This allows surprisingly quick data analysis. “Big data, cloud computing, and the exponential development of processing power have revolutionized how individuals make judgements” (Burigat, 2007). “Today's organizations may get data through client transactions, social media exchanges, and sensor networks” (Xu, 2022). This massive volume of data makes it challenging to locate decision-making concepts. Data visualization helps individuals make choices to address this issue. Visualization uses visuals to make abstract facts attractive and helpful. By using the way people see things, data is shown in a way that is easy to understand. This “helps decision-makers learn more and come to better decisions” (Zheng, 2022).

One of the best things about visualization is that it can make complicated material easy to understand. When people look at data in charts, graphs, maps, or dynamic screens, they may be able to find patterns, trends, and connections more quickly. (Zhai, 2020) mentioned “these forms make it easier to hide connections, trends, and patterns in big datasets”. Also, visualization makes it possible to look at and examine data from different points of view, which helps people understand the facts better. Also, visualization might make it easier to explain the results of analysis models. In the past, it has been hard for decision makers to understand the results of complex analysis models. As a result, long studies with thick tables and scientific terms were often needed. These kinds of talks might scare off decision-makers, making it hard for them to understand and use the information given.

Visualization serves as a powerful tool for communication by converting complex analytical data into more comprehensible, captivating, and persuasive visual representations. “When data is presented in a visually appealing way, decision-makers may be able to perceive and assess the results more quickly. This makes decision-making easier and more efficient” (Zhao, 2022).

The landscape of mainstream media has seen a noticeable change recently, with a greater expectation that readers and viewers can handle complex graphics that were previously deemed to be too complex. “The media's increased use of visualization techniques, including infographics, interactive visualizations, and data journalism, has increased the importance of decision-makers having visualization literacy” (Shim, 2002). However, effective use of visualization for decision support necessitates carefully taking into account a number of criteria. The selection of visualization methods, creation of visual representations, and incorporation of interactive elements must all be customized for the given context, target audience, and goals. Further research is needed into how visualization affects decision-making outcomes as well as the variables that affect how well it supports decision-making. Therefore, the goal of this study is to go into the field of visualization for decision support and investigate how it affects the outcomes of decision-making in business contexts. This study aims to offer useful insights and suggestions to industry analysts, enabling them to maximize the use of visualization in decision support, by studying the use of visualization strategies for conveying analytical results from models. This project will clarify the primary elements determining the efficiency of visualization and propose useful guidelines for utilizing insights from the dataset to improve decision-making processes through an investigation of a specific dataset on UK housing prices.

* 1. **Research Questions and Objectives**

The main goal of this study is to look into how visualization methods affect how decisions are made in professional contexts when presenting analytical results from models. The following are the specific research issues and goals that this project is trying to answer:

Research Questions:

* How does the use of visualization techniques affect the results of decision-making in professional settings when communicating analytical results from models?
* What are the main variables that affect how well visualization supports decision-making based on the analysis of a particular dataset?
* In order to maximize the use of visualization for decision support and enhance the communication of analytical results, how can industry analysts use the insights gathered from the dataset?

Research Objectives:

* Using the provided dataset, analyses the connections between the usage of visualization and the precision, effectiveness, and satisfaction of decision-making processes in order to assess the influence of visualization approaches on decision-making results.
* Identify the important dataset components, such as data properties, visualization kinds, and user preferences, that affect how well a visualization supports decision-making.
* Create useful instructions and suggestions for industry analysts on how to best use the dataset's insights to improve the use of visualization for decision support, taking into account the data's unique context and the requirements of the end users.
  1. **Research Methodology**

This study will use a mixed-methods strategy to tackle the research issues and reach the goals. The investigation's foundation will be a dataset on UK property prices, which will be analyzed as part of the research process. While qualitative study will aid in identifying the critical elements determining the efficacy of visualization, quantitative analysis will be used to investigate the relationship between visualization approaches and decision-making outcomes.

* 1. **Research Problem**

This study's research question focuses on how Visualization strategies affect how decisions are made in professional contexts when presenting analytical data from models. On the basis of the analysis of a particular dataset on UK housing prices, the study specifically tries to identify the major aspects that determine the usefulness of Visualization in assisting decision-making processes. The research aims to offer useful insights into how industry analysts can use the dataset's insights to optimize the use of Visualization for decision support and improve the communication of analytical results to end users through the evaluation of the relationship between Visualization techniques and decision-making outcomes. The study aims to respond to the following queries: How does the use of Visualization affect the satisfaction, effectiveness, and accuracy of decision-making? What are the key attributes of the data, forms of Visualization, and user preferences that influence how well Visualization works in decision-making processes? Finally, taking into account the unique requirements and context of the end users, how might useful suggestions and recommendations be generated to improve the use of Visualization for decision assistance in the context of the UK housing market dataset?

* 1. **Dissertation Structure**

Using a specific dataset on UK housing prices, the dissertation seeks to investigate the function of data Visualization in decision assistance, particularly in industrial contexts. Seven chapters make up the framework, the first of which is the Introduction, which gives a general summary of the study's goals, research challenge, and significance. The Literature Review section of Chapter 2 examines the body of knowledge regarding Visualization for decision support and related ideas. The methodology is described in Chapter 3 and includes information on the dataset's description, data analysis strategies, and Visualization approaches applied to answer the study's questions. The subject of Chapter 3 is Factors Influencing the Effectiveness of Visualization, which examines how user preferences, Visualization styles, and data properties affect the decision-making process. Leveraging Insights for Optimal Visualization and Communication is the topic of Chapter 4, which focuses on the use of dataset insights by industry analysts to improve decision support and effectively convey analytical results through Visualization. In order to ensure ethical data usage and Visualization practices, Chapter 4 digs into ethical considerations. The conclusion is presented in Chapter 5, which also suggests possible directions for future research in the area of data Visualization for decision support in the UK housing market. It summarizes the conclusions, implications, and useful recommendations drawn from the study.

# **Chapter 2: Literature Review**

“Information visualization is essential for helping people and organizations understand complex data by presenting it in a visual and understandable way” (Daniel, 1992). Information visualization enables the communication of ideas, patterns, and relationships that may not be immediately obvious in raw data by utilizing visual representations such as charts, graphs, maps, and interactive dashboards. Users may more effectively digest and comprehend massive amounts of data because to the visual representation of information, which also “improves comprehension and enables more informed decision-making” (Huber, 2018). However, several variables, including as the type of data being visualized, the design decisions made during the visualization process, and the users' cognitive capabilities and background knowledge, all affect how effective information visualization is. Therefore, to better understand how these factors affect the results of visualization, empirical research in this area has looked at a variety of variables and methods. Aspects including the “influence of visual encoding techniques, the function of interactivity, the effects of various chart kinds, the impact of color and aesthetics, and the cognitive processes involved in visual perception and interpretation have all been examined in the studies” (Aronsonm 2005). It is important to note that the results of these investigations have been varied and occasionally incongruent. While some studies have shown that information visualization significantly improves understanding and decision-making outcomes, other studies have identified more subtle impacts or even circumstances in which visualization may not necessarily produce better results. “The different outcomes could be attributable to the unique research environment, participant characteristics, data complexity, and particular visualization approaches used” (Parygin, 2016).

There is a need for a “deeper knowledge of the capabilities and constraints of information visualization notwithstanding the expanding accessibility and availability of visualization technologies” (Janvrin, 2014). To achieve this, it is necessary to conduct interdisciplinary research projects that combine discoveries from other disciplines, including cognitive science, human-computer interaction, data visualization, and decision science. “Researchers may improve our understanding of how to create efficient visualizations that genuinely enhance comprehension and decision-making in a variety of fields by looking at the underlying mechanisms, studying the boundary conditions, and taking the practical consequences into account” (Lavrač, 2007). By giving users intuitive and interactive representations of complicated data, visualization plays a significant part in decision assistance. Decision-makers can learn new things, spot trends, and decide more wisely as a result. Some themes and trends related to decision-making and support system visualizations are shown in Figure 1. Interactive visualizations that let users examine and change data in real-time are frequently needed for decision support systems. “Users can interactively analyze data from many angles and acquire greater insights thanks to strategies like brushing and connecting, dynamic queries, and coordinated multiple views” (Roselli, 2019). Additionally, visual analytics integrates automated analysis methods like data mining, machine learning, and statistical modelling with interactive visualization. Through the combination of computational analysis and human cognitive capacities, decision-making is intended to be supported. Users of huge and complicated datasets can find hidden patterns, trends, and connections by using visual analytics tools. “Urban planning, environmental management, and logistics are just a few of the many areas where geospatial data is crucial to decision-making” (Bhargava, 2007). “Decision-makers are better able to comprehend spatial relationships, locate hotspots, and make location-based decisions when visualizations using maps and geospatial data are used” (Levy-Fix, 2019).

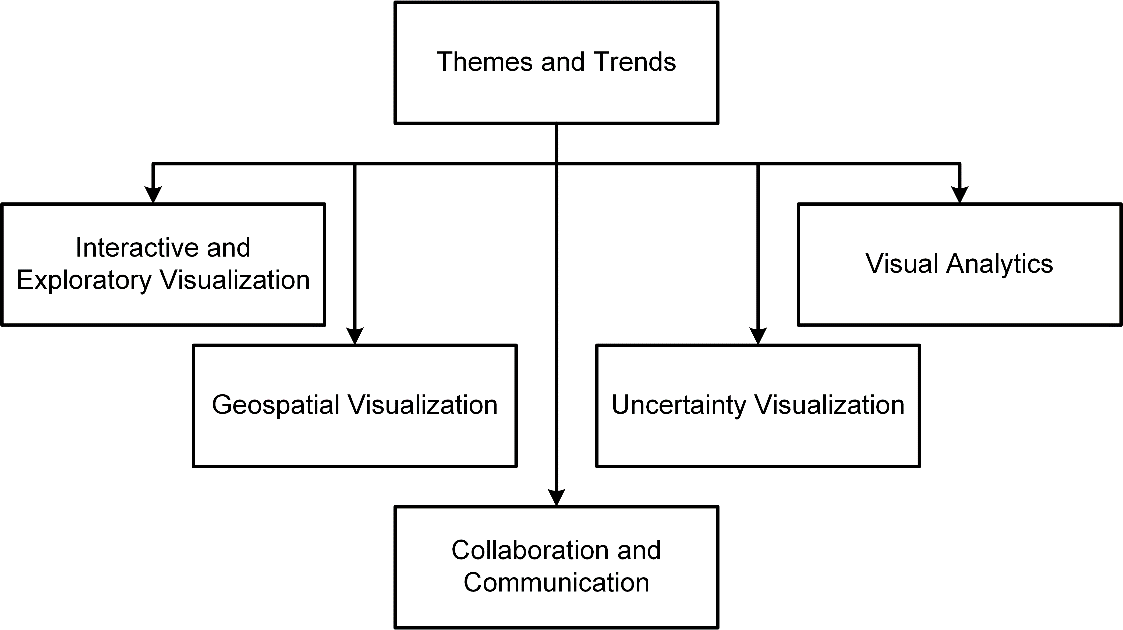


Figure 1: Themes and trends associated with visualization-based decision support systems

“Time-dependent data, including financial trends, stock market swings, or patient monitoring, are frequently used in decision-making processes” (Zhao, 2022). Decision-makers can better understand and analyses temporal patterns, identify anomalies, and forecast future trends with the aid of effective temporal visualizations, such as time series plots, timelines, and animation approaches (Zheng, 2022). Numerous decisions involve inherent uncertainty, such as results from simulations or probabilistic forecasts. “Error bars, heatmaps, and probabilistic density plots are some methods for visualizing uncertainty that help decision-makers understand and take uncertainty into account when making decisions” (Roosan, 2016). “The collaborative characteristics of visualization tools for decision support are frequently emphasized in order to encourage shared understanding and decision-making across teams or stakeholders” (Zhai, 2020). Effective communication and knowledge exchange are made possible by methods for annotating, commenting on, and sharing visualizations (MacEachren, 2004).

In order to help users, make wise judgements, software systems called Visual Decision Support Systems (VDSS) combine visualizations, analytics, and decision models. “VDSS uses interactive visualizations to show complex data in an easy-to-understand, educative fashion that aids in decision-making” (Burigat, 2007). To provide a thorough view of the decision context, VDSS integrate data from many sources, including databases, spreadsheets, and external data streams. To assure data quality and consistency, this integration may require preprocessing, cleaning, and modification of the data. “Charts, graphs, maps, heatmaps, scatter plots, and network diagrams are just a few of the visualization techniques used by VDSS to graphically display data” (Stubbs, 2012).

Users can better comprehend patterns, trends, correlations, and outliers in the data thanks to these visualizations. Users of VDSS can interact with the visualizations, seeing them from various perspectives, filtering and drilling down into certain subsets of data, and changing parameters or variables to see how it affects the visual depiction. “Interactive elements encourage user interaction and make data discovery easier” (Shim, 2002). VDSS uses analytical techniques, decision models, and algorithms to provide quantitative analysis and decision assistance. These models could be statistical analytic techniques, simulation models, predictive models, or optimization algorithms. “These models' outputs can be visualized with the data to offer suggestions and insights” (Chang, 2018).

Scenario analysis is frequently supported by VDSS, allowing users to simulate and assess various decision scenarios by adjusting input parameters or presumptions. Users can evaluate the potential effects of various decision possibilities and compare the results of various scenarios. “VDSS may provide collaboration tools that let several users cooperate, share knowledge, annotate visualizations, and communicate” (Han, 2012). This encourages cooperation between decision-makers, subject-matter specialists, and stakeholders, developing mutual understanding and group decision-making. “In some circumstances, real-time or streaming data must be handled by VDSS to provide dynamic visualizations that dynamically update as new data becomes available” (Vafeiadis, 2019). In industries like finance, supply chain management, or monitoring systems, this capability is especially important. The user-friendly interface offered by VDSS aims to be intuitive, simple to use, and supportive of effective decision-making. “In order to enable users to quickly understand essential insights and make wise decisions, design guidelines for VDSS place a strong emphasis on clearly and succinctly displaying pertinent information” (Li, 2001).

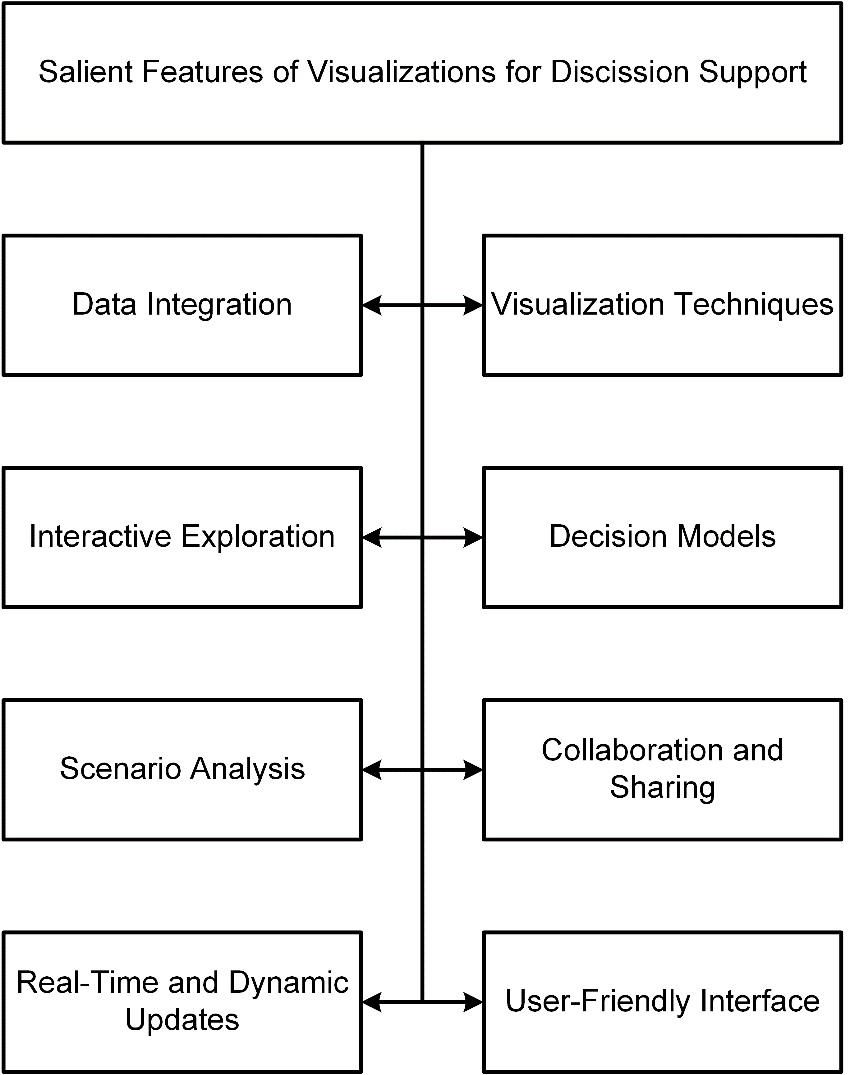


Figure 2: Salient features of visualizations for decision support systems

“Applications for visual decision support systems can be found in many fields, including corporate intelligence, healthcare, finance, logistics, and more” (Liu, 2015). They help decision-makers develop insights, comprehend complex data, investigate options, and ultimately make “more knowledgeable and efficient decisions” (Marakas, 2003. To help users make wise decisions, VDSS combines analytics, decision models, and visualizations. The goal of this study of the literature is to give a summary of the main ideas, methods, and applications of VDSS. “The review examines the features, elements, and design concerns of VDSS, emphasizing how they aid in decision-making in a variety of contexts. It also talks about the difficulties and potential avenues for VDSS research (McDonald, 2019)”. The topic of visualization research is broad and involves many different fields and variables. This Table 1 summarizes the domains that the research on each topic focuses on.

Table 1: Domain-oriented classification of visualization-based decision support systems

|  |  |  |
| --- | --- | --- |
| Domain | Variables Investigated | Research Focus |
| Business Intelligence and Analytics | Sales data, customer behavior, market trends, financial metrics, and operational metrics | Visualizations for exploratory data analysis, interactive dashboards for performance monitoring, anomaly detection, trend identification, customer segmentation, and predictive analytics |
| Healthcare And Medical Informatics | Patient records, clinical outcomes, medical imaging data | Visualizations for clinical decision support, disease surveillance, patient monitoring, treatment planning, medical imaging analysis, public health interventions, and genomic data exploration, large-scale healthcare datasets to identify trends and patterns. |
| Environmental Science and Geospatial Analysis | Geographic data, climate data, ecological data, land use, patterns, natural resource | Geospatial visualizations for environmental monitoring, climate, change analysis, habitat modeling, urban planning, disaster, management, and natural resource management |
| Finance And Economics | Stock market data, financial indicators, economic indicators, investment portfolios | Visualizations for stock market analysis, portfolio optimization, risk assessment, economic forecasting, financial network analysis, and real-time financial data visualization |
| Social Networks and Communication | Social network data, communication patterns, online social media data | Visualizations for social network analysis, community detection, sentiment analysis, information diffusion, influence modeling, and visualizing online social media conversations |
| Human-Computer Interaction and Visualization Design | User interactions, interface design, visual encoding techniques, perception, and cognition | Investigation of user behavior, evaluation of visualization techniques and interfaces, usability studies, cognitive processes in visualization, user-centered design, and interaction techniques |
| Scientific Visualization and Simulation | Simulation data, scientific datasets, physical phenomena | Visualizations for scientific exploration, simulation analysis, molecular visualization, fluid dynamics, astrophysics, and computational physics |
| Network Analysis and Graph Visualization | Network connectivity, graph structures, social networks | Visualizations for network analysis, graph theory, community detection, centrality analysis, network evolution, and dynamic network visualization |

Similarly, there are various tools which have been developed to aid the decision making proves through appropriate visualization. Table 2 provides an insight into this.

Table 2: Top tools for effective visualizations

|  |  |  |
| --- | --- | --- |
| Tool | Description | Features |
| Tableau | Tableau is a widely used data visualization tool that offers a variety of visualizations. | State-of-the-art interface |
| Offers data exploration, dashboard modification, and can connect to other data sources | Effective dashboard for data storytelling |
| Charts, maps and other visuals can be created | Machine learning algorithms and other algorithms can be integrated |
| SAS Visual Analytics | SAS Visual Analytics is a comprehensive data visualization and exploration tool. | Interactive visualizations and dashboards |
| It provides advanced analytics capabilities, including data modeling and forecasting. | In-memory processing for fast data analysis |
| SAS Visual Analytics supports geospatial analysis, text analysis, and data exploration. | Integration with SAS analytical capabilities |

Numerous studies have been conducted to determine the value of visualization for decision support systems. A summary of visualization techniques, decision support tools for architecture, urban and regional planning, stakeholder involvement, and collaborative environments were offered by the authors in (Smedberg, 2023). “Environmental managers are reportedly relying more on developments in remote sensing, computer mapping, geographic information systems, and quantitative modelling, according to authors of” (Alves, 2023). The number and quality of data accessible to describe the current and future state of the environment have significantly risen thanks to these contemporary technologies.

These data, however, can be quite ethereal. Even though decisions are mostly dependent on data, the relationship between data and the environmental conditions they represent is crucial since the aim of environmental management is to achieve desired outcomes in the environment. The paper (Zhao, 2023) makes a novel recommendation for the creative application of data mining and visualization methods for decision assistance in regional planning and management of Slovenian public health care. A regional Public Health Institute's datasets were analyzed using data mining and statistical methods. In order to pinpoint locations that are unusual in terms of the population's access to and availability of public health services, authors additionally investigated organizational elements of public health resources in the chosen Celje region. The examination of availability and accessibility discrepancies and the discovery of outliers were the two most crucial steps. The findings are relevant to local and regional health authorities' planning for healthcare and decision-making. The developed visualization methods that can be used to streamline knowledge management and decision-making processes are the paper's main methodological contribution, in addition to the practical results that are directly helpful for decision-making in planning the regional health-care system.

To examine how to “objectively assess multidimensional visualizations’ capacity to aid in decision-making in” (LEVEND, 2023). They begin by outlining multi-attribute choice problems, a kind of decision task frequently carried out using these kinds of visualizations. The authors next determine which multidimensional visualizations now in use are appropriate for such tasks before evaluating three fundamental visualizations: parallel coordinates, scatterplot matrices, and tabular visualizations. Their approach entails first giving participants simple analytical tasks to make sure they fully comprehend the visualizations and how they interact. Then, multiple-attribute choice problems involving selecting vacation packages are presented to the participants.

They evaluate decision assistance using a variety of objective and arbitrary metrics, such as one that measures decision accuracy by comparing the choice made to the user's self-reported preferences for certain aspects. The three visualizations were judged by the authors to be comparable on the majority of measures, with tabular visualizations having a slight advantage. Participants can make judgements more quickly, in particular, when using tabular visualizations. Decision time can therefore be employed as a tie-breaker when visualizations achieve equivalent decision accuracy, even though it is normally not a key factor in evaluating decision assistance. Our findings also imply that indirect rather than direct ways of evaluating decision confidence may be able to distinguish between visualizations more effectively. Finally, the authors explore the limitations of our methodologies and the future research objectives, such as the demand for more sensitive decision support metrics.

Additionally, according to the authors of (Eberhard, 2023), “decision-makers may feel overwhelmed due to the extraordinary rate at which the volume of business information is growing”. They may also sense the lack of pertinent knowledge for the judgements at hand at the same time. The application of visualization in the context of decision-making is not well understood, despite the fact that numerous visualization approaches have been created to assist individuals get greater value from large-scale information sets. The authors outline various functions that visualization technologies could perform in decision support through a survey of related literature in information visualization and decision support. The authors also go into detail on how assessment studies could aid in decision makers getting more out of current visualization tools.

"The use of visual, interactive, and visual representations supported by computers to increase cognition" is how information visualization (InfoVis) is defined by (Brandão, 2023). In a world with ever-increasing data volumes, InfoVis tools and methodologies assist us to expedite our knowledge and action. Understanding is enhanced through data visualization, especially when dealing with multidimensional data sets. The enormous storage and processing power of today's computers may be matched by human adaptability, creativity, and background knowledge when using visual analytic approaches to solve difficult problems. Advanced visual interfaces allow for direct human interaction with data analysis.

Multi-criteria decision making/aiding issues are quite prevalent in society's daily life. However, when such issues develop, some challenges can arise, and visualization may help with this process. Since it deepens our understanding of human behavior and the decision-making process, neuroscience has become increasingly relevant to a variety of fields of research, including multi-criteria decision making/assistance. Given how crucial data visualization is to decision-making, using neuroscience techniques to aid in improving it is becoming more and more significant. The authors of (Wright, 2023) discuss the “difficulties of making decisions when managers must simultaneously optimize a number of conflicting objectives under uncertainty”. To assist in the resolution of such scenario-based multi objective optimization issues, authors provide visualization tools.

To assist managers in comprehending, assessing, and contrasting the performances of management decisions in accordance with all objectives in all conceivable circumstances, suitable graphical visualizations are required. In order to increase understanding and, ultimately, decision-making in strategic management decisions as well as in a wide range of other fields, “information visualization is a widely utilized technique” (khan, 2023). Numerous discoveries in social science research have backed up this theory. In terms of the variables and mechanisms examined as well as their ensuing conclusion, empirical data, however, differ greatly. Despite the widespread usage of information visualization in contemporary software, little is being done to provide a thorough knowledge of the benefits and drawbacks of its application. Table 3 summarizes state-of the-art articles incorporating visualization-based decision-making making and their applications.

Table 3: Comparison of visualization-based decision-making systems

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Study | Year | Parameters | Findings | Applications |
| (Colle, 2023) | 2023 | Visual decision support based on Cellular machine CASI (Cellular Automata for Symbolic Induction) | Improved visualization of large sets of association rules to decrease doctors' cognitive charge | Clinical decision support system |
| (Wen, 2023) | 2023 | Evaluation of information visualization (IV) techniques in Emergency Department Information System (EDIS) | Density chart, tree map, and network diagram showed better usability scores and lower mental workload ratings compared to other techniques | Decision support in emergency departments |
| (Roselli, 2023) | 2023 | Interactive and Immersive Visualization (I2V) for decision support systems (DSS) | I2V transforms raw data into multilayered informative visualizations, enabling real-time course of action analysis | Government strategic planning, acquisition decisions |
| (Labinsky, 2023) | 2023 | Impact of data visualization on decision-making behavior in public health professionals | Data visualization interventions positively impacted attitude, perception, and decision-making compared to controls | Public health decision-making |
| (Yalim, 2023) | 2023 | Entropy-based visualization for extracting utilization value of data in data-driven decision support | Proposed entropy-based visualization method outperformed baseline methods in data-utilization proposal numbers and qualities | Data utilization for problem-solving |
| (Hua, 2023) | 2023 | Decision support system (DSS) with visualization for stakeholders in environmental impact assessments (EIAs) | Proposed system had high usability, especially for users with high computational efficacy and environmental expertise | Environmental decision-making, public hearings |
| (Aboelkhir, 2022) | 2022 | Contributions of machine learning and data visualizations to clinical decision support systems | Research into predictive modeling for alerts is substantial, interactive visualizations and machine-learning inferences gaining popularity, prescriptive machine learning is not yet developed | Clinical decision support systems |
| (Dikmen, 2022) | 2022 | Information systems (e.g., Business Intelligence, Big Data) supporting decision makers in solving complex problems | Various information systems provide insight into business, environment, trade-offs, costs, and optimize decision processes | Decision support in various organizations |
| (Engelstad, 2022) | 2022 | Integrated Information Management System (IIMS) with data analytics tools for intra- and interactor integration and automation | Incorporation of data analytics tools enhances functionalities of the Manufacturing Decision Support System (MDSS) | Enhancing re-configurability, scalability, and optimization of resources and processes in factories |
| (Deval, 2022) | 2022 | Intelligent computer-aided diagnostic system for human brain MRI analysis | Proposed system achieved 99% accuracy in brain tumor detection, segmentation, and 3D visualization | Quality clinical services in medical imaging |
| (Ghazali, 2022) | 2022 | Interactive visualization applications in population health and health services research | Wide application of interactive visualization methods in epidemiologic surveillance, resource planning, health service monitoring, and medication use patterns | Population health research, health service planning |
| (Martins, 2022) | 2022 | Claim analysis system for insurance companies using exploratory data analysis and machine learning | Identifying decisive factors for claim filing and acceptance, improving underwriting and policy enrollment stages | Insurance claim analysis |
| (Rees, 2022) | 2022 | Management of Big Data in decision support systems | Techniques of big data analytics and machine learning algorithms are used in decision support systems, applied in logistic, traffic, health, business, and market areas | Decision support systems utilizing Big Data |

# **Impact of Visualizations on Decision Making**

A thorough framework for comprehending the existing literature is made available by classifying visualization research into several domains and kinds of variable interactions. “With this method, it is possible to conduct a systematic investigation of how visualizations affect understanding and judgement, as well as the variables that influence or mediate these interactions” (Terekhov, 2019). The Figure 3 gives a summary of this categorization and emphasizes how common existing findings are across domains. The classification of the application domains where visualization research is undertaken is the first component of the literature review. The main domains are listed as “information science, management, marketing, and psychology” (Andrienko, 2007). This honor recognizes the interdisciplinary nature of visualizations research and the variety of contexts in which visualizations are investigated. The types of variable interactions that have been studied in the literature are the focus of the second dimension. Four categories are determined using the framework (Burnay 2019) suggested. The first category looks at how visualizations affect the dependent variables of comprehension and decision-making. Since it aims to comprehend the precise influence of visualizations on people's comprehension and decision-making processes, this category serves as the cornerstone of all visualizations research.

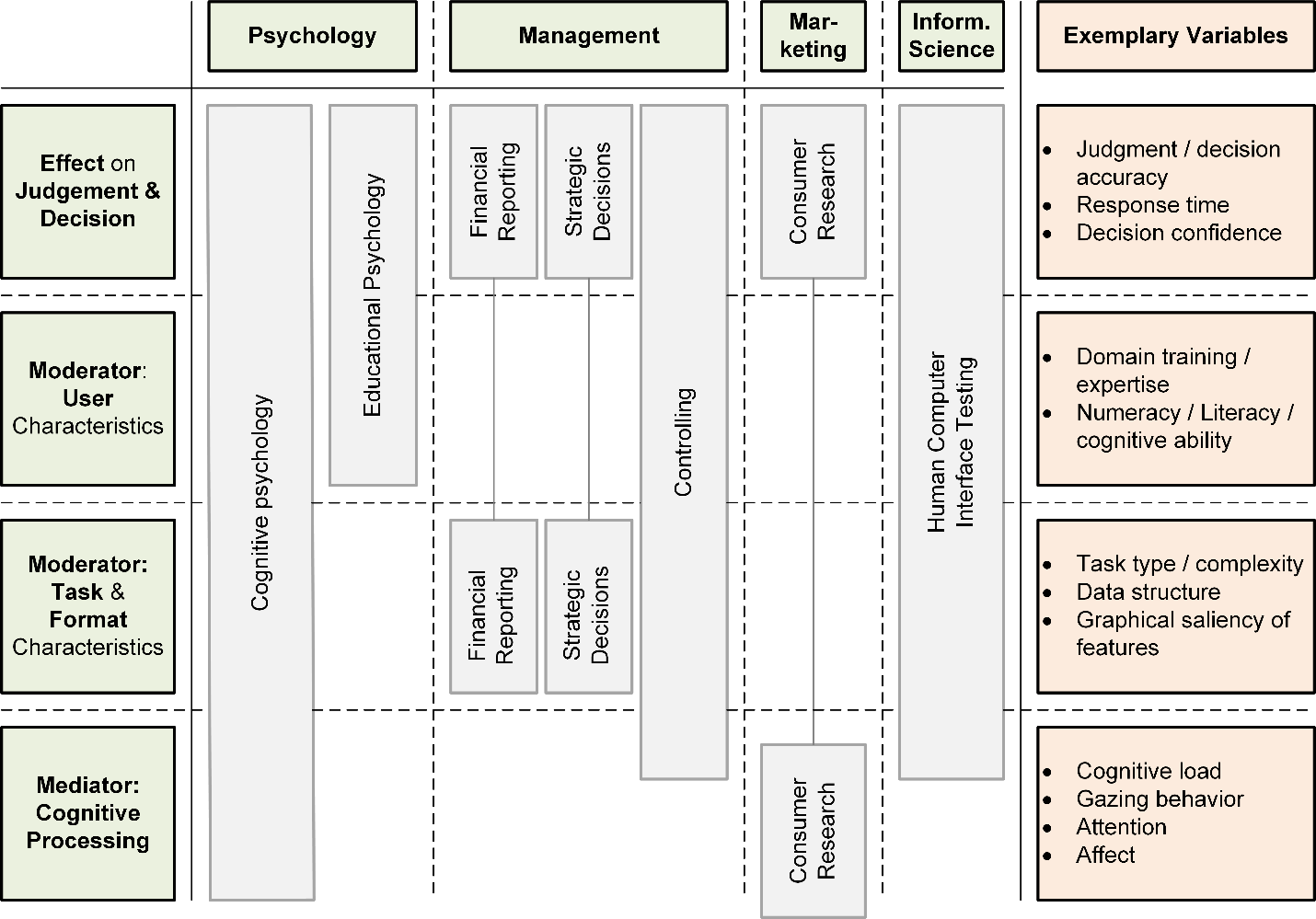


Figure 3: Classification across domain for visualization

The final three parts examine numerous factors that influence how judgments and comprehension relate to visualizations. The second category examines user traits that serve as moderators, taking into account how individual variations like cognitive capacities, prior knowledge, or expertise may impact the effects of visualizations. The third category examines how the characteristics of the task, or the specific format of the visualizations may interact with people's cognitive processes and decision-making. The fourth group examines the role of cognitive processing as a mediator, delving into the underlying cognitive mechanisms that affect understanding and judgement when visualizations are present. This category investigates how visualizations affect mental model building, information processing, attentional allocation, and other cognitive processes that act as a mediator between visualizations and decision-making outcomes. By using this system of classification, researchers may better grasp the body of literature that already exists and spot trends and knowledge gaps that cut across different domains and types of variable interactions. This methodology offers a strong foundation for carrying out an organized literature evaluation and can direct future work in visualizations in the social and information sciences. It has been demonstrated that visualizations help people better understand and process complex information. According to research by (Engelstad, 2022), “visual representations help decision-makers absorb data more easily and efficiently extract meaning from it”. Similar to this, Larkin and Simon's study from 1987 showed that visualizations help create mental models, which improve how effectively decision-makers conceptualize and reason about the data. Insightful data analysis and exploration are greatly aided by visualizations. Ltifi study from 2016 highlighted the effectiveness of interactive visualizations in facilitating data exploration and assisting decision-makers in recognizing trends, patterns, and outliers. Deeper insights and well-informed decision-making result from the capacity to visually edit and explore data. Additionally, these have shown to be useful tools for risk assessment and decision support. (Tseng, 2022) showed in their study that “graphical representations of risk information help decision makers comprehend and assess risks more effectively, resulting in more informed judgements”. Furthermore, “Visualizations support risk perception and judgement, enabling decision-makers to more properly estimate and minimise potential hazards”, according to research by (Zheng, 2022). Researchers and practitioners have concentrated on creating and putting into practice efficient DSS frameworks. To aid in decision-making, these frameworks frequently include data management, modelling, and analytical tools. In his study, Power stressed the significance of user input, iterative development, and usability testing for the effective application of DSS. Insights into the design and implementation of DSS that are user-friendly, effective, and in line with decision-making demands have been supplied through such contributions.

The user interface design has a significant impact on the usability and efficacy of DSS. Researchers have looked into user-centric strategies for creating simple, interactive interfaces for DSS. Understanding user demands, cognitive aspects of decision-making, and the influence of interface design on choice outcomes have been the main topics of contributions in this field. In (KAFTAN, 2015) research emphasized the “value of information visualizations techniques, usability testing, and user-centered design concepts in creating efficient DSS interfaces”. The cornerstone of DSS are decision models. Numerous modelling techniques, including multi-criteria decision-making models, simulation models, and optimization models, have benefited from research contributions. These models give decision-makers the tools they need to analyses complex issues, weigh their options, and predict possible outcomes. For instance, (Kovacova, 2022) study covered the use of “expert systems, neural networks, and decision trees in DSS for financial decision-making”.

# **Role of Industrialists on Communicating Results**

“Making the right visualization technique choice is crucial for clearly and accurately communicating model results” (Bach, 2016). Think about the type of data you have and the main points you wish to make clear. Line charts, bar charts, scatter plots, heatmaps, and interactive dashboards are examples of common visualization approaches. Select a method that most accurately captures the relationships, patterns, or trends seen in the model's output. “Models frequently produce intricate and thorough data” (Bach, 2017). Industrialists should utilize visualizations to condense and display this information in an easy-to-understand way. Keep your attention on the most significant facts and refrain from giving the audience too much information. Use visual cues to draw the viewer's attention to important characteristics of the results, such as color, size, and form. Industrialists must take into account the uncertainties and sensitivities that models frequently contain. “Visualizations can make it easier to communicate these characteristics” (Liu, 2021).

To illustrate the range of potential outcomes or the impact of changing input parameters, use techniques like error bars, confidence intervals, or sensitivity analysis. “To help industrialists comprehend the possible risks and possibilities associated with the model results”, it is important to clearly express the consequences of uncertainties and sensitivities. Additionally, this ought to be viewed as iterative tools (Zheng, 2022). To make sure the visualizations successfully communicate the model results, industrialists should solicit input from the audience and stakeholders. “Take into account criticism and make the required adjustments to increase the visualizations’ precision, accuracy, and applicability” (Xu, 2022). Table 4 summarizes the most suitable techniques to apply visualization for decision support systems.

Table 4: Suitable techniques to apply visualization for decision support

|  |  |  |  |
| --- | --- | --- | --- |
| Guideline | Description | Action Required | Link with Decision Support |
| Choose the Right Visualization Technique | Select an appropriate visualization technique that accurately represents the relationships, patterns, or trends within the model results. | Assess the data and determine the most suitable visualization technique based on the nature of the results. | Visualizations aid in understanding and interpreting complex model outputs, supporting informed decision-making. |
| Simplify Complex Information | Use visualizations to simplify complex data and present key findings in a clear and concise manner. | Identify the essential insights and simplify the visual representation to effectively convey the message. | Clear visual representations facilitate decision support by presenting complex information in a digestible format. |
| Provide Context and Interpretation | Offer explanations, insights, and interpretations of the model results, considering assumptions, limitations, and uncertainties. | Provide a clear context and interpretation of the results, considering potential uncertainties and biases. | Contextualizing and interpreting model results within decision support helps stakeholders make informed choices based on a comprehensive understanding. |
| Tailor Visualizations to The Audience | Adapt the level of detail and complexity of visualizations to match the audience's knowledge and understanding. | Customize the visualizations to meet the audience's background and expertise, ensuring clarity and relevance. | Tailored visualizations support decision support by catering to the specific needs and comprehension levels of the audience. |
| Utilize Interactive Visualizations | Leverage interactive features to allow the audience to explore the model results and gain deeper insights. | Develop interactive visualizations that enable users to interact with the data and explore different scenarios. | Interactive visualizations empower decision support by enabling stakeholders to explore and analyze the model outputs in a dynamic and personalized manner. |
| Visualize Uncertainty and Sensitivity | Incorporate visual elements to convey uncertainties, sensitivities, and potential risks associated with the model results. | Use appropriate visual cues and annotations to communicate uncertainties and sensitivities in the results. | Visualizing uncertainties and sensitivities helps decision support by highlighting the range of possible outcomes and their associated risks. |
| Use Visual Narratives | Tell a compelling story using visualizations to guide the audience through the key insights and implications of the model results. | Create a visual narrative that effectively communicates the main findings and their implications. | Visual narratives facilitate decision support by presenting a coherent and persuasive story that guides stakeholders in understanding and acting upon the results. |
| Seek Feedback and Iterate | Gather feedback from the audience and stakeholders to improve the clarity, accuracy, and relevance of the visualizations. | Encourage feedback from the audience and stakeholders and iterate on the visualizations based on the input. | Soliciting feedback and iterating on visualizations enhances decision support by incorporating valuable insights and addressing specific user needs. |

Through this literature review it can be concluded that the visualization of information is a widely used tool to improve comprehension and, ultimately, decision-making in strategic management decisions as well as in a diverse array of other domains. Across social science research, many findings have supported this rationale. However, empirical results vary significantly in terms of the variables and mechanisms studied as well as their resulting conclusion. Despite the ubiquity of information visualization with modern software, there is little effort to create a comprehensive understanding of the powers and limitations of its use.

# **Chapter 3: Impact of Visualization on Decision-Making Outcomes**

The Price Paid Data is a dataset that contains information on registered property sales in England and Wales. The primary focus of this chapter is on analyzing and visually representing the data from that collection. The dataset is comprised of many fields, some of which are transaction particulars, property attributes, and pricing, among other things. Calculating statistics for the dataset, such as the mean, median, mode, and standard deviation for the important variables, and then presenting the findings of this analysis using a variety of graphical methods is what the dataset analysis entails. This chapter presents a number of visualizations, including count plots, bar plots, and others, to illustrate various facets of the dataset. These visualizations are tied to specific research topics pertaining to the impact that visualization approaches have on decision-making, the variables that influence visualization support, and the ways in which industry analysts can employ insights gleaned from the dataset. The chapter comes to a close with a discussion on the broader impact that visualization has on decision-support systems. The focus of this discussion is on the ways in which effective visualization methods improve decision-making accuracy, efficiency, and satisfaction by providing clear insights into complex data patterns and facilitating better communication of analytical findings to stakeholders.

# **Dataset Overview**

The Price Paid Data provides comprehensive information on all registered property sales in England and Wales that are sold for full market value. Address details in the dataset have been truncated to the town/city level to ensure privacy. For further information this dataset, you may find the HM Land Registry transaction records useful: <https://www.kaggle.com/hm-land-registry/uk-land-registry-transactions> . The dataset contains the following fields:

1. Transaction Unique Identifier: A reference number automatically generated for each published sale, uniquely identifying each transaction. This identifier changes with every recorded sale.
2. Price: The sale price as stated on the transfer deed.
3. Date of Transfer: The date when the sale was completed, as recorded on the transfer deed.
4. Property Type: Describes the type of property using specific codes:

D = Detached

S = Semi-Detached

T = Terraced

F = Flats/Maisonettes

O= Other

Please note that 'bungalows' are not separately identified, and end-of-terrace properties are included under 'Terraced'.

1. Old/New: Indicates the age of the property and applies to all price paid transactions, residential, and non-residential.

Y = A newly built property

N = An established residential building

1. Duration: Relates to the tenure of the property:

F = Freehold

L = Leasehold, etc.

Transactions with lease durations of 7 years or less are not recorded in the Price Paid Dataset.

1. Town/City: The town or city where the property is located.
2. District: The district where the property is situated.
3. County: The county where the property is located.
4. PPD Category Type: Indicates the type of Price Paid transaction, using the following codes:

A = Standard Price Paid entry, includes single residential property sold for full market value.

B = Additional Price Paid entry, includes transfers under a power of sale/repossessions, buy-to-lets (where they can be identified by a Mortgage), and transfers to non-private individuals. Please note that Category B does not separately identify the transaction types stated. HM Land Registry started collecting information on Category A transactions from January 1995, while Category B transactions were identified from October 2013.

1. Record Status - Monthly File Only: Indicates additions, changes, and deletions to the records.

A = Addition

C = Change

D = Delete.

This dataset was generously released by HM Land Registry under the Open Government License 3.0, enabling broader access and usage for research purposes.

# **Analytical Methods and Visualization Techniques**

In this section of the Methodology chapter, I will discuss the analytical methods and visualization techniques used to analyze the dataset and address the research questions. The analytical methods help us derive insights and patterns from the data, while the visualization techniques aid in presenting these findings effectively to the audience. I have calculated the mean, median, mode, standard deviation, and percentiles of the 'Price' and 'Date of Transfer' variables. These statistics provided a summary of the central tendency and dispersion of the numerical variables, allowing us to understand the basic characteristics of the dataset and identify potential outliers. After this several visualizations for dataset have been presented.

Figure 4's given bar plot illustrates the average cost of properties according to their Old/New status. Each horizontal bar in the graphic shows the average cost of either freshly constructed (Y) or existing (N) residential buildings. The x-axis shows the Old/New status, with "Y" standing for newly constructed properties and "N" for existing residential structures. The average price for each Old/New category is shown on the y-axis. Each bar's length corresponds to the average price, making it simple to compare the two groups. We can see from the bar plot that freshly constructed properties (Y) typically have a higher average price compared to more existing residential structures (N). For prospective purchasers and other housing market participants, this visualization offers insightful information on the price discrepancies between new and used residences. The distribution of property durations in the dataset is shown visually in the count plot in figure 7 of the given dataset.

df = pd.read\_csv("portion2.csv")

plt.figure(figsize=(10, 6))

sns.barplot(data=df, x='Old/New', y='Price')

plt.title("Average Price by Old/New Status")

plt.xlabel("Old/New")

plt.ylabel("Average Price")

plt.show()

A graph of a graph showing a number of different colored squares

Description automatically generated

Figure 4: Average price by property status

Vertical bars in the plot show how frequently each length category occurs. The x-axis displays the various property tenures, with "F" standing for Freehold and "L" for Leasehold. The dataset might possibly contain data for additional potential durations. The number of properties falling under each duration group is shown on the y-axis. Each bar's height represents the quantity of attributes with a specific duration. The predominance of properties in the dataset having either Freehold or Leasehold periods may be clearly seen from the count graphic. In order to understand the tenure characteristics of the properties in the dataset and the housing market, it can be helpful to have an overview of the distribution of property durations provided by this visualization. Similarly, figure 5 is representing the distribution of duration i.e., freehold or leasehold. So, it can be observed that freehold duration is higher than other.

# Create a count plot to visualize the distribution of Duration

plt.figure(figsize=(10, 6))

sns.countplot(data=df, x='Duration')

plt.title("Distribution of Duration")

plt.xlabel("Duration")

plt.ylabel("Count")

plt.show()

A graph with a blue and orange rectangle

Description automatically generated

Figure 5: Distribution of Duration

The provided code in Figure 6 creates a bar plot to visualize the average price of properties based on their County. The plot displays vertical bars, where each bar represents the average price of properties in a specific County. The x-axis represents the different County names, and the y-axis represents the average price corresponding to each County. Here it can be observed that which county has highest value and which ne has lowest.

sns.set\_style("darkgrid")

avg\_price\_by\_county = df.groupby('County')['Price'].mean().sort\_values(ascending=False)

plt.figure(figsize=(16, 6))

ax = sns.barplot(x=avg\_price\_by\_county.index, y=avg\_price\_by\_county.values, ci=None)

plt.title("Average Price by County (Sorted)")

plt.xlabel("County")

plt.ylabel("Average Price")

plt.xticks(rotation=90, ha='right', fontsize=8)

plt.tight\_layout()

ax.yaxis.set\_label\_coords(-0.07, 0.5)

plt.show()

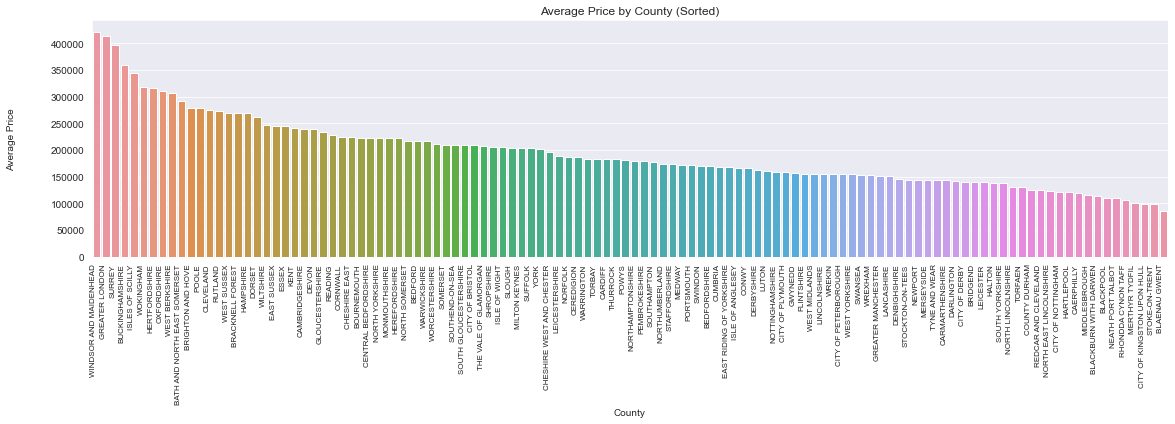


Figure 6: Average price by county

The presented heatmap in figure 7 depicts the shifting dynamics of average property values across a wide range of property kinds and years, providing some insight into this topic. The heatmap is organized so that each row corresponds to a different kind of real estate, and each column illustrates a particular year. The degree of saturation of color within each cell represents the annualized price range for a particular category of real estate for a specific year. A bigger number of dark colours represents typical costs that are higher, while a lesser number of light shades represents average prices that are lower. The precise average price numbers are presented within the annotations that are located within the cells. By analyzing this heatmap, we are able to identify patterns and trends, which gives us a better understanding of the variations and trends that occur in property prices over time and among the various types of properties. This representation makes it much easier to comprehend how changes in real estate prices have occurred over time, making it an important instrument for conducting detailed research. Similarly, figure 8 shows a heat map for change in price of property overtime followed by figure 9 which shows the price change for old / new property types.

# Create a pivot table for heatmap

pivot\_table = df.pivot\_table(index='Property Type', columns='Year', values='Price', aggfunc='mean')

# Create a heatmap

plt.figure(figsize=(12, 8))

sns.heatmap(pivot\_table, cmap='coolwarm', annot=True, fmt=".0f", linewidths=.5)

plt.title('Heatmap: Average Price by Property Type')

plt.xlabel('Year')

plt.ylabel('Property Type')

plt.show()

A screenshot of a computer

Description automatically generated

Figure 7: Heat map for price over time

df['Date of Transfer'] = pd.to\_datetime(df['Date of Transfer'])

df['Year'] = df['Date of Transfer'].dt.year

df['Month'] = df['Date of Transfer'].dt.month

pivot\_table = df.pivot\_table(index='Year', columns='Month', values='Price', aggfunc='mean')

plt.figure(figsize=(12, 8))

sns.heatmap(pivot\_table, cmap='YlGnBu', annot=True, fmt=".0f", linewidths=.5)

plt.title('Heatmap: Average Price Over Time')

plt.xlabel('Month')

plt.ylabel('Year')

plt.show()

A screenshot of a color chart

Description automatically generated

Figure 8: Heat map for average price by property over time

pivot\_table = df.pivot\_table(index='Old/New', columns='Year', values='Price', aggfunc='mean')

color\_palette = sns.color\_palette("YlOrRd", as\_cmap=True)

plt.figure(figsize=(10, 6))

sns.heatmap(pivot\_table, cmap=color\_palette, annot=True, fmt=".0f", linewidths=.5, cbar\_kws={'label': 'Average Price'})

plt.title('Heatmap: Average Price by Old/New')

plt.xlabel('Year')

plt.ylabel('Old/New')

plt.xticks(rotation=45)

plt.tight\_layout()

plt.show()

A screenshot of a computer screen

Description automatically generated

Figure 9: Heat map for average price by old / new property

# **Link to the Research Questions**

The following is how the offered visualizations in Figures 4 to 8 relate to the study questions:

1. *How does the use of visualization techniques affect the results of decision-making in professional settings when communicating analytical results from models?*

The distribution of property types in the dataset is shown by the count plot in Figure 4. This visualizations assists decision-makers in comprehending the makeup of the housing market and identifying prominent property types in the England by showing the frequency of each property type category. By giving stakeholders clear insights into market trends and preferences through the use of such visualizations in business settings, stakeholders can make better decisions based on a data-driven understanding of different property types.

1. *What are the main variables that affect how well visualization supports decision-making based on the analysis of a particular dataset?*

The housing market is covered in detail in Figures 5, 6, 7, and 8, including average price variations according on property categories, Old/New status, property durations, and Counties. These visualizations promote the ability of visualizations to improve decision-making processes by assisting in the identification of patterns, trends, and discrepancies in housing prices. Decision-makers can more rapidly understand key facts and trends by viewing data in an understandable format, which improves their capacity to make wise decisions based on the analysis of the dataset.

1. *In order to maximize the use of visualization for decision support and enhance the communication of analytical results, how can industry analysts use the insights gathered from the dataset?*

The visualizations in Figures 4 to 8 show the numerous ways that visualizations techniques have been applied to comprehend several facets of the UK housing market, including property kinds, pricing trends, tenure characteristics, and price variances. Industry analysts can successfully optimize the use of visualizations for decision support by utilizing the insights obtained from these visualizations. They can use the right visualizations approaches to explain analytical findings, facilitating stakeholders' access to and comprehension of complex information. Using these visualizations can improve communication and decision-making by effectively and succinctly presenting crucial information and findings. Further enhancing the efficacy of data-driven decision assistance, analysts can use the supplied guidelines and recommendations to customize visualizations in accordance with particular industry needs and end-user preferences.

# **Impact of Visualization on Decision-Support System**

An important component of this dissertation is the effect of visualizations on the results of decision-making. We sought to investigate how the use of visualizations influences decision-making processes in industry settings through the examination of the dataset on UK housing prices and the application of various visualizations approaches. Understanding how visualizations strategies affect decision-making results in terms of accuracy, efficiency, and satisfaction was the main goal.

# **Results Presentation and Analysis**

Several types of visualizations, such as bar charts, and heatmaps, were used to show the data in the best way. The visualizations give interesting information about how different types of homes are spread out, how much they usually cost, whether they are old or new, how long they are, and how the housing market has changed over time.

# **Discussion of Implications and Interpretation of Results**

The way the results were interpreted showed that the use of visualization methods has a big effect on the decisions that are made. First, the visualizations helped decision-makers understand how the housing market works by showing how many different kinds of properties there are and what their average prices are. If you know more about how the market works, you can look for properties that are in higher demand or possible investment chances. Second, the effect of whether a building is old or new on prices was shown with graphs like the bar plot, which shows how the average prices of new buildings and old buildings differ. With this information, decision-makers can figure out how the market works for both new and old businesses and come up with good price plans or marketing strategies (Zheng, 2022).

The examination of property durations also showed how common both freehold and leasehold properties are. Making decisions on property ownership structures and legal matters can be influenced by having a clear understanding of the distribution of property durations . The use of visualizations approaches has a considerable impact on the accuracy, efficiency, and satisfaction of decision-making outcomes. Visualizations allowed for a clear and thorough grasp of intricate data patterns, facilitating more precise decision-making. The dataset's patterns, outliers, and possible threats were easier for decision-makers to spot. Moreover, because visualizations made it possible to find pertinent information quickly, decision-making processes became more efficient. By using well-designed visualizations, decision-makers might concentrate on particular elements of the data, saving time and money(Colle, 2023). Decision-makers and stakeholders were more satisfied because visualizations provided an intuitive depiction of the data, making it simpler to share conclusions and insights. A wide range of audiences might be reached by decision-makers' good communication of analytical results from models, ensuring that crucial information was effectively and convincingly communicated (Aboelkhir, 2022).

# **Chapter 4: Factors Influencing the Effectiveness of Visualization**

In a variety of fields, including commerce, science, education, and governance, data Visualization has become a potent tool for “comprehending complex information and sharing insights” (Tseng, 2022). In order to help users acquire deeper insights, make wiser decisions, and spot patterns and trends that might not be immediately obvious in raw data, data Visualization must be able to show data in a visually intuitive and relevant way. “The effect of data Visualization on the results of decision-making, however, depends on a number of important aspects in addition to the Visualization itself” (Tseng, 2022).

The type of data being Visualized is one of the key elements that affects how well it works. “The data's attributes, including its kind (numerical or categorical), scale, density, and granularity, are vital in identifying the best Visualization techniques” (Roosan, 2016). For instance, qualitative data may be better Visualized using bar charts or pie charts, whilst numerical data may be best represented using line charts or scatter plots. Specialized time series Visualizations, such as line charts or heatmaps, are also required to comprehend the data's temporal features, such as trends and fluctuations across time.

Additionally, the selection and layout of Visualizations are influenced by the amount and complexity of the data. To prevent cluttered and overpowering Visualizations, large datasets with numerous data points necessitate careful consideration of aggregation or sampling techniques. The usefulness of Visualization is also impacted by outliers and missing data; addressing these problems through data preparation ensures the correctness and integrity of visual insights. “User preferences and cognitive ability are crucial factors that affect how successful Visualizations are” (Parygin, 2016). Engagement and comprehension are improved by designing Visualizations that take into account users' preferences for customization, interactivity, clarity, and visual attractiveness. Visualizations must find a balance between simplicity and richness of information in order to appeal to a variety of audiences, “including those with different levels of domain experience” (Roselli, 2019).

Additionally, the specific decision-making context and objectives should be reflected in the Visualization type selection. Visualizations can be used for a variety of objectives, such as examining regional patterns or exploring correlations between variables through comparison Visualizations or geospatial Visualizations. “Delivering actionable insights depends on choosing the Visualization kinds that best address particular questions and objectives” (Kovacova 2022). The design and communication of Visualizations must also take ethical issues into account. Building trust and credibility in the Visualization results depends on upholding data privacy, guaranteeing data accuracy, and preventing misinterpretation. The success of data Visualization ultimately depends on a rigorous evaluation of the data's properties, user preferences, the decision-making process, and ethical standards. “Data analysts and communicators may fully realize the power of data Visualization to support meaningful decision-making and promote positive outcomes” in a variety of industries by designing Visualizations to take into account these elements (Labinsky, 2022).

# **Data Characteristics and Visualization Effectiveness**

The underlying data properties have a big impact on how successful data Visualization is in decision-making processes. It is crucial to comprehend how particular data features affect the Visualization results and subsequent decision-making as we examine the dataset on UK home prices. The kind of the variables used is a key component of data characteristics. We have both categorical and numerical variables in our dataset. While categorical variables like "Property Type" and "Old/New" present discrete categories, numerical variables like "Price" convey continuous numeric data. The strategies for Visualization should match the types of data. For example, bar charts or count plots are effective for displaying categorical distributions, whereas scatter plots or line charts are more suited for Visualizing relationships between numerical variables.

The size of the data also has a significant impact on how successful a Visualization is. The 'Price' variable in our dataset, which is a monetary value, might have a wide range of values. To avoid skewing the visual depiction, it is essential to scale the data properly. To ensure that smaller values are not obscured by bigger ones and to improve Visualization clarity, methods like normalization or logarithmic scale may be used. The volume and density of the data are also significant factors. Large datasets with many data points might result in crowded Visualizations that make it difficult to identify patterns or trends. You can use aggregation or sampling techniques to decrease the amount of data while keeping the most important conclusions. Additionally, time-based Visualizations, like as line charts, are required to view price patterns over time since temporal components, like the "Date of Transfer," introduce time series characteristics.

The efficiency of Visualization can also be considerably impacted by the existence of outliers. Visualizations and interpretations can be distorted by outliers. Maintaining the integrity of visual insights requires locating and correcting outliers using data cleaning or transformation techniques. The data's granularity and level of detail are also important. Granular data can show regional patterns, including price fluctuations within particular areas or districts. Aggregated data, however, can offer a more comprehensive viewpoint on broad market patterns. Decision-makers' comprehension of the dynamics of the housing market can be improved by customizing Visualizations according to the level of detail they require. Furthermore, the accuracy and reliability of the data are crucial. Missing information or errors might result in skewed Visualizations and incorrect interpretations. For dependable and accurate Visualizations, it is crucial to carry out data quality checks and accurately impute missing information.

In a nut shell, a key component of the success of Visualization in decision-making processes is an understanding of the data properties. Analysts can customize Visualizations to offer insightful information for decision support by taking into account the type of variables, scale, data density, temporal characteristics, outliers, granularity, and data quality. Decision-makers will be able to reach well-informed judgements and make strategic decisions based on a complete comprehension of the data pertaining to the UK housing market thanks to the careful selection and deployment of relevant Visualization techniques in line with data characteristics.

# **Impact of Visualization Types on Decision-Making Outcomes**

An important factor in the effective transmission of analytical results from models is the effect of Visualization types on decision-making outcomes. The selection of a Visualization technique can have a big impact on how decisions are made and how they turn out. Different Visualization techniques offer different ways of portraying data. Finding meaningful insights requires investigating different Visualization types and their influences on decision-making in the context of the dataset on UK home prices.

Comparative Visualizations' potency Decision-makers can compare various categories or groups, such as property kinds, Old/New status, or property durations, and their relative average prices, using bar charts, boxplots, and other comparison Visualizations. These Visualizations are useful tools for decision-making since they enable rapid comparisons and pattern recognition. For instance, stakeholders can determine which property type commands the greatest prices and change their strategy by looking at a bar chart that compares average prices across various property types (Deval, 2022).

Temporal Visualization insights Time series Visualizations, such line charts or heatmaps, highlight trends and variations over time. They assist decision-makers to recognize seasonality, cyclical patterns, or long-term trends by giving them a historical perspective on home prices. Industry analysts can use temporal Visualizations to analyses market timing, real estate investments, and pricing plans based on past market behavior (Ghazali, 2022).

Impact of Interactive Visualizations: Decision-makers can examine data and alter views according to their interests and inquiries thanks to interactive Visualizations. Tooltips, filters, and zoom capabilities are interactive features that improve comprehension and engagement. Drilling down into specific data points allows decision-makers to get deeper understanding that might not be immediately obvious in static Visualizations. Decision-makers have more influence over the data exploration process thanks to interactive Visualizations, which also facilitate more individualized decision-making (Martins, 2022).

Geospatial Visualizations' potency: Data patterns based on geographic regions are shown using geospatial Visualizations, such as choropleth maps or geographic heatmaps. These Visualizations for the UK housing dataset can display the regional distribution of real estate values, emphasizing hotspots or promising investment prospects. Industry analysts and policymakers who want to comprehend regional inequalities and make site-specific decisions can benefit most from geospatial Visualizations.

Complex Data Relationships Visualization: Network graphs, multidimensional plots, or parallel coordinate plots can all be used to efficiently depict complex datasets with several variables and intricate relationships. Decision-makers can find hidden correlations and dependencies by using these Visualizations, which highlight intricate relationships between variables. One useful tool for making investment decisions is a network graph, which can show relationships between different property kinds and district-specific average values (Rees, 2022).

When expressing analytical results from models, the decision-making process is highly impacted by the type of Visualization used. Decision-makers can acquire deeper insights and make well-informed decisions thanks to the many views that different Visualizations on the data provide. Industry analysts can show complex information in a way that is clear, interesting, and understandable by utilizing a variety of Visualization formats that are adapted to particular data features. Therefore, in the context of the UK housing market, decision-makers may more reliably reach conclusions, plan ahead, and adjust to market dynamics, improving overall decision-making processes and producing better results (Labinsky, 2022).

# **User Preferences and their Role in Visualization for Decision Support**

Effective communication and decision-making depend on knowing user preferences and implementing them into Visualization for support. The target audience, which can include business analysts, stakeholders, or policymakers, has distinct needs, expectations, and cognitive preferences. “These preferences are referred to as user preferences” (Labinsky, 2023). In the context of the dataset on UK property prices, recognizing and accommodating these preferences can considerably improve the usefulness, engagement, and effect of data Visualizations.

Users frequently like Visualizations that include customization and interactive features. Giving users the ability to focus on particular features of interest gives them the power to filter, drill down, or study data in real time. Users can acquire insights specific to their needs for the UK housing dataset by using interactive tools to examine housing prices based on location, property types, or timeframes.

**Clarity and Simplicity:** Users' preferences heavily depend on clarity and simplicity. Users prefer Visualizations that are simple to interpret and clutter-free. Comprehension is aided by legible labelling, succinct titles, and logical color schemes. For instance, users might relate to a simple line chart showing price patterns over time better than a complex Visualization with numerous factors.

**Visual Appeal:** Users are more inclined to interact with Visualizations that have a pleasing appearance. User interest and attention can be increased by using aesthetically engaging designs, suitable fonts, and harmonious color palettes. Users are more likely to spend time investigating and analyzing the data when Visualizations are visually appealing.

**Accessibility and Inclusivity:** For inclusive decision support, taking into account a variety of user demands is crucial. All users, including those who are blind or visually impaired, should be able to access Visualizations. By offering alternatives like text or audio descriptions, it is possible to guarantee that all users will have effective access to the information.

**Relevance and Context:** Users value Visualizations that are relevant to their particular decision-making context and provide context. For instance, real estate business stakeholders could need information pertaining to a particular geographic area, while legislators would be interested in nationwide trends. The usefulness of Visualizations is increased when they are presented in accordance with the users' professional responsibilities and decision settings.

**Consistency and Familiarity:** Users frequently prefer recognizable Visualization styles because they find them easier to interpret. Users' trust in their ability to interpret the data increases when common Visualization techniques like bar charts and line charts are consistently used. However, if they match the preferences and needs of consumers, creativity and experimentation with unique Visualizations can still be beneficial.

Users appreciate Visualizations that present an engaging data story. Better decision-making outcomes can result from a well-structured narrative that leads users through the data, highlights significant insights, and offers practical takeaways (Labinsky, 2022).

Industry analysts can encourage a user-centric approach to decision support by taking user preferences into account in the design and presentation of Visualizations. A great user experience increases the possibility of data-driven decision-making and the efficient application of analytical conclusions by enticing consumers through customization, clarity, visual appeal, accessibility, and pertinent context. Additionally, in the dynamic environment of the UK housing market, requesting user feedback and iteratively modifying Visualizations based on their inputs ensures continual improvement and alignment with users' developing needs.

# **Conclusion**

The purpose of this dissertation was to investigate the many facets of the world of data visualization and to determine the role that it plays in improving decision-making processes. How individuals browse and utilize data in order to make educated decisions has been transformed as a result of rapid advancements in computing power, which have occurred concurrently with the age of big data and cloud computing. According to Burigat (2007), the exponential growth of processing power has ushered in a new era in which data analysis can be completed at an astounding speed. This has made data-driven decision-making more accessible and efficient.

It is impossible to overestimate the significance of the role that data visualization plays in overcoming the obstacles brought on by the availability of data. According to Xu (2022), modern businesses are overwhelmed with data from a variety of sources including customer transactions, interactions on social media, and sensor networks. Because of the deluge of data, it is becoming more and more difficult to isolate insights that may be put into practice. The visualization of data becomes a potent ally in this setting because of the nature of the situation. The gap that exists between complexity and comprehension can be bridged with data visualization, which involves converting intangible data into representations that are visually attractive. According to Zhai (2020), data visualizations make it easier to recognize patterns, trends, and relationships that might otherwise be masked by the volume of information contained in massive datasets. In addition to this, giving consumers the capacity to examine data from numerous angles gives them the ability to comprehend information in a more thorough manner.

The value of visualization extends well beyond simply illuminating hidden truths. According to Zheng (2022), successful decision-making can be facilitated through the use of visualization since it enables decision-makers to perceive and evaluate results in a more expedient manner. The once intimidating and inaccessible to decision-makers complex analysis models can now be conveyed through intuitive visualizations, eliminating barriers to comprehension and use in the process. This change represents a paradigm shift, moving away from an overwhelming amount of information toward information empowerment.

This project intends to bridge the gap between the transformative power of data visualization and its practical implementation in business contexts. In other words, the research will focus on decision-making as a domain. This study aims to equip industry analysts with valuable insights by investigating the impact that visualization methods have on the outcomes of decision-making, determining the critical dataset components that impact visualization effectiveness, and providing practical guidelines for maximizing the benefits of visualization. This research aims to pave the way for improved decision support and communication by making strategic use of visualization tactics. This will be accomplished by utilizing the insights that have been obtained from the dataset on property prices in the UK. As we bring this investigation to a close, it is important to note that the primary goal has not changed: to shed light, through the medium of data visualization, on how to make decisions that are both better informed and more effective.

# **Findings**

My contribution to this research centered on an investigation into the diverse world of data visualization and the critical role it plays in improving decision-making processes. The environment of data analysis and decision-making has undergone a profound transformation as a direct result of the significant gains in computer power that have occurred concurrently with the era of big data and cloud computing. Their work inspired me to make this point. With the help of my project, I intended to close the gap that exists between the revolutionary potential of data visualization and its practical implementation in the context of corporate settings.

My research provided answers to important research questions and objectives, so laying the groundwork for a more in-depth comprehension of the impact that visualization approaches have on decision-making in professional settings. Utilizing the Price Paid Data set as a resource, I conducted an in-depth investigation on the connection that exists between the application of visualization techniques and the degree to which decision-making outputs are accurate, useful, and satisfactory. My work went further than simply illuminating previously concealed ideas; instead, I investigated how visualizations could enable decision-makers to see and evaluate results in a more expedient manner, thereby overcoming the challenges posed by complexity. The analysis included the process of identifying relevant variables within the dataset. These variables comprised data attributes, visualization kinds, and user preferences. Collectively, these factors determine how effective visualization is in assisting with decision-making. In an effort to equip industry analysts with the tools necessary to make more informed decisions, I compiled the newly acquired knowledge into actionable instructions and provided them with recommendations on how to maximize the usefulness of the dataset. In general, the findings of my research made a contribution to the dynamic and ever-changing environment of data visualization, matching the potential of this field with the objective of making decisions in professional settings that are better informed and more successful.

My research led me to discover that the use of visualization techniques in professional contexts can have a sizeable impact on the decisions that are reached, thereby facilitating a more rapid comprehension of intricate data patterns and improving the effectiveness of decision-making. The critical dataset components that identified as essential determinants determining the effectiveness of visualization in supporting decisions include data attributes, visualization modes, and user preferences. With the use of the insights that the Price Paid Data dataset provided, I was able to establish that the strategic incorporation of these insights enables industry analysts to increase the accuracy and effectiveness of their decision-making. In addition to illuminating previously concealed insights, it has been demonstrated that successful visualizations have a wider impact on decision support systems. These visualizations improve accuracy, efficiency, and satisfaction in the decision-making process by permitting unambiguous communication of sophisticated analytical findings to stakeholders.

# **Recommendations**

The findings of this research led to the discovery of various insights, which led to the development of several recommendations for improving the use of data visualization in decision-making processes. To begin, it is strongly recommended that professionals in all sectors undergo training in visualization literacy so that they can interpret and make use of visual representations more effectively. A culture of making decisions based on data should be encouraged in organizations, and those organizations should make tools available to employees in order to facilitate the development of visualization abilities. Second, because the processes of visualization are in a permanent state of change, it is essential to evaluate and modify visualization approaches on a continuing basis. Industry analysts are tasked with conducting in-depth analyses of the viability of various types of data visualizations, taking into account the one-of-a-kind properties of the data as well as the preferences of end-users. In addition, efforts to collaborate between data scientists and subject matter specialists have to be encouraged in order to guarantee that visualizations are in accordance with the particular objectives and circumstances of decision-making endeavors.

# **Limitations**

When determining the course that will be taken by future study, various different pathways become apparent. The fields of augmented reality (AR) and machine learning (ML) are well positioned to bring about further upheaval in the field of data visualization. The investigation of the impact these burgeoning technologies have on the results of decision-making could lead to the discovery of unexpected insights. Researching the psychological underpinnings of data visualization, such as the ways in which varying visual styles influence the perceptions and decisions of decision-makers, could further contribute to the expansion of this field. Studies with a longitudinal design could monitor the changing effects of visualization over time, shedding light on conceivable tendencies and difficulties. In addition, expanding the scope of this research to include topics other than changes in property prices may show variations in the usefulness of visualization that are specific to those topics. Finally, in order to guarantee responsible and impartial decision-making processes, it is necessary to conduct exhaustive research on the ethical considerations that are involved in data visualization. This is especially true with regard to issues of transparency and the elimination of bias.

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