Financial investors' Preferences for Data Visualisation Features to Aid Decision-making: a Literature Survey

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1 Introduction

This is a short literature survey exploring how financial traders' preferences for data visualisation vary with respect to their financial knowledge. It focuses on collecting empirical evidence of the effectiveness of different data visualisation techniques which can be generalised to present financial data. A total of 8 papers had been selected and reviewed, and both their experimental & questionnaire-based results are compared against each other.

2 Search methods

I conducted a keyword search on the online search engine Google Scholar, limited to English-language works that had been peer-reviewed and published, in order to ensure the quality of the sources. The keywords used were "financial", "data", "visualisation" and "questionnaire", they were chosen as "financial" and "data" narrowed down the type of data being visualised, "visualisation" was used as a category name for visualised information, "questionnaire" limited the type of experiments. The search results were ordered based on their relevance to the keywords. This keyword search returned 137,000 results.
It is impractical to identify all 137,000 search results, the first thirty results shown in the keyword search were sampled and their abstracts have been carefully studied. An article would be selected for this review and further analysed if (1) the visualisation methods discussed can be generalised to present financial data. (2) subjective Likert-scale questionnaires were used to collect participants' attitudes toward the specific visualisation methods. (3) The financial characteristics of the participants are reported

3 Findings

Many research regarding the effects of data visualisation on decision-making were developed from Vessey's original theory of cognitive fit (Vessey, 1991) [1]. He proposed that matching the problem representation with the specific task leads to more efficient and effective decision-making results. Specifically, graphical representations are more efficient and effective for spatial tasks (i.e., assessing relationships among data), while textual representations are better for symbolic tasks (i.e., extracting individual data values). The cognitive fit theory was subsequently extended to consider both the external problem representation (the visualisation method) and the decision maker's internal representation of the problem domain which is influenced by the decision maker's expertise in the specific domain. (Vessey, 2006) [2]
The effects of the visualisation method on financial decision-making can be analysed from two aspects. (1) Accuracy, to make a correct conclusion about the pattern of the data, and to correctly identify outliers (possible opportunities) in the data set. (2) Time spent processing the data set before making final conclusions/decisions.
The correctness of the final financial decision (whether it returns profits or losses) should not be a measure of the effects of data visualisation on decision-making since it is related to the decision-maker's methods and influenced by the market chaos. The findings of the eight selected research are demonstrated in table 1.

Table 1: Overview of research findings

Study	**Participant Profile**	**Findings**
Wei, Webber and Herbert (2005) [7]	40 adults with little financial knowledge	Participants preferred Sunburst to Treemap and found it is easier to learn when performing various tasks on simulated financial market data using visualisation techniques. On the other hand, participants using the large data set were generally more positive than those using the small data set, and those using fisheye-lens were generally more positive than those not using fisheye-lens, both contrary to their results in the objective tasks.
Dorina (2007) [4]	12 University Students with professional financial knowledge	The effectiveness of 9 different data visualisation methods in solving financial problems has been assessed individually. Experimental results show (1) Permutation matrix, Survey plot, Scatter plot, Parallel coordinates, and Principal Component Analysis were more effective in comparing companies' financial states (2) Permutation matrix, Survey plot, Scatter plot matrix, and Parallel coordinates were more effective in revealing clusters within the data (3) Line graphs, Survey plots, and Treemaps were more effective in revealing classes in the data. (4) Scatter plots were the most effective in revealing relationships between variables in the data
Tanlamai (2012) [5]	124 Students, mostly with little financial experience	Participants were shown financial data that were displayed in 2D, 3D, and MR (mix-reality layer added to 3D table) tables. Results suggest that 2D tables are the most efficient modes of representation, while MR graphs were seen as complex and difficult to use.

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Table 1: Overview of research findings

Study	**Participant Profile**	**Findings**
Tanlama et al. (2017) [7]	116 adults with moderate financial experience	Time-series AR visuals which allow comparisons between companies' financial performance were examined in this study, they provide maximum data with less text and more 3D visuals. Novice investors found it easier to use whereas more experienced investors prefer detailed excel-style tables and graphs with more numbers over AR simplifications, as they are more familiar with them and would feel more confident working with them.
Abdalla et al. (2018) [8]	135 of both professional and non-professional investors	Experimental results suggest that interactive data visualisation tools significantly improve both accuracy and response time in complex financial tasks, consistent with cognitive fit theory. Also, theory-based decisional guidance besides the visualisations has a significant positive effect on the accuracy of professional investors, however, it has a negative effect on the accuracy of nonprofessional investors. (In the interactive visualisation setting of this experiment, participants were allowed to select which data to display, and how they are displayed)
Perdana et al. (2019) [9]	404 non-professional investors	When using interactive visualisation to perform investment tasks, non-professional investors perceived better cognitive fit which lead to greater accuracy. (visualisation on calcbench.com was used in this study, which allows text-search, and data comparison between companies)
Kojić et al. (2020) [10]	23 adults with moderate financial experience	Participants reported interaction is significantly more natural with 2D data than interactions with 3D data in VR although both 2D and 3D data were highly effective and accurate when performing financial tasks.

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Table 1: Overview of research findings

Study	Participant Profile	Findings
Luo (2022) [11]	248 business students with professional financial knowledge	This study suggests that when choosing visualisation methods, most participants put more weight on task characteristics than their visual experience, they tend to select a visualisation format that fits better with task requirements rather than relying on their past experience and gut feelings in selecting a visualisation format

six conclusions are generalised from the eight selected studies and their findings in table 1:

- Interactive data visualisation tools significantly improve both the accuracy and response time in financial decision-making, in comparison to static data visualisations. This is true regardless of users' financial knowledge and it's supported by Vessey's original theory of cognitive fit. [1][8][9]
- The effectiveness of different visualisation methods on decision-making varies from task to task. (Supported by all eight selected studies)
- There is no clear linkage between users' preferences for visualisation methods and their performance in decision-making, as the visualisation method they prefer may not fit the particular financial task. [3][10][8]
- Knowledge of data type, decision-making methods and characteristics of visualisation methods, specifically which method fits better with which task have a joint effect on users' performance in financial tasks. They are the main difference between professional and non-professional investors when making financial decisions. This conclusion is consistent with the extended theory of cognitive fit. [2][7][11]
- No distinct difference between the effectiveness of 2D & 3D visualisations. [5][7][10]
- Users are more accepting of 3D visualisations in later-year studies. [5][7]

4 Discussion

Data Visualisations can effectively improve users' performance in financial decision-making, both in terms of accuracy and response time. This short literature survey took a sample of eight studies and reviewed their findings with respect to different characteristics of visualisation techniques and participants.

Successful financial decision-making depends on the user's ability to detect patterns, outliers, and differences between variables within the data set. The external representation of the data (the visualisation methods) is perceived by the user and then processed internally. Its outcome is influenced by both the external representation of the data and the internal representation of the problem (Expertise in the financial domain, individual cognitive style, and complexity of the given task all play an important role in the internal processes).

For the development of website-based financial data visualisations, the selected studies suggest that interactive visualisations which allow users to (1) select which data to display and (2) how they are displayed can significantly improve the accuracy and response time in financial decision-making for all types of investors.

Besides this, it is important to provide different visualisation methods for different financial tasks & scenarios, for different users (For example, users with certain cognitive styles may prefer 3D visualisations over 2D)

It is also crucial to inform the user about the functions of the particular visualisation methods

and the meaning of the data being displayed, especially for non-professional investors. Because sometimes inexperienced users may rely on past visual experiences, their preferences for certain visualisation methods may not fit the current financial tasks and their actual performance may be contrary to their feelings.

Decisional guidance may be used along with interactive techniques to allow the users to select a suitable visualisation format in different scenarios. Interestingly, Abdalla et al. (2018) found that such guidance can have a negative effect on non-professional investors. One explanation for this problem is that informational guidance was provided in Abdalla's study, and the extra details may add to the complexity of the visualisations and inexperienced users may find them more difficult to understand. There is a prior study suggesting that informational guidance is more useful for professionals, while suggestive guidance is more beneficial for improving the results of inexperienced decision-makers (Parkes, 2013).

To overcome the problem, it is important to provide two different sets of guidance for users with different investment experiences, informational guidance are beneficial for professionals and simplified, suggestive guidance will likely improve the effectiveness of data visualisations for non-professional users.

This literature survey has several limitations: (1) only eight studies were selected, (Dorina, 2007) and (Kojić et al, 2020) sampled a relatively small number of participants. A small sample size reduces the reliability of the conclusions, as it leads to a higher variability, which may then lead to bias. (2) The selected studies were conducted in different countries, so there is the possibility for Culture bias, the findings of studies conducted in one culture may not apply directly to another. For example, American participants and Thai participants may have different attitudes towards 3D visualisations.

Further research on the recent development of financial data visualisation methods and their characteristics is needed, in order to generate decisional guidance for users and to recommend different visualising tools for different decision-making scenarios.

References

[1] Vessey, Iris. "Cognitive fit: A theory-based analysis of the graphs versus tables literature." Decision sciences 22.2 (1991): 219-240.

[2] Vessey I. The theory of cognitive fit: one aspect of a general theory of problem solving? In: Zhang P, Galletta D, editors. Human–Computer Interaction and Management Information Systems: Applications, 6. Advances in Management Information Systems; 2006. p. 141–83

[3] Jiang, Wei and Richard Webber & Ric D Herbert, Information visualisation Of An Agent-Based Financial System Model, No 468, Computing in Economics and Finance 2005, Society for Computational Economics, https://EconPapers.repec.org/RePEc:sce:scecf5:468.

[4] Marghescu, Dorina. "User evaluation of multidimensional data visualisation techniques for financial benchmarking." Proceedings of the European Conference on Information Management and Evaluation (ECIME 2007). 2007.

[5] Tanlamai, Uthai, Phannaphatr Savetpanuvong, and Wisit Kunarittipol. "Financial data assessment using table-graph-mixed reality visualisation." Journal of Information Technology Applications and Management 19.1 (2012): 13-24.

[6] Parkes, A.: 'The effect of task–individual–technology fit on user attitude and performance: An experimental investigation', Decision support systems, 2013, 54, (2), pp. 997-1009

[7] Tanlamai, Uthai, Aim-Orn Jaikengkit, and Teerayout Wattanasupachoke. "Financial analysis of thai banks: Effectiveness of augmented reality visualization." Journal of Information Technology Applications and Management 24.3 (2017): 51-61.

[8] Abdalla, Menatalla, Ismail Gomaa, and Ghada El-Khayat. "Interactive Data visualisation: Factors Influencing Effective and Efficient Financial Decision Making–An Experimental Study." theme is: Humanitarian ICT.: 138. (2018)

[9] Perdana, Arif, Alastair Robb, and Fiona Rohde. "Interactive data visualisation for accounting information: a three-fit perspective." Behaviour & Information Technology 38.1 (2019): 85-100.

[10] T. Kojić, S. Ashipala, S. Möller and J. -N. Voigt-Antons, "Exploring Visualisations for Financial Statements in Virtual Reality," 2020 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR), 2020, pp. 49-52, doi: 10.1109/AIVR50618.2020.00018.

[11] Luo, Wenhong. "User Selection Strategies of Interactive Data Visualization Format." Journal of Computer Information Systems (2022): 1-13.