

The Role of Data Visualization in the Finance – The Case of Publicly Listed EdTech Companies

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Abstract

This study explored the application of data visualizations in finance, focusing on publicly listed EdTech companies from the New York Stock Exchange (NYSE) and NASDAQ. By adopting a qualitative approach combining literature review with document analysis, the study has revealed a limited use of graphical items in 10-K reports of these companies. Most visualizations are used to illustrate cumulative shareholder returns over specific periods and use the major indexes for comparison purposes. The financial information platforms like Yahoo Finance and Google Finance provides to investors advanced, interactive data visualizations features such as Bollinger bands visualizations that meet the requirements of sophisticated investors and traders. There are potential benefits of integrating more graphical elements in official financial reports to improve data comprehension, interpretation, and investment decision-making

Key words: data visualization, EdTech, financial reporting

J.E.L. classification: C80, C88, G10, G30

1. Introduction

Data visualization, often named “DataViz”, in its simplest definition is “*the representation of information and data using charts, graphs, maps, and other visual tools*” (Coursera, n.d.).

Data visualization lies at the intersection of art and science, combining principles of visual perception with analytical thinking to enhance the understanding and impact of graphically displayed information. As a scientific discipline, DataViz relies on principles of visual perception and human cognition to enhance understanding and make data memorable.

Its utility is visible in many major fields such as healthcare, education, energy, manufacturing, and finance, to name just a few. For example, data visualization is used in healthcare for visualizing patient data, medical research, and improving hospital operations. In manufacturing, it is used in product development and quality control. In the energy sector, it is utilized for visualizing production and distribution flows of electricity. Data visualization is particularly important in the financial sector. In this field, data visualization is useful for analyzing stock price, financial statements, illustrating various comparisons and trends of key performance indicators or financial ratios, and forecasting cash flows or revenues. Other uses include detecting banking fraud, analyzing investment portfolios, and applying technical analysis to stocks.

The goals of data visualization include intuitive and quick understanding of data, making better decisions, improving efficiency, and adding greater value to organizations.

As financial reports become more complex and harder to read, due to adapting to reporting requirements (Schoenmaker and Schramade, 2023), data visualization has the potential to provide an efficient way to transform data into an easily understandable and analyzable form.

Data visualization can be achieved with line plots, scatter plots, box plots, density plots, violin plots, bar charts, area charts, pie charts, histograms and so on. More advanced forms of data visualization include heat maps, tree maps, parallel coordinate plots, or spider plots.

Particularities of financial data: These are predominantly quantitative data related to costs, stock levels, and the display of statements—mandatory accounting data for investors—as well as time series with various indicators such as stock prices. In the field of companies’ financial valuation, we differentiate between two types of analysis: fundamental and technical. Technical analysis has generated sophisticated elements for the analysis and interpretation of financial data, such as MACD or Bollinger Bands.

Over time, various software programs have been developed to aid in data visualization, such as Microsoft Excel, Google Charts, Tableau, Power BI, D3.js, Grafana, etc.

Additionally, programming languages Python and R have become popular among data scientists through their data analysis and visualization libraries. Among these, we mention matplotlib, bokeh, and seaborn in Python, or ggplot2, ggvis, and plotly in the R language.

The purpose of this article is to explore the role of data visualization in the financial field, with examples from the financial reporting and analysis of public companies in the EdTech sector. For this, we have provide examples of visualizations from companies’ annual reports and from financial platforms such as Yahoo Finance or Google Finance.

2. Literature review

Data visualization has become a popular topic in the last decades. This was influenced by the development of data science and data analytics applications (Schmidt, 2021). A simple query in Web of Science Core Collection database on the “data visualization” topic has returned 12,795 results that included articles (7660), proceeding papers (5094) and reviews (402). The highest number of papers (1363) were published in 2022.

In the current section, the authors have reviewed the most relevant papers returned by the query in WoS. On a thorough review, we have removed a few papers from the original list that were not fully relevant for the topic of this paper.

Kawahara and Takeuchi (2021) have proposed a scalable graph analysis and machine-learning platform in order to improve the cash flow prediction in banks. They introduced two new graph features: an internal money flow feature based on Markov processes and an anomaly score derived from other graph features. Tested with real bank transaction data, their method significantly improved prediction accuracy over traditional time-series models.

Laidroo (2019) investigated how graphical elements from the annual reports of 33 banks located in Central and Eastern Europe influence performance attributions. The study found that negative performance attributions increase the use of external indicator graphs. This is in line with the previous researches and may indicate intentional impression management by banks.

Similarly, impression management strategies have been investigated in an older paper by Laidroo and Tamme (2016). They have analyzed the usages of graphs in annual reports from Central and Eastern European (CEE) banks over a five-year period, identifying impression management strategies and recommending vigilance from annual report users due to potential material distortions in the visual display of the information or sudden disappearance of certain graphs. Furthermore, Laidroo (2016) assessed the reliability of graphs in CEE bank reports during crisis and non-crisis periods. The research revealed a prevalence of favorable measurement distortions and an increase in impression management during crises.

Melis and Aresu (2022) have studied the selective use of graphical information in corporate annual reports across different countries. Since the pressure to deliver good performance is high, companies may be inclined to provide a subjective, non-neutral image of their performance. Based on this, the authors have recommended that the readers of annual reports to be cautious when using graphical information provided by companies.

Zhang (2020) has investigated the effect of the visual impact defined as graphical vividness on non-professional investors. Based on the conclusions drawn from an experiment with 470 participants, the author has found that the graphical vividness degree had an influence on the non-professional investors’ judgments and decisions.

Falschlunger et al. (2015) have examined the graphical representation from the annual reports of the top 50 publicly listed companies in Europe. This analysis included the annual reports from seven years, which included more than 4600 graphic displays. The authors concluded that topics and the

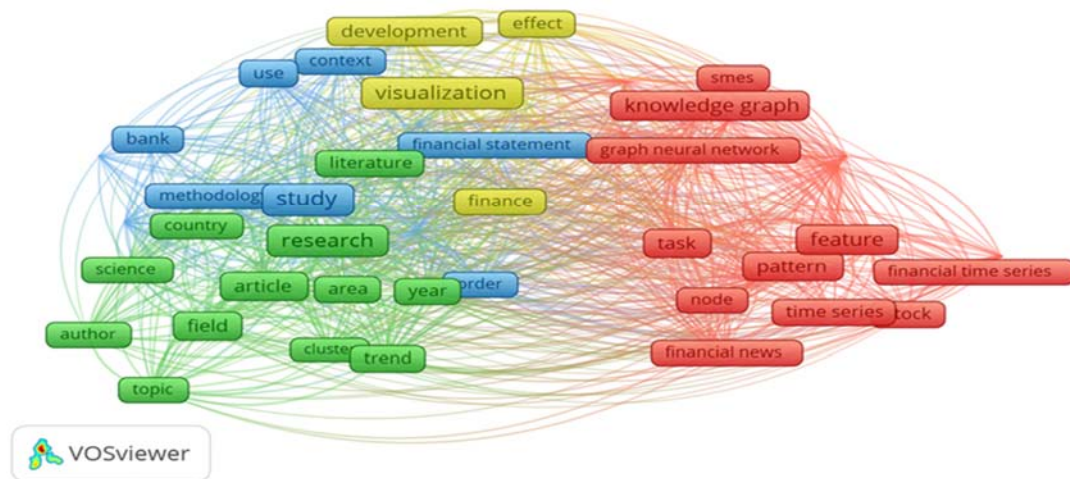
ways that are illustrated have changed in time. Furthermore, the graphs seem to exaggerate positive trends.

As it can be seen, the data visualization is used in a variety of domains related to finance, including enhancements in predictive accuracy for bank cash flow, impression management through graphical display, selective use of graphical information in annual reports.

Based on the papers extracted from WoS, we have used VosViewer, version 1.6.19, Leiden University, The Netherlands (Van Eck and Waltman, 2010) in order to perform co-word analysis in order to identify notable key terms associated with our research topic.

In the Figure 1 below, we have illustrated the co-word analysis.

Figure no.1. – The keyword co-occurrence map generated by VosViewer



Source: generated by authors with VosViewer

3. Research methodology

The objective of this research is to examine the role of data visualization in understanding complex data from the financial domain.

The authors have adopted a qualitative approach, combining the literature review with content analysis.

Literature review: The authors have conducted an analysis of scientific literature published in journal entries indexed in Web of Science Core Collection (WoS) database, reviewing relevant journal articles and research reports published in the last decade.

The approach that has been adopted was to focus on the most relevant papers written in English that included in their titles the relevant keywords pertaining to data visualization and finance. The complete query in WoS is presented below:

data visualization" OR "data viz" OR visualization* OR chart* OR plot* OR diagram* OR dashboard* OR graph* OR heat*map* OR histogram* OR tree*map* OR infographic* OR box*plot* OR "graphical representation" OR "visual analysis" OR "information visualization" OR "visual data analysis" (Title) AND "finance" OR "financial*" OR "annual report*" OR "quarterly report*" 10-K OR 10-Q OR "balance sheet" OR "income statement*" OR "cash flow*" (Title) AND 2014-01-01/2024-05-31 (Publication Date) AND English (Language) and Review Article or Proceeding Paper or Article (Document Types)

The query above has returned 268 results that included 182 articles and 83 Proceeding Papers that have been exported in text and RIS file formats. Next, we have used the VosViewer software tool, version 1.6.19 (Van Eck and Waltman, 2010) in order to generate a co-occurrence analysis based on extracted data.

Content analysis: we have performed a document analysis of the latest annual reports of a sample of 11 publicly listed companies on NYSE and Nasdaq stock exchanges from EdTech sector: 2U, Inc., Adtalem Global Education Inc. , American Public Education Inc. , Chegg, Inc. , Coursera, Inc., Duolingo, Inc., Grand Canyon Education Inc., Perdoceo Education Corporation, Stride, Inc., Strategic Education Inc., Udemy, Inc. Furthermore, we have reviewed the data visualization features of the financial platforms such as Google Finance and Yahoo Finance in order to assess the

4. Findings

We have identified the following companies from the EdTech sector that are listed on New York Stock Exchange (NYSE) or NASDAQ stock exchanges.

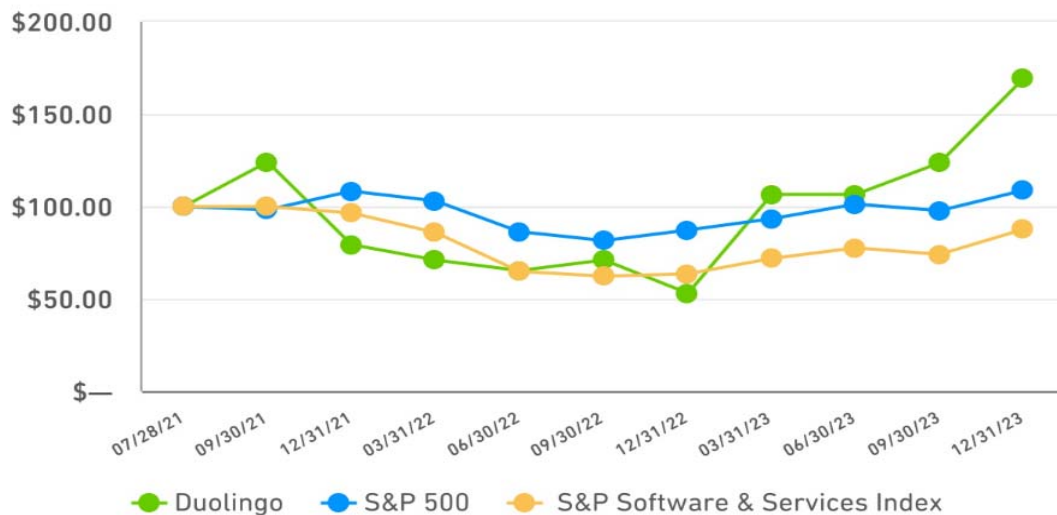
Table no. 1 The list of publicly listed EdTech companies on NYSE or NASDAQ

Company Name	Symbol	Number of charts or graphs from 10-K Reports
2U, Inc.	TWOU	1
Adtalem Global Education Inc.	ATGE	1
American Public Education Inc.	APEI	3
Chegg, Inc.	CHGG	1
Coursera, Inc.	COUR	2
Duolingo, Inc.	DUOL	1
Grand Canyon Education Inc.	LOPE	1
Perdoceo Education Corporation	PRDO	1
Stride, Inc.	LRN	1
Strategic Education Inc.	STRA	1
Udemy, Inc.	UDMY	1

Source: Authors

After identifying these companies, we examined their 10-K reports to understand how they utilize graphical items such as charts or graphs. We observed that there are limited occurrences of visualizations in official 10-K reports. This means that investors should rely more on often on numerical and text data, which can be less intuitive and harder to understand or interpret comparing with chart or graphs visualizations. The analyzed companies use graphs to illustrate the cumulative return of their common shares over a period, such as two to five years. Figure 2 below illustrates this for Duolingo Inc.

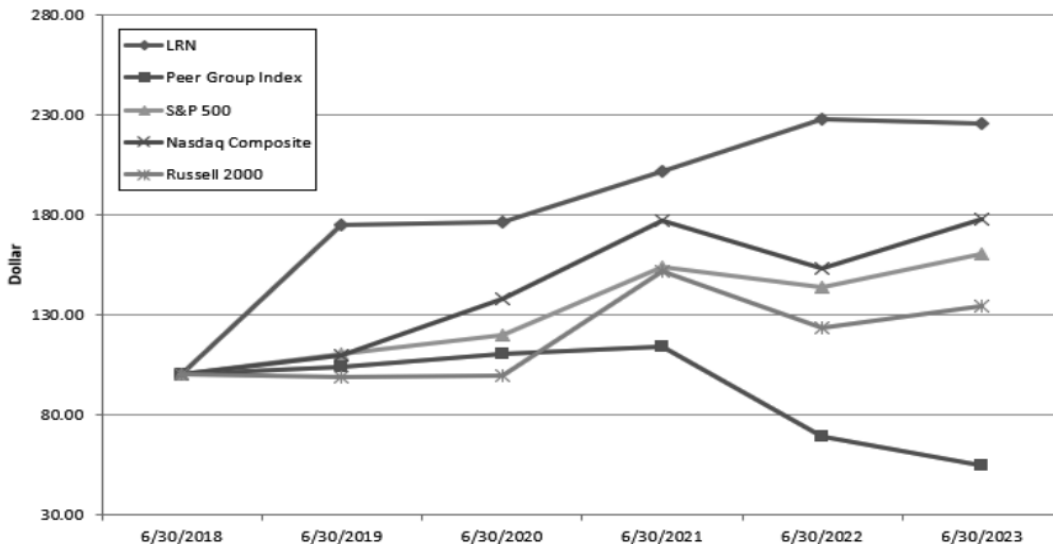
Figure no. 2 Comparison of Cumulative Total Return, Duolingo Inc.



Source: Duolingo Inc., 2024

Also, the companies compare this with a number of various indexes such as S&P 500 Index, S&P 500 Information Technology Index, Nasdaq Composite Index, Russell 2000 Index. Besides the well-established indexes, some of the analyzed companies used additional benchmarks such as a peer group of companies from the same sector to measure the cumulative total return (Stride, Inc., 2024 ; Adtalem Global Education, 2024). Figure 3 shows a comparison of five-year cumulative total returns for Stride Inc. against various benchmarks.

Figure no. 3 Comparison of Five-Year Cumulative Total Return for Stride Inc.

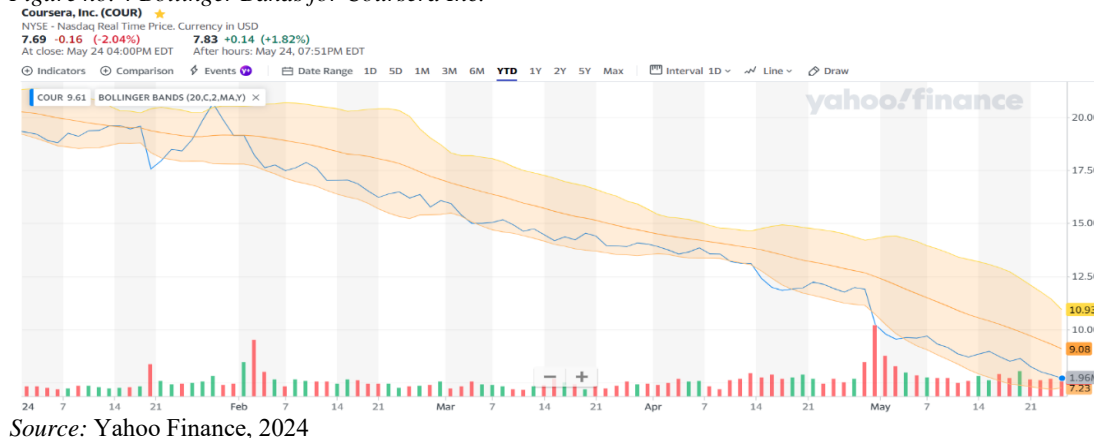


Source: Stride Inc., 2023

The analysis of annual reports revealed the scarcity of the visualizations included in the official 10-K reports. This may be explained by the rigorous communication rules that need to be enforced in the audited materials.

If the graphical displays in annual reports were mainly used to illustrate the evolution of the stock price and to compare against various benchmarks such as S&P 500 index, the financial platforms offer more advanced data visualization features that are more appropriate for technical analyses. In contrast with 10-K Reports filled by analyzed companies, the financial platforms such as Yahoo Finance offer multiple options of interactive data visualization of stock price. This include advanced visualizations that can illustrate the volatility of stocks, such as Bollinger Bands – a popular instrument among traders and investors (Investopedia, 2024). We have illustrated below the Bollinger Bands for Coursera Inc. on Yahoo Finance platform.

Figure no. 4 Bollinger Bands for Coursera Inc.



Source: Yahoo Finance, 2024

Also, financial platforms can provide comparisons of multiple stocks like Google Financials. The Figure 6 below illustrates an example of such comparison.

Figure no. 6 Evolution of the stock price for the current year three companies



Source: Google Finance, 2024

While 10-K Reports adhere to the regulatory requirements and ensure accuracy of the financial disclosures the diverse options of data visualizations from platforms such as Yahoo Finance or Google Finance, play an important role in helping investors to understand the financial data. These platforms help investors in gaining more insights regarding the trends of the stock price and provide a wide variety of displaying historical data.

The inclusion of more advanced graphical elements in official financial reports such as 10-K Reports, where possible, has the potential to improve the understanding of the financial data.

The financial research platforms can be used together with 10-K reports to improve the understanding of the financial positions of the analyzed companies and to make better investment decisions.

5. Conclusions

When applied correctly, data visualizations have the potential to improve the understanding of the financial data.

The current analysis has shown that there is a limited utilization of visual graphs and charts in 10-K reports of EdTech companies listed on NASDAQ or NYSE.

Whenever used, the purpose of these graphs and charts was to show the cumulative shareholder returns over specific periods. This limited utilization of data visualizations suggests that investors should rely very often on number or text data – that are less intuitive and harder to be processed comparing with visual information.

While 10-K reports adhere to regulatory requirements and provide accurate data, they lack the power of advanced data visualizations. The inclusion of more advanced graphical elements in official financial reports such as 10-K Reports could have a positive impact on understanding and make sense of the financial data.

This research has shown that using advanced visualization tools could add significant value to financial reporting and analysis.

The current study has a number of limitations: we have considered a limited sample of companies that are listed on NYSE or NASDAQ. This leaved aside the publicly listed companies from other regions.

Also, we have examined a very limited number of platforms that delivers financial information. Including more such financial research platforms may be beneficial for understanding the available visualization options in financial domain.

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