INTERACTIVE INFORMATION VISUALIZATION OF FINANCIAL STABILITIES OF COMPANIES FOR EFFECTIVE STOCK MARKET DECISION MAKING

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Degree of Master of Business Administration in Information Technology

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Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

May 2020

DECLARATION

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ABSTRACT

The Stock market is where billions of money exchanging daily. Investment decisions of the Stock market are very critical. There are many types of factors affect investment decisions. Among them, observation of share price fluctuation is the very common method that many investors are referring. Therefore, they invest money with a risk of failure.

Share price fluctuation does not directly reflect the financial stability of companies. It may have various other reasons. The financial performance analysis of companies is one of the best methods to analyze the financial stability of companies. It can be used for industry-wise financial performance analysis. From 2012 to 2017 financial years data from annual reports were collected and calculated as required. The year 2018 was forecasted using a simple moving average. Ten financial ratios under four main types of ratios have calculated. These are price to book, earning per share, price to earnings and dividends payout ratios under the stock market ratio, return on equity, net margin and asset turnover ratio under the profitability ratio, debt to asset and debt to equity ratios under the solvency ratio and finally liquidity versus quick acid ratios under the liquidity ratio. These data were taken for descriptive analysis and Altman's Z-score and forecasted year were calculated for predictive analysis. Financial ratios describe financial performances throughout the given period and Altman's Z-score describes the prediction of the likelihood of being bankruptcy.

Very few ratios do exist in annual reports but there is no interpretation has described. For calculation and interpretation, high knowledge of finance and accounting is required. Therefore, the neediness of the easy analyzing tool is present. The research addressed this problem by proposing an interactive information visualization of financial performance to help investors to make clever decisions in the stock market.

The research was conducted as a quantitative analysis based on survey results of the user-based evaluation. The user-based evaluation was performed for the preference test and A/B test with users who are interested in company data. The preference test was performed to identify how people read, understand and analyze data provided by the graphs and also drawbacks of graphs. Based on the results of the preference test, the proposed dashboard was designed as a solution for interactive information visualization. The dashboard of typical graph designs with existing data found in an annual report and the proposed dashboard design with new insights creation were tested under the A/B test.

This research found that the proposed dashboard design was easy to read and understand insights of the data, even though if the user does not have good domain knowledge. It leads users to the right direction where users should be.

Keywords: Interactive information visualization, financial performance analysis, financial ratios, Altman's Z-score, graph design techniques, preference test, A/B test.

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LIST OF ABBREVIATIONS

ACC	Access Engineering PLC
CSE	Colombo Stock Exchange
D/A	Debt to Asset ratio
D/E	Debt to Equity ratio
DPS	Dividend per share
EPS	Earnings Per Share
IIV	Interactive Information Visualization
IT	Information Technology
IV	Information Visualization
MCQ	Multiple Choice Questions
MTD	MTD Walkers PLC
LKM	Lankem Development PLC
P/B	Price to Book ratio
P/E	Price to Equity
PLC	Public Limited Companies
ROE	Return on Equity

1 INTRODUCTION

This research focused on interactive information visualization (IIV) of the financial stability of companies for effective stock market decision making. In this chapter describes the background and motivation, research scope, problem statement, research objectives, research significance and outline.

1.1 Background and motivation

The stock market is the place that meets buyers and sellers of stocks/shares which claims the ownership of the business. Stocks are issued by publicly owned companies which are named as public limited companies (PLC). These companies are listed in the stock exchange. The stock exchange is the medium where shares, bonds and other securities are trading between a stockbroker and a trader. The stock exchange in Sri Lanka is Colombo Stock Exchange (CSE).

Many ways control share prices. In the previous study by Hutabarat &Tarigan (2016) explained share price and share selection are depend on company financial performance, management policy decisions, dividend policies, expected cash flows risk, economic environment factors, shareholder. None of the company can control external factors to control their share price. Internal factors such as financial performance, dividend policies, management control and expected cash flow are performed under the control of the company. The investor's interest in the company is highly relying on past financial performance as well as the plans bring positive benefits to the company.

Annual reports are the direct source to analyze the financial performance of a company (Hutabarat &Tarigan, 2016). Each company publishes its annual reports to the general public at the end of each fiscal year. Investors are experiencing financial losses in the stock market due to less analysis of the real value of share price. Not understanding market cycles, emotional decision making and looking to get rich quick are some of the reasons where investors experience financial losses (Friedberg, 2018). They tend to make decisions by looking at price fluctuations. Gain profit to recover the loss is not easy. Due to continued internal and external changes in the financial environment, Investors should have to make a clever decision to rescue.

Below table explains the relationship between the loss and gain need to be recovered the loss.

Table 1.1 - Relationship between share loss and gain needed to recover

Initial loss	**Gain needed to recover**
8%	8.7%
25%	33%
30%	43%
40%	67%
50%	100%

(Source Chung, 2019)

There is a positive correlation between initial loss and gain needed to recover. When loss increases, Investors should take big steps forward to recover it. Therefore being a loser in the stock market is not easy.

In the situation of set share price under many factors, people should have good knowledge about company performance before making investment decisions. CSE has 290 companies under 20 business sectors as at 20th January 2020 (Sector classification, n.d.). Selecting a company from the pool of 290 is a hard choice. Analyze information from annual reports help to decide the correct company. To do that task, people should have good financial literacy at an acceptable level. Lusardi (2015) found that some investors do not have good financial literacy to read and understand financial information. It's not practical to learn Finance and Accounting as an initial requirement before becoming an investor. People learn through the experience. Meanwhile, a lot of time and money may lose when he/she become a good analyzer.

There are many financial performance analysis methods (Financial Performance Analysis, n.d.). From these methods, the most popular and easy method is financial ratio analysis. Calculation of these ratios is hard work. Annual reports do not share every ratio and also do not maintain the same list of ratios in every report

publications. It is a barrier to get quick information from annual reports. Readers should have to do the calculation by themselves to analyze company performances. Annual reports provide data/figures under each financial statement only. Therefore it is a barrier to create information from financial data.

The present study aims to provide a solution to this barrier by proposing an interactive dashboard. It provides information visualization of the financial performance of companies and helps to analyze insights to users, even though they are poor in financial literacy.

1.1.1 Research Scope

Under the financial performance analysis, the proposed study was used financial ratio calculation as descriptive analysis and results of Altman's Z-score and forecasted data were chosen as predictive analysis. The simple moving average was used to calculate forecast data of the company and industry-wise. Other methods of financial performance analysis are excluded.

The existing graph designs have taken from common graph designs practices on the web and modified based on the user-based evaluation. The users of this study were people who are interested in company data. Proposed dashboard design was accepted by users as the most preferred and acceptable design. The proposed dashboard may have alternatives. It was not tested with visually impaired people. Furthermore, the researcher assumed that all responses were true beliefs of users and no external interferes occurred.

1.2 Problem Statement

The stock market is an unpredictable market space. Today winner may become looser tomorrow. To win this game, actions of Investors should be taken at the right time in the right company. Selecting the right company to invest to increase the wealth of the Investor is tricky. Currently, CSE has 290 companies. Each company operates differently under their management. It is very important to know about the financial stability of each company before making investment decisions. Otherwise, Investors may plant in the wrong climate which leads to dropping the harvest. Financial performance analysis is a method to analyze the financial health of the

company. To do the analysis, Investors should have good knowledge of Accounting and Finance. That is something impractical because it is a subject matter. Therefore as a solution, the neediness of an easy analyzing tool is existing. Therefore this present study specifically attempts to address the following research question:

"How information visualization of financial performance help Investors to make clever decisions in the Stock market?"

1.2.1 Research Objectives

- ✓ Identify the most successful graph designs which are easy to identify insights.
- ✓ Provide relevant financial information about the financial stability of companies
- ✓ Propose an interactive, user-friendly dashboard, especially those who are not aware of Accounting and Finance.

1.2.2 Research Significance

The finding of this study redounds to the benefits of society considering that information visualization of financial performance plays an important role in effective stock market decisions. Internal and external users who are interested in company data can be identified as the beneficiaries of the proposed solution. The results of the study can apply as a recommended approach to visualize information helps to abstract insights of data. Not only Investors but also the decision-makers in any sector can use the proposed solution as a management information tool. The results found out under the section of information visualization will be benefited to designers as new design concepts in graph designing.

1.2.3 Outline

The rest of the thesis is organized as follows: Chapter 2 presents a literature review including stock market investment and risks, financial performance analysis and financial literacy. Chapter 3 presents the research methodology which applied quantitative method approach. Chapter 4 presents the data analysis and conclusion and future work presents in chapter 5 as the last chapter of the thesis. All survey questionnaires and prototypes of dashboards are kept in appendices.

2 LITERATURE REVIEW

In the first section, stock market investment was presented. Under that investment risks and stocks were discussed. As the second section, financial performance analysis was presented. Under that financial performance methods, economic value-added analysis, DuPont analysis and Tobin's Q analysis were discussed. As final sections, information visualization and financial literacy were discussed.

2.1 Stock market investment

The stock market is the place that meets buyers and sellers of stocks/shares which claims the ownership of the business. Public Limited Companies (PLC) issues their stocks/shares to the public in the Stock Market. For every share has a monetary value. This requires buyers and sellers to agree on a price. The purpose of a stock exchange is to facilitate a marketplace to trade stocks. All exchanges provide real-time trading information on the dashboard facilitating price list. For the same stock, a buyer bids a price for a stock, and a seller asks a price for a stock. Trading means in the market, the buyer accepts any ask /bid price for the stock. When the bid and ask prices match, a sale takes place. It happens on a first-come, first-served basis. Corporate is issue two types of stock. These are Common stock and Preferred stocks. By listing a company in a national or international stock exchange, they can liquidate their stocks, not only that, can easily trade stocks to a large number of investors (Hutabarat &Tarigan, 2016).

Different types of stock trading can be classified based on the duration of stock holding. These are day trading, short term trading, medium-term trading and Long term trading (Types of Stock Trading, n.d.).

Furthermore, Types of Stock Trading (n.d.) explained types of Stock trading classified concerning the trend. These are Trend following, Contrarian investing and Range trading.

Every Investor put their money to someone else business considering the return they can gain out of their investment. If the business is profitable, Investors willing to invest more money and if business shows decline, Investors take out their money

immediately. That is the nature of business. Investment is a return on funds that can be earned over some time (Hutabarat &Tarigan, 2016). Every investment carries both good and bad risks. The risk associated with systematic risk and unsystematic risk. According to the study of Hutabarat & Tarigan (2016), systematic risk comes from common factors and unsystematic risk is due to unique factors.

The stock market is the mirror of the Economy of a Country. Simply because when companies grow, they increase in values. Sometimes traders pay more value than the companies actual value, anticipating companies will perform well in the future. For example, when the Government of Sri Lanka receives a loan from International Monitory Funds for the new investment on Tourism Industry, share prices of tourism companies will rise. The positive growth of Stock market signals the growth of the country's economy and vice versa.

According to the Guide to Investing in Colombo Stock Exchange CSE (2012) the sectors of CSE are Bank Finance And Insurance (BFI), Beverage Food And Tobacco (BFT), Chemicals And Pharmaceuticals (C&P), Construction And Engineering (C&E), Diversified Holdings (DIV), Footwear And Textile (F&T), Health Care (HLT), Hotels And Travels (H&T), Information Technology (IT), Investment Trusts (INV), Land And Property (L&P), Manufacturing (MFG), Motors (MTR), Oil Palms (OIL), Plantations (PLT), Power & Energy (P&E), Services (SRV), Stores Supplies (S&S), Telecommunications (TLE), Trading (TRD).

Selecting the best company to invest is a hard choice. How Investors are aware of the financial health of all these companies? how about the current financial position? Is it worth to invest in this company? To answer these questions, financial performance analysis should be taken place (Basics of Stock Market [Personal interview], 2017).

2.2 Financial performance analysis

The financial performance analysis identifies the financial health of the company by the diagnosis of the data from the balance sheet and profit and loss account.

Financial performance is used to measure the firm's overall financial health over a given period and can also be used to compare similar firms across the same industry

or to compare industries or sectors in aggregation. There are several financial ratios which can measure the financial performance of each company.

The most popular measures in financial literature are ROA (Return on Asset) and ROE (Return on equity) (Katchova & Enlow, 2013). Hansen & Wernerfelt (1989) defined ROA as consideration of company performance. Johnson & Soenen (2003) provided indicators of successful financial performance analysis. Those are quick acid ratio, ROE, ROA, a capital structure ratio and sustainable growth. In the study of Alanazi, Liu, & Forster (2011) examined financial performance with ROA and ROS of 16 Saudi Arabia's IPO (Initial public offering). The study found that firms had started financial performance decline from the year of IPO and intensified in magnitude in the subsequent years. Furthermore, regression analysis indicates that the performance decline among IPOs was associated with IPO occurrence.

In the study of Hutabarat & Tarigan (2016), they have found out seven types of financial ratios which are essential to analyze for share selection in the mining sector in Indonesia. Those are profit margin, ROA, ROE, Current ratio, D/E ratio and D/A ratio.

Colombo Stock Exchange has published six financial ratios and seven other factors to analyze before select stocks. Those are EPS, Profit margin, Dividend history, ROE, Cash flow details, BVPS, Business segment and growth, company size, Competitive advantage, Brand value, product differentiation, Economic environment. (Guide to Investing in Colombo Stock Exchange CSE, 2012).

Furthermore, the study indicates external factors which affect the selection of stock. The first point is Economic environment factors. Under that, economic activities, tax and regulations, market competition, substitute products in the market, global conditions on business, currency exchange rates and bargaining power are the subcategories. The second point is management policy decisions and under that, sale products and services, technologies of production, marketing and distribution network, employment policies, compensation packages, ownership, partnership or corporation are the subcategories. The third point is Conditions in Financial market and under that, interest rates, investor optimism and forecasted inflation are the

subcategories. Dividend policies, risk of expected cash flows and shareholder equity are considered as last points of external factors.

There is no research found that indicates financial performance analysis is not helpful to decide the financial stability of PLCs. All the researches have proved that analyzing financial performance is a good tool to measure financial stability and they have used several techniques to do that.

According to the Financial Performance Analysis - A Conceptual Framework [PDF] (n.d.) there are three main types of tools and techniques to analyze financial performance. Those are Accounting/ financial techniques, Statistical techniques/Statistical averages and Mathematical techniques. Under the accounting/ financial techniques there are eight sub-analysis techniques. Those are Comparative financial statement analysis, Value-added analysis, Correlation and regression analysis, Analysis of time series, Cross-sectional analysis, Ratios and Trend analysis. Under the Statistical techniques/Statistical averages, there are three sub-analysis techniques. Those are Measures of central tendency, Measures of dispersion and Statistical tests. Last technique is Mathematical technique and under that Programmed evaluation and review technique (PERT), Critical path method (CPM) and Linear programming are the subcategories. However, the same study explained that mathematical techniques are not useful for the present study.

When approaching investment in the stock market there are two common methodologies used. These are fundamental analysis and technical analysis. As with any investment strategy, there are advocates and detractors of each approach (Glen, 2013).

To conduct a successful evaluation of the financial performance of PLC, we cannot analyze financial ratios along. A collaborative method should be followed for accurate results.

Here are some benefits of analyzing financial statements. The major benefit is Investors can decide a suitable company to be invested. Secondary regulatory authorities like the International Accounting Standards Board can guide their accounting standards. Thirdly government agencies can analyze taxation.

2.2.1 Economy value-added analysis

In the study of Setiabudhi (2017) explained about the Financial performance analysis using Economic value-added. Using Economic value-added, it can be evaluated financial performance in another aspect. It is the difference between Net operating profit after tax and the cost of capital. In the study explained that EVA focuses on value creation. It focuses to create policies of capital structure, maximizing the return on investment and also minimize the cost of capital. There are three categories. EVA > 0 or EVA is positive. It indicates best in management of adding economic value to the company. EVA value = 0. Break-even in management of adding economic value to the company EVA < 0 or EVA is negative. It's bad in the management of adding economic value to the company. Under the discussion and implementation, it explained the reasons for each result found. This study is not just showing results and concluded. In this method consider only about internal aspects of financial performance. It does not provide a balanced decision based on only the EVA method. It is a limitation of this method.

2.2.2 Du point analysis

DuPont analysis is a method of performance measurement method which assets are measured at their gross book value rather than at net book value to produce a higher return on equity (ROE) (DuPont Analysis, n.d.). ROE measures how efficiently a company can generate profits using shareholder's equity, which includes stock offerings and retained earnings (Lan, n.d.). Further explained three factors affected by ROE. Operating efficiency - measured by profit margin, asset use efficiency - measured by total asset turnover and financial leverage - measured by the equity multiplier.

In the study of Lan (n.d.) mentioned through the use of DuPont analysis, investors can determine the actual drivers behind a company's ROE. The DuPont formula allows ascertaining if a company has been able to effectively use debt to drive stronger profits as well as how margins and asset turnover are trending over time. The DuPont formula provides insight on a firm's strengths and weaknesses, which may give as an investor, a better idea of what to look for when performing fundamental analysis.

Katchova & Enlow (2013) explained that Du Pont analysis has shown that the agricultural businesses take high ROE because it has high Asset turnover that leads to high operating efficiency. A good financial performance of this industry makes agribusiness as a valuable investment even though the economy has a recession.

The above study had analyzed both financial ratios and Du Pont. Therefore results can be considered as accurate. This study had not used any external data. If they had used them, they may have a better conclusion with more findings. They have mentioned that they will look at external criteria as well in recommendations and future work sections.

2.2.3 Tobin's Q analysis

This is an assumption that the replacement cost of all PLCs should be equal to its total market values. There are two categories. A low Q and a high Q. The low Q indicates the undervalued stocks. In other words, the replacement cost of assets is higher than the stock value. The high Q indicates the overvalued stocks. In other words, the replacement cost of assets is lower than the stock value. The stock value is the key factor in Tobin's Q. (Q Ratio (Tobin's Q Ratio), n.d.).

This article further explained an undervalued company is more attractive among purchases because they can purchase the firm rather than making another company.

In the other hand, an overvalued company gets the attention of competitors. A high ratio indicates high earnings than replacement cost and that leads to creating another company in the same firm by competitors.

Sum (2014) study explained that the percentage change in the S&P 500 PE ratio significantly jumps immediately following the stock to the change in aggregate Tobin's q ratio. Further explained the results from the Granger-causality test indicated that the change in aggregate Tobin's q causes percentage change in the Standard & Poor's 500 Index PE ratio.

Standard & Poor's 500 Index is a market value-weighted index and one of the common benchmarks for the U.S. stock market. It is the index of 505 stocks issued by 500 large companies with market capitalizations of at least $6.1 billion. It is seen

as a leading indicator of U.S. equities and a reflection of the performance of the large-cap universe (Standard & Poor's 500 Index - S&P 500, n.d.).

2.3 Information visualization

Information visualization was the next challenge to the researcher. By observing past literature, the researcher found similar research which implemented software as a tool for financial performance analysis. It was implemented with the data of financial ratios and DuPont profitability analysis model. The computer software is used for calculation of the current financial performance of the company as well as computer simulation method for predicting how management decisions will affect the financial performance of the company (Boshkoska & Prisaganec, 2017).

According to the study of Boshkoska and Prisaganec (2017), DuPont analysis model was the only financial performance indicator. They implemented software to interpret the result of DuPont analysis and how it effects to management decisions. However other financial performance analysis methods can be delivered more results of the financial stability of companies. It covered profitability, liquidity, activity and coverage ratios. This software was designed for the management of companies. The system required to be entered the data fields of financial reports. After adding all data by the user, calculation and graph were updated. This solution was good for only internal users because to work with this system need financial knowledge. The researcher found some of the problems in this system. Mainly this was for management not for investors. This would be worthless for outsiders because none of the information can identify due to the lack of domain knowledge. Even though for internal users, the graphical representation of data was very poor. It used old user interface techniques and also the arrangement of data was very poor. The system did not cover major aspects of financial performance analysis. The information provided was insufficient for decision making. The main reason was they displayed only one-year data at a time. There were no comparisons between data. Isolated data was useless for decision making. The graph design was very poor. It had only two data points of new and before of DuPont values. None of the other common graph elements was used. In that case, it was very difficult to understand the data. None of them was labelled. Users need to look here and there to find out some clues for graph

reading. There was no industry average data line for comparison, no forecasted data line for prediction. These items play a very important role in decision making.

According to the Knaflic (2015), mentioned how to make the graph more readable. In this book explained 3D graphs, pie charts, bar charts, doughnut charts should be avoided. It explained those charts could not differentiate data and it loses visual hierarchy. Further, it explained by maintaining the visual hierarchy of data, users can make stories with data. Finally, the book explained that graphs can be used for storytelling, where we can build understanding the context, choose effective visuals, eliminate clutters, focus attention and tell a story.

2.4 Financial literacy

Every Annual Report consists of accounts highlights which are easy to analyze current company performance with past performance. It's a graphical explanation by graphs. Lusardi (2015) found that some investors do not have good financial literacy to read and understand financial information. Therefore these highlights are helpful for them to visualize financial performance. However, Investors should know to read the graphs and identify insights.

In Lusardi (2015, the study was examined at financial literacy. It focused on people's ability to process economic information, how they make decisions about financial planning, debt and pensions. This article helps to understand people's financial awareness which useful to create Interactive Information Visualization as mentioned in the title. This study evaluated people by asking questions of basic and advanced financial knowledge and rated as correct answers, incorrect answers and do not know. Most of them unable to perform simple calculations and failed to understand basic financial concepts. Knowledge of more complex concepts was worst. The study has found an interesting fact about financial literacy. That is financial literacy affects behaviour. The study explained financial literacy was less mostly among women, young, old, and those with low educational attainment. The users who ignored about basic financial concepts were linked to lack of retirement planning, investment in the stock market, and poor borrowing behaviour and also these behaviours can affect individual well-being. As findings, financially sophisticated households are more

likely to participate in investment plans rather than saving plans and they are willing to make good financial decisions.

One of the speeches by Mr Dhammika Perera, at Chartered Accountants Conference 2016, Sri Lanka explained the value of financial literacy in share market trading. He explained traders' loss of billions of money because they just considering share price fluctuation. Lack of calculations of net asset value per share, dividend per share and other information lead to unsuccessful investment (How Mr Dhammika Perera started investing in CSE Stocks [Video file], 2017).

In this research, supposed to create a user friendly, understandable dashboard which facilitates users/traders to compare Companies financial performance. It will help to reduce the gap in financial literacy.

The purpose of this study is to do a descriptive analysis of the financial performance of listed companies based on several methods to provide considerable knowledge to make effective stock market decisions. Every method has drawbacks. To provide effective or accurate information, a collaboration of many methods would express justifiable results. 'To improve company performance, the company should use several parameters or methods' (Setiabudhi 2017, p.8).

3 RESEARCH METHODOLOGY

The research methodology is the specific procedures or techniques used to identify, select, process, and analyze information about a topic (Libguides: research support: research methodology, n.d.). In this chapter describes the research method, research methodology, population and sample selection and the process of data collection.

3.1 Research Problem

This research aims to study how Information visualization of financial performance helps Investors to make clever decisions in the Stock Market. In this research experimented various graphs designs which enhance usability by providing good visual hierarchy. The ultimate objective of the study is to suggest user-centred design dashboard of the financial performance of companies which helps to identify insights of given data for any person even though they do not have a sound knowledge of Accounting and Finance.

3.2 Research Method

The research method of the study was quantitative. This research had two phrases. These were financial performance analysis and evaluation of dashboard design to present calculated financial ratios.

3.2.1 Financial performance analysis

Financial ratios are relationships determined from a company's financial information and used for comparison purposes (financial ratios, n.d.).

From the standpoint of users and time, this analysis is fallen under the external analysis and static/vertical analysis respectively (Subho, 2016). Calculated ratios were categorized as liquidity ratios, profitability ratios, solvency ratios and stock market ratios. Altman Z-score was used to predict the likelihood of being bankruptcy.

3.2.2 Evaluation of dashboard design

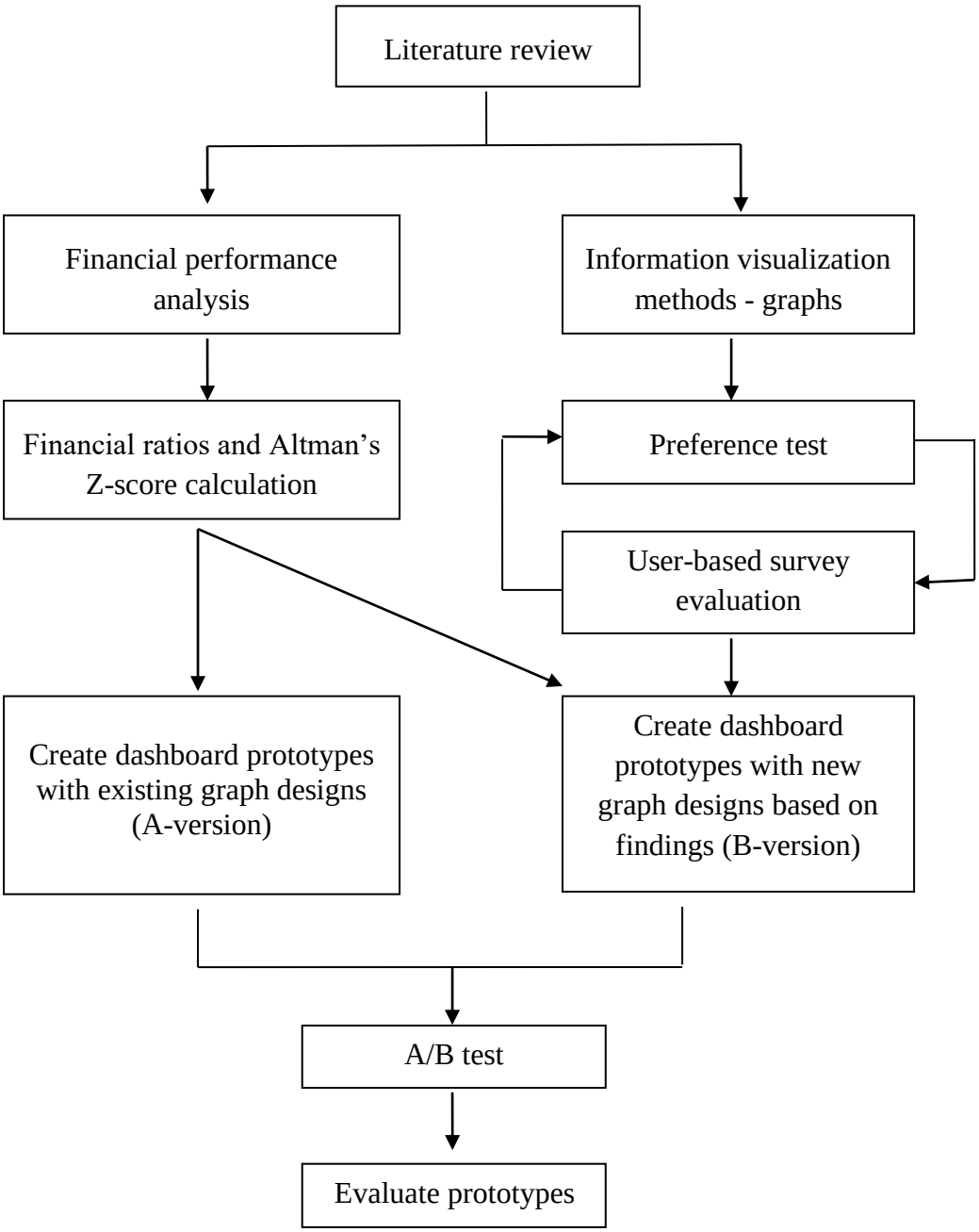
The survey instruments were developed for the user-based evaluation of interactive dashboard design selection. Surveys were distributed among users. The user group

was people who interested in company data. Surveys were divided into three categories according to the purpose of the findings. Those were understanding graphs, build a visual hierarchy of graphs and validate effective stock market decision making. All these categories were repeated based on the user-based evaluation. Surveys were made available for the target users online.

3.3 Data Collection

The methodology diagram proposed for the present study is illustrated below in figure 3.1.

Figure 3.1- Methodology diagram



Each component of the methodology diagram is described below in table 3.1

Table 3.1 - Methodology diagram description

Section	Description
Financial performance analysis	Identify methods to analyze past financial performance and predictions
Financial ratios and Altman z-score calculation	Selection of financial ratios and calculations
Information visualization methods – graph-related	Identify various common graph designs
Preference test	Testing user preferences towards graphs and visual hierarchies
User-based survey evaluation	Evaluate feedback of the above test and repeat it with new modifications until finalizing most acceptable designs.
Create dashboard prototypes with existing graph designs (A-version)	Design typical graphs with calculated financial ratio values as data.
Create dashboard prototypes with new graph designs based on findings (B-version)	Based on the results of the preference test, create dashboard prototype to present calculated values of financial ratios.
A/B test (A version and B version test)	Test variations of user decisions on common graph dashboard with proposed graph dashboard
Evaluate dashboard prototype	Evaluate proposed dashboard has succeeded in effective decision making or not.

3.4 Population and Sample Selection

Currently, CSE has 290 companies under 20 sectors (Sector classification, n.d.). Financial data required for financial ratio calculations were taken from Annual reports published on CSE official website (https://www.cse.lk/home/CSESectors). Data was gathered from the period of 2012 to 2018. Hence all companies were filtered according to the availability of annual report during this period. After filtering, 189 companies in 18 business sectors were eligible.

The population of this study was annual reports published companies from 2012 to 2018, which was 189 companies. Since this study evaluated the effectiveness of stock market decision making, companies within one sector were selected as the most appropriate comparison. Hence the selected Industry was Construction and engineering Industry which included three companies named as Access engineering PLC (ACC), Lankem development PLC (LKM) and MTD walkers PLC (MTD).

3.5 Process of Data Collection

Data was collected under the categories of financial performance analysis and propose an interactive dashboard design. Financial data collected for financial performance analysis was used to calculate financial ratios and Altman's Z-score to analyze the financial stability of each company and its industry. User-based evaluated data for the proposed dashboard design was used to analyze user perceptions towards graph designs. These data helped to enhance information visualization of the proposed dashboard.

3.5.1 Financial performance analysis

Out of the total population of 189 companies in 18 sectors, one sector was selected. The main source of financial information published to the general public is annual reports. It is mandatory to be published at the end of each fiscal year. These reports are available on the CSE official website. In the study of Hutabarat & Tarigan (2016) indicated that financial statements or the annual reports are the only direct source for collecting data of financial performance to the general public.

Since this study was referring to financial statements of the past seven years from the year of 2012 to 2018, under each sector, companies were filtered according to the annual report availability. Those were eligible companies and sectors for the study. The construction and engineering sector with three companies were selected using a simple random sampling method.

The present study was analyzed four types of financial ratios. Those were liquidity ratios, profitability ratios, solvency ratios and stock market ratios. Each ratio contained several selected ratios. P/B, EPS, P/E and dividend payout ratios under the stock market ratios, ROE, net margin and asset turnover under the profitability ratios,

D/A and D/E under the solvency ratios and finally liquidity and quick acid ratio under the liquidity ratios were calculated. These ratios are supported by previous research and carried out in the area of financial performance analysis.

3.5.2 Evaluation of dashboard design

Conduct surveys are the most appropriate method for design feedback on users' reflection towards usability. Other methods are not suitable because of time-consuming and also since it's about user perceptions, categorizing feedback may be difficult. All surveys were available online. Twelve respondents were included for preference testing surveys and six respondents were included for A/B testing surveys. Types of survey questions were closed-ended, open-ended and Likert Scale. Surveys were divided into three categories based on the data needed to analyze. Those were understanding graphs, build a visual hierarchy of graphs and validate effective Stock market decision making. These were named as survey version 1, survey version 2 and survey version 3 respectively. Each survey was repeated by modifying designs based on the results of the user-based evaluation.

The purpose of survey version 1 was to identify how people read, understand and analyze data provided in graphs, drawbacks of graphs and user preferences towards various graph designs. The purpose of survey version 2 was to identify how users understand information by establishing an order of importance within the data, allowing the reader to easily find what they are looking for and navigate the content. The purpose of survey version 3 was to analyze how financial decisions are vary based on the ability to understand insights by comparing typical graph dashboards and proposed graph dashboard.

4 DATA ANALYSIS

This chapter presents the data analysis of financial performance analysis and evaluation of dashboard designs. Past data of 3 companies in Construction and Engineering sector was selected to conduct financial performance analysis to analyze the financial stability of PLCs and its Sector/Industry. Preference test was conducted with 12 respondents to determine best dashboard designs and A/B test was conducted with 4 respondents to analyze how decisions have changed in different Information Visualization.

4.1 Financial performance analysis

Financial performance is a general term to measure the company's overall financial health or stability over a given period. It is a subjective measure of how well a company can utilize its assets to generate revenue. It can be used as a measurement of compare company performances within one sector and/or many sectors. Data provided by annual reports under the statement of profit or loss and other comprehensive income and statement of financial position (balance sheet) sections used to calculate financial ratios and Z-Score. In the current study, company performances were calculated within one sector because some ratios are not favourable to compare with other sectors due to changes in nature and the size of the business.

Other than calculating historical values as descriptive analysis, the current study was calculated two additional new values called industry average and one-year forecast value. Industry average values are to compare company position concerning the industrial position and also one-year forecast value as predicting value. Forecasting was limited to one year to provide the most accurate value because company data do not fully depend on historical behaviour. Company data always depend on both internal and external decisions. The industry average was calculated as the average value of each company.

$$\text{Industry average} = \frac{\text{Ratio values of Companies}}{N} = \frac{N1 + N2 + Nn}{N}$$

Predicted value was calculated as Simple moving average.

$$\text{Simple moving average} = \frac{\text{Ratio values of year}}{7} = \frac{2012 + 2013 + 2014 + 2015 + 2016 + 2017 + 2018}{7}$$

In the below section describes each selected ratio types, formulas threshold points to determine the status of ratio and calculated figures.

4.1.1 Financial ratios

There were four main types of financial ratios. Those were liquidity ratios, profitability ratios, solvency ratios and stock market ratios. According to past literature, many researchers have done financial performance analysis under these ratios. For the present study, the researcher selected the most popular ratios.

4.1.1.1 Liquidity ratio

Ability to pay all its short term (less than one year) debts using its short term assets is measure in liquidity ratio. The current ratio and quick acid ratio were calculated under this category. The difference between the current ratio and the quick acid ratio is the more liquidated ratio which filters the current ratio into more detail. The formulas and threshold points of each ratio as follows.

Table 4.1- Liquidity ratio formulas

Ratio	Formula	Threshold point (tp)
Current ratio	$\frac{\text{Total current assets}}{\text{Total current liabilities}}$	tp = 1 tp > 1 = good ratio tp < 1 = bad ratio

Quick acid ratio	$\frac{\text{Total current assets - Inventories}}{\text{Total current liabilities}}$	tp = 1 tp > 1 = good ratio tp < 1 = bad ratio

To be a good liquidity ratio, liquidity and quick acid ratios should be laid above the 1. Current ratio with very high figure indicates that short term assets are not utilized effectively as well as a quick acid ratio with very high figure indicates cash is not utilized effectively. A quick acid ratio less than the current ratio indicates that indicates current assets are depending on inventories which have low liquidity.

Liquidity ratio values of each company described below in table 4.2

Table 4.2 - Liquidity ratio calculated values

	Current Ratio				**Quick acid ratio**			
	ACC	**LKM**	**MTD**	**Industry Average**	**ACC**	**LKM**	**MTD**	**Industry Average**
2012	2.60	0.51	1	**1.37**	2.2	0.32	1	**1.17**
2013	2.50	0.42	1	**1.31**	2.1	0.22	1	**1.11**
2014	2.90	0.42	1.2	**1.51**	2.6	0.22	1.1	**1.31**
2015	3.30	0.35	1.4	**1.68**	3	0.16	1.1	**1.42**
2016	3.80	0.29	1.4	**1.83**	3.6	0.15	1.2	**1.65**
2017	2.20	0.29	1.3	**1.26**	2.3	0.14	1.1	**1.18**
2018	1.60	0.56	1	**1.05**	1.2	0.27	0.8	**0.76**
2019	**2.70**	**0.41**	**1.19**	**1.43**	**2.43**	**0.21**	**1.04**	**1.23**

4.1.1.2 Profitability ratio

Probability ratios are used to conclude the ability to generate earnings relative of a company to its revenue, operating costs, balanced sheet assets and shareholder's equity. Under this category net margin ratio, asset turnover ratio and return on equity were calculated. Net margin ratio determines how much sales generated in each dollar of profit. Asset turnover ratio determines how effectively generate sales using assets. Return on equity determines how effectively generate revenue using shareholder's equity.

Table 4.3 - Profitability ratio formulas

Ratio	Formula	Threshold point (tp)
Net margin ratio	$\frac{\text{Profit after tax}}{\text{Revenue}}$	tp = comparatively high value High tp = good ratio Low tp = bad ratio
Asset turnover ratio	$\frac{\text{Revenue}}{\text{Average total assets}}$	tp = comparatively high value High tp = good ratio Low tp = bad ratio
Return on equity	$\frac{\text{Net income}}{\text{Shareholder's equity}}$	tp = comparatively high value tp >= Industry average is good Negative or extremely high levels are critical

The increment of net margin ratio indicates that the company continuously earns the profit. It is one of the primary ratios that Investors are generally analyzed. Assets are playing a major role in generating sales. If a company increases its sales which generate per asset, then it indicates the company is utilizing assets more effectively. Return on Equity is a very popular ratio among Investors. It determines how well the company utilizes shareholder's equity (Investments) to generate earnings growth.

Profitability ratio values of each company described below in table 4.4

Table 4.4 - Profitability ratio calculated values

	Net margin %				Asset turnover %			
	ACC	**LKM**	**MTD**	**Industry Average**	**ACC**	**LKM**	**MTD**	**Industry Average**
2012	20.50	-33.45	6.82	**-2.04**	0.74	0.81	0.9	**0.82**
2013	18.50	-5.61	7.50	**6.80**	0.8	0.73	0.7	**0.74**
2014	19.10	0.40	6	**8.50**	-6.70	1.60	-21.80	**-0.09**
2015	15.60	-9.58	7.90	**4.64**	-6.70	1.60	-21.80	**-0.09**
2016	18	-5.14	-6.70	**2.05**	-6.70	1.60	-21.80	**-0.09**
2017	18.20	0.69	1.60	**6.83**	-6.70	1.60	-21.80	**-0.09**
2018	10.60	11.10	-21.80	**-0.03**	-6.70	1.60	-21.80	**-0.09**
2019	**17.21**	**-5.94**	**0.19**	**3.82**	**0.17**	**0.23**	**0.07**	**0.16**

	Return on Equity %			
	ACC	**LKM**	**MTD**	**Industry Average**
2012	13.60	-70.20	9.70	**-15.63**
2013	17.40	-9.10	12.10	**6.80**
2014	17.70	11.80	11.80	**13.77**
2015	11.70	-12.60	12.60	**3.90**

2016	13.10	-9.90	-10	**-2.33**
2017	15.60	2.40	2	**6.80**
2018	13.10	2.40	-70	**-18.23**
2019	**14.60**	**-12.17**	**-4.54**	**-0.70**

4.1.1.3 Solvency ratio

Solvency ratios are used to determine how well the company can pay short and long term debts using their cash flow. Under this category, debt to assets ratio and debt to equity ratios were calculated. Debt to asset ratio indicates the total amount of debts relative to its assets. Debt to equity ratio indicates the total amount of debt and equity used to finance its operations.

Table 4.5 - Solvency ratio formulas

Ratio	Formula	Threshold point (tp)
Debt to assets ratio	$\frac{\text{Total liabilities}}{\text{Total assets}}$	tp = 0.5 tp < 0.5 = good ratio tp > 0.5 = bad ratio
Debt to equity ratio	$\frac{\text{Total liabilities}}{\text{Total shareholder's equity}}$	tp = comparatively low value Low tp = good ratio High tp = bad ratio

These two ratios are very popular among Investors. Debt to asset ratio above 0.5 indicates the company has high debts which could not cover by its total assets. Debt

to equity ratio indicates the ability of shareholder's equity to cover all its debts when the company is a downturn.

Solvency ratio values of each company described below in table 4.6

Table 4.6 - Solvency ratio calculated values

	Debt to asset ratio %				**Debt to equity ratio**			
	ACC	**LKM**	**MTD**	**Industry Average**	**ACC**	**LKM**	**MTD**	**Industry Average**
2012	0.10	81.32	30.56	**37.33**	0.25	4.35	0.44	**1.68**
2013	0.04	60.27	27.04	**29.12**	0.27	1.52	0.37	**0.72**
2014	0.03	61.60	33.84	**31.82**	0.28	1.60	0.51	**0.80**
2015	0.00	51.30	39.73	**30.34**	0.22	1.05	0.66	**0.64**
2016	20.50	67.75	49.65	**45.97**	0.58	2.10	0.99	**1.22**
2017	18.30	67.01	52.77	**46.03**	0.65	2.03	1.12	**1.27**
2018	21.50	58.34	63.95	**47.93**	0.85	1.40	1.77	**1.34**
2019	**8.64**	**63.94**	**42.51**	**38.36**	**0.44**	**2.01**	**0.84**	**1.10**

4.1.1.4 Stock market ratio

The stock market ratio is evaluated current share price, whether the shares are undervalued or overvalued. Under this category, the most popular four ratios were selected. Those were EPS, P/B ratio, P/E ratio, dividend payout ratio. Earnings per share indicate the company's profitability. It's the portion of profit allocated for each share. Price to book ratio compares the company's book value relative to its market value. It indicates whether a company is in a survival situation in a downturn. Price to earnings ratio indicates that the sum of rupees an investor should be invested to

receive one rupee of earnings. The dividend payout ratio is one of the attractive ratios. It indicates how much profit allocated to shareholders as dividends.

Table 4.7 - Stock market formulas

Ratio	**Formula**	**Threshold point (tp)**
Earnings per share	$\frac{\text{Net income – preferred dividend}}{\text{Weighted average common shares}}$	tp = comparatively high value High tp = good ratio Low tp = bad ratio
Price to book ratio	$\frac{\text{Market price per share}}{\text{Book value per share}}$	tp = 1 tp < 1 = good ratio tp > 1 = bad ratio
Price to earnings ratio	$\frac{\text{Market price per share}}{\text{Earnings per share}}$	tp = comparatively high value High tp = good ratio Low tp = bad ratio
Dividend payout ratio	$\frac{\text{Dividends}}{\text{Net income}}$	A steady rising ratio is good Spiking ratio is bad

Higher Earnings per share indicates that investors are willing to invest more to receive higher profit in the future. Price to book value less than 1 indicates it's potentially undervalued stocks. Higher price to earnings indicates that Investors are anticipating higher growth in future.

Stock market ratio values of each company described below in table 4.8

Table 4.8 - Stock market ratio calculated values

	Earnings per share				**Price to Book ratio**			
	ACC	**LKM**	**MTD**	**Industry Average**	**ACC**	**LKM**	**MTD**	**Industry Average**
2012	1.52	-8.36	2.9	**-1.31**	2.5	0.39	0.64	**1.18**
2013	2.13	-2.94	3.9	**1.03**	1.58	0.49	0.61	**0.89**
2014	1.75	0.26	4.2	**2.07**	1.51	0.41	0.73	**0.88**
2015	2.52	-3.14	4.6	**1.33**	1.18	0.75	0.97	**0.97**
2016	2.09	-1.79	-5.2	**-1.63**	1.19	0.48	0.77	**0.81**
2017	2.68	0.2	0.5	**1.13**	1.26	0.24	0.75	**0.75**
2018	3.07	2.92	-19	**-4.34**	0.99	0.85	0.8	**0.88**
2019	**2.25**	**-1.84**	**-1.16**	**-0.25**	**1.46**	**0.52**	**0.75**	**0.91**

	Price-earnings ratio				**Dividend payout ratio %**			
	ACC	**LKM**	**MTD**	**Industry Average**	**ACC**	**LKM**	**MTD**	**Industry Average**
2012	17.57	-1.49	7.93	**8.00**	11	0	0	**3.67**
2013	9.25	-0.53	6.28	**5.00**	24	0	20	**14.67**
2014	12.86	0.06	7.17	**6.70**	20	0	0	**6.67**
2015	7.62	-0.52	10.09	**5.73**	57	0	13	**23.33**

2016	9.95	-0.45	-6.35	**1.05**	36	0	0	**12.00**
2017	8.88	0.08	70	**26.32**	30	0	12	**14.00**
2018	6.68	0.4	-1.08	**2.00**	39.08	0	0	**13.03**
2019	**10.40**	**-0.35**	**13.43**	**7.83**	**31.01**	**0**	**6.43**	**12.48**

4.1.2 Altman's Z-score

Altman's Z-score tests the company's credit strength that predicts a company's likelihood of being insolvent. Calculated financial ratios have taken to calculate Z-score. Based on the result, it declares the status of a company's likelihood of being insolvent. Below tables demonstrates the formula, zones and accuracy levels of prediction over the years. Sources are taken from Models in ratios.ppt by Prof. Kennedy D. Gunawardena, University of Sri Jayawardanapura.

Table 4.9 - Altman's Z-score formula

$\mathbf{Z = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4}$	
X_1	$\frac{\text{Current assets – Current liabilities}}{\text{Total assets}}$
X_2	$\frac{\text{Retained earnings}}{\text{Total assets}}$
X_3	$\frac{\text{Earnings before interest and taxes}}{\text{Total assets}}$
X_4	$\frac{\text{Book value of equity}}{\text{Total liabilities}}$

Table 4.10 - Altman z-score zones and its interpretation

Zones	**Zone boundaries (Z)**	**Interpretation of zones**
Safe zone	**Z** > 2.60	Financially stable
Grey zone	1.1 < **Z** < 2.60	Likely to go bankruptcy
Distress zone	**Z** < 1.1	Headed to bankruptcy

Table 4.11 - Altman's Z-score prediction accuracy

Year before failure	**Accuracy rate**
1	95%
2	72%
3	48%
4	29%
5	36%

Altman's Z-score values of each company described below in table 4.12

Table 4.12- Altman's Z-score calculated values

Altman's Z-score				
	ACC	**LKM**	**MTD**	**Industry Average**
2012	1.53	1.51	2.16	**1.73**
2013	2.1	1.35	1.9	**1.78**
2014	2.38	1.1	1.74	**1.74**
2015	3.64	1.23	2.29	**2.39**
2016	1.99	1.3	2.75	**2.01**
2017	1.85	1.26	1.21	**1.44**
2018	1.97	1.56	1.03	**1.52**

The collected figures from financial ratios and Altman's Z-score were considered as data to create graphs in the next step of the research. The next step was to propose a dashboard design which can be easily interpreted by anyone interested in company data.

4.2 Evaluation of proposed dashboard design

Dashboard design evaluation was conducted by analyzing user-based evaluation. This phase was evaluated on preference test and A/B test. Surveys of preference test were conducted to identify user preferences about various graph designs. Two surveys were conducted under this method. It is called as Survey 1.0 and Survey 1.1 as one set of survey and Survey 2.0 and Survey 2.1 as another set of the survey. A/B test survey as Survey 3.0 and Survey 3.1 was conducted as a final evaluation to analyze how Information visualization to help Investors to make clever decisions and it was observed how Investment decisions have been changed.

4.2.1 Preference test

Preference test is a very common type of usability testing which simply asks questions from users about what they prefer. It is very easy to finalize the easiest and understandable graph designs.

There are nine basic visual elements of a graph. These are a title, y-axis, y-axis label, x-axis, x-axis label, legend, grid line, data object and data label. There are many styles have been using these visual elements. When considering graph reading, there are pros and cons to these styles. The purpose of the preference testing was to identify how people read, understand and analyze data provided by the graphs and also identify the drawbacks of graphs.

Below sections explain how preference testing was performed and results found.

4.2.1.1 Survey 1.0

The purpose of this survey was to identify basic user preferences of graphs. Twelve respondents were responded to this survey successfully. The survey contained two sections called understanding graphs and graph preferences. Under the understanding graphs section, a simple case study was given and four types of graphs were drawn. Those graph types were line chart, column chart, bar chart and stacked area chart. These graph types were selected as most frequently using graphs types which are used in the day today.

According to the Knaflic (2015) pie charts, doughnut charts, 3D and secondary y-axes graphs have named as graphs that should be avoided. Here are the reasons to avoid these types of graphs. In the pie charts, when segments are very close to each other, it is very hard to recognize which segment is bigger than to another by the human eye. The same reason applies to doughnut charts too. The human eye cannot observe the quantitative value accurately on these graphs. 3D graphs are not good, especially for single dimension graphs. It creates side and floor elements which make more complex. In secondary y-axes, graphs have two vertical axes by sides. It takes time to map data with these axes. The same study further explained points, lines, bars and area charts as recommended graph types to use.

Appendix A holds the survey 1.0 questionnaire. The results of understanding graphs section as below.

Table 4.13 describes the results which determined how respondents were able to interpret four graphs according to the case study given. Grey coloured cells are representing the correct answers to each question.

Table 4.13 - Survey 1.0 result - Graph interpretation

Question	True	False	Cannot understand
The overall behaviour of current assets is good	4	7	1
After 2017, incremental of total current asset symbolized that the company can solve/pay cash payment immediately	6	4	2
Incremental of inventories after 2016, is a good indicator of total current assets	4	7	1

The majority of 58.3% of respondents were answered correctly to questions 1 and 3. They have successfully interpreted the overall behaviour of the graph. The second question was not straight-forward. A deep analysis of the graph is needed. Only 33.33% of the respondents were able to answer correctly. Even-though majority of respondents were answered correctly for question 1 and 3, 41.6% were failed to answer correctly for question 2. These results interpreted that traditional graph designs are less effective to analyze insights of graph especially for users who do not know the domain. Survey 1.1 was conducted to overcome this problem. It explained in the next section.

Table 4.14 - Survey 1.0 result - Graph selection

To find out answers for each question, which graphs help most?	**Line chart**	**Column chart**	**Bar chart**	**Stacked area chart**
Question 1	4	3	-	5
Question 2	2	6	2	2
Question 3	5	4	-	3
Total respondents	**11**	**13**	**2**	**10**

In this question, respondents have selected graphs as their preferences. Column chart and line chart got the most number of likes. The bar chart was the least understandable graph.

Therefore the column chart and line chart were selected as graph types for the proposed dashboard.

Table 4.15 - Survey 1.0 result - Graph description

Question	**Yes**	**No**
The description of the current asset was helped me to understand the graph	11	1

The description of the current asset was helped for 91.7% of respondents to answer the survey questions. Since this was an accounting and finance domain-specific research, it is difficult to understand some of the jargon. Very common terms such as profit and expenses are familiar to the general public but may not be familiar with

special terms like current assets and liquidity. Therefore a short description of the ratio was improved understandability of the graph.

Based on this result, a short description was added to the proposed dashboard which helped to reduce the complexity of the domain and make users friendlier towards the dashboard.

The next section of Survey 1.0 was graph preferences. It was tested under gridlines, numbering and colours. Table 4.16, 4.17 and 4.18 describe the results which determined user preferences towards gridlines, numbering and colours respectively.

Table 4.16 - Survey 1.0 result - Gridlines preferences

Which graph can easily find out the value of Receivables (y-axis value) in 2016?	**No. of preferences**
Figure 1 - Only vertical gridline	2
Figure 2 - Only horizontal gridline	2
Figure 3 - Both vertical and horizontal gridline	8
Figure 4 - No gridline	-

This question specifically asked about one data point to determine the easiest gridline design. 66.7% of respondents accepted “Figure 2 - both vertical and horizontal gridline” option. When considering the design of a graph, having both x and y-axis gridlines make graph design more complex. However, there are existing graph drawing applications which display the value of data point when mouse hover on top of the data point. If we think about the graph axis, reading figures in the vertical axis (y-axis) is easier than the horizontal axis (x-axis).

Even though respondents were selected “Figure 2 - Both vertical and horizontal gridline” option, considering design limitations and ability to read data point using new technology, the researcher selected “Figure 2 – Only horizontal grid line” option.

According to the Knaflic (2015) explained “Figure 4 – No gridline” option would be best because it eliminates design clutter as much as possible. Furthermore, the author explained by removing all gridlines and makes space empty will help readers to read graph fast. However, none of the respondents in this survey has selected this option.

Table 4.17 - Survey 1.0 result - Numbering preferences

Do you like these numbering designs?	**Yes**	**No**
Figure 1 - Numbers on the line – 1	8	4
Figure 2 - Numbers on the line – 2	4	8
Figure 3 - Numbers on the line – 3	9	3

As majority selection, 75% of respondents were selected “Figure 3 – Numbers on the line – 3” option. However, all these three options were not suitable for line charts. Numbers on every data points in every data lines make the graph more complex. It reduces the simplicity of graphs. However, it is suitable for a column chart.

Therefore “Figure 3 – Numbers on line – 3” option was applied for column charts only

Table 4.18 - Survey 1.0 result – Color preferences

Which graph design do you prefer?	**Prefer**	**Not Prefer**
Figure 1 - Solid fill Black	11	1
Figure 2 - Solid fill White	9	3
Figure 3 - Gradient fill	2	10
Figure 4 - Picture or texture fill	2	10

Figure 5 - Pattern fill	2	10

As majority selection, 91.6% of respondents were selected “Figure 1 – Solid fill black” option. Since this was the user preference option, black background graphs increase complexity for the proposed dashboard (Knaflic, 2015). The proposed graph design has lines with many colours, text, highlighted areas in different colours.

Visual elements of the graph are clearer with the white background than a black background. Therefore the researcher selected the second-best option, the white background.

Other options such as gradient fill, picture or texture fill and pattern fill make visual elements unclear and more disturbances. Therefore those options were rejected by the majority of respondents.

4.2.1.2 Survey 1.1

The purpose of this survey was to build a suitable graph design that increases the readability of graphs. It was focused to improve the results of Table 4.13 - Survey 1.0 result-Graph interpretation. This survey was conducted to analyze how the interpretation of graphs changed when traditional graph design was changed to a new design which drew with Insight text. Insight note was added on top of specific data points to provide a special note to readers. By adding insight note, the researcher tried to compare results between Survey 1.0 question 1 to 3 and Survey 1.1.

The jargons of Insight note are a critical factor to map the meaning of the note with the graph. To test how users understand the insight note with the help of ratio description, the researcher has done this survey using two Insight notes by changing specific jargon, called “liquidity” and “current assets”.

Here is the added description about ratio in Survey 1.1. Appendix B holds the questionnaire of survey 1.1.

“Current assets represent all the assets of a company that are expected to be conveniently sold, consumed, utilized or exhausted through the standard business

operations which can lead to their conversion to a cash value over the next one year. Current assets include cash, cash equivalents, accounts receivable, stock inventory, marketable securities, pre-paid liabilities and other liquid assets. These are important to businesses because they can be used to fund day-to-day business operations and to pay for the ongoing operating expenses."

Respondents of 4 out of 12 users have surveyed with the graph included below Insight note.

"Incremental of inventories more than cash and receivables make **liquidity** at risk."

Results are described in Table 4.19. Grey coloured cells are representing the correct answers to each question.

Table 4.19 - Survey 1.1 results - Insight note with different jargon

Question	**True**	**False**	**Cannot understand**
The overall behaviour of current assets is good	3	1	-
After 2017, incremental of total current asset symbolized that the company can solve/pay cash payment immediately	2	1	1
Incremental of inventories after 2016, is a good indicator of total current assets	2	2	-
Question	**Yes**		**No**
The description of current assets was helped me to understand the graph	3		1

Still, respondents were unable to understand the graph. The survey did not ask the reasons for their answers. Therefore, to identify where they went wrong, the researcher conducted small informal interviews with respondents. As a result of informal interviews, the researcher found that respondents were unable to interpret the word “liquidity” because it is technical jargon and also it was not mentioned in the ratio description.

The same survey repeated with 12 respondents including new Insight note, by changing term liquidity to current assets and additional questions as “Why does you think so?” for all questions. The new Insight note is mentioned below. Results are described in Table 4.20.

“Incremental of inventories more than cash and receivables make current assets at risk.”

Table 4.20 - Survey 1.1 results - Insight note with similar jargon

Question	**True**	**False**	**Cannot understand**
The overall behaviour of current assets is good	-	12	-
After 2017, incremental of total current asset symbolized that the company can solve/pay cash payment immediately	1	10	1
Incremental of inventories after 2016, is a good indicator of total current assets	4	6	2
Question	**Yes**		**No**
The description of current assets was helped me to understand the graph	12		-

Short answers for Question 1	
True	-
False	According to the description, it is at risk because inventories are higher than cash and receivables.
	Form 2017- 2018 the inventories have to increase more than the cash and receivables
	Because they have inventory more than cash and receivables.
	Incremental of inventories are higher than cash and receivables
	Current Assets are being decreased
	total decreased than past years
	The trend of cash and receivables seems reducing while inventories show an increasing trend
	Increase current assets than cash and receivable
	Incremental of inventories is more than cash
	Incremental of inventories more than cash and receivables after 2017
	Total current assets are decreasing over the above years
	Total current assets have been drastically reduced from 2014 to 2017
Cannot understand	-

Short answers for Question 2	
True	Then assets need to convert to cash
False	Still, the inventories are increasing. So the total assets are at a risk.
	Even though the total current assets have increased the cash and receivables are less than the inventories
	Cash and receivables are not increasing
	no increment of cash
	Cash has gone low
	The increment is not powerful enough to be solved/paid cash payment immediately.
	We get no idea about sales from this graph to make a prediction.
	cash is not incremented
	Because however the total current asset totals current asset of cash, keep decreasing.
Cannot understand	-
Short answers for Question 3	
True	it affects for current asset increment
	Inventories getting increased to some extent
	Good for assets but less money is an issue
	it adds up to the total current assets
False	Because incremental inventory more than cash and receivable is putting total assets at a risk according to the description.

	Inventories have increased beyond cash and receivable which puts current assets at risk.
	They have inventories. But they don't invest them into profitable projects.
	Inventory might be bought using current assets
	Though inventories are increased after 2016, total current assets are decreased after 2016 and it is increased after 2017
	Because of the total current assets unstable after 2016
Cannot understand	Total current assets have been in a reducing trend from 2016 to 2017
	-

The results have shown a positive impact towards similar jargon on insight note and ratio description. “Current assets” was described as what it is in ratio description.

When using similar jargon in insight note, respondents were able to understand the graph and they have focused on where they should be focused to make the correct decision.

Below table explains the overall results of insight notes in table 4.21.

Table 4.21- Survey 1.1 results - Overall results of insight note

Questions	**Correct answers % of different jargon**	**Correct answers % of similar jargon**
Question 1	25%	100%
Question 2	25%	83.3%
Question 3	50%	50%
	Answer “Yes” %	**Answer “Yes” %**

Question 5	75%	100%

Since correct responses for question 1 and 2 were increased, question 3 held the same percentage. When observing the short answers in the true category of question 3 in table 4.20 - Results of insight note – similar jargon, the researcher found that respondents have analyzed the question in different ways. Even though the researcher provided insight text, the final decision depends on the respondent's opinion. This research was not tried to provide conclusion about correct or wrong decisions. It only provided information which users may face difficult to analyze.

4.2.1.3 Summary of survey results of 1.0 and 1.1

Table 4.22 - Survey 1.0 and 1.1 - Summary

	Survey 1.0	**Survey 1.1**	**Increment or decrement %**
Question 1	58.33%	100%	+ 41.67%
Question 2	33.33%	83.3%	+ 49.97%
Question 3	58.33%	50%	-8.33%
Question 5	91.6%	100%	+ 8.4%

This comparison came up with below conclusions

- ✓ *Ratio description is highly important to understand the domain-specific graphs.*
- ✓ *Providing a new visual element of "Insight note" on top of specific data point/s help users to focus where they should be focused and reduce the cognitive load of analyze as well.*

- ✓ *When using similar jargons in both ratio descriptions and insight note, it increases the understandability of graph and assists for effective decision making*

4.2.1.4 Survey 2.0

The basic visual elements of a graph are used to visualize graphs in a meaningful manner. These are title, y-axis, y-axis label, x-axis, x-axis label, legend, grid line, data object, and data label. Other than the title and legend, other elements cannot change the place where they should be for successful graph design. Legend is a very important element if graph plots more than one data object. Otherwise, users cannot map each data object and it becomes useless. Therefore the researcher tried to build a new way to enhance the visual hierarchy using legend because the legend is used to name the data object with its colour. The main purpose was to graphically display the fluctuation of latest figures and reduce cognitive load to make easy to compare each other. Other than use as a key to data object's label, the researcher found that legend can be used to graphically display the latest data points which easily provide information about growth or decline comparing each other.

Visual hierarchy is the order in which a user processes the information on a page; its function in a user interface (UI) design is to allow users to understand the information easily (What is Visual Hierarchy? n.d.).Further found the visual characteristics that influence a user's perception of information. These are size, colour, contrast, alignment, repetition, proximity, texture and style and whitespace. The researcher tried to build a visual hierarchy for legends by enhancing these characteristics. Below table explains visual characteristics of visual hierarchy.

Table 4.23 - Survey 2.0 - Description of visual characteristics

Visual characteristics	Description
Size	More attraction when larger the size
Colour	More attention when bright the colour

Contrast	More attention when contrasting the colour
Alignment	More attention when aligning with relevant information
Repetition	When elements repeat, it indicates that content is similar
Proximity	When elements are closer, it indicates that content is similar
Whitespace	More attention when more space around
Texture and style	More attention when ricer the texture

The researcher designed a new legend style by placing closer to its endpoint of each data object. This design has proved two visual characteristics of alignment and proximity.

The purpose of this survey was to identify how users understand legend when each legend placed near to its endpoint of the data object which is not commonly used. It was conducted with 12 respondents.

Appendix C holds the questionnaire of survey 2.0.

As the first question, the researcher added a graph of two data objects which had a considerable gap between two legends. As the second question, the researcher added the same graph with a close gap that made poor visualization of the gap between two legends. The task was to identify legend with relevant to its data object. Below table 4.24 and 4.25 are explained results of questions 1 and 2 respectively. The grey coloured cells represent the correct answers.

Table 4.24 - Survey 2.0 results - Legend design with a considerable gap

Question 1	Yes	No	Not clear
Figure 1 - the Industry average is shown by a solid line	-	11	1

Table 4.25 - Survey 2.0 results- Legend design with a close gap

Question 2	Yes	No	Not clear
Access PLC line is shown by a solid line	7	-	5
The industry average is shown by a dotted line	5	2	5

According to the results of table 4.24, except one respondent, all other respondents were able to identify correct data object concerning its legend. It emphasized that ***when the gap of data lines are placed in considerable length, users can easily identify correct legend respect to its data line.*** It provided a rich visual hierarchy.

According to the results of table 4.25, only 5 respondents were able to identify the correct data line concerning its legend and other 7 respondents answered wrongly as well as unable to answer anyway. It emphasized that ***when the gap of data lines are placed very closely, users get confused to identify correct legend respect to its data line.*** It provided a poor visual hierarchy.

As the third question, a graph of coloured legend text aligned with its data object was tested. The purpose was to test how it helps users to map data object and relevant legend when objects are closed. Because close objects have the difficulty of recognition as we discussed above.

Below table 4.26 explains the results of question 3 of the coloured legend text.

Table 4.26 - Survey 2.0 results - Colored legend text

Question 3	Yes	No	Complicated
Figure 3 - Legend with the coloured text help me to identify its relevant line	10	-	2

A coloured legend text is a very rare design which most of the users have not seen. The common design is a legend placing on one side of the graph including labels and colour of data objects. People cannot hold many items at once in their short term memory. If so, it increases cognitive load and it leads more processing time and effort. Therefore the researcher believes that people can easily remember coloured text rather than text along with its colour line. It is very useful when there are more data objects.

The test results were positive towards the cognitive load. 10 out of 12 respondents felt comfortable with coloured legend text.

Based on the results, proved that coloured legend text was readable and it helped to recognize its relevant data object.

As the final question, the survey tested two graphs with traditional right-sided legend and new design discussed above. It tested which legend design users like most. Below table 4.27 explains the results of legend design preference.

Table 4.27 - Survey 2.0 results - Legend design preference

Question 4	Graph A	Graph B
Figure 4 - Which graph has an easy, convenient legend design which helps you to understand the graph?	6	6

The result was 50% of each graph. Since Graph B included commonly use design, respondents may prefer it. A similar number of respondents have preferred Graph A with a new legend design.

However, the researcher selected Graph A, which is a new legend design because coloured legend text design was accepted by the majority of respondents under question 3 and also it has the additional advantage to reduce cognitive load by visualizing growth or decline of latest data points of each other.

Furthermore, the selected legend was further modified to increase the readability of legend. When data objects are placing very closely, legend texts also be placed very closely. It creates a disturbance. Therefore the researcher added a solid line before the legend text which connects the endpoint of data objects and the legend texts. It further increases the readability of legends especially when data objects are placed very closely. This design was selected as the legend design of proposed graph.

4.2.1.5 Survey 2.1

The graph represents a lot of data. Some of the data should be analyzed further as insights to make use of the data. Analyzing data may be a hard task for users who are not familiar with the domain. Therefore arranging information in an order of importance is highly important to the proposed dashboard. Text and colours can make information in an order of importance. It creates visual hierarchy and it helps analyze purposes.

The most common visual hierarchies are typography and colour visual hierarchies. Typography is the art and technique of arranging type to make written language legible, readable, and appealing when displayed (Typography, 2019). Further explained, this arrangement involves size, contrast and spacing. According to the 5 Reasons Why Typography is Powerful. (2015), explained the impact of using typography. Those are attracted audience attraction, reader-friendly, information hierarchy, harmony and build recognition. Similar to the typography, the Colour also builds up the visual hierarchy.

Typography and colour visual hierarchies were tested in Survey 2.1. The researcher tried to test how typography and colours can be used to enhance usability by creating a rich visual hierarchy. Under the typography visual hierarchy, there were three questions arranged in the survey.

Appendix D holds the survey 2.1 questionnaires.

As a first question, three sentences were given under three types of type scale. The first sentence was the single type scale. The second sentence included two type-scales and the third sentence included three type scales. Size and weight of the word in a sentence was determined by the information which needs to be highlighted. Most important word/s was written with the biggest size and weight of the font. It is the primary word/s. The words which emphasize the primary word/s were written with the second biggest size and weight. It is the secondary word/s. Finally, the rest of the words were written with the base size and weight of the font. It is the tertiary word/s. The objective was to identify how users understand information by establishing an order of importance within the data, allowing the reader to easily find what they are looking for and navigate the content. This survey was conducted with 12 respondents. Below table 4.28 explains the results of understanding type scale.

Table 4.28 - Survey 2.1 results - Understandability of type scale

There are 3 sentences written in different font sizes and weight (type scale). Which sentence helps you to understand the sentence better?	**Least understandable**	**Less understandable**	**Neutral**	**High understandable**	**Highest understandable**
Sentence 1	1	2	3	1	5
Sentence 2	-	4	3	5	-
Sentence 3	1	1	2	5	3
Results as a percentage					

Sentence 1	25%	25%	50%
Sentence 2	33%	25%	42%
Sentence 3	17%	17%	67%

Least understandable and less understandable were categorized as “sentence was not understandable”. Neutral was categorized as “sentence was confused to understand” and high understand and highest understand were categorized as “sentence was understandable”. When comparing percentage values of each sentence under the sentence was not understandable, the sentence was confused to understand and sentence was understandable, sentence 3 got the highest percentage value of 67% under the sentence was understandable and also the lowest value of 17% each under both sentences was not understandable and sentence was confused to understand. Sentence 2 was rejected by respondents with the highest value of 33% under sentence was not understandable and 25% of the sentence was confusing to understand.

As the second question, it tested how users interpret the sentence written with three type scale. The main purpose was to test how users understand the importance of words when the size of the weight is changed comparing to other words. Below table 4.29 explains the results of understanding the importance of words using type scale.

Table 4.29 - Survey 2.1 results - Importance of words using type scale

How do you interpret the message of the sentence?	**Yes**	**No**	**Not clear**
The writer tries to emphasize the word "bankrupt" as a highly important word.	10	1	1
"40%" and "next 2 years" words are giving more meaning to the word "bankrupt".	11	1	-

The results have proven that the respondents were able to interpret the importance of the words by the size and weight change. 83% of respondents able to understand that the highest size of font word as the primary word and also 92% respondents were able to understand that the second-highest size of font words as secondary words whereas these words provide more meaning to primary words.

As a conclusion of typography visual hierarchy, sentence 3 in question 1 which was three sizes of type scaling style was selected to add to the proposed dashboard. By accepting the sentence with three sizes of type scale emphasized that ***people focus to big text fast among small text and it helps to understand the sentence fast. This method can be used to navigate users to what we want them to be focused.***

The third question was designed to analyze how typography works with colours. Adding colours make not the only attraction to the dashboard, but also it makes more meaning to the sentence. The colours of red, yellow and orange are considered as warm colours which stimulate the users. The colours of blue, green and purple are considered as cool colours which calm and relax users (Hauff, 2018).

The researcher tried to analyze how users understand colours as the meaning indicates for danger, on-alert and safety precautions. As the world, standard design patterns, red, yellow and green are used as precautions colours similar to the concept of traffic lights. In traffic lights concept red as "stop", yellow as "get ready" and green as "go".

In the third question, three sentences were provided. Those were *"90% of a possibility to be bankrupt within the next 2 years", "90% of a possibility to be bankrupt within the next 10 years" and "90% of a possibility to be bankrupt within the next 5 years".*

The word "bankrupt was coloured as red to indicate it as dangerous. In the first sentence, 90% was coloured red because the period of being bankruptcy is 2 years. Therefore it has the highest risk than the other two sentences. The second sentence, 90% was coloured green because the period of being bankruptcy is 10 years. It has a very low risk of bankruptcy. The last sentence coloured yellow to word 90% because the period of being bankruptcy is 5 years. It has a medium level of risk of

bankruptcy. Below table 4.30 explains the results of understanding type scale with colours. Grey coloured cells are representing the correct answers to each question.

Table 4.30 - Survey 2.1 results - understanding type scale with colours

A, B and C Companies have 90% of a possibility to be bankrupt in future. Below image shows 90% text in 3 colours which symbolize the status of going bankruptcy in each Company respectively.	**Company A**	**Company B**	**Company C**	**Not clear**
Company in danger/ high risk to invest is	11	-	-	1
Company in alert or 50-50 margin to invest is	1	3	7	1
Company in safety or ok to invest for a short term is	-	9	2	1

Respondents of 92% understood colour red as a danger because they noticed Company A is in danger to invest. Respondents had understood green as safety because 75% of them had answered that Company B as safe to invest. By analyzing these statistics, we can assume that respondents able to answer question 1 and 3 correctly because by seeing the colour red and green, humans can interpret its nature psychologically.

According to Colour psychology (2019), colour red associated with energy, war, danger, strength, power, determination, passion, desire and love. Colour green associated with growth, harmony, freshness, safety, fertility and environment. Colour yellow associated with competence, happiness.

However, the majority of respondents were failed to recognize the colour yellow as proceed with caution. The traffic lights use a yellow colour as proceeding with caution. Drivers get ready to drive at this stage. Somehow respondents were unable to determine *"90% of a possibility to be bankrupt within the next 5 years"* text.

Word ‘90%’ was coloured in yellow as a company in alert to investing. 58% was given the correct answer but 42% were wrong.

According to the above statistics, the researcher finalized colour red and green are suitable to add to the proposed dashboard as colours for danger and safe respectively. Because of the complexity faced by respondents, the colour yellow was rejected.

Next sections were for colour visual hierarchy. The purpose of this section was to identify how colours can be used to understand graph lines without its legends. Since there were many data objects, the graph should be used in many colour lines and bars. The proposed dashboard was included industry average line as a comparison with individual companies. It is called the baseline. Therefore the researcher tried to analyze how users understand baseline and company data lines by its colour.

To select colours for lines, the researcher used to tint and shade colours. According to Heaston (2019), tint colours are any colour with a mixture of white. Those are reduced darkness and increase lightness. Shade colours are any colour with a mixture of black. Those are reduced lightness and increasing darkness.

The researcher tried to analyze whether users will be able to differentiate the baseline with other lines by applying tint and shade colours. Not only colours, but the researcher also changed the style of the line to analyze the most effective way to differentiate the baseline. The speciality of this section was respondents should be able to determine graph lines by looking at the colour or style of the line without legends.

Question 4 to 7 included a simple case study. It was *“A Footwear Industry has 3 companies named A, B and C. Below graphs shows the profit of these companies and the overall average profit of the Industry. The purpose of these graphs is to compare each company's profit line concerning the Industry profit line. The industry profit line is taken as a baseline.”* Four types of graphs were provided. Those were data lines with all tint colours, dotted baseline, data lines with all shade colours, data lines of both tint and shade colours. Other than question 5 - dotted baseline, all other baselines of graphs were coloured in grey. Grey is the colour of neutral, cool and

balanced (Bourn & Digital Strategist, 2016). Since colours have psychological meanings, the researcher applied grey colour to baseline.

Below table 4.31 explains the results of data lines with all tint colours. Grey coloured cells are representing the correct answers to each question.

Table 4.31 - Survey 2.1 results - Data lines with all tint colours

Question	Blue line	Grey line	Green line	Brown line	Not clear
As you think, the baseline is	16.7%	-	8.3%	8.3%	66.7%

Table 4.32 - Survey 2.1 results - Data lines with all shade colours

Question	Blue line	Grey line	Green line	Not clear
As you think, the baseline is	16.7%	8.4%	16.7%	58.3%

Table 4.33 - Survey 2.1 results - Data lines with both tint and shade colours

Question	Dark blue line	Light blue line	Not clear
As you think, the baseline is	33.3%	25%	41.7%

According to the above statistics, all tint, all shades and both tint and shade colour data lines made respondents confused to find the baseline. Majority of respondents answered ‘not clear’ or gave wrong answers for each question. Here are the percentages of wrong answers including ‘not clear’ answers. Table 4.31- 100%, Table 4.32 - 91.7% and Table 4.33 - 66.7%.

Table 4.34 - Survey 2.1 results - Dotted data lines

Question	Blue line	Grey line	Green line	Brown line	Not clear
As you think, the baseline is	8.3%	-	66.7%	-	25%

Dotted data line was successfully recognized by the majority of 67% respondents. It was easy to differentiate with other lines because other company lines drawn as solid lines whereas baseline is drawn as a dotted line.

As a conclusion of colour visual hierarchy, the researcher found that adding different colour tones to data lines were meaningless whereas it was easy when changing the style of a data line. Adding different colour tones does not help users to reduce the cognitive load.

The main advantage of this finding is, it will reduce the cognitive load of users by reducing reading and searching time of data lines and legends. It will be an impact on the overall performance of the dashboard users because it includes a lot of graphs under each type of ratios.

4.2.1.6 Summary of survey results of 2.0 and 2.1

Table 4.35 - Survey 2.0 and 2.1 Summary - Understanding legends

Legends with			
considerable gaps	**close gaps**	**coloured text**	**New legend design vs old legend designs**
92%	50%	83%	50%

Table 4.36 - Survey 2.0 and 2.1 Summary - Understanding legends

1 type scale	**2 type scale**	**3 type scale**	**Importance of wording with type scale**
50%	42%	67%	88%

Table 4.37 - Survey 2.0 and 2.1 Summary - Understanding type scale with colours

Red	**Yellow**	**Green**
92%	58%	75%

Table 4.38 - Survey 2.0 and 2.1 Summary - Understanding data lines without legends

All tint colours	**All shades colours**	**Both tint and shade colours**	**Dotted line**
0%	8%	33%	67%

This comparison came up with below conclusions

- ✓ *The new legend design was selected to the proposed dashboard because legends with coloured text were accepted by 83% of respondents*
- ✓ *Majority of respondents were able to understand the importance of wording with 3 type scaling as the most understandable type scale.*
- ✓ *Colour red and green were selected for font colours to indicate the status of values as danger and safe.*
- ✓ *Dotted line design was selected to baseline because having many coloured lines do not help to separate the data objects.*

4.2.2 A/B test

A/B testing (A version and B version) is a very common usability test. It tests two versions of user interfaces to identify which user interfaces perform best. This way can get the statistics of how users understand and read graphs well. In the first version or else the A-version was designed as how PLCs displayed graphs in their annual reports. It had typical graph design patterns that hard to analyze insights. The usual way of graphs or data presented in annual reports were very narrow down. The reporting style of annual reports is a storytelling style. When comparing the set of annual reports of the three companies, the researcher found that they are not providing data of a similar set of ratios in each year. One ratio value may contain in one year but not in the other years. Annual reports have limited graphs whereas they provide all data as numbers. Below figure is an example of how annual reports are presented ratio data. Data was taken from the annual report of Access Engineering PLC in 2018.

Figure 4.1 - Snapshot of financial highlights - Annual report of ACC in 2018

		2017/18		2016/17		Change (%)	
		Group	Company	Group	Company	Group	Company
Earnings highlights and ratios							
Revenue	LKR Mn.	26,056	17,937	20,448	14,787	27.4	21.3
Gross profit	LKR Mn.	4,061	2,811	4,732	3,404	-14.2	-17.4
EBITDA	LKR Mn.	5,677	3,697	4,272	3,886	31.9	-4.9
EBIT	LKR Mn.	4,623	2,837	3,352	3,132	31.0	-14.9
Earnings before tax	LKR Mn.	4,231	2,391	3,231	3,003	31.2	-20.4
Profit attributable to equity holders	LKR Mn.	3,071	1,908	2,708	2,684	14.7	-28.9
Dividend	LKR Mn.	1,200	1,200	1,500	1,500	-20.0	-20.0
Earnings per share	LKR	3.07	1.91	2.71	2.68	14.7	-28.8
Dividend per share	LKR	1.20	1.20	1.50	1.50	-20.0	-20.0
Dividend payout	%	39	63	55	56	-30.2	12.4

Most common analysis method in annual reports is vertical analysis. All companies follow the table as a layout of presenting data. It includes current year data, previous one-year data and the change in percentage. According to the company standards, in some years a section called “ten years summery or eight years summery” has included. By refereeing that section, readers can analyze past financial performance. The major disadvantage is analyzing written numbers is harder than analyzing data on graphs. Annual reports can be used for descriptive analyzing purposes because it provides past data only.

As an example of how annual reports graphically presented ratio data on a graph, below column graph is taken from the annual report of Access Engineering PLC in 2018.

Figure 4.2 - Snapshot of Graph - Annual Report of ACC in 2018

When referring all annual reports which selected for this study, the researcher found that graphically presented data and numeric data do not have a base-line data to compare the financial performance of the company concerning the overall financial performance of the industry.

Furthermore, the researcher observed that some of the ratio formulas are provided in an annual report. According to the ACC annual report in 2018, a formula of earning per share is described as "*Basic earnings per share amounts are calculated by dividing the net profit attributable to equity holders of Access Engineering PLC by the weighted average number of ordinary shares in issue during the year"*. Even though the formula has given, readers are still facing difficulty for calculations and interpret the real meaning of the result because of the lack of domain knowledge.

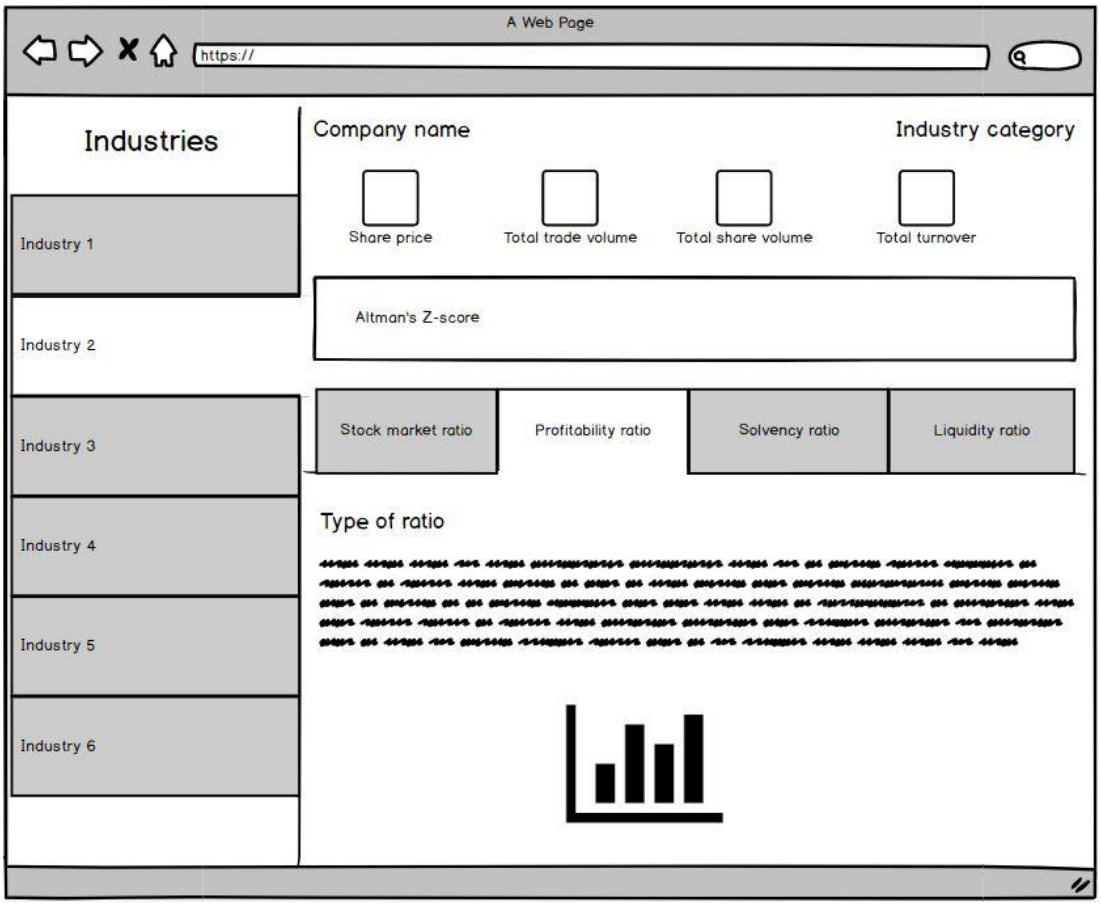
By observing these problems, the researcher decided to design two dashboards prototypes. Dashboard one was taken as A-version. Dashboard two was taken as B-version. The A-version dashboard was designed according to the data provided by annual reports. The B-version was the proposed dashboard designed based on the feedback of survey 1.0, 1.1, 2.0 and 2.1. All the data was common for both versions and the only difference was the techniques used for information visualization.

As computer-aided online software to design prototypes, the mock flow application was used to draw mockups, Balsamiq application was used for wireframing and the Invision application was used to create prototypes. All are well-known tools and very easy to use.

There were common elements in both two versions of dashboards. The major difference was graph designs. The dashboards consist of sidebar, sector name, company name, general information about the sector/company such as share price, total trade volume, total share volume and total turnover. The Altman's Z-score was displayed as the second set of elements in the body. Four tabs were designs under the Altman's Z-score to navigate four types of ratios. Under each ratio, the ratio description was provided and the graph was placed after next. In both prototypes, graphs were designed according to the data calculated for each ratio. In the sidebar, sector names appeared but only Construction and Engineering was able to be clicked.

ACC, MTD and LKM were placed under the sector. Those were able to be clicked. Users can click tabs, and sidebar sector names and company names to see every graph. Below wireframe visualizes the elements of the dashboard as explained above.

Figure 4.3 - Wireframe of dashboard elements

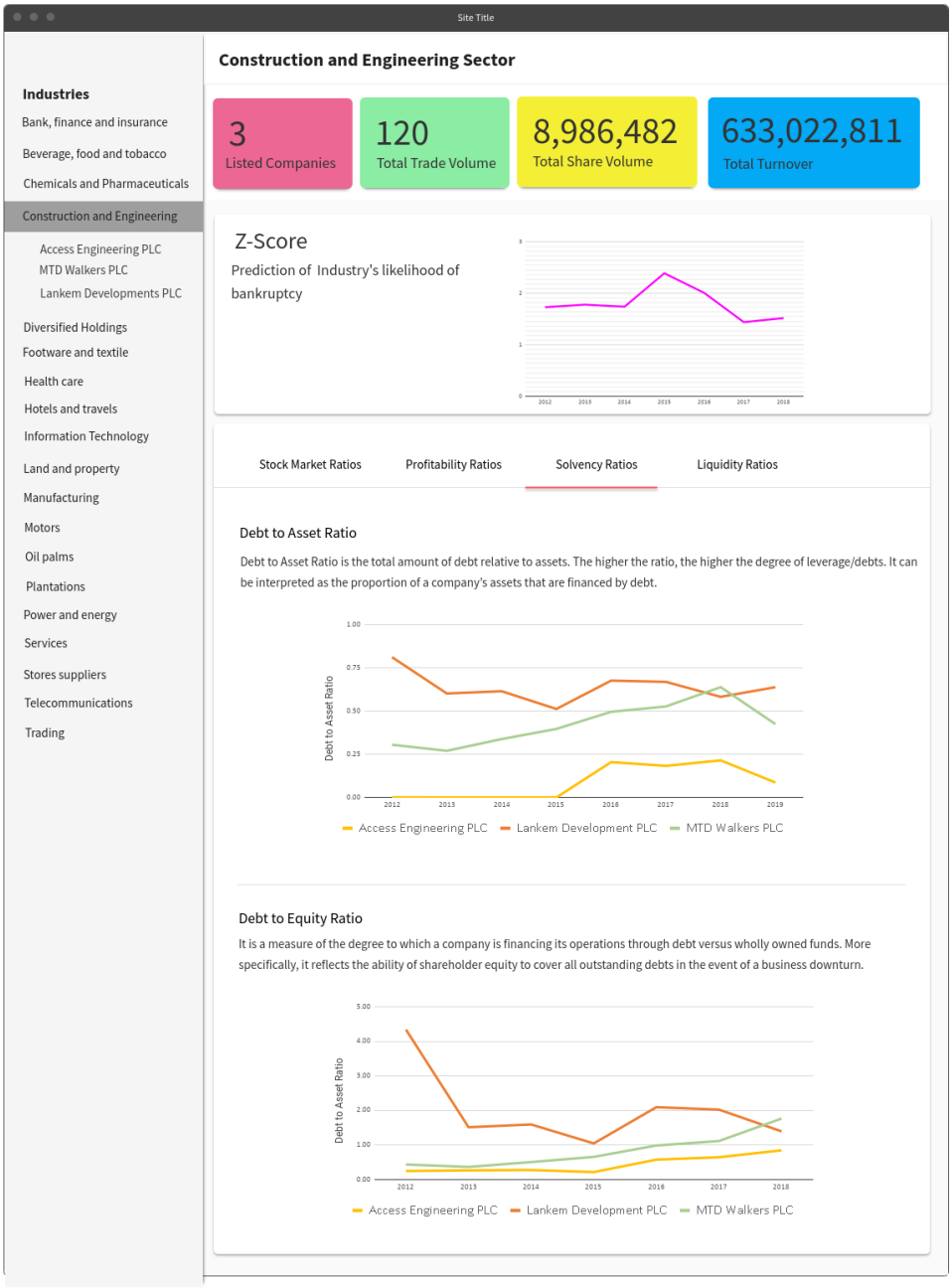


The survey was done by four respondents in each version. A-version was tested as survey 3.0 and B-version was tested as survey 3.1. Each respondent filled only one survey. Otherwise, the results of surveys would be biased because the same data was used for both versions.

4.2.2.1 Design of A-version dashboard

As mentioned above, the A-version was designed based on the information provided by the annual reports. It was a descriptive analysis dashboard.

Figure 4.4 - A-version - Design of dashboard



In annual reports calculated Altman's Z-score and description of ratio were excluded. Those elements were added by the researcher to A-version purposely because those two elements were added to B-version as improvements to the proposed dashboard. If the researcher did not include those to A-version, the results of A/B testing could

be unfair. It helped to balance the decisions. Mainly the graph section had three components. Those were a description of ratio, graph and legends.

Appendix F holds the prototype of A-version.

4.2.2.2 Design of B-version dashboard

The B-version design consisted of direct and indirect data from annual reports. Direct data were figures of financial performances and indirect data was ratios calculated with direct data. The graph design was implemented based on the feedback of previous surveys of 1.0, 1.1. 2.0 and 2.1. Appendix G holds the prototype of B-version.

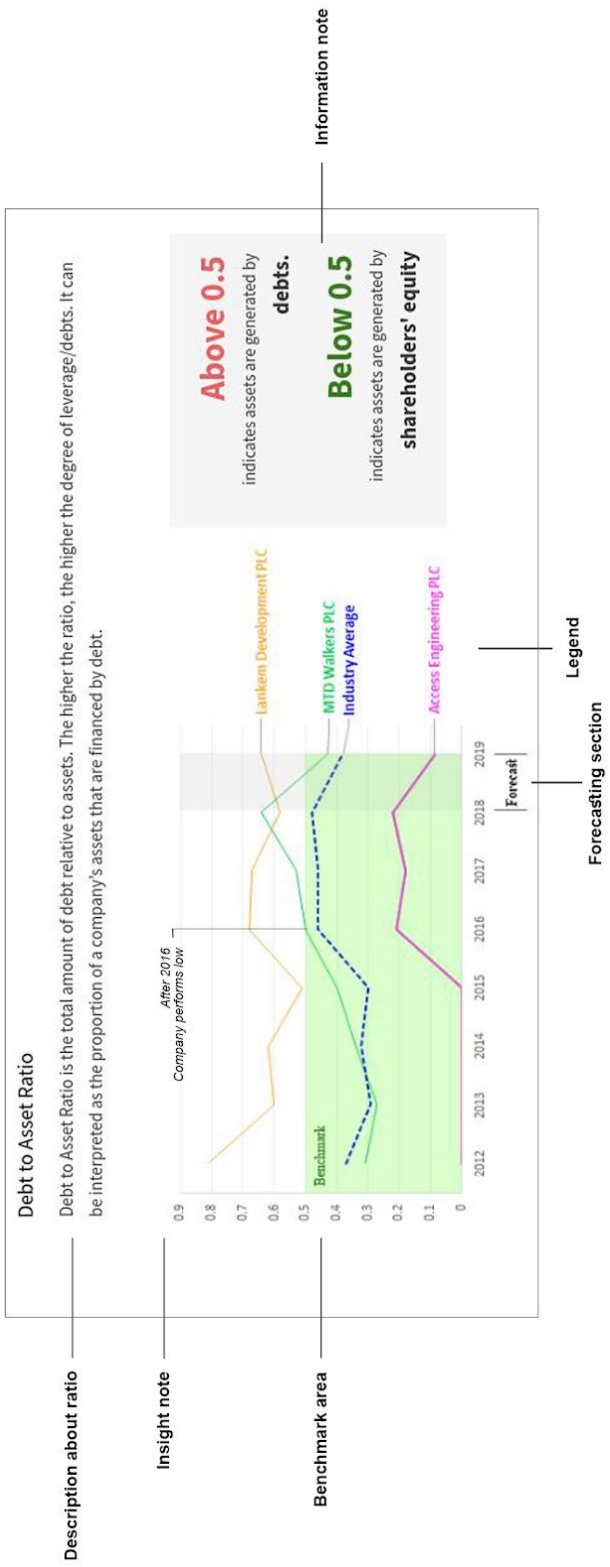
Figure 4.5 - B-version - Design of dashboard

The Altman's Z-score was very informative comparing with A-version. It provided insights with colour and status. There are three stages of z-score under three ranges. These are safe zone, grey zone and distress zone. The researcher used background colours that symbolized the respective zones. Green, grey and red were used respectively. In this study, none of the company had fallen into a safe zone. Below figure shows the designs of grey zone and distress zone respectively.

Figure 4.6 - B-version - Designs of Altman's Z-score

Financial ratios section was placed under the Z-score section. Four tabs of types of ratios helped to maintain a good arrangement of the user interface. The important change of this version was the graph designs of financial ratios. Below figure shows the elements of the graph section.

Figure 4.7 – B - version - Elements of proposed graph design



The improvement of the graph section had a high impact on decision making. The graph section consisted of three main components. Those were description about ratio, graph and information note. The graph was divided into sub-components of insight note, benchmark, forecasting section and legend.

The description of ratio was similar in both versions. It was a brief introduction to the ratio. It helped uses to know about what is this ratio and how is it helpful. The graph was an important element here. Coloured solid lines were visualized company wise data and coloured dotted line was the industry average, which was the average of all three companies. Those solid and dotted lines were designed based on the feedback of survey 2.1 under the colour visual hierarchy. The dotted line was highlighted and comparable with other lines. The insight note was derived from the feedback of survey 1.1. The use of the insight note was, it pointed out some of the important data that users should be focused on. It eliminated being away from important insights. It proved that it's a very helpful element to deliver a better understanding of the graph. The information note was very useful to analyze the insight of the graph. It provided information on how ratio could be best or worst and also the threshold points of the ratio. The threshold point is called as the benchmark. This benchmark was green coloured which visualized the positive threshold point of the ratio. The benchmark was designed based on the information note. The forecasting section was displayed the forecasted data. It helped users to understand how the ratio works next year. Only one year was forecasted because the financial performance is subject to be changed due to the internal and external factors. There is no assumption that the company's financial performance depends on past factors. This section was coloured with grey with low opacity. By applying a background colour, it made attraction or focus toward this section because forecasted data is very important to make the final decision making. The legend was designed based on the feedback of survey 2.0. Legend closer to its data line was a successful design to reduce the cognitive load of graph analyze.

4.2.2.3 Surveys of 3.0 and 3.1

A-version and B-version prototypes were tested with survey 3.0 and 3.1 respectively. The same questions were asked in both surveys. A simple case study was provided. The case study was '*Imagine that you are a fresh or existing Investor of the Colombo Stock Exchange. You have Rs.100,000 cash in hand and you want to invest it on any company. You decide to choose a company from the Construction and Engineering sector. Before investing, you want to know how each company financially perform. This decision is critical for you to decide the most suitable and profitable company to make a profit out of your investment.'* Based on this case study, 'Which company performs best?' and 'What are the reasons for your answer?' were the questions asked in each financial ratio. The start and end time of the survey were required to analyze the average time of each version. At the end of the survey, there were some general questions about the overall evaluation of the prototype. Do you have colour blindness problem?, your knowledge about Finance and Accounting, provided information is sufficient to make decisions, graphs are readable and easy to understand, provided information helped me to analyze insights, after analyzing graphs I was able to understand financial health/position of each company, as a final decision would you like to invest Rs.100,000 and please submit problems and suggestions to improve the prototype were general questions. Other than the first and last two questions, all others were five-scaled questions.

Appendix E holds the survey questions of survey 3.0 and survey 3.1 respectively.

Appendix F and G hold prototypes of A-version and B-version respectively.

4.2.2.4 Analysis of best company performed

As part of the financial performance of each company, '*which company performs best?*' and *'what are the reasons for your answer?*' were asked under each financial ratio. By analyzing answers for those questions, the researcher tried to analyze how users understandability towards the company data was changed. '*Which company performs best?*' was multi-select question type where *Access Engineering PLC, Lankem Development PLC, MTD Walkers PLC, None of them and No idea* were

available options. Answers of *'what are the reasons for your answer?'* will be discussed under the analysis of open-ended questions.

There were ten MCQs categorized under each ratio. Below table 4.39 described the responses of each MCQ in survey 3.0 and survey 3.1.

Table 4.39 - A/B test - Best company performed responses analysis

Type of ratios	**Ratios**	**Respondents**	**A-version**	**B-version**
Stock market ratio	P/B	1	ACC	LKM
		2	LKM	LKM
		3	MTD	ACC
		4	ACC	ACC
	EPS	1	None of them	ACC
		2	LKM	ACC
		3	ACC	ACC
		4	ACC	ACC
	P/E	1	LKM	ACC
		2	LKM	ACC
		3	MTD	ACC
		4	ACC	MTD
	Dividend payout	1	ACC	ACC
		2	LKM	ACC
		3	ACC	ACC
		4	ACC	None of them
Profitability ratio	ROE	1	ACC	ACC
		2	LKM	ACC

		3	ACC	ACC
		4	ACC	ACC
	Net margin	1	MTD	ACC
		2	No Idea	ACC
		3	MTD	ACC
		4	MTD	ACC
	Asset turnover	1	LKM	ACC
		2	ACC	ACC
		3	MTD	ACC
		4	ACC	LKM
Solvency ratio	D/A	1	ACC	ACC
		2	LKM	ACC
		3	ACC	ACC
		4	ACC	MTD
	D/E	1	ACC	ACC
		2	MTD	ACC
		3	ACC	ACC
		4	ACC	ACC
Liquidity Ratio	Liquidity VS Quick acid ratio	1	No Idea	MTD
		2	LKM	ACC
		3	ACC	ACC
		4	ACC	MTD

Frequency of best company performed and its percentage is described in below table 4.40. The coloured cells represented the significant changes discovered of frequencies.

Table 4.40 - A/B test - Best company performed frequency analysis

Type of ratios	Ratios	Versions	ACC	LKM	MTD	None of them	No Idea
Stock market ratio	P/B	A-version	2	1	1	0	0
			50%	25%	25%	0%	0%
		B-version	2	2	0	0	0
			50%	50%	0%	0%	0%
	EPS	A-version	2	1	0	1	0
			50%	25%	0%	25%	0%
		B-version	4	0	0	0	0
			100%	0%	0%	0%	0%
	P/E	A-version	1	2	1	0	0
			25%	50%	1%	0%	0%
		B-version	3	0	1	0	0
			75%	0%	25%	0%	0%
	Dividend payout	A-version	3	1	0	0	0
			75%	25%	0%	0%	0%
		B-version	3	0	0	1	0
			75%	0%	0%	25%	0%
Profitability ratio	ROE	A-version	3	1	0	0	0
			75%	25%	0%	0%	0%
		B-version	4	0	0	0	0

			100%	0%	0%	0%	0%
	Net margin	A-version	0	0	3	0	1
			0%	25%	75%	0%	25%
		B-version	4	0	0	0	0
			100%	0%	0%	0%	0%
	Asset turnover	A-version	2	1	1	0	0
			50%	25%	25%	0%	0%
		B-version	3	1	0	0	0
			75%	25%	0%	0%	0%
Solvency ratio	D/A	A-version	3	1	0	0	0
			75%	25%	0%	0%	0%
		B-version	3	0	1	0	0
			75%	0%	25%	0%	0%
	D/E	A-version	3	0	1	0	0
			75%	0%	0%	0%	0%
		B-version	4	0	0	0	0
			100%	0%	0%	0%	0%
Liquidity Ratio	Liquidity VS Quick acid ratio	A-version	2	1	0	0	1
			50%	25%	0%	0%	25%
		B-version	2	0	2	0	0
			50%	0%	50%	0%	0%

This table was helpful to analyze how best company selection has deviated in both dashboard designs. Almost all responses were different comparing both surveys but the researcher identified some of the major changes of frequencies.

Under the stock market ratio, the earnings per share ratio was the first change of frequency discovered by the researcher. In A-version, ACC got 2, LKM and None of them got 1 each but in B-version all four respondents selected ACC. Below table helped to compare the responses related to EPS in both surveys.

Table 4.41 - A/B test - Open-ended responses comparison of EPS

A-version		**B-version**	
Company	**Reason**	**Company**	**Reason**
None of them	EPS ratio has not been the highest in any year (It varies year to year)	ACC	continues improvement beyond the industry
LKM	Financially stable and current assets can cover its current liabilities	ACC	EPS of Access Engineering PLC is way above the industry standards and shows continuous improvement.
ACC	it keeps a steady line	ACC	Company is profitable.
ACC	Access Engineering PLC is the best performer as per the EPS ratio. EPS is the company's portion of a profit allocated to determine the value of earnings and how investors feel about future growth.	ACC	It has the highest EPS

According to the above table, responses of A-version were collapsed. Responses did not cover the real reason of why this company is the best. As per the responses of A-version, the researcher analyzed, other than the second answer of company LKM, all other three answered were given based on the observation of data line fluctuations. Those respondents were not able to recognize the purpose of the ratio. Whereas responses of B-version were very straightforward and it described how this company

is the best. Based on the analysis, the researcher observed that all respondents of B-version able to understand the purpose of the ratio and it led to giving the same answer by all of them.

The second change of frequency was ROE. In A-version there were three responses for ACC and one for LKM but in B-version all four were ACC.

Table 4.42 - A/B test - Open-ended responses comparison of ROE

A-version		**B-version**	
Company	**Reason**	**Company**	**Reason**
ACC	Highest ROE among other companies in each year	ACC	More efficient at generating revenue
LKM	Management is using a company's assets to create profits effectively	ACC	ROE of Access Engineering is just above the industry level
ACC	it keeps a steady line	ACC	More efficient.
ACC	Companies can finance themselves with debt and equity capital. By increasing the amount of debt capital relative to its equity capital, a company can increase its return on equity.	ACC	the ratio is above the average

As per the responses of A-version, the researcher analyzed, the second response of company LKM was able to understand the purpose of the ratio. The last response was an indirect answer. The responder has described the ratio not the answer. Other two answers were given based on the observation of data line fluctuations. Based on the analysis, the researcher observed that all respondents of B-version able to understand the purpose of the ratio and it led to giving the same answer by all of them.

The third change of frequency was the net margin. In A-version there were three responses for MTD and one for No idea but in B-version all four were ACC.

Table 4.43 - A/B test - Open-ended responses comparison of net margin

A-version		**B-version**	
Company	**Reason**	**Company**	**Reason**
MTD	After 2014 MTD walkers show the highest net margin ratio	ACC	High efficiency to convert sales into a profit
No Idea	All three performing well	ACC	Compared with the other two companies this company's net margin ratio is way beyond the industry average which shows the efficiency
MTD	line going up	ACC	High efficiency
MTD	The goal of any business is to improve its net margin	ACC	Highest ratio

As per the responses of A-version, the researcher analyzed, the last response of company MTD was able to understand the purpose of the ratio. Other three answers were given based on the observation of data line fluctuations. Based on the analysis, the researcher observed that all respondents of B-version able to understand the purpose of the ratio and it led to giving the same answer by all of them.

The fourth change of frequency was D/E. In A-version there were three responses for ACC and one for MTD but in B-version all four were ACC.

Table 4.44 - A/B test - Open-ended responses comparison of D/E

A-version		B-version	
Company	**Reason**	**Company**	**Reason**
ACC	Lowest DE ratio all the time	ACC	safe to shareholders
MTD	Ability to stakeholder equity to cover all outstanding debts is high	ACC	hey are maintaining lowest debt to equity ratio which is well safe for investors
ACC	keeps low ratio	ACC	safe for shareholders
ACC	The more debt a company uses, the higher the debt-to-equity ratio will be. Debt typically has a lower cost of capital compared to equity.	ACC	lower ratio

As per the responses of A-version, the researcher analyzed, the second response of company MTD was able to understand the purpose of the ratio. The last response was an indirect answer. The responder has described the ratio not the answer. Other two answers were given based on the observation of data line fluctuations. Based on the analysis, the researcher observed that all respondents of B-version able to understand the purpose of the ratio and it led to giving the same answer by all of them.

The last change of frequency was liquidity vs quick acid ratio. In A-version there were two responses for ACC and LKM and No idea got 1 each but in B-version two got ACC and MTD each.

Table 4.45 - A/B test - Open-ended responses comparison of liquidity vs quick acid

A-version		B-version	
Company	**Reason**	**Company**	**Reason**
No Idea	Cannot understand	MTD	Able to pay short term debts quickly
LKM	Current assets can cover its current liabilities well	ACC	Maintaining the lowest gap between the current ratio and quick acid ratio than the other two
ACC	ratio is high	ACC	able to pay short term debts quickly
ACC	Both the current ratio and quick ratio measures a company's short-term liquidity, or its ability to generate enough cash to pay off all debts should they become due at once.	MTD	having low gaps

As per the responses of A-version, the researcher analyzed, the second response of company LKM was able to understand the purpose of the ratio. The last response was an indirect answer. The responder has described the ratio not the answer. The third response of company ACC answers was given based on the observation of data line fluctuations. The first responses of No idea were unable to understand the ratio. Based on the analysis, the researcher observed that all respondents of B-version able to understand the purpose of the ratio and it led to giving the same answer by all of them. As the correct answer for this ratio, ACC and MTD both companies can be considered as the best company.

The analysis of open-ended questions was described in the below section.

4.2.2.5 Analysis of open-ended questions

The objective of the open-ended questions was to analyze how users have understood the data provided and the insights they found. The researcher analyzed the reason why they choose a particular company as the best company in each ratio. After listed down all responses, the researcher categorized those into six themes. Based on those themes, the codes for each theme were labelled for all responses. Below table shows the themes and codes for responses.

Table 4.46 - A/B test - Open-ended analysis - Themes and codes

Themes	Codes	Explanation
Observed lines fluctuations only	Obs	Decision made by observing data lines ups and downs only.
Considered forecast data	For	Forecasted data helped for the decision
Considered industry average data	Avg	Company data compared with overall industry performances
Purpose of the ratio was clear	Pur	Decision made with a clear understanding of ratio
Indirect answers	InD	Described the ratio not the answer
Cannot understand	CnU	Cannot understand

Below table describes the open-ended question analysis of A-version.

Table 4.47 - A/B test - Open-ended analysis - Adding codes for A-version

Type of ratios	Ratios	Responses	Codes
Stock market ratio	P/B	Each year P/B ratio is higher than other companies	Obs
		Highest share price	Obs
		it keeps a steady line	Obs
		Access Engineering PLC is the best performer as per the PB ratio of the year of 2018 than Lankem & MTD. But Access Engineering PLC PB ratio is down in 2018 compared with past years.	Obs
	EPS	EPS ratio has not been the highest in any year (It varies year to year)	Obs
		Financially stable and current assets can cover its current liabilities	Pur
		it keeps a steady line	Obs
		Access Engineering PLC is the best performer as per the EPS ratio. EPS is the company's portion of a profit allocated to determine the value of earnings and how investors feel about future growth.	Obs
	P/E	If we take an average, PE ratio of Lankem is lower, except in 2016	Avg
		Company's stock is overvalued and investors expecting more on future	For
		Differ in the upper area. didn't go down	Obs
		Investor Expectations In general, a high P/E suggests that investors are expecting higher earnings growth in the future compared to companies with a lower P/E.	InD
	Dividend payout	Through all the years Access engineering shows the highest dividend payout ratio	Obs
		Company is in a maturity state because the ration is zero. They can go to new products or new	Pur

		investments	
		a high rate of payouts	Obs
		The dividend payout ratio is the measure of dividends paid out to. If a company pays out some of its earnings as dividends, the remaining dividend payout ratio is a better indicator of a company's.	InD
Profitability ratio	ROE	Highest ROE among other companies in each year	Obs
		Management is using a company’s assets to create profits effectively	Pur
		It keeps a steady line	Obs
		Companies can finance themselves with debt and equity capital. By increasing the amount of debt capital relative to its equity capital, a company can increase its return on equity.	InD
	Net margin	After 2014 MTD walkers show the highest net margin ratio	Obs
		All three performing well	Obs
		line going up	Obs
		The goal of any business is to improve its net margin	Pur
	Asset turnover	since 2013 it shows the highest asset turnover ratio	Obs
		Effectively using their assets to generate sales.	Pur
		low ratio	Obs
		A higher asset turnover ratio implies that the company is more efficient at using its assets. A low asset turnover ratio, on the other hand, reflects the bad management of assets by the company. It may also indicate production or management problems.	InD
Solvency ratio	D/A	Lowest DA ratio all the time	Obs
		Low level of debt	Obs
		ratio is low	Obs

		A high debt/equity ratio is often associated with high risk; it means that a company has been aggressive in financing its growth with debt.	InD
	D/E	Lowest DE ratio all the time	Obs
		Ability to stakeholder equity to cover all outstanding debts is high	Pur
		keeps low ratio	Obs
		The more debt a company uses, the higher the debt-to-equity ratio will be. Debt typically has a lower cost of capital compared to equity.	InD
Liquidity Ratio	Liquidity VS Quick acid ratio	Cannot understand	CnU
		Current assets can cover its current liabilities well	Pur
		ratio is high	Obs
		Both the current ratio and quick ratio measure a company's short-term liquidity, or its ability to generate enough cash to pay off all debts should they become due at once.	InD

Table 4.48 - A/B test - Open-ended analysis - Statistics of A-version

Themes	Codes	Frequency	Proportion
Observed lines fluctuations only	Obs	23	58%
Considered forecast data	For	1	3%
Considered industry average data	Avg	1	3%
Purpose of the ratio was clear	Pur	7	18%
Indirect answers	InD	7	18%
Cannot understand	CnU	1	3%

As per the above statistics, 58% of responses were based on the observation of line fluctuations only. It indicated that users did not have good knowledge about the ratio and they could not be able to read the graph correctly. This happens when people do not have good knowledge about the domain. The second highest was the purpose of the ratio was clear and indirect answers categories. Only 18% of users able to understand the purpose of the ratio and other 18% have described the ratio rather than describe their answers. It is also one way of answering questions when people do not have a clear or direct answer to provide. Forecasted and industry average data were considered only once. However, A-version prototypes were not provided with both information. They might be assumed and answered.

As a conclusion, A-version prototypes were failed to make knowledge out of the data provided and also very poor in insight creation.

The B-version which was the proposed graph design, here is the analysis of open-ended questions including coding.

Table 4.49 - A/B test - Open-ended analysis - Adding codes for B-version

Type of ratios	Ratios	Responses	Codes
Stock market ratio	P/B	Company is Forecasted to maintain a good ratio	For
		Price to book ratio of Lankan Development PLC is showing a good trend along with the industry. It's in a good position compared to the industry average than the other two companies	Avg
		Progress towards good ratio.	Obs
		It has the highest P/B ratio	Obs
	EPS	continues improvement beyond the industry	Avg
		EPS of Access Engineering PLC is way above the industry standards and shows continuous improvement.	Avg
		Company is profitable.	Pur

		It has the highest EPS	Pur
	P/E	High growth is anticipated in the future	For
		Currently, the highest P/E ratio is maintained by Access Engineering	Pur
		High anticipated growth in future.	For
		It has the highest P/E ratio in Forecasting	For
	Dividend payout	More investors are likely to attract as they pay the highest dividends	Pur
		Currently, they are paying the highest dividend and there's a good tendency to attract more investors.	Pur
		Can attract more investors. Pay high dividends.	Pur
		no steady rising	Pur
Profitability ratio	ROE	More efficient at generating revenue	Pur
		ROE of Access Engineering is just above the industry level	Pur
		More efficient.	Pur
		the ratio is above the average	Avg
	Net margin	High efficiency to convert sales into a profit	Pur
		Compared with the other two companies this company's net margin ratio is way beyond the industry average which shows the efficiency	Pur
		High efficiency	Pur
		Highest ratio	Pur
	Asset turnover	Forecasted to perform an industry average	For
		Compared to the other two companies they generate the highest sales in low assets currently	Pur
		Align with the industry average.	Avg

		Highest ratio	Pur
Solvency ratio	D/A	Better debt ratio	Pur
		It's in a comfortable position maintaining a low debt ratio. It's well below the industry average	Pur
		Good debt ratio.	Pur
		near to the industry average	Avg
	D/E	safe to shareholders	Pur
		They are maintaining the lowest debt to equity ratio which is well safe for investors	Pur
		Safe for shareholders.	Pur
		lower ratio	Pur
Liquidity Ratio	Liquidity VS Quick acid ratio	Able to pay short term debts quickly	Pur
		Maintaining the lowest gap between the current ratio and quick acid ratio than the other two	Pur
		able to pay short term debts quickly	Pur
		having low gaps	Pur

Table 4.50 - A/B test - Open-ended analysis - Statistics of B-version

Themes	Codes	Frequency	Proportion
Observed lines fluctuations only	Obs	2	5%
Considered forecast data	For	5	13%
Considered industry average data	Avg	6	15%
Purpose of the ratio was clear	Pur	27	68%
Indirect answers	InD	0	0%

Cannot understand	CnU	0	0%

As per the above statistics, 68% of responses were able to understand the purpose of the ratio. The second and third highest was based on industry average and forecasted data. In B-version, those data were added and users were successfully analyzed those data and able to see the insights of the ratio. It was a positive achievement of the proposed dashboard. Only 5% of responses were provided answers only by observing the data line fluctuations. There were no indirect and cannot understand the answers provided.

As a summary of open-ended question analysis, below table describes the changes of statistics in both versions.

Table 4.51 - A/B test - Open-ended analysis -Summary

Themes	**Frequency of A-version**	**Frequency of B-version**
Observed lines fluctuations only	23	2
Considered forecast data	1	5
Considered industry average data	1	6
Purpose of the ratio was clear	7	27
Indirect answers	7	0
Cannot understand	1	0

As per the above statistics, more than 100% of the responses had improved with the proposed dashboard. The coloured rows represented the improvement. In B-version, users have gone through the forecasted data, industry average data and statistics shows those data was helpful to have correct answers. Increment of both categories

were 900% of the responses. There was a 91% drop of responses which were based on the observation of data line fluctuations and 286% improvement of responses given with a proper understanding of the ratio. The B-version had no indirect answers received. It indicates B-version proposed dashboard have high readability and understandability concerning typical graph designs in A-version. ***Adding forecasted data and visualize the comparison between each company with industry average was very helpful for users to make correct decisions. Those two data provided value to the proposed dashboard.***

4.2.2.6 Analysis of general questions

There were eight general questions were asked in both surveys. The purpose of those questions was to analyze the overall performance of the prototypes. As an addition to those questions, the start time and end time was required. It helped to analyze the average time taken to complete each task.

The first question was *'Do you have colour blindness?.'* All responses were 'No'. This study was not provided with a solution for colour blind people. It was out of scope. Therefore all eight users were eligible to be tested.

The second question was *'Your knowledge about Finance and Accounting'.* The five-scaled options were provided. None of the respondents had good or very good knowledge about the domain. One to three scale, which was very poor, poor and neutral knowledge users were the test group.

General questions from three to six were related to the overall performance of the prototypes. Those were five-scaled questions. Below table describes the results of A-version

Table 4.52 - A/B test - General questions - Overall performance of A-version

General questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Provided information is sufficient to make decisions	0	1	2	1	0
Graphs are readable and easy to understand	0	1	2	1	0
Provided information helped me to analyze insights	0	1	1	1	1
After analyzing graphs, I was able to understand the financial health/position of each company	0	2	0	2	0
Total	**31%**		**31%**	**38%**	

Those four questions covered how dashboard helped to make clever decisions. 31% of responses belonged to ‘disagree’ and ‘neutral’ categories. The ‘neutral’ category represented the middle state of agreeing and disagree. Those answered could be considered as ‘not sure or not direct answer’. Whereas agree and strongly agree categories were very clear that those responses were positive towards the answer. There were 38% of positive answers and 31% of negative answers. ***By analyzing, the researcher understood that A-version dashboard had low performances.***

Below table describes the overall performance of the B-version prototype.

Table 4.53 - A/B test - General questions - Overall performance of B-version

General questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Provided information is sufficient to make decisions	0	0	1	1	2
Graphs are readable and easy to understand	0	0	0	1	3
Provided information helped me to analyze insights	0	0	1	0	3
After analyzing graphs, I was able to understand the financial health/position of each company	0	0	0	2	2
Total	**0%**		**12%**	**88%**	

Above results were completely different from A-version results. There were no responses received under the disagree categories. It was an improvement of B-version. Only 12% of responses were received under the 'neutral' category and the highest numbers of responses received under 'agree' categories. That was 88% of the responses. ***Above statistics have proven that the overall performance of B-version was higher than the A-version***.

As a result of overall performances of dashboards, below table describes the changes of results.

Table 4.54 - A/B test - General questions - Summary of overall performances

Categories	A-version	B-version
Disagree category (strongly disagree and disagree)	31%	0%
Neutral	31%	12%
Agree category (strongly agree and agree)	38%	88%

As per the above statistics, 100% drop in disagree category and 61% drop in the neutral category were observed. There was a 132% of increment in agree category. ***These analytics clearly shows that overall performance of B-version had improved more than 100%. The ease of use, understandability and insight recognition became easy with the B-version.***

Based on the overall performance, the researcher identified how the lowest domain knowledge person had performed in both versions. Below table describes the five-scaled responses provided by the lowest domain knowledge person. The five-scaled options for knowledge about Finance and Accounting were strongly poor, poor, neutral, good, and strongly good. The numbers of these options were 1,2,3,4 and 5 respectively.

Table 4.55 - A/B test -Overall performance - lowest domain knowledge users

	A-version	**B-version**		
General Questions	**User 3**	**User 1**	**User 2**	**User 4**
Your knowledge about Finance and Accounting	1	2	2	2
The provided information is sufficient to make decisions	2	5	3	5
Graphs are readable and easy to understand	2	5	4	5
Provided information helped me to analyze insights	2	5	3	5
After analyzing graphs, I was able to understand the financial health/position of each company	2	5	4	5

The lowest domain knowledge category of the user in A-version was ‘strongly poor’. The user had selected the second option, which was ‘poor category’ for all questions. ***This indicated the A-version dashboard was not helpful to analyze data of financial and accounting. It was hard to use and less understandable.***

The lowest domain knowledge category of the user in B-version was ‘poor’. User 1 and 4 had selected ‘strongly agree’ option for all questions. The users 2 had selected neutral and agree by two each. ***This indicated the lowest domain knowledge user had able to analyze data of financial and accounting well. They found that the dashboard was very easy to use and high in understandability.***

The researcher analyzed the time spent on each user in both dashboards. It was a good indicator to test the most efficient dashboard. The efficient is the art of getting things right with least time and effort (Tarrobal, 2018).

Below table describes the overall average time spent on both dashboards.

Table 4.56 - A/B test -Overall performance -Average time spent on dashboards

	A-version				**B-version**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Time spent in minutes	4	30	29	60	23	25	8	11
Average time spent in minutes	31				17			

As per the above statistics, it indicated that B-version was efficient than A-version. It took less time to complete the task because the B-version dashboard was easy to use and higher understandable. It was statistically proved. The insights were brought to the interface whereas A-version was not provided. This was the reason for less time consumption.

As a result of the analysis of general questions, the B-version has successfully increased the understandability and ease of use by reducing the cognitive load which was the primary aim of this study.

4.2.2.7 Observations

The researcher found that open-ended responses had included some of the keywords of the information note. Therefore the researcher tried to analyze those answers concerning its information notes. Then found that there was a relationship with the information note and what users had understood. Below table describes the responses with its information note.

Table 4.57 - A/B test - Observations - Responses toward the information note

Ratios	Respondents	Information note	Observation
P/E	High growth is anticipated in the future		All four answers included keywords of information note
	Currently, the highest P/E ratio is maintained by Access Engineering		
	High anticipated growth in future.		
	It has the highest P/E ratio in Forecasting		
Dividend payout	More investors are likely to attract as they pay the highest dividends		Three answers included keywords of information note
	Currently, they are paying the highest dividend and there's a good tendency to attract more investors.		
	Can attract more investors. Pay high dividends.		
	no steady rising		
ROE	More efficient at generating revenue		All four answers included keywords of information note
	ROE of Access Engineering is just above the industry level		
	More efficient.		
	the ratio is above the average		
Net margin	High efficiency to convert sales into a profit		All four answers included keywords of information note
	Compared with the other two companies this		

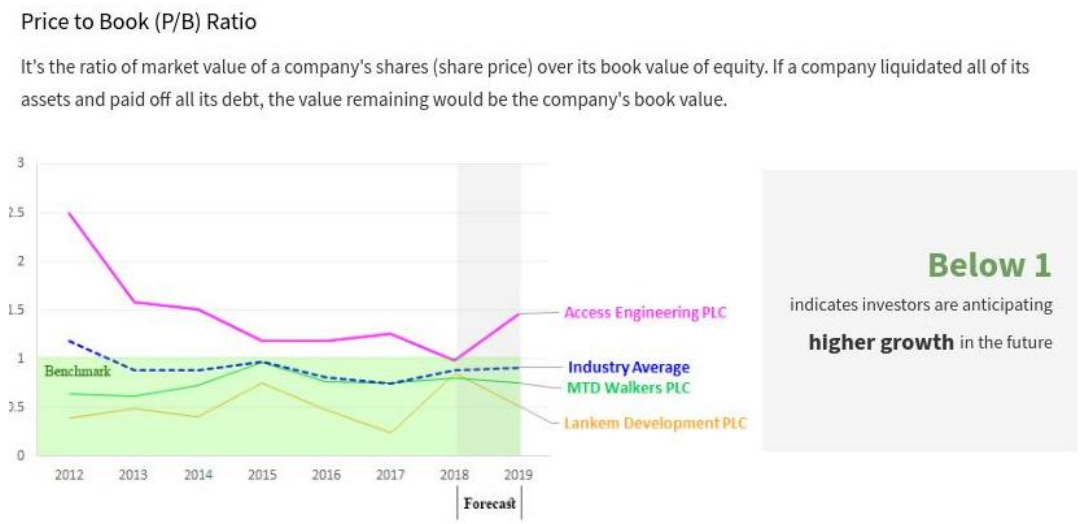
	company's net margin ratio is way beyond the industry average which shows the efficiency		
	High efficiency		
	Highest ratio		
D/E	safe to shareholders		All four answers included keywords of information note
	They are maintaining the lowest debt to equity ratio which is well safe for investors		
	Safe for shareholders.		
	lower ratio		
Liquidity VS Quick acid ratio	Able to pay short term debts quickly		All four answers included keywords of information note
	Maintaining the lowest gap between the current ratio and quick acid ratio than the other two		
	able to pay short term debts quickly		
	having low gaps		

As per the above data, users tried to provide answers with referring keywords of the information note. According to the open-ended question analysis, all these responses were categorized as forecasted data, industry average and purpose of the ratio was clear. It indicated that users had referred information note to read and understand graphs. They had followed the information or else the benchmark note. There was evidence that proved users had followed information note and compared it with the benchmark. ***Since users do not have good domain knowledge, they believed what included in information note, benchmark and insight note to make decisions.***

Not only that, the researcher found that the way of displaying information note also affected decision making. The images of information note in the above table, the benchmark point is not a number. It displayed 'higher value or lower value'. It was a comparative value. Whereas the benchmark point with numbers, users had gone wrong in one scenario.

Below figure shows the P/B graph.

Figure 4.8 - A/B test - Observation - P/B graph



On the graph, below 1 area was coloured in green with the label of 'Benchmark'. In the information note said *'Below 1 indicates investors are anticipating higher growth in the future*'. This information did not include the status of above 1 value. As per the note, the direct message was all companies who placed below 1 are good and the indirect message was companies who placed above 1 are bad. Then definitely the ACC was not a good company and all other companies were good. However, 50% of users had selected ACC as their option.

After observing this matter, the researcher observed the options chosen for D/A ratio because it had both benchmark values displayed. Below figure shows the D/A ratio.

Figure 4.9 - A/B test - Observation - D/A graph

According to this information note, below 0.5 values are good and above o.5 are bad. Red and green coloured text symbolized the status of good and bad. Other than LKM, all other companies were good and users also identified it and selected MTD and ACC and no one had selected LKM.

The reason for the misled of P/B ratio was users could not be identified that below 1 values are good means above 1 values are bad. Statistics proved that reasons for choosing companies and information note had a positive relationship. Because the domain knowledge of users was not good enough to analyze them alone. They always biased on what the note says. Maybe the fear of the unknown domain tends them to believe the same as what the note says. ***Therefore it was highly important to indicate both positive and negative benchmark values in the information note. Otherwise, the use of information note will be reduced and it will put users on the wrong path.***

Add colours represent positive information also highly important. It was not tested but as per the professional experience of the researcher, leading to the positive values have a high chance of getting the right decision.

This comparison came up with below conclusions

- ✓ *Adding forecasted data and visualize the comparison between each company with industry average was very helpful for users to make correct decisions.*
- ✓ *Since users do not have good domain knowledge, they believed what included in information note, benchmark and insight note to make decisions.*
- ✓ *Information note should provide positive and negative benchmark values. Otherwise, users may mislead insights.*
- ✓ *Overall performance of B-version had improved more than 100%. The ease of use, understandability and insight recognition became easy with the B-version.*
- ✓ *The lowest domain knowledge user had able to analyze data of financial and accounting of B-version well.*
- ✓ *Users found that the proposed dashboard was very easy to use and high in understandability*

4.3 Summary

As the summary of A/B testing, the researcher able to conduct successful surveys. The statistics found from the analysis of best company performed, open-ended questions, general questions and observations, it was proved that the proposed dashboard design was able to achieve the three objectives of this study. Those were *'identify most successful graph designs which are easy to identify insights, provide relevant financial information about the financial stability of companies and propose interactive, user-friendly dashboard, especially those who are not aware of Accounting and Finance'*. The current study was able to provide an answer to the research question which was '*how information visualization of financial performance help Investors to make clever decisions in the Stock market?'*

5 CONCLUSION AND FUTURE WORK

This chapter presents the overall summary of research as a conclusion and the areas that can look into and implement further in the research area as future work.

5.1 Conclusion

Stock market Investors do not have a tool to analyze the financial stability of PLCs and also to analyze themselves, need a good level of finance and accounting knowledge. This research was conducted as a solution to both problems. This research aims to study how Information visualization of financial performance helps Investors to make clever decisions in the Stock Market. The research experimented various graph designs that can be used to enhance the usability of the dashboard by providing a good visual hierarchy.

As the research method, financial performance analysis and evaluation of proposed dashboard design were conducted. Under the financial performance analysis, ten financial ratios under four main types of ratios and Altman's Z-score were calculated. All data was taken from annual reports from the financial years of 2012 to 2017. Using a simple moving average, the 2018 financial year data was forecasted.

The preference test and A/B test were conducted under the evaluation of proposed dashboard design. Four surveys conducted as preference test.

5.1.1 Survey 1.0

The researcher tested basic user preferences of graph designs. Chart types, gridline designs, numbering designs, colours were tested. As most preferred chart types, line chart and column charts were selected. Under the gridline preferences, the researcher used horizontal gridlines for the proposed dashboard. Under how values are placing on the graph, the numbering, the majority selected numbers on the line. To reduce the complexity of the graph, it was used to column charts only and not applied to line charts. As per the colours, the researcher used a white background for the proposed dashboard because the visual elements of graphs are very clear with white background. apart from that, the researcher analyzed methods that help to increase

the readability of graphs. The researcher analyzed, by describing ratio helped to increase the readability.

5.1.2 Survey 1.1

The description of the ratio was further studied. The researcher added insight notes which pointed out some of the insights of the data line. By this survey, the researcher found that the jargons we used in the description should be matched with the jargons in the insight note. Otherwise, the readability of the graph will be reduced for those who have less domain knowledge. Further studied that providing a new visual element of “Insight note” on top of specific data point/s helped users to focus where they should be focused and reduce the cognitive load of analyze as well.

5.1.3 Survey 2.0

It tested legend designs approaches. Rather than having typical legend designs, the researcher found that legends can be used as a visual hierarchy to visualize the increments and decrements of the latest data points relative to others. Legends closer to its end data points were successfully accepted by the respondents. The legends with coloured text also accepted and increase the map between data lines and legend text.

5.1.4 Survey 2.1

It tested typography and colour visual hierarchies. Three types of sentences under three different font sizes and weight (type scale) were provided. Sentence with one type scale and sentence with three type scale was preferred by the users. To visualize the status of the text symbolized, the red, yellow and green coloured texts were provided. Red for danger or on-alert, yellow as proceeding with caution and green as safe. The status symbolized by the red and green were recognized but the colour yellow was failed to recognized by the majority of the users. As per the colour visual hierarchy, the dotted line was preferred as an industry average line as the baseline of each graph.

5.1.5 Survey 3.0 and 3.1

The prototypes of typical graph designs were tested as A-version and the proposed dashboard was tested as B-version. By analyzing A/B test, below conclusions were made. Adding forecasted data, industry average, information note, benchmark and insight notes were helpful for users to make correct decisions. Overall performance of B-version had improved more than 100%. The lowest domain knowledge users had able to analyze data of financial and accounting of B-version well. Finally, users found that the proposed dashboard was very easy to use and high in understandability.

5.2 Future work

As future works of this research, the researcher found recommendations based on the priority levels.

The present study was forecasted data by calculating simple moving average method. When comparing with new computer science technologies, artificial intelligence techniques can be used to generate forecast data with high accuracy.

The proposed dashboard displayed only calculated past and future data. By providing real-time data with recommendations, the researcher believed that the importance of the dashboard will be improved. For example, if company A is going to take over company D, the impact on the current share prices and future share prices can be displayed as recommendations. Therefore, expand the dashboard to real-time scenarios also help to improve the investment decisions.

This study was done as an investment consultation solution. Financial ratio calculation is not the only consultation need by the real investors. The proposed dashboard can facilitate other consultation services too.

This research provided a tool to make decisions. As future work, the research recommended visualizing predicted return on investment of each investment before they make a real investment. It will help investors to conclude the investment decision.

The financial ratios and Altman's Z-score was good at company-wise analysis within one industry. The proposed dashboard was unable to make industry-wise decisions. It is one of the drawbacks of financial performance analysis. As future work, the researcher recommends to find out a method for industry-wise financial performance analysis.

The proposed dashboard was a design prototype yet. At this extent, all calculations were done on spreadsheets. When this dashboard is going to implement, the backend should be developed for the calculation of ratios.

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APPENDIX A: QUESTIONNAIRE OF SURVEY 1.0

INTERACTIVE INFORMATION VISUALIZATION OF FINANCIAL STABILITY OF COMPANIES FOR EFFECTIVE STOCK MARKET DECISION MAKING - SURVEY 1.0

Hi, I'm Piyumika Dissanayake, final year student of MBA-IT. This survey is conducted as partial fulfilment of MBA-IT degree program at the Department of Computer Science and Engineering, University of Moratuwa. This survey takes about 15 minutes to complete. Your participation is entirely voluntary and your responses are completely anonymous. Responses of anonymous surveys cannot be traced back to the respondent. The information provided is treated as strictly confidential and only be utilized for academic purposes.

This is a sub-survey to identify how people read, understand and analyze data provided by the graphs and also identify the drawbacks of graphs. All provided graphs are commonly used in well-known graphs. The main intention is to identify how graphs help users to create insights.

This survey has mainly 2 subsections. The first section is about graph reading. The second section is about your graph preferences.

I am truly grateful for your valuable time to spend on completing this survey. Please do not hesitate to contact me for any further clarifications at piyumika.17@cse.mrt.ac.lk

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Understanding graphs

It's about how you read, understand and analyze graphs

Analyzing current asset of the company from 2014 to 2018

Current assets represent all the assets of a company that are expected to be conveniently sold, consumed, utilized or exhausted through the standard business operations which can lead to their conversion to a cash value over the next one year.

Current assets include cash, cash equivalents, accounts receivable, stock inventory, marketable securities, prepaid liabilities and another liquid asset.

These are important to businesses because they can be used to fund day-to-day business operations and to pay for the ongoing operating expenses.

Below graphs indicate the components of Current Assets of Company A and their contribution towards the total current asset from 2014 to 2018

Figure 1 - line chart

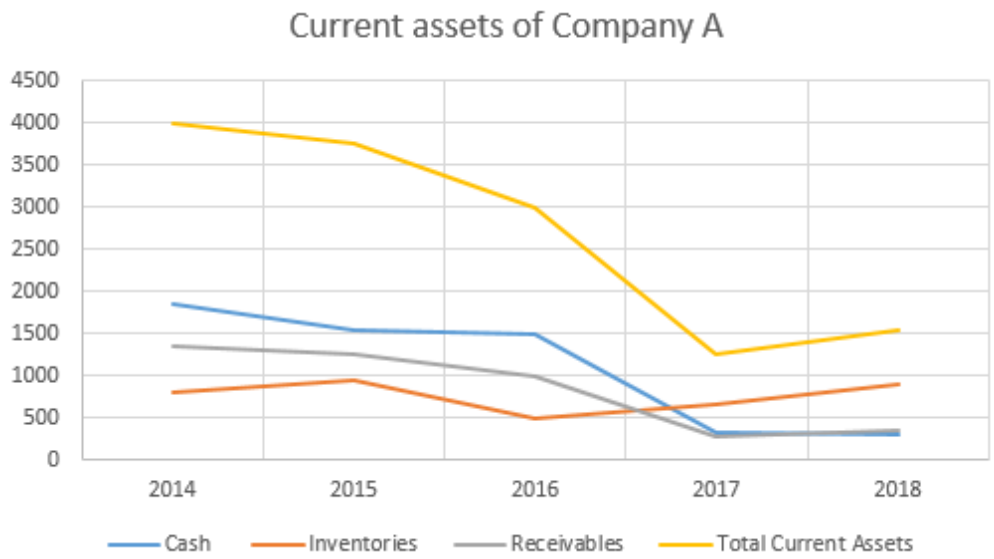


Figure 2 - column chart

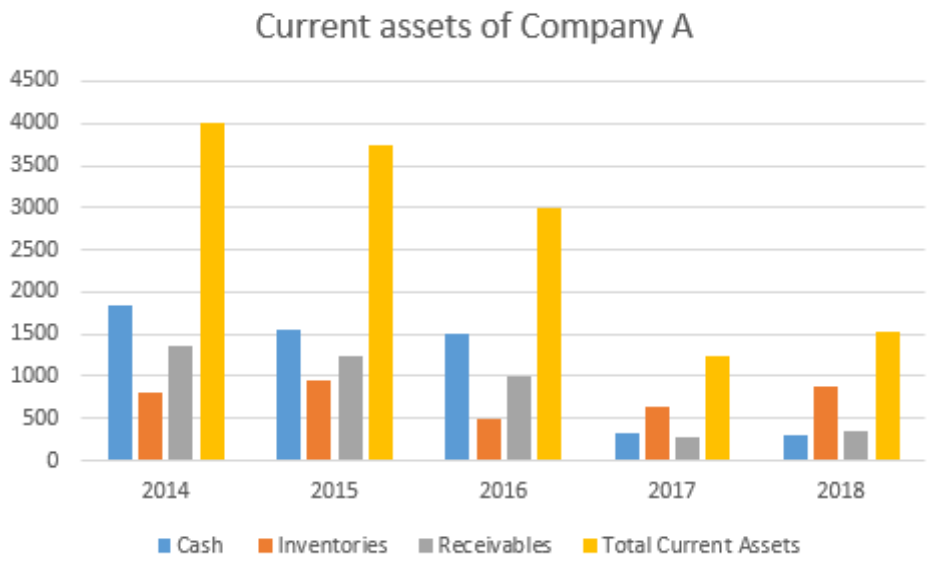


Figure 3 - bar chart

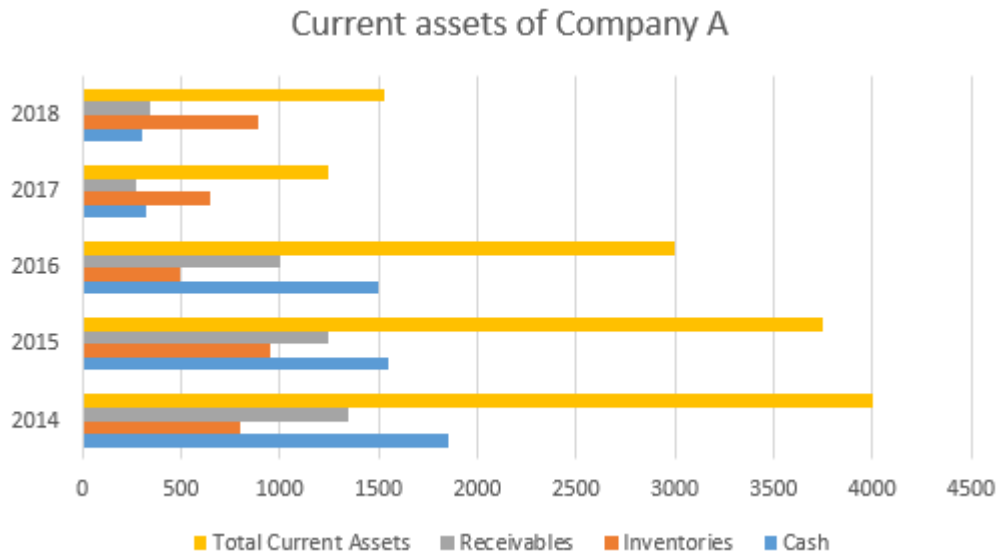
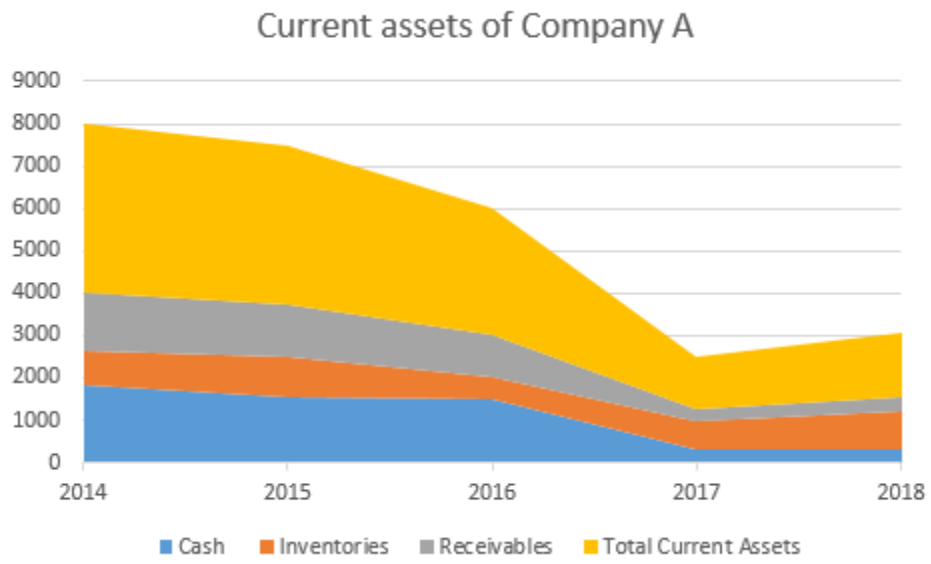


Figure 4 – stacked area chart



		Question	True	False	Cannot understand
1	Question 1	The overall behaviour of the current assets is good.			
2	Question 2	After 2017, incremental of total current asset symbolized that the company can solve/pay cash payment immediately.			
3	Question 3	Incremental of inventories after 2016, is a good indicator of total current assets.			

4	**To find out answers for each question, which graphs help most?**	**Line chart**	**Column chart**	**Bar chart**	**Stacked area chart**
	Question 1				
	Question 2				
	Question 3				

5	The description of the current asset was helped me to understand the graph	Yes	No

Graph appearance - It's about your preferences

6	Do you have colour blindness?	Yes	No	Maybe

Preferences - grid lines

7	**Which graph can easily find out the value of Receivables (y-axis value) in 2016?**
	Figure 1 - Only vertical gridline
	Figure 2 - Only horizontal gridline
	Figure 3 - Both vertical and horizontal gridline
	Figure 4 - No gridline

Figure 1 - only vertical grid lines

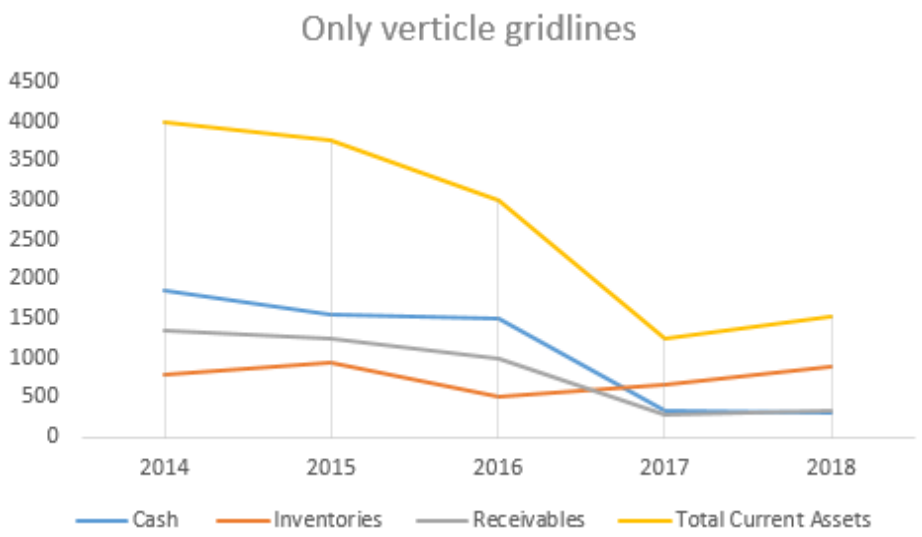


Figure 2 - only horizontal grid lines

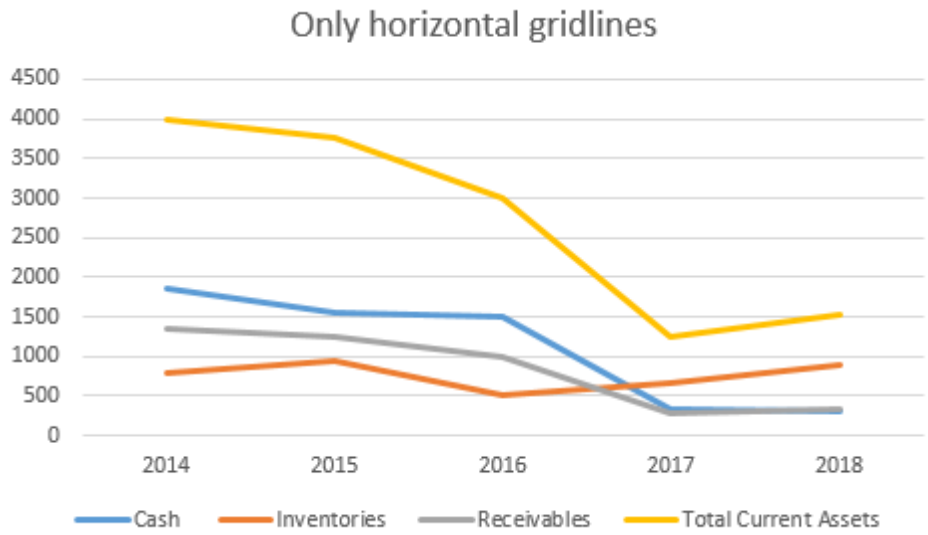


Figure 3 - both horizontal and vertical grid lines

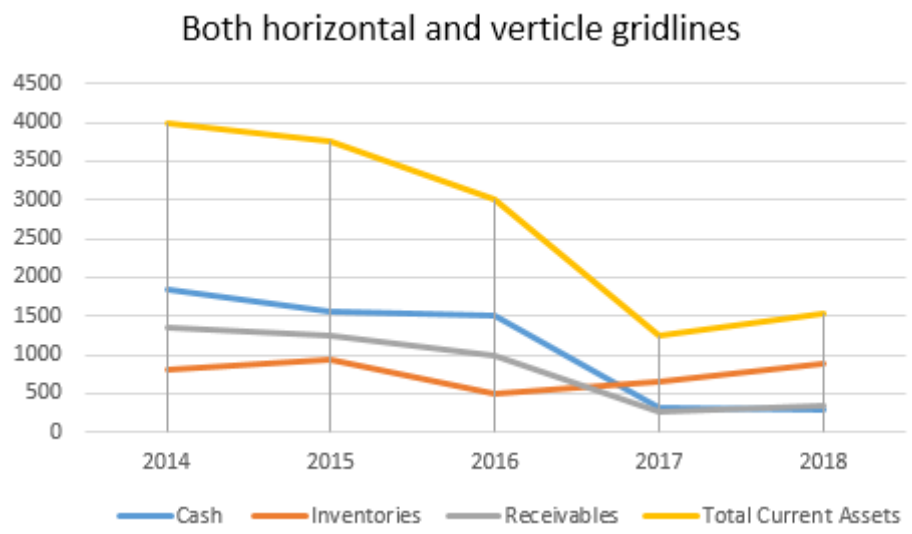
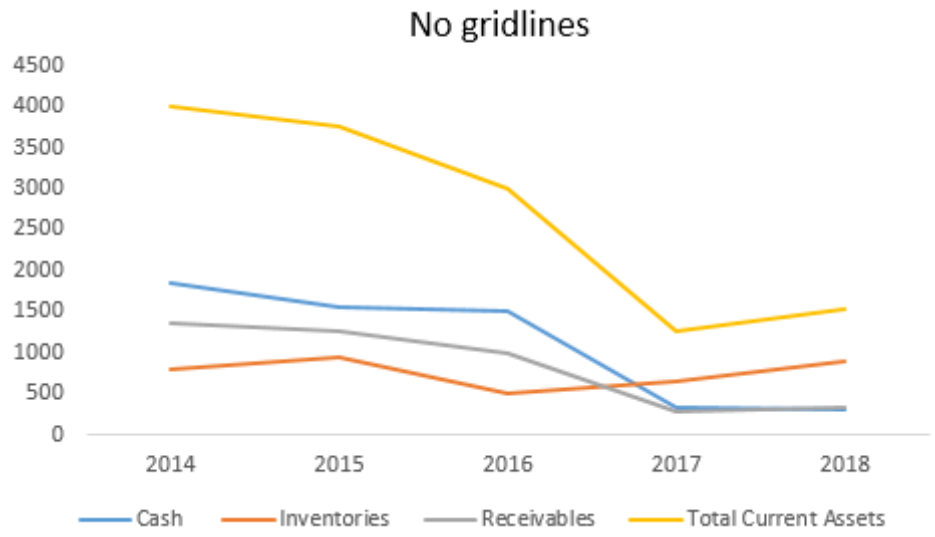


Figure 4 - no grid lines



Preferences – numbering

8	Do you like these numbering designs?	Yes	No
	Figure 1 - numbers on the line - 1		
	Figure 2 - numbers on the line - 2		
	Figure 3 - numbers on the line - 3		

Figure 1 - numbers on the line – 1

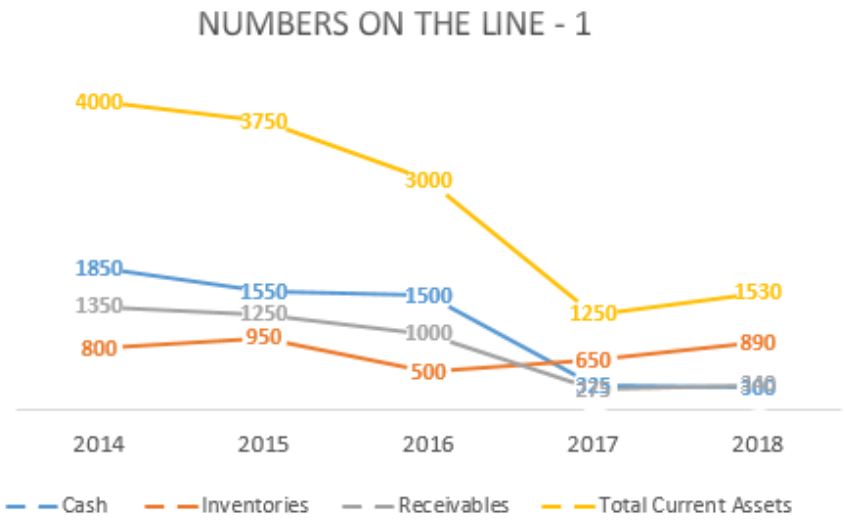


Figure 2 - numbers on the line – 2

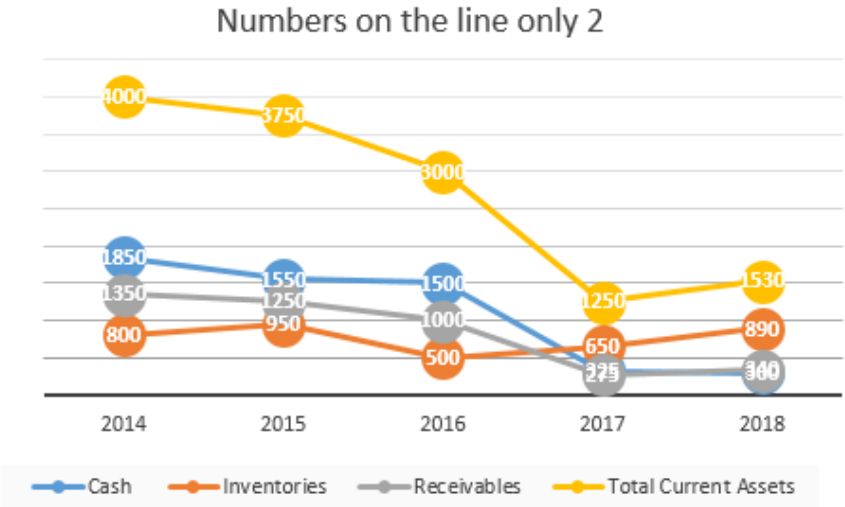
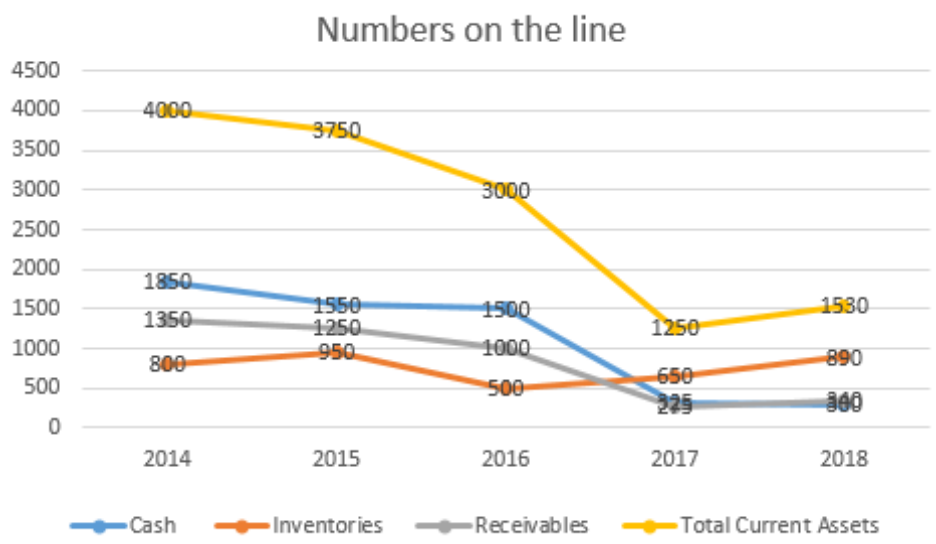


Figure 3 - numbers on the line – 3



Preferences – colours

9	Which graph design do you prefer?	Prefer	Not prefer
	Figure 1 - solid fill black		
	Figure 2 - solid fill white		
	Figure 3 - gradient fill		
	Figure 4 - picture or texture fill		
	Figure 5 - pattern fill		

Figure 1 - solid fill black

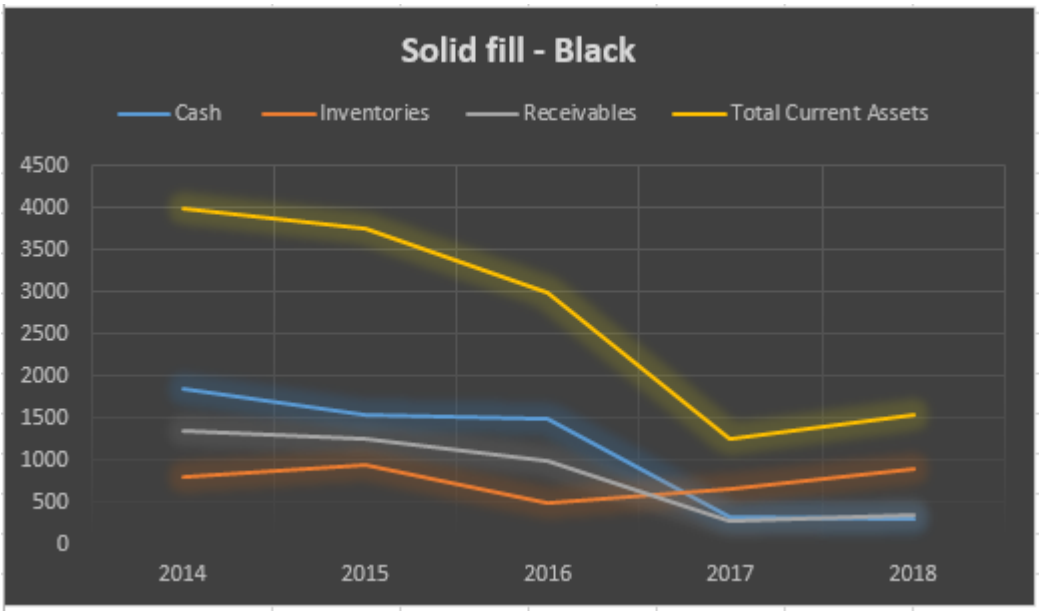


Figure 2 - solid fill white

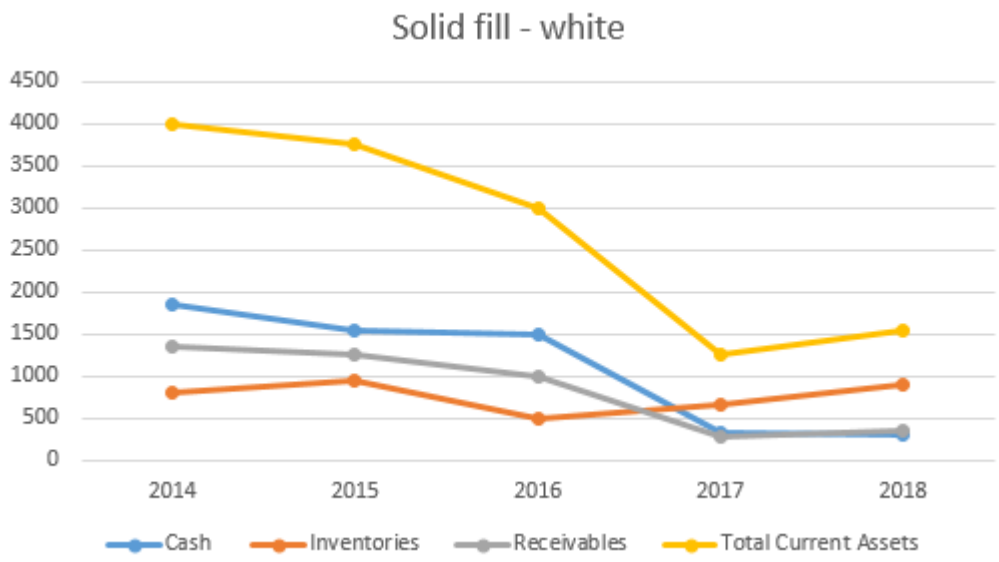


Figure 3 - gradient fill

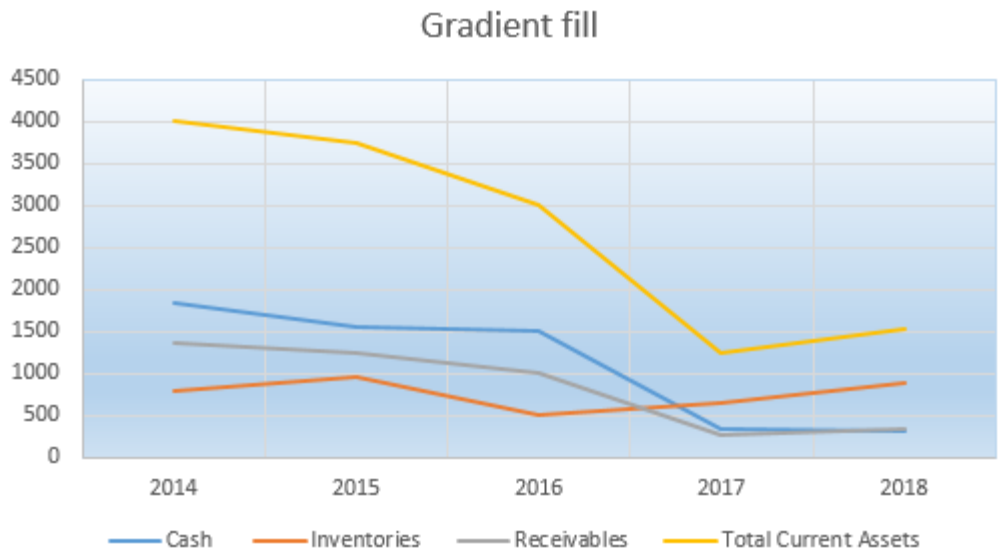


Figure 4 - picture or texture fill

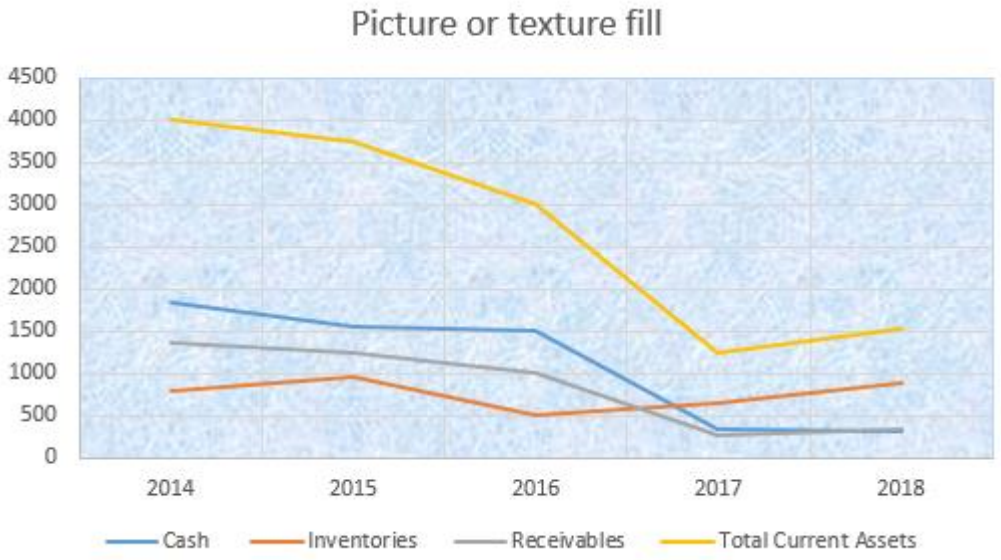
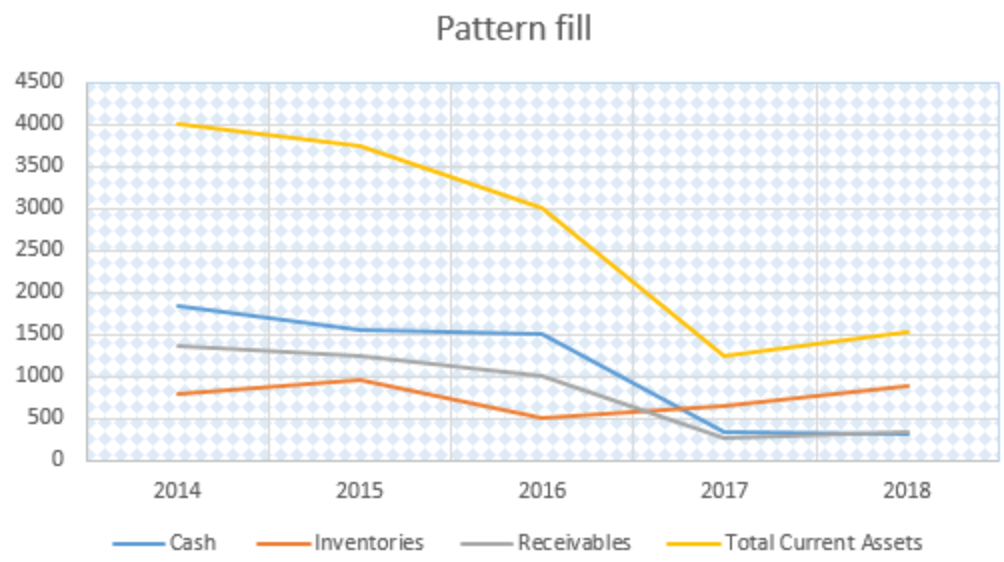


Figure 5 - pattern fill



APPENDIX B: QUESTIONNAIRE OF SURVEY 1.1

INTERACTIVE INFORMATION VISUALIZATION OF FINANCIAL STABILITY OF COMPANIES FOR EFFECTIVE STOCK MARKET DECISION MAKING - SURVEY 1.1

Hi, I'm Piyumika Dissanayake, final year student of MBA-IT. This survey is conducted as partial fulfilment of MBA-IT degree program at the Department of Computer Science and Engineering, University of Moratuwa. This survey takes about 5 minutes to complete. Your participation is entirely voluntary and your responses are completely anonymous. Responses of anonymous surveys cannot be traced back to the respondent. The information provided is treated as strictly confidential and only be utilized for academic purposes.

This is a sub-survey to identify how people read, understand and analyze data provided by the graphs and also identify the drawbacks of graphs. The main intention is to identify how graphs help users to create insights.

I am truly grateful for your valuable time to spend on completing this survey. Please do not hesitate to contact me for any further clarifications at piyumika.17@cse.mrt.ac.lk

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Understanding graphs

It's about how you read, understand and analyze graphs

Analyzing current asset of the company from 2014 to 2018

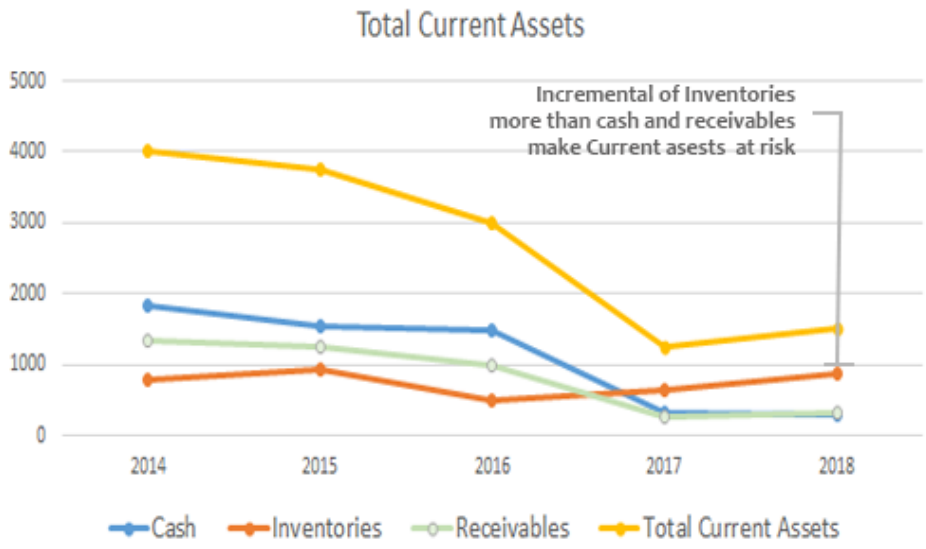
Current assets represent all the assets of a company that are expected to be conveniently sold, consumed, utilized or exhausted through the standard business operations which can lead to their conversion to a cash value over the next one year.

Current assets include cash, cash equivalents, accounts receivable, stock inventory, marketable securities, pre-paid liabilities and another liquid asset.

These are important to businesses because they can be used to fund day-to-day business operations and to pay for the ongoing operating expenses.

Below graphs indicate the components of Current Assets of Company A and their contribution towards the total current asset from 2014 to 2018.

Answer the questions below base on this graph



1	The overall behaviour of current assets is good	Yes	No	Cannot understand
2	Why do you think so?	----------		
3	After 2017, incremental of total current asset symbolized that the Company can solve/pay cash payment immediately	Yes	No	Cannot understand
4	Why do you think so?	----------		
5	Incremental of inventories after 2016, is a good indicator for total current assets	Yes	No	Cannot understand
6	Why do you think so?	----------		
7	The Description of the graph about inventory helped me to answer the above questions	Yes	No	

APPENDIX C: QUESTIONNAIRE OF SURVEY 2.0

INTERACTIVE INFORMATION VISUALIZATION OF FINANCIAL STABILITY OF COMPANIES FOR EFFECTIVE STOCK MARKET DECISION MAKING - SURVEY 2.0

Hi, I'm Piyumika Dissanayake, final year student of MBA-IT. This survey is conducted as partial fulfilment of MBA-IT degree program at the Department of Computer Science and Engineering, University of Moratuwa. This survey takes about 15 minutes to complete. Your participation is entirely voluntary and your responses are completely anonymous. Responses of anonymous surveys cannot be traced back to the respondent. The information provided is treated as strictly confidential and only be utilized for academic purposes.

This is a sub survey to identify how people identify graph lines concerning its legend. There are some common legend designs as well as new designs. The main intention is to identify how graphs help users to create insights.

I am truly grateful for your valuable time to spend on completing this survey. Please do not hesitate to contact me for any further clarifications at piyumika.17@cse.mrt.ac.lk

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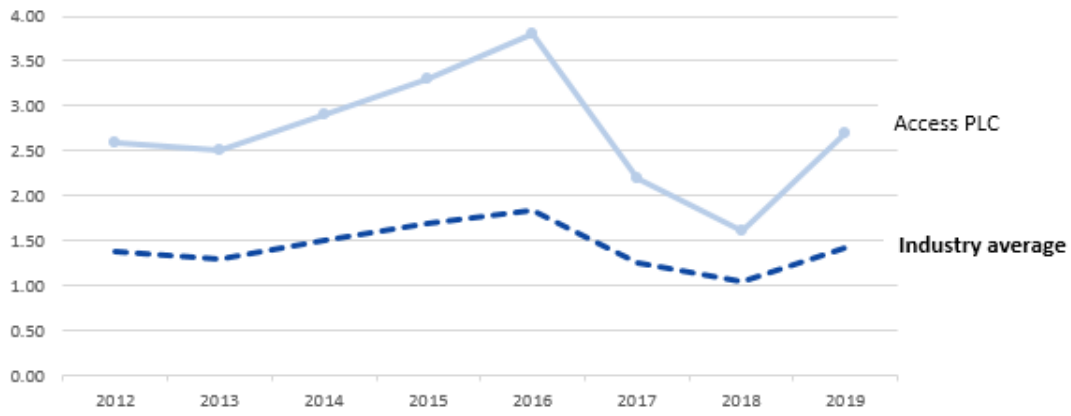
Understanding Legends

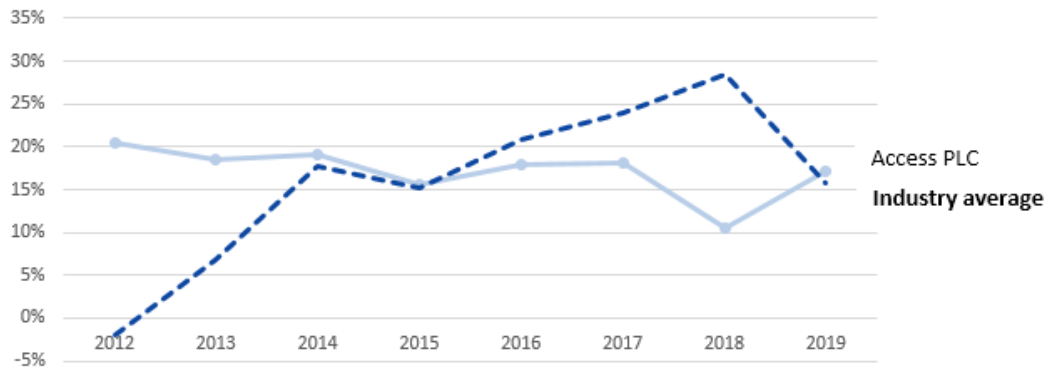
Select the correct answer

Figure 1



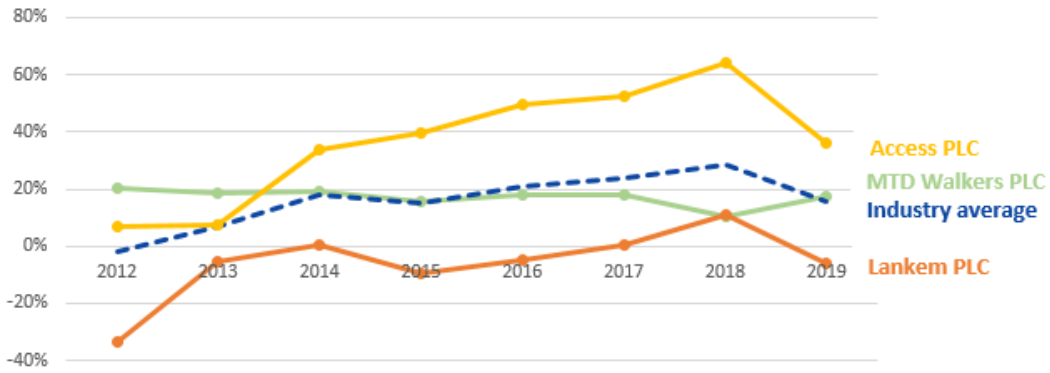
Question 1	Yes	No	Not clear
Figure 1 - The industry average is shown by a solid line			

Figure 2



Question 2	Yes	No	Not clear
Access PLC line is shown by a solid line			
The industry average is shown by a dotted line			

Figure 3



Question 3	Yes	No	Complicated
Figure 3 - Legend with the coloured text help me to identify its relevant line			

Figure 4

Question 4	Graph A	Graph B
Figure 4 - which graph has an easy, convenient legend design which helps you to understand the graph?		

APPENDIX D: QUESTIONNAIRE OF SURVEY 2.1

INTERACTIVE INFORMATION VISUALIZATION OF FINANCIAL STABILITY OF COMPANIES FOR EFFECTIVE STOCK MARKET DECISION MAKING - SURVEY 2.1

Hi, I'm Piyumika Dissanayake, final year student of MBA-IT. This survey is conducted as partial fulfilment of MBA-IT degree program at the Department of Computer Science and Engineering, University of Moratuwa. This survey takes about 15 minutes to complete. Your participation is entirely voluntary and your responses are completely anonymous. Responses of anonymous surveys cannot be traced back to the respondent. The information provided is treated as strictly confidential and only be utilized for academic purposes.

Purpose of this sub survey is to identify how users understand information by establishing an order of importance within the data, allowing the reader to easily find what they are looking for and navigate the content.

I am truly grateful for your valuable time to spend on completing this survey. Please do not hesitate to contact me for any further clarifications at piyumika.17@cse.mrt.ac.lk

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piyumika.17@cse.mrt.ac.lk

Typography Visual Hierarchy

1. There are 3 sentences written in different font sizes and weight (type scale). Which sentence helps you to understand the sentence better?

Industry has 40% of possibility to be bankrupt within next 2 years

Industry has 40% of possibility to be **bankrupt** within next 2 years

Industry has **40%** of possibility to be **bankrupt** within **next 2 years**

Question 1 **There are 3 sentences written in different font sizes and weight (type scale). Which sentence helps you to understand the sentence better?**	**Least understandable**	**Less understandable**	**Confused**	**High understandable**	**Highest understandable**
Sentence 1					
Sentence 2					
Sentence 3					

2. How do you interpret the message of the sentence?

Industry has **40%** of possibility to be **bankrupt** within **next 2 years**

Question 2	Yes	No	Not clear
The writer tries to emphasize the word "bankrupt" as a highly important word.			
The writer tries to emphasize the word "next 2 years" as a highly important word.			
"40%" and "next 2 years" words are giving more meaning to the word "bankrupt"			

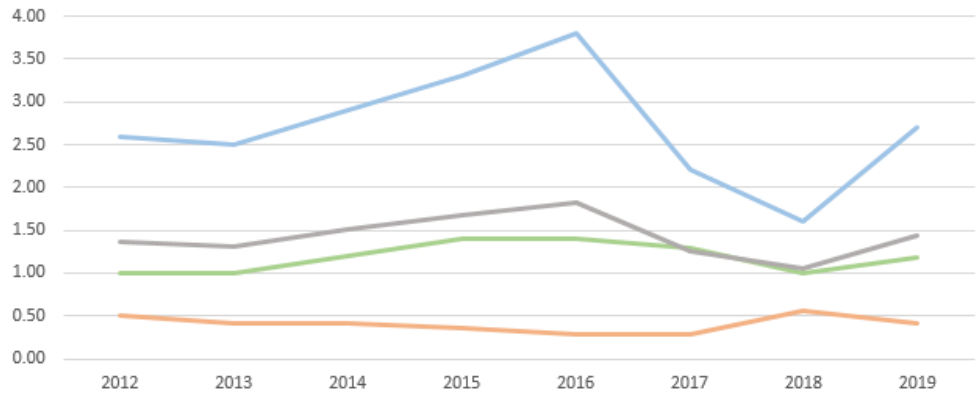
3. A, B and C Companies have 90% of a possibility to be bankrupt in future. Below image shows 90% text in 3 colours which symbolize the status of going bankrupt in each company respectively**.**

Question 3	Company A	Company B	Company C	Not Clear
Company in danger/ high risk to invest is				
Company in alert or 50-50 margin to invest is				
Company in safety or ok to invest for a short term is				

Colour Visual Hierarchy

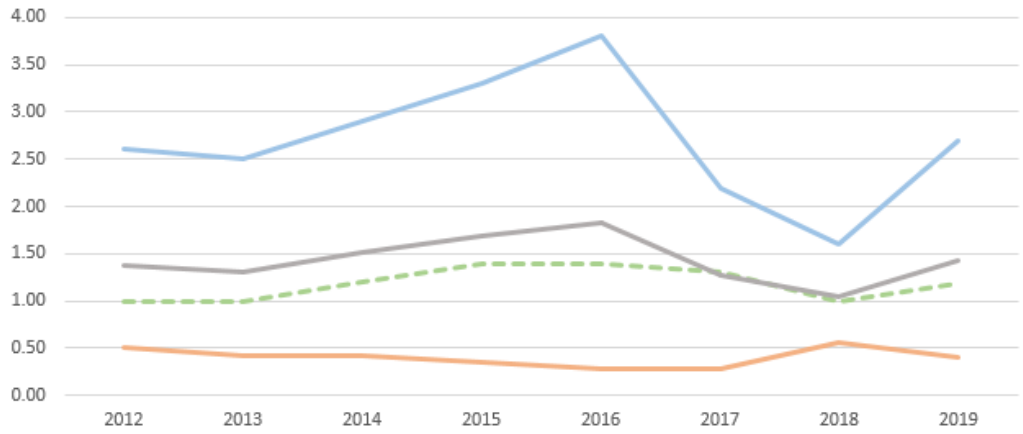
A Footwear Industry has 3 companies named as A, B and C. Below graphs show the profit of these companies and the overall average profit of the Industry. The purpose of these graphs is to compare each company's profit line concerning Industry profit line. Industry profit line is taken as baseline.

Question 4



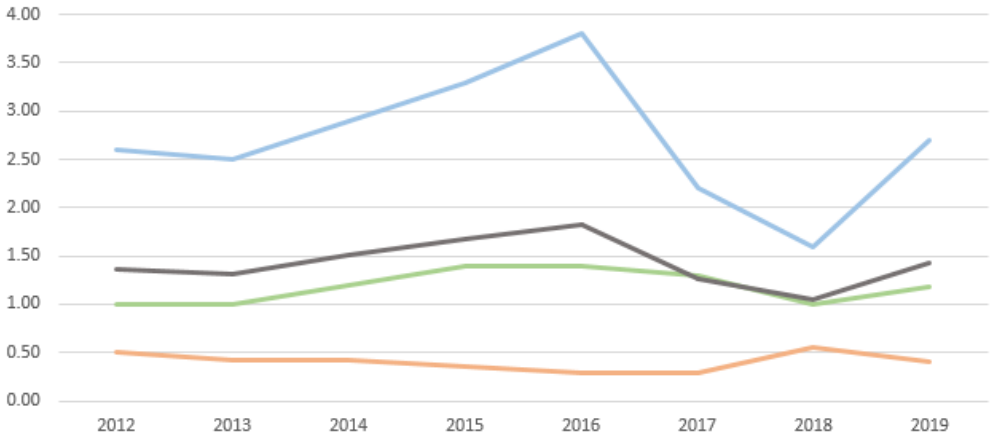
Question 4	Blue line	Grey line	Green line	Brown line	Not clear
As you think, the baseline is					

Question 5



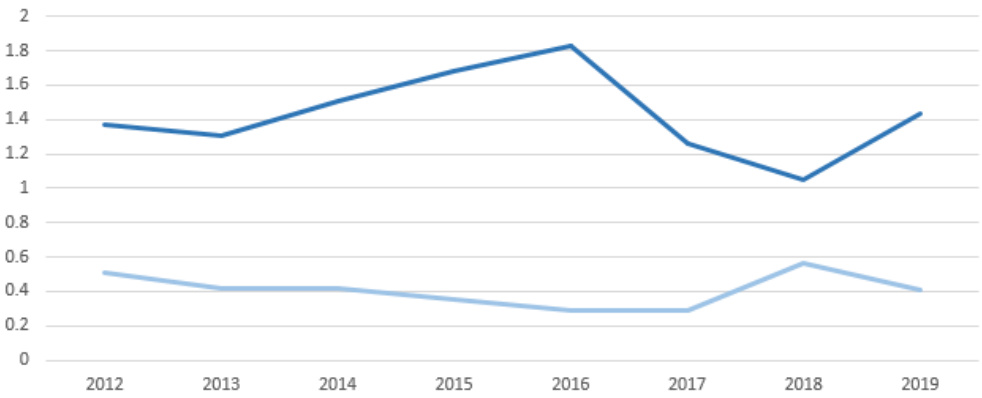
Question 5	Blue line	Grey line	Green line	Brown line	Not clear
As you think, the baseline is					

Question 6



Question 6	Blue line	Grey line	Green line	Brown line	Not clear
As you think, the baseline is					

Question 7



Question 7	Dark blue line	Light blue line	Not clear
As you think, the baseline is			

APPENDIX E: QUESTIONNAIRE OF SURVEY 3.0 AND 3.1

INTERACTIVE INFORMATION VISUALIZATION OF FINANCIAL STABILITY OF COMPANIES FOR EFFECTIVE STOCK MARKET DECISION MAKING - SURVEY 3.0 AND 3.1

Hi, I'm Piyumika Dissanayake, final year student of MBA-IT. This survey is conducted as partial fulfilment of MBA-IT degree program at the Department of Computer Science and Engineering, University of Moratuwa. The purpose of this survey is to analyze how Information visualization to help Investors to make clever decisions in the Stock market. This is the "Aversion" of the survey.

First of all, respondents should refer to the prototype of dashboards that display financial data of Access Engineering PLC, Lankem Development PLC and MTD Walkers PLC under the Construction and Engineering sector of the Colombo Stock Exchange.

The prototype guide is given in the next section.

After referring to the prototype, please start answering survey questions. All questions are mandatory. Perhaps you may feel difficult to answer because the survey is about accounting and finance. However, feel free to answer according to your knowledge.

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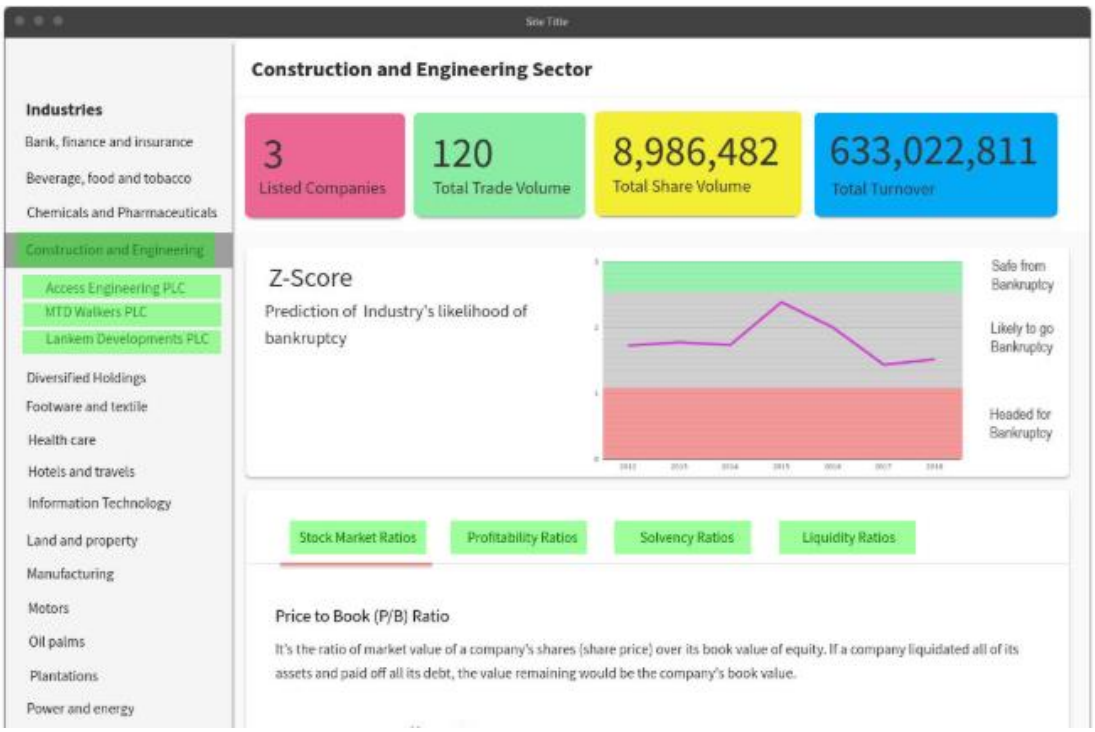
_____

Prototype link for A-version - https://invis.io/WHR5D7BVMY7

Prototype link for B-version - https://invis.io/8GRHU85U2YQ

The dashboard has 2 sections called sidebar and main section. In the sidebar, there are 20 sectors. You have to refer to the "Construction and Engineering" sector only. The prototype is clickable for green-coloured texts. By clicking Construction and Engineering text in sidebar, you will direct to Industry-wise graphs under 4 tabs in the main section called "Stock market ratio, Probability ratio, Solvency ratio, and Liquidity ratio." Those 4 tabs are also clickable. You can find graphs by clicking each tab. Likewise, graphs are available under each company.

Snapshot of the prototype.



Case Study

Imagine that you are a fresh or existing Investor of the Colombo Stock Exchange. You have Rs.100,000 cash in hand and you want to invest it on any company. You decide to choose a company from the Construction and Engineering sector. Before

invest, you want to know how each company financially perform. This decision is critical for you to decide the most suitable and profitable company to make a profit out of your investment.

Starting time of the survey? __:__

Stock market ratio

Ratio	Questions	ACC	LKM	MTD	None of them	No Idea
P/B	Which company performs best?					
	What are the reasons for your answer?	----------				
EPS	Which company performs best?					
	What are the reasons for your answer?	----------				
P/E	Which company performs best?					
	What are the reasons for your answer?	----------				
Dividend payout	Which company performs best?					
	What are the reasons for your answer?	----------				

Profitability ratio

Ratio	Questions	ACC	LKM	MTD	None of them	No Idea
ROE	Which company performs best?					
	What are the reasons for your answer?	----------				
Net margin	Which company performs best?					
	What are the reasons for your answer?	----------				
Asset turnover	Which company performs best?					
	What are the reasons for your answer?	----------				

Solvency ratio

Ratio	Questions	ACC	LKM	MTD	None of them	No Idea
D/A	Which company performs best?					
	What are the reasons for your answer?	----------				
D/E	Which company performs best?					
	What are the reasons for your answer?	----------				

Liquidity ratio

Ratio	Questions	ACC	LKM	MTD	None of them	No Idea
Current ratio vs Quick acid ratio	Which company performs best?					
	What are the reasons for your answer?	----------				

Ending time of the survey? __:__

Overall evaluation of the prototype

Question	Yes	No	May be
Do you have colour blindness problem?			

Question	Very poor	Poor	Neutral	Good	Very good
Do you have colour blindness problem?					

Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The provided information is sufficient to make decisions					
Graphs are readable and easy to understand					
Provided information helped me to analyze					

insights					
After analyzing graphs, I was able to understand the financial health/position of each company					

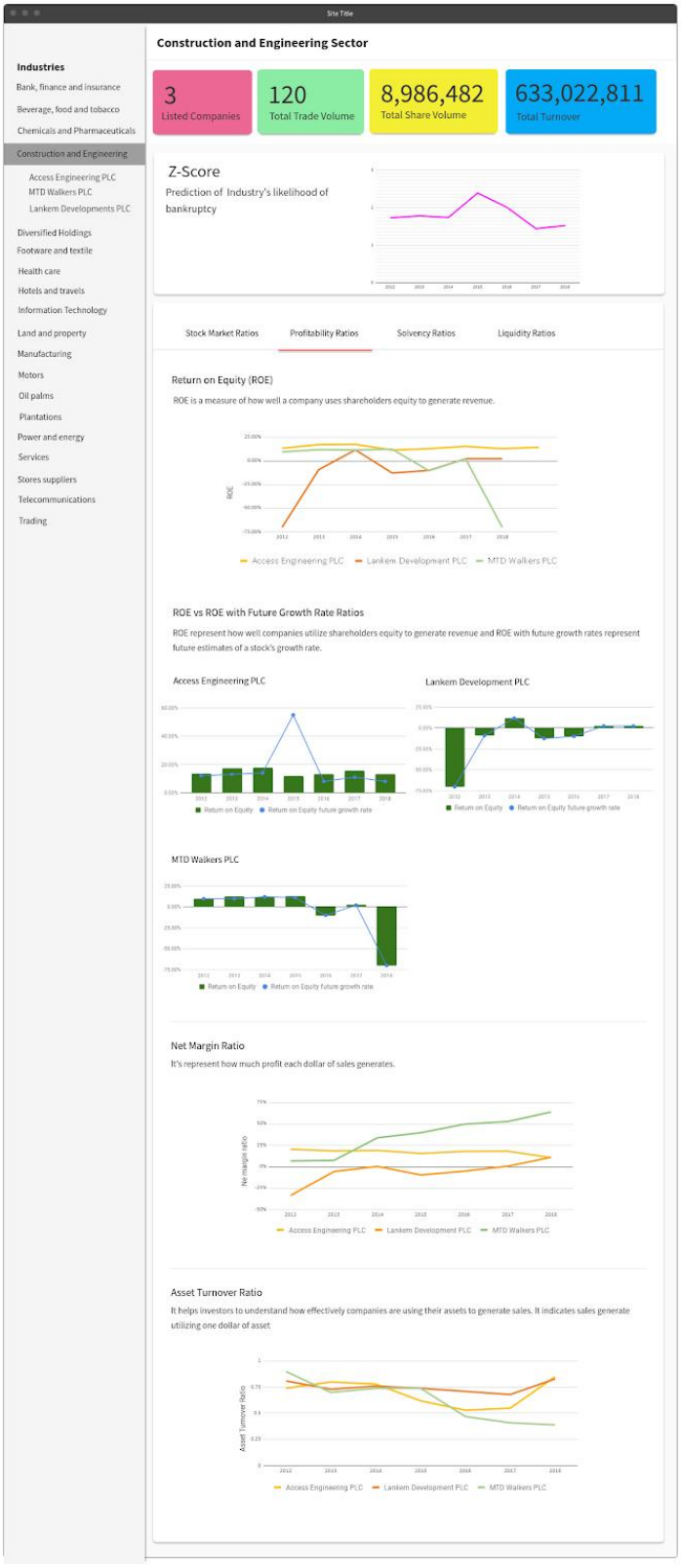
Question	ACC	LKM	MTD
As a final decision, would you like to invest Rs.100,000 on			

Question	LKM
Please submit problems and suggestions to improve the prototype	----------

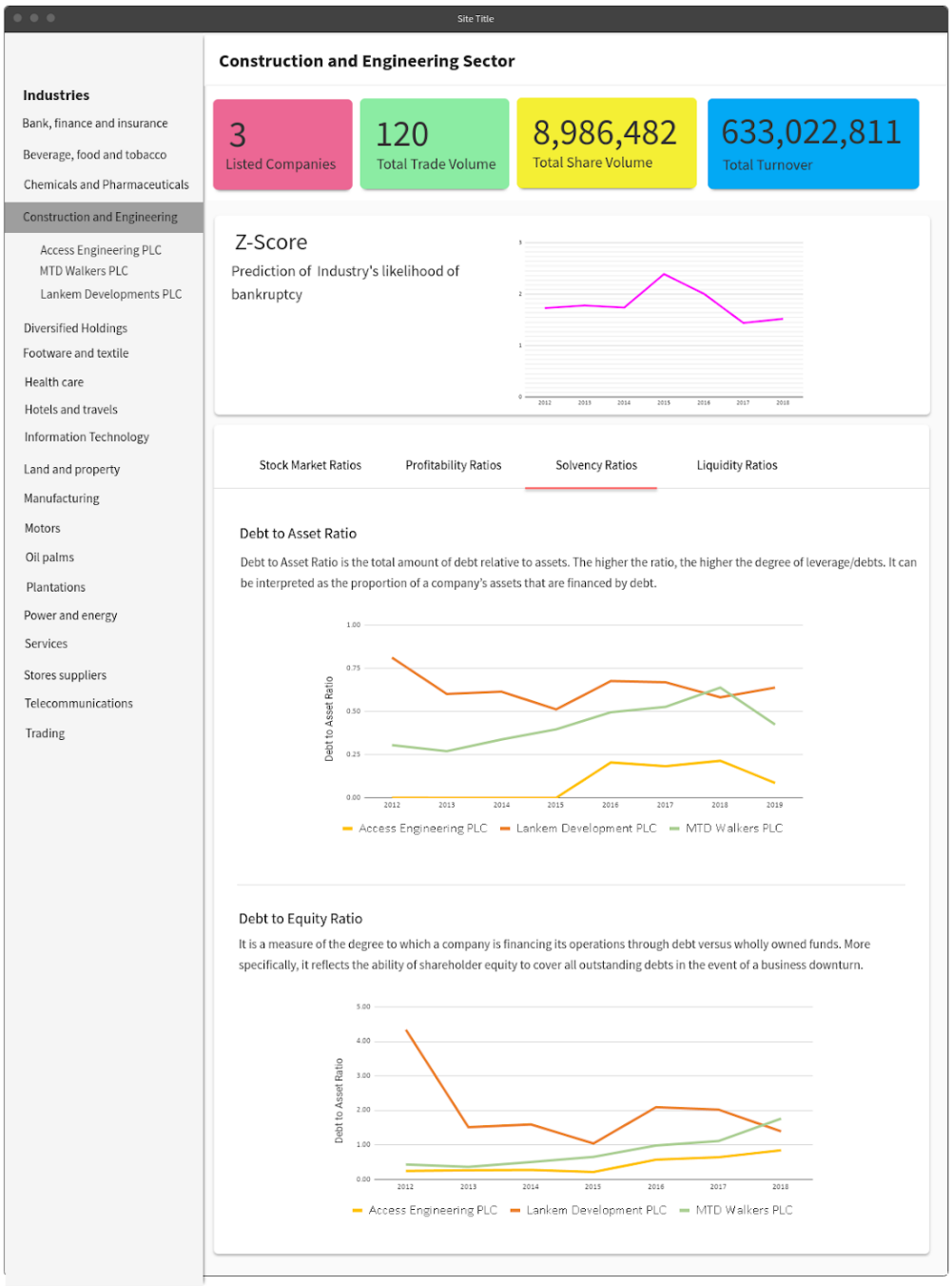
APPENDIX F: PROTOTYPES OF A-VERSION

Industry-wise - Stock market ratio

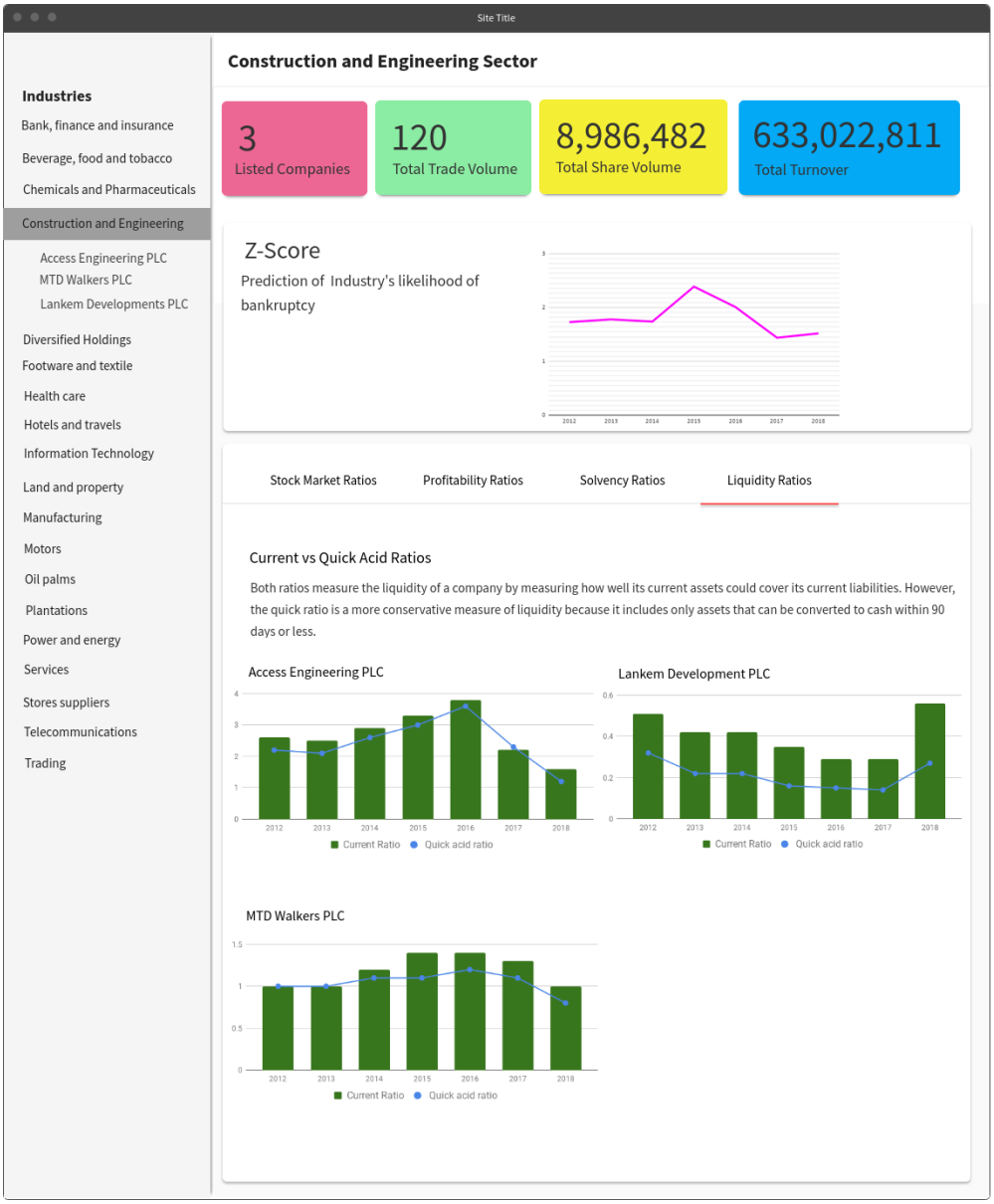
Industry-wise – Profitability ratio



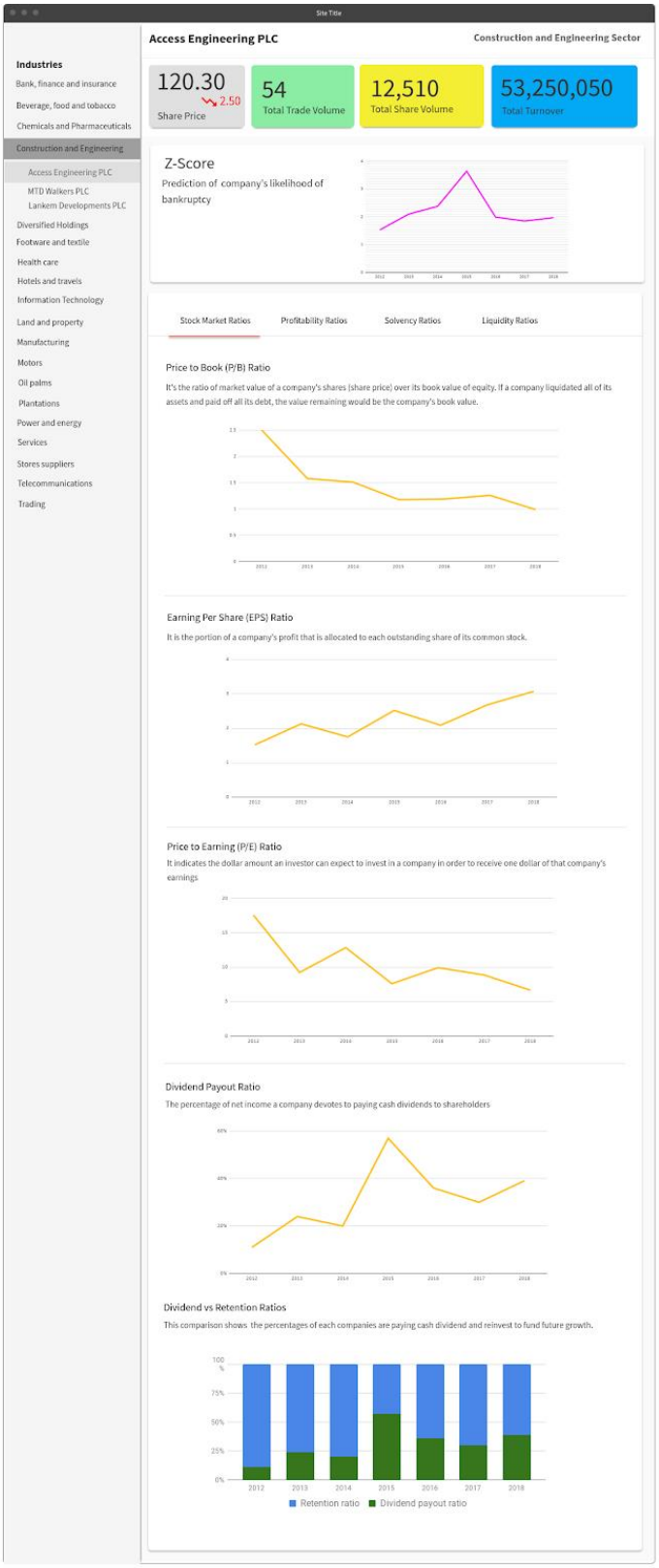
Industry-wise – Solvency ratio



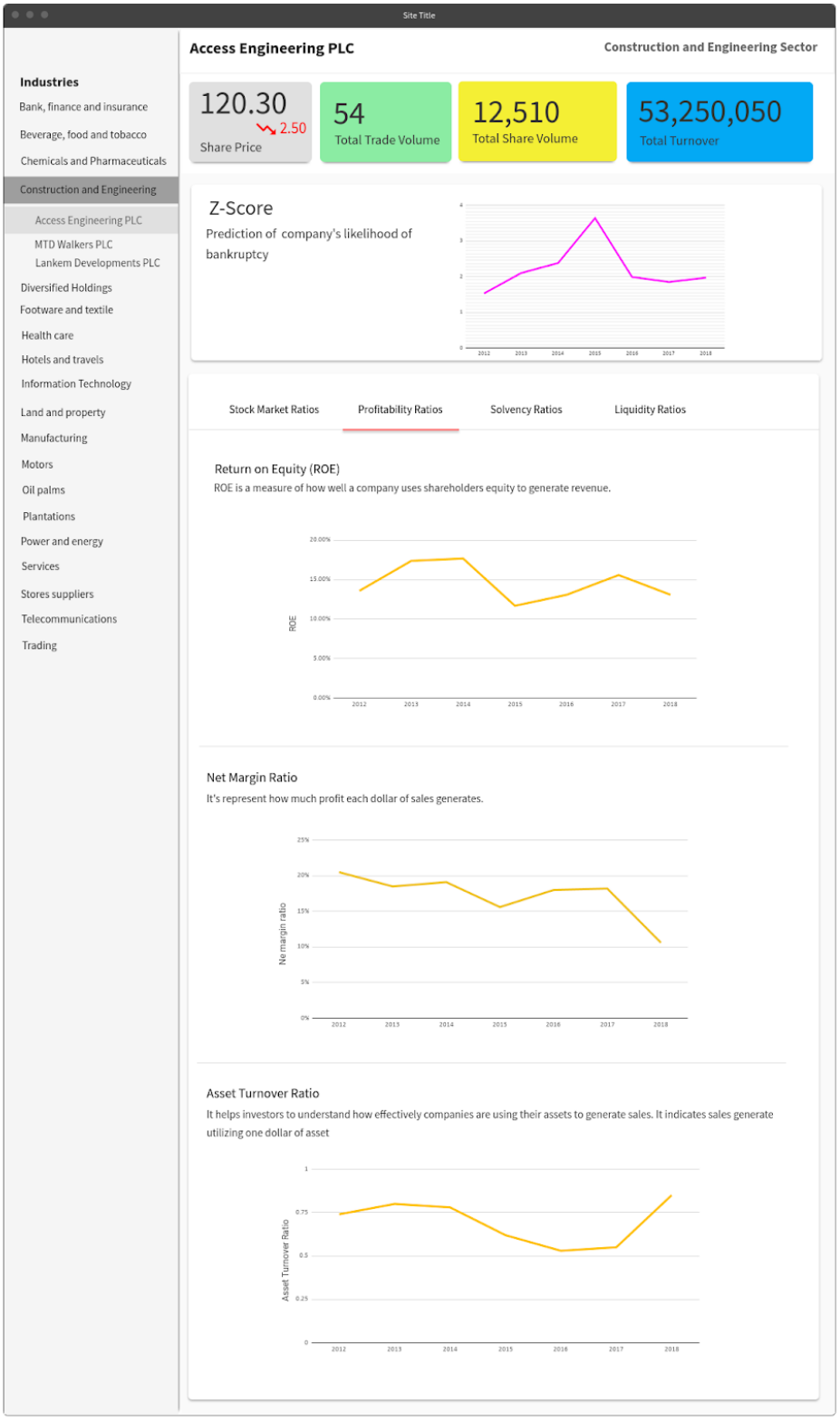
Industry-wise – Liquidity ratio



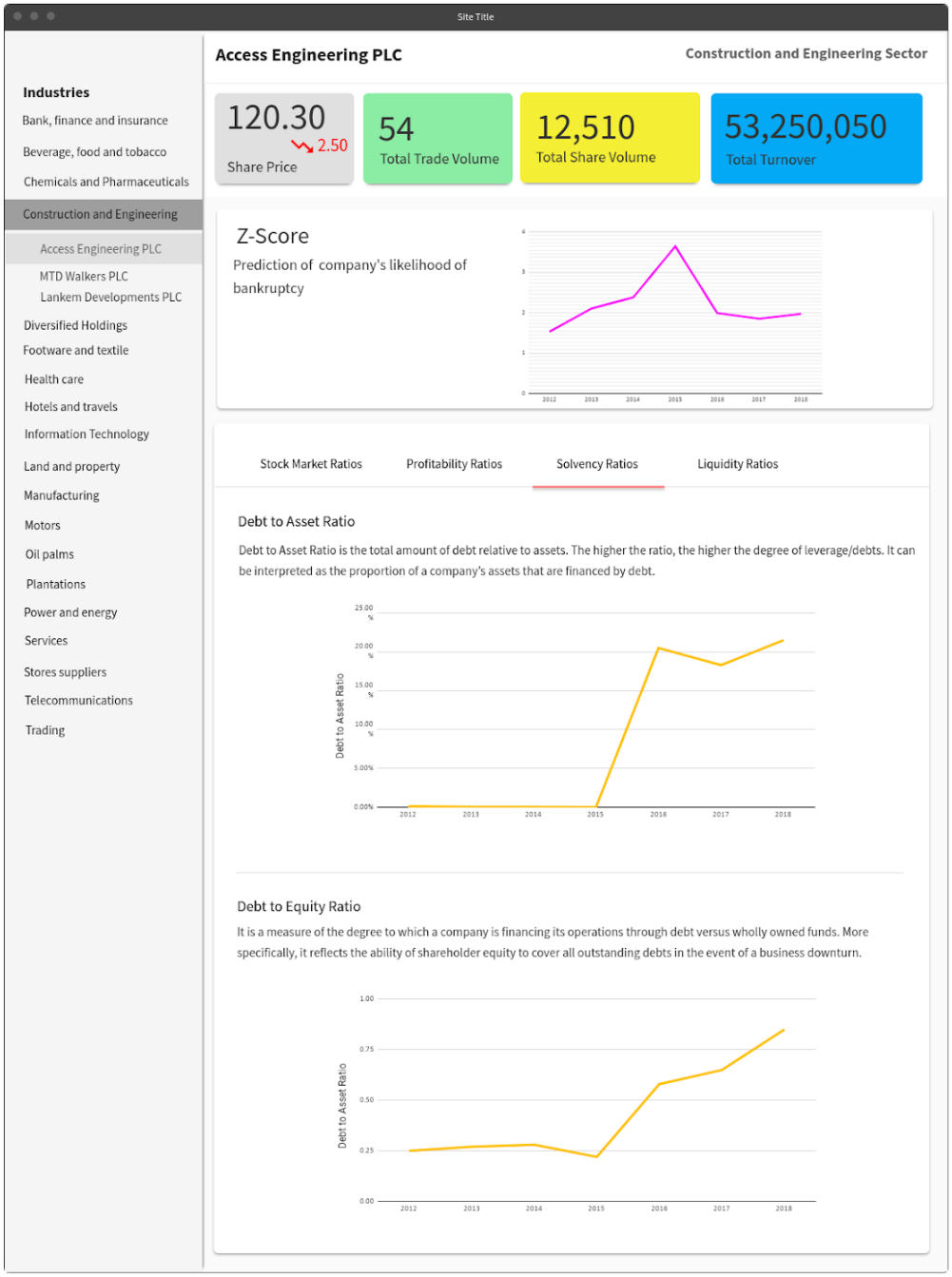
Access Engineering PLC - Stock market ratio



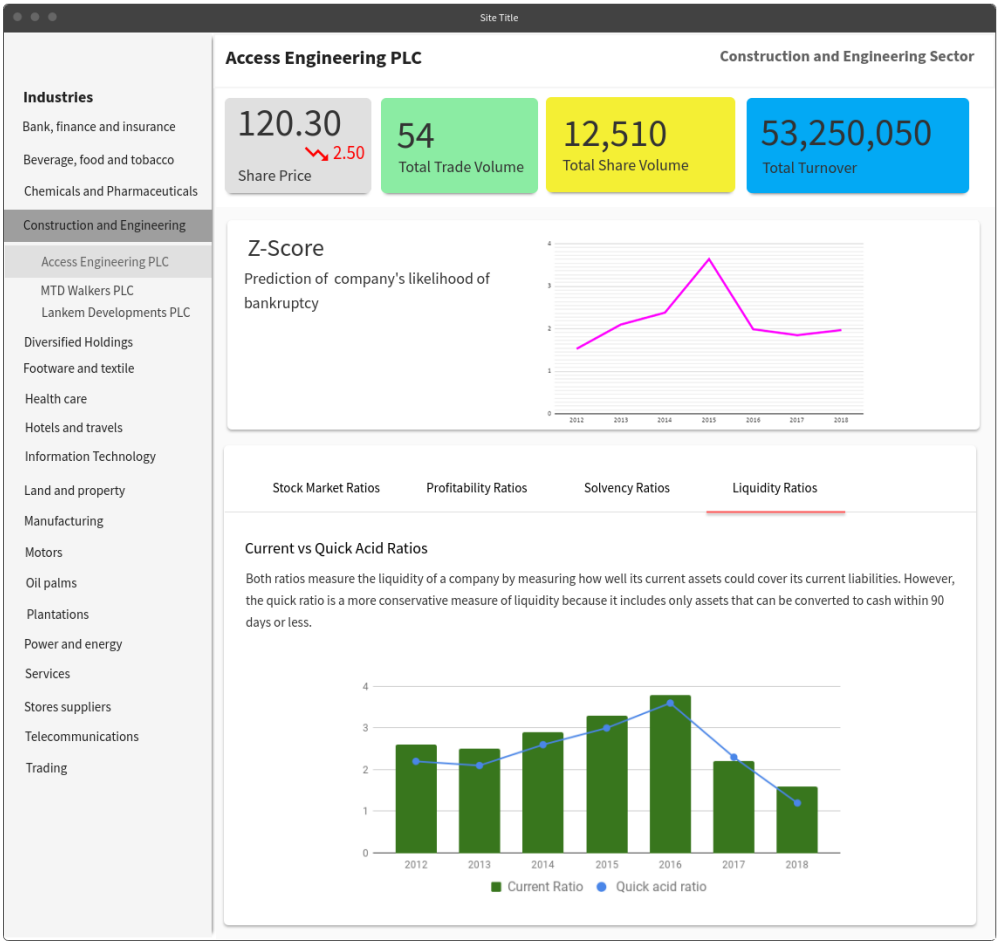
Access Engineering PLC - Profitability ratio



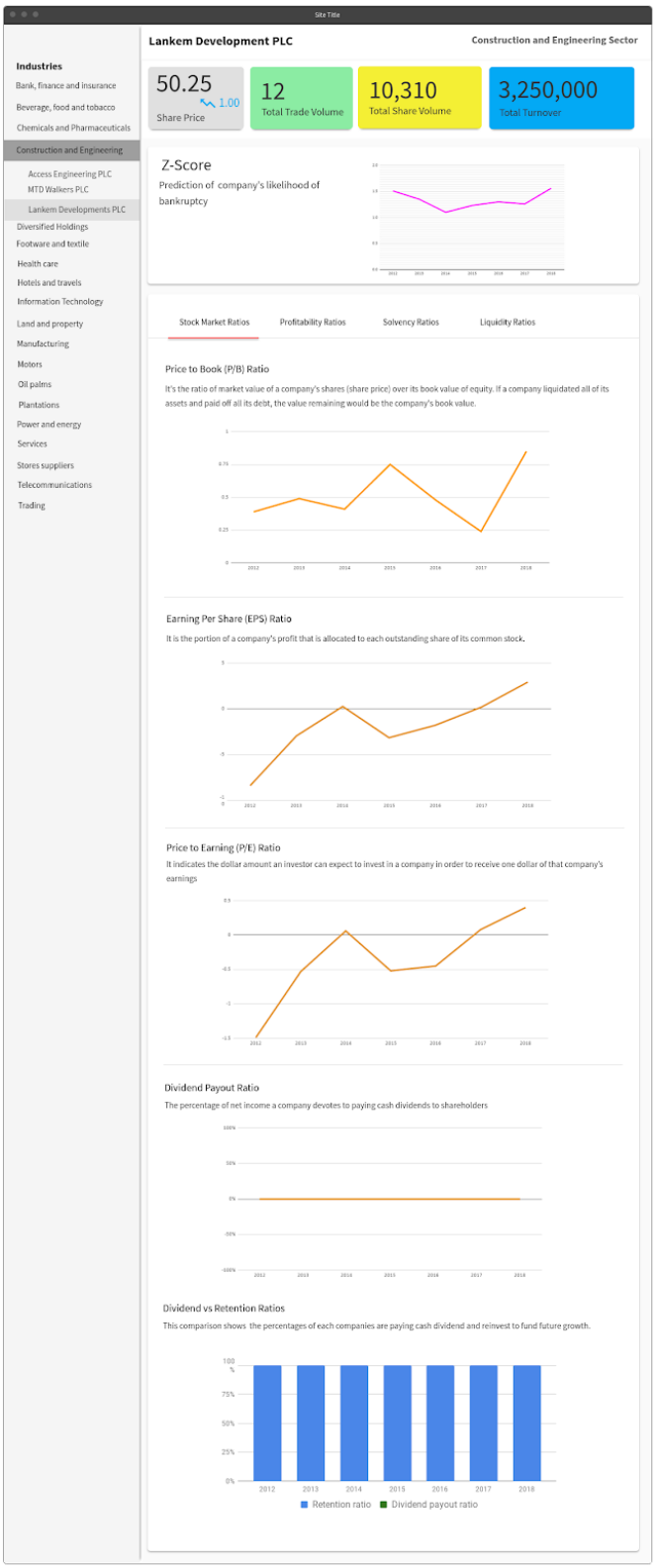
Access Engineering PLC - Solvency ratio



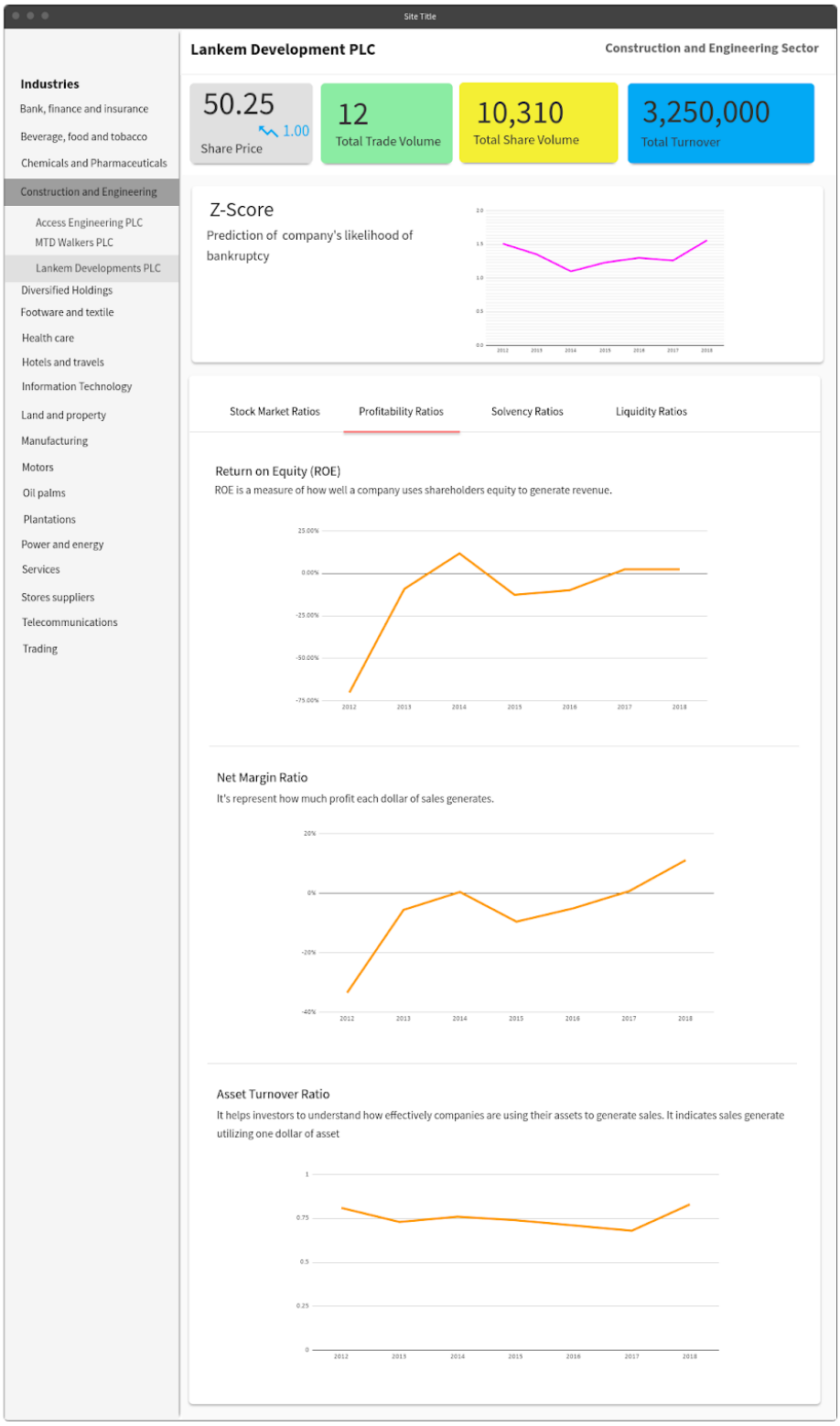
Access Engineering PLC - Liquidity ratio



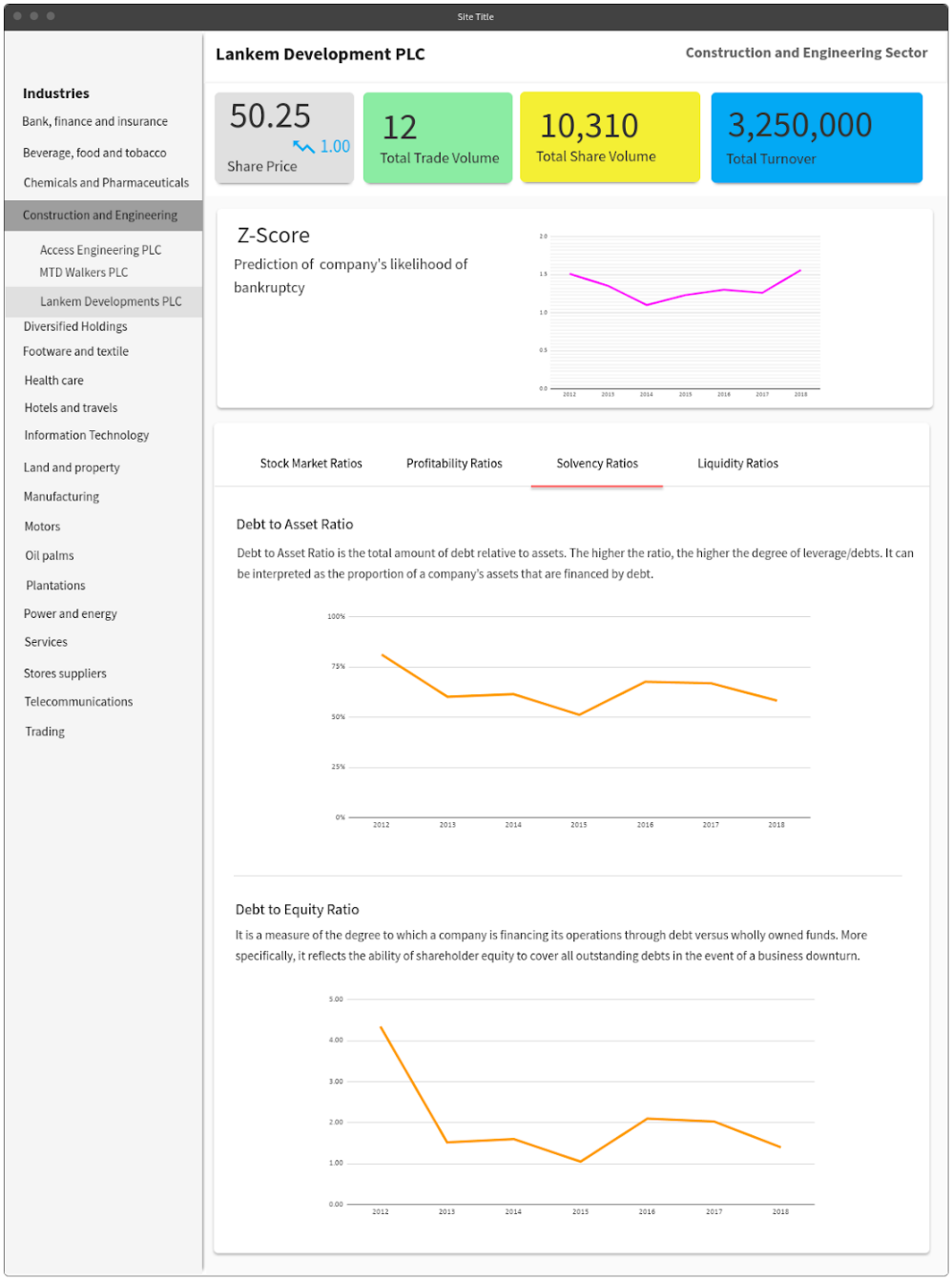
Lankem Development PLC - Stock market ratio



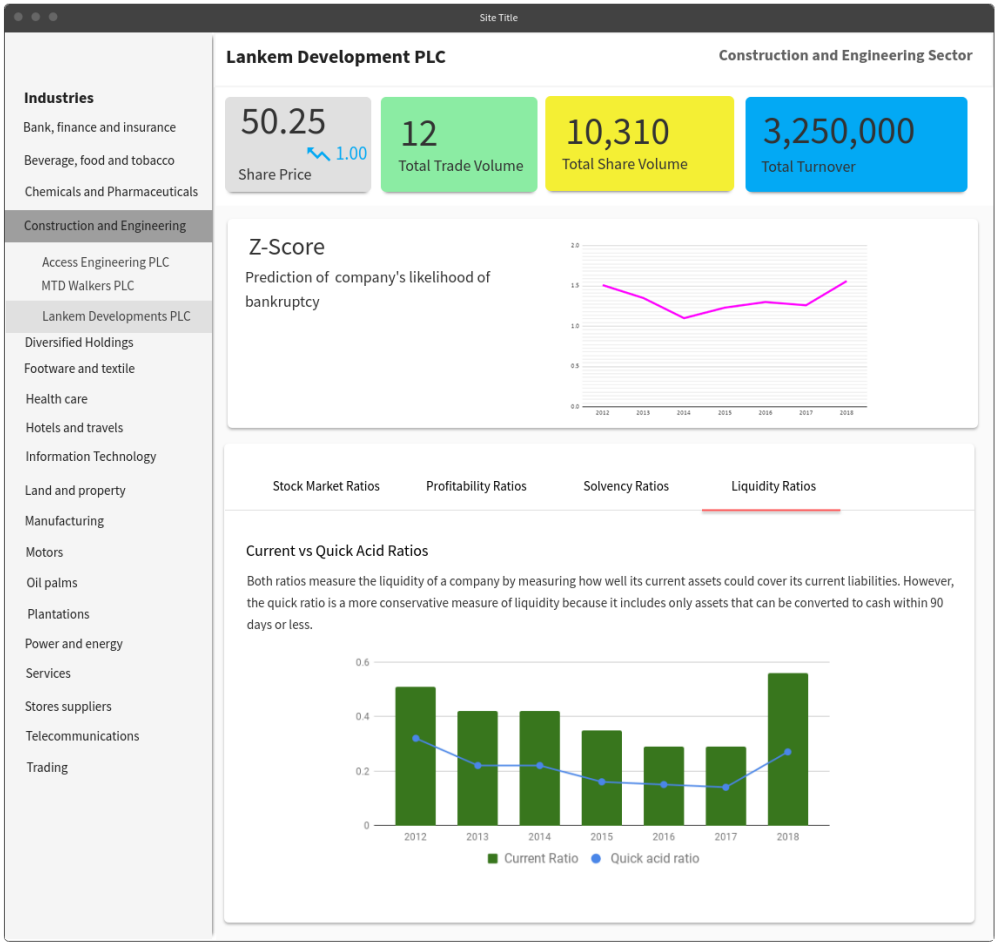
Lankem Development PLC – Profitability ratio



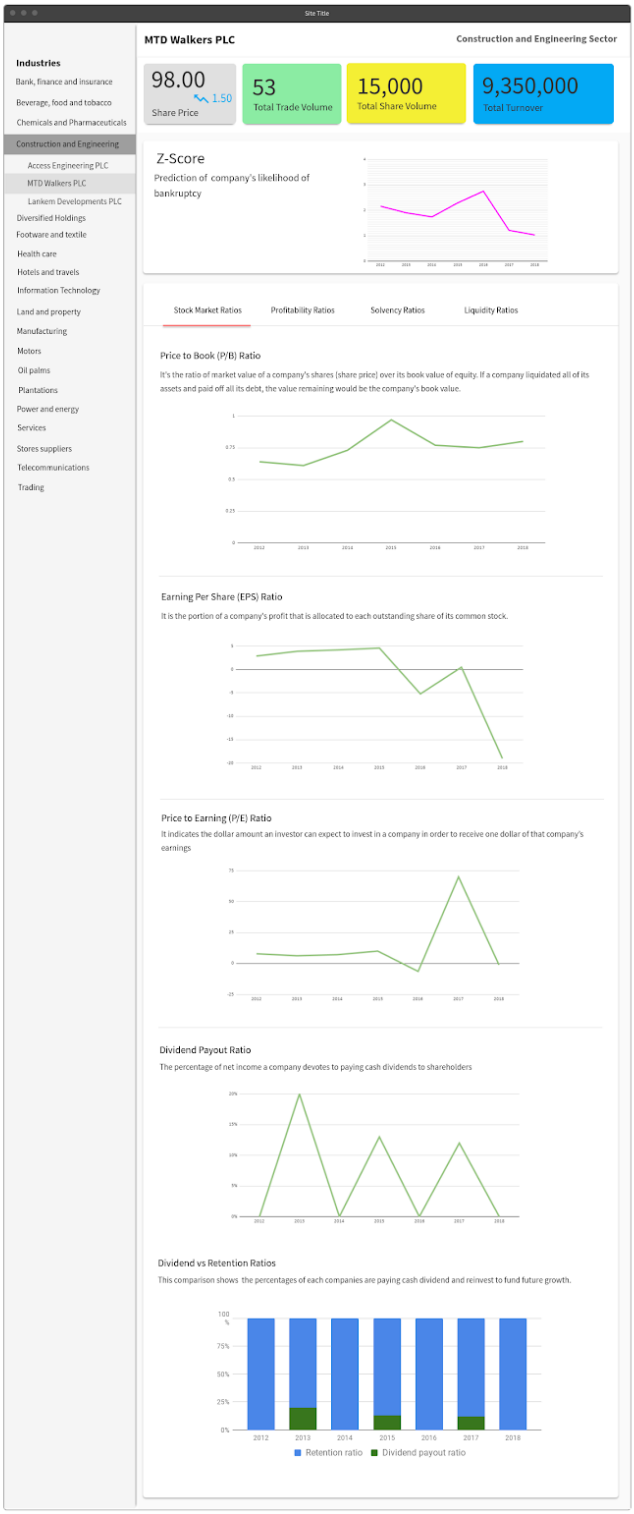
Lankem Development PLC - Solvency ratio



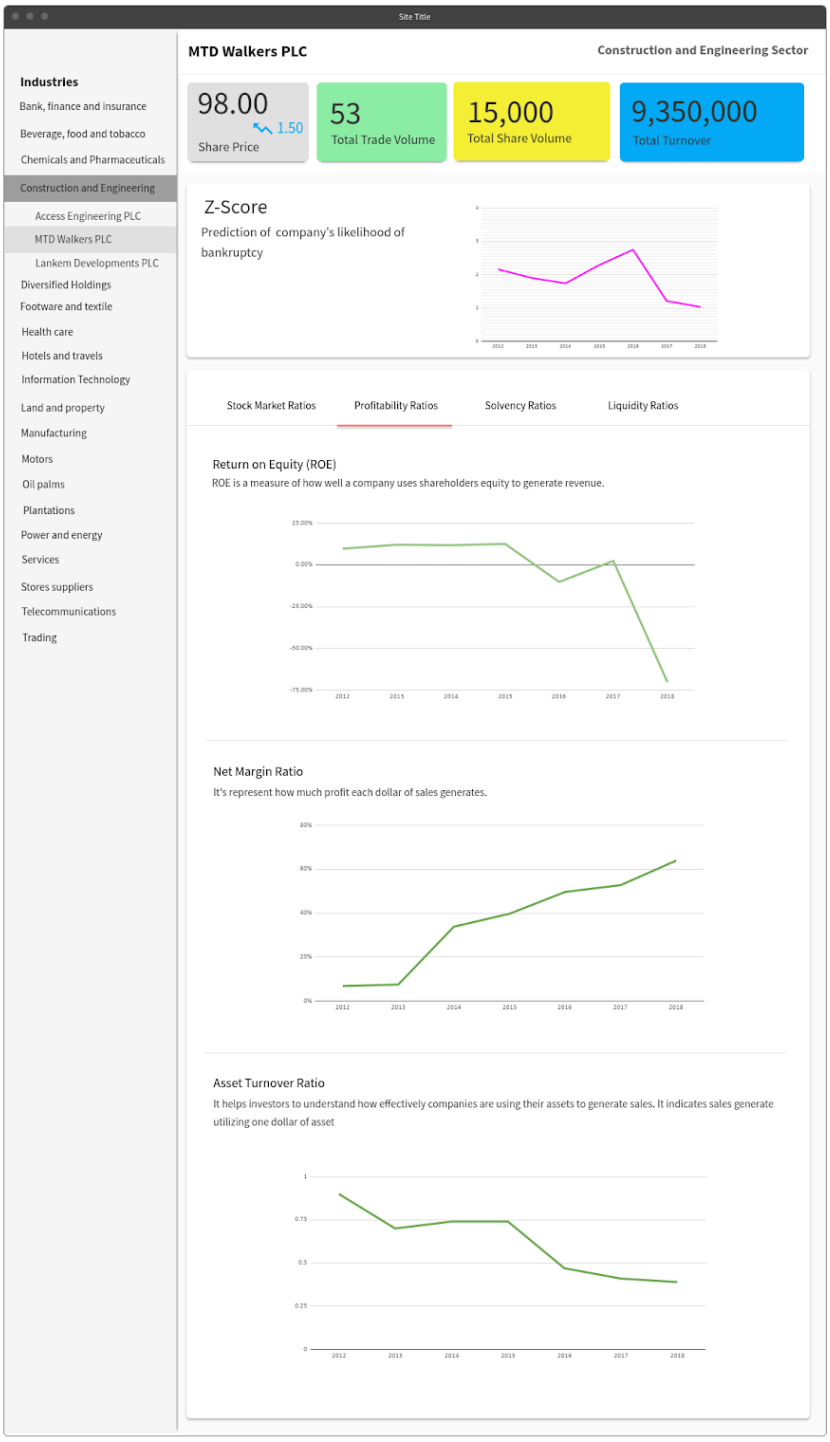
Lankem Development PLC - Liquidity ratio



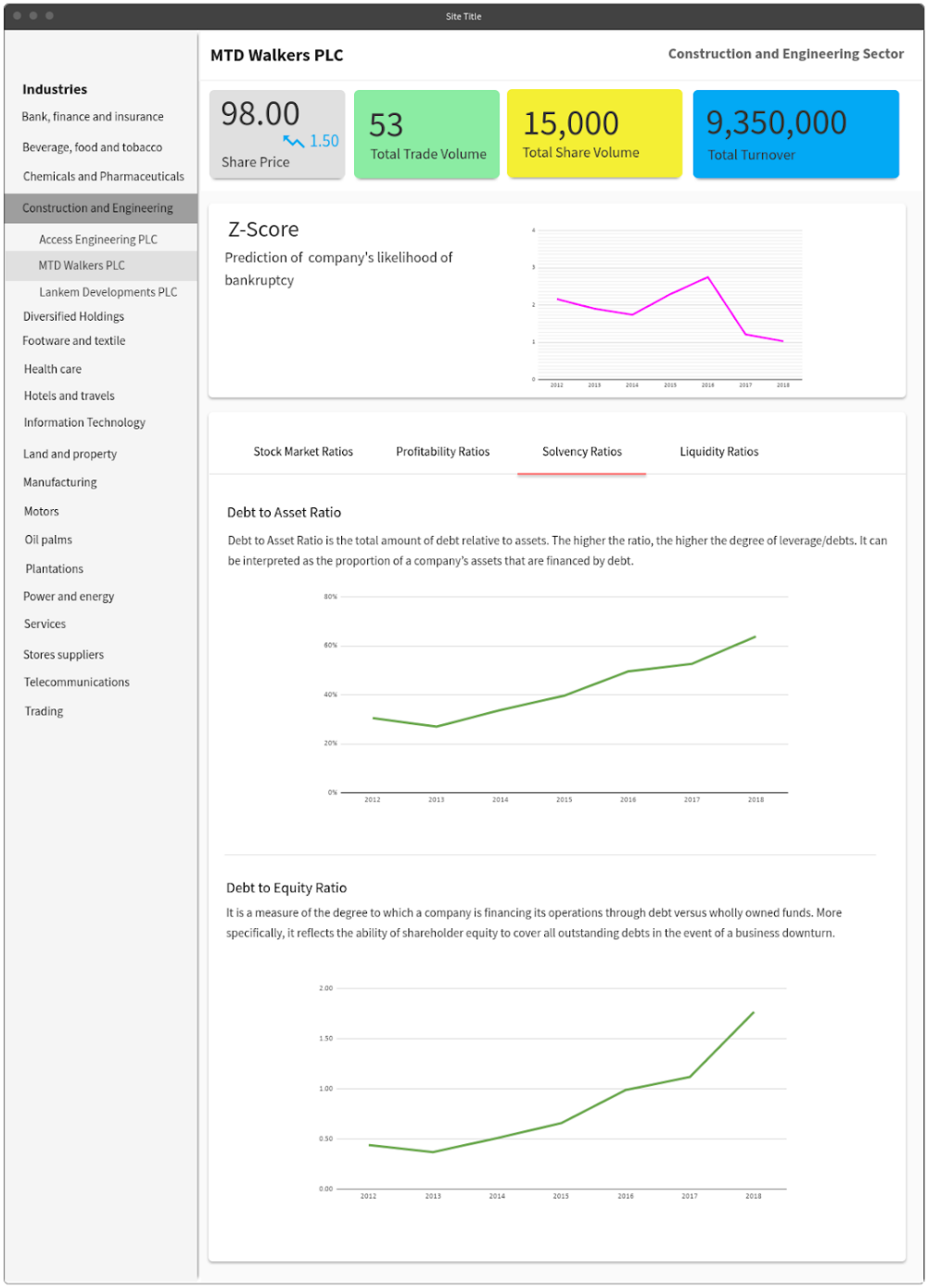
MTD Walkers PLC - Stock market ratio



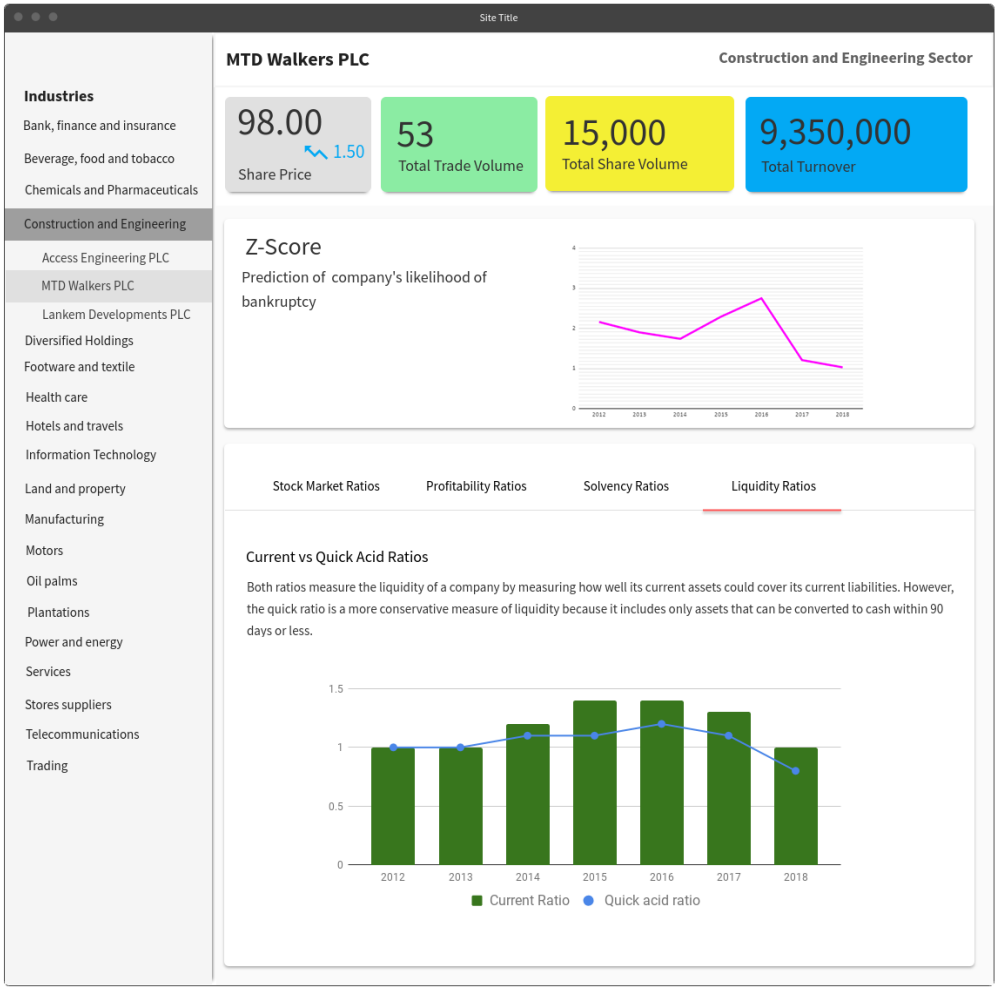
MTD Walkers PLC - Profitability ratio



MTD Walkers PLC - Solvency ratio

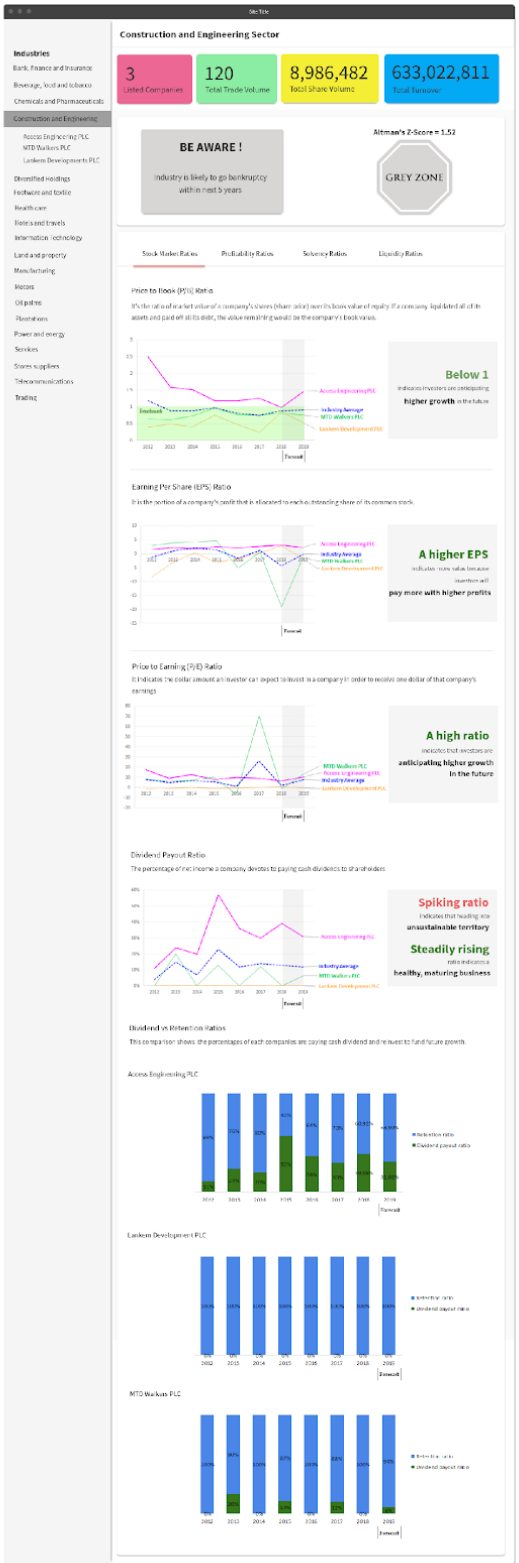


MTD Walkers PLC - Liquidity ratio



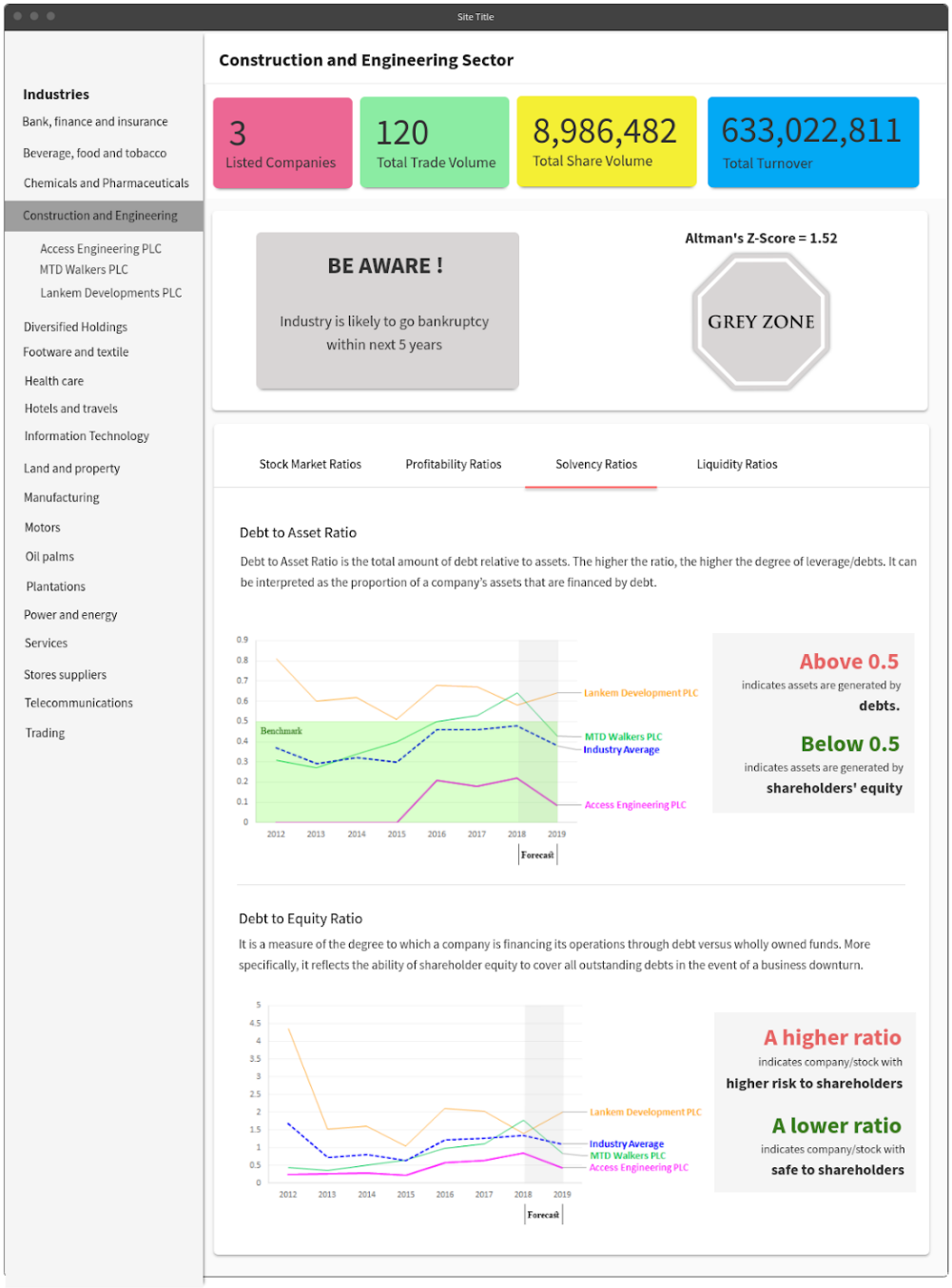
APPENDIX G: PROTOTYPES OF B-VERSION

Industry-wise – Stock market ratio

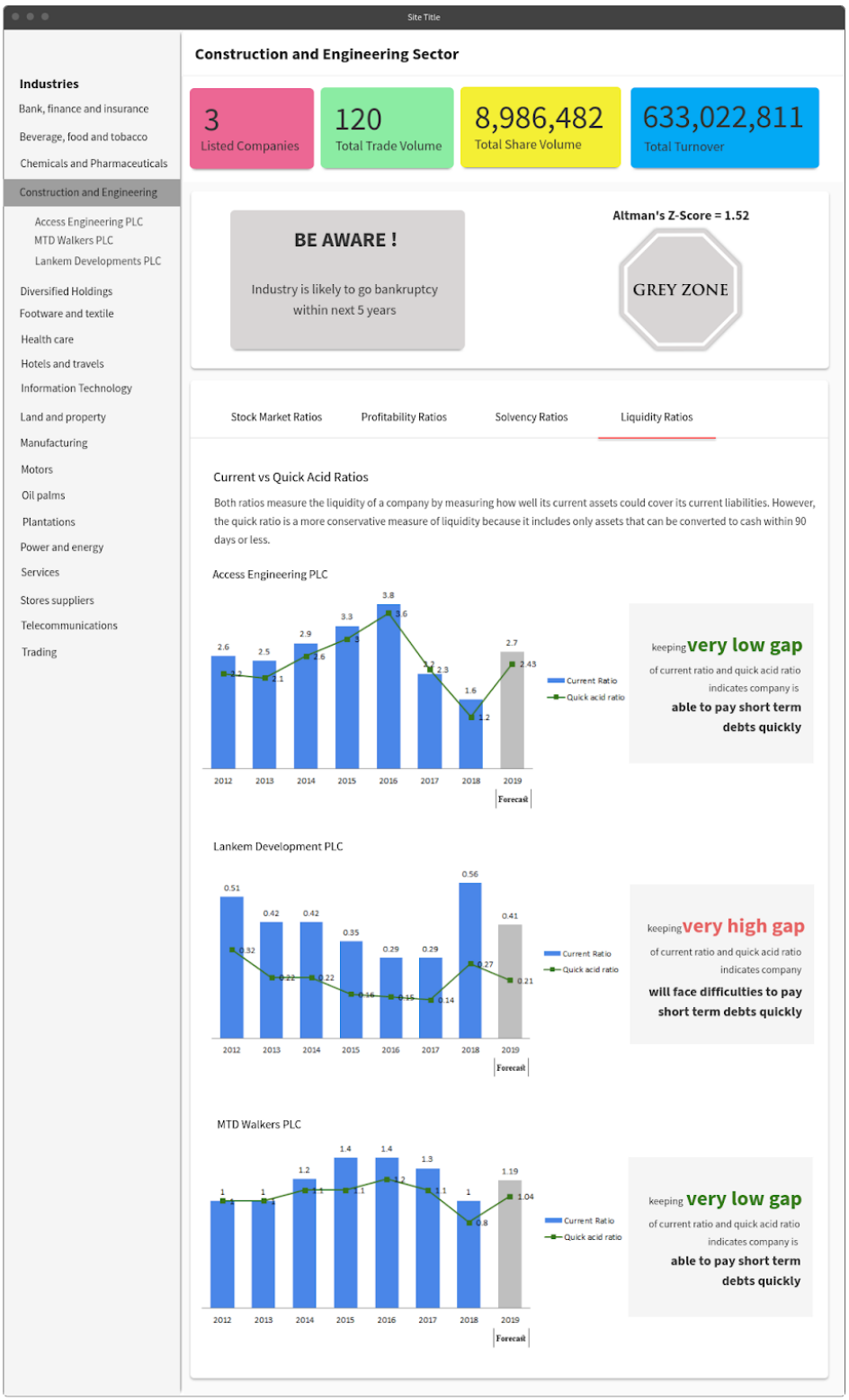


Industry-wise – Profitability ratio

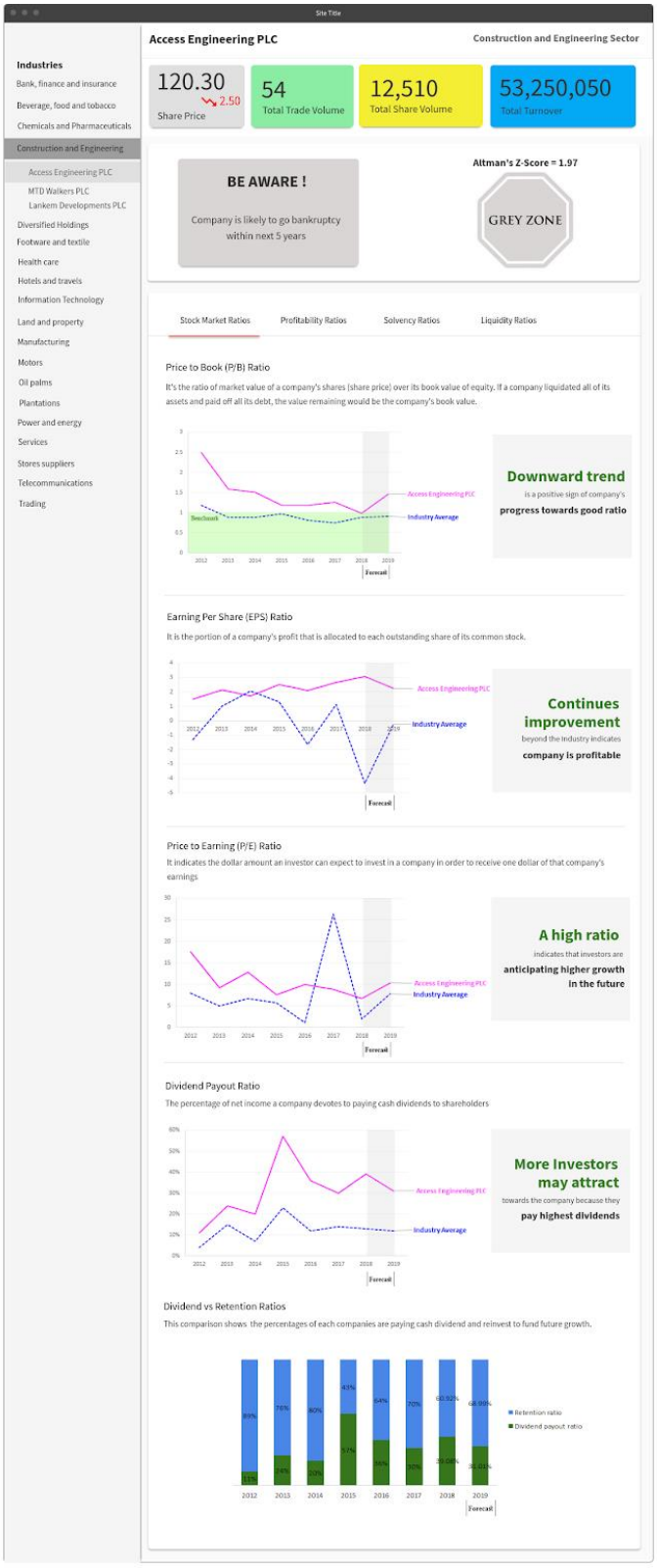
Industry-wise – Solvency ratio



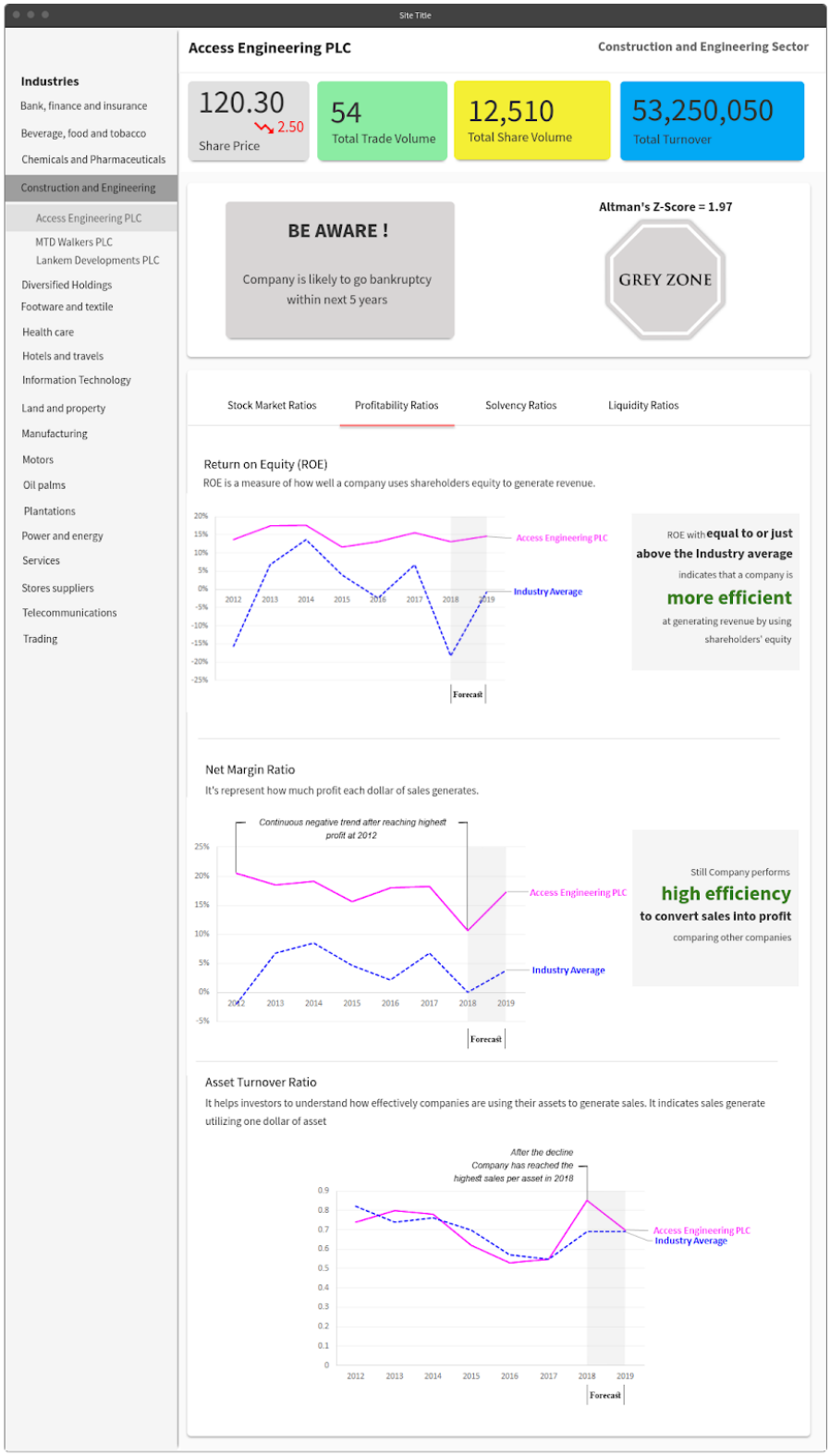
Industry-wise – Liquidity ratio



Access Engineering PLC – Stock market ratio

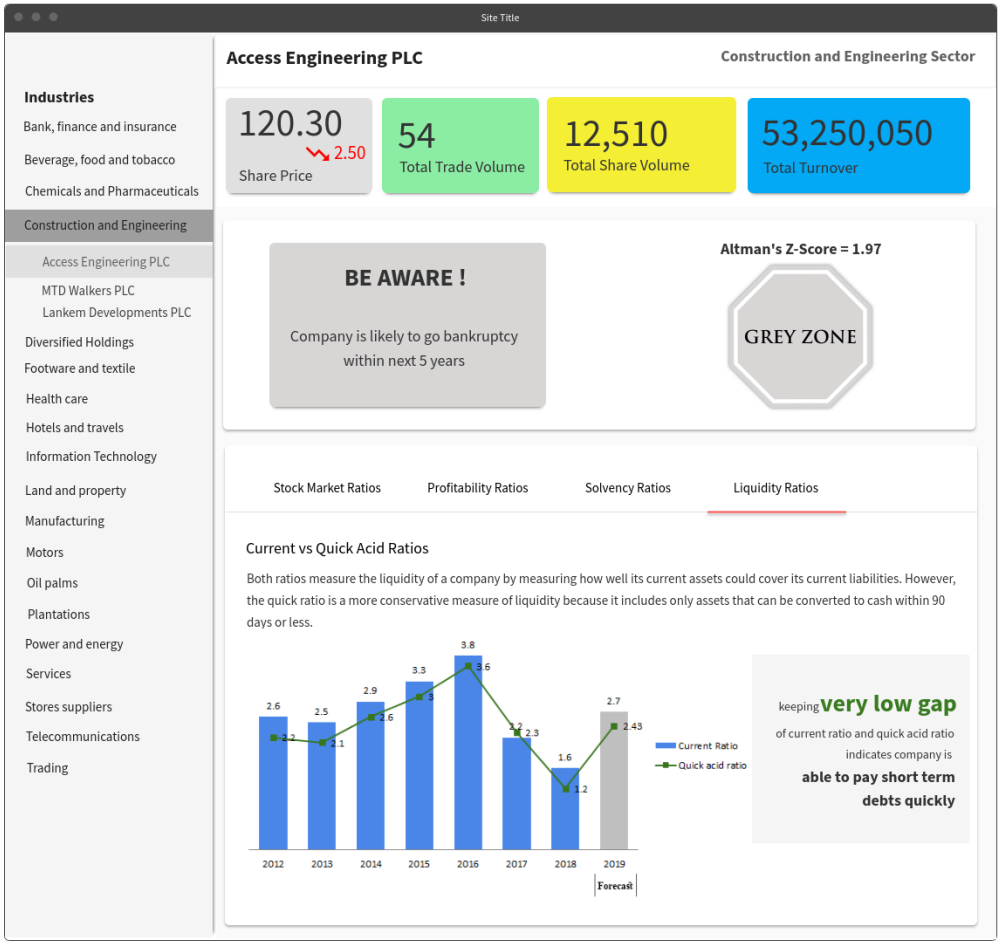


Access Engineering PLC – Profitability ratio



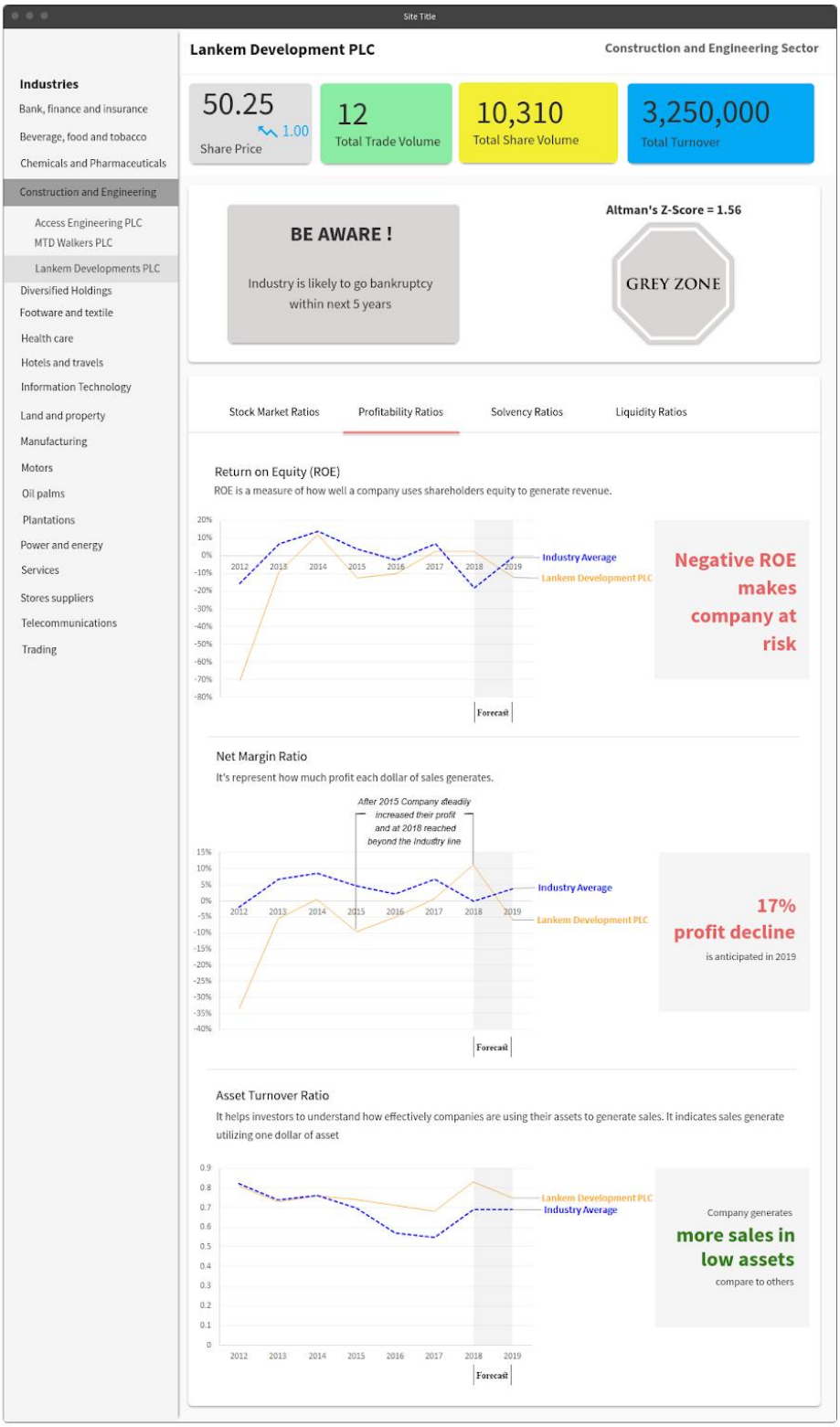
Access Engineering PLC – Solvency ratio

Access Engineering PLC – Liquidity ratio

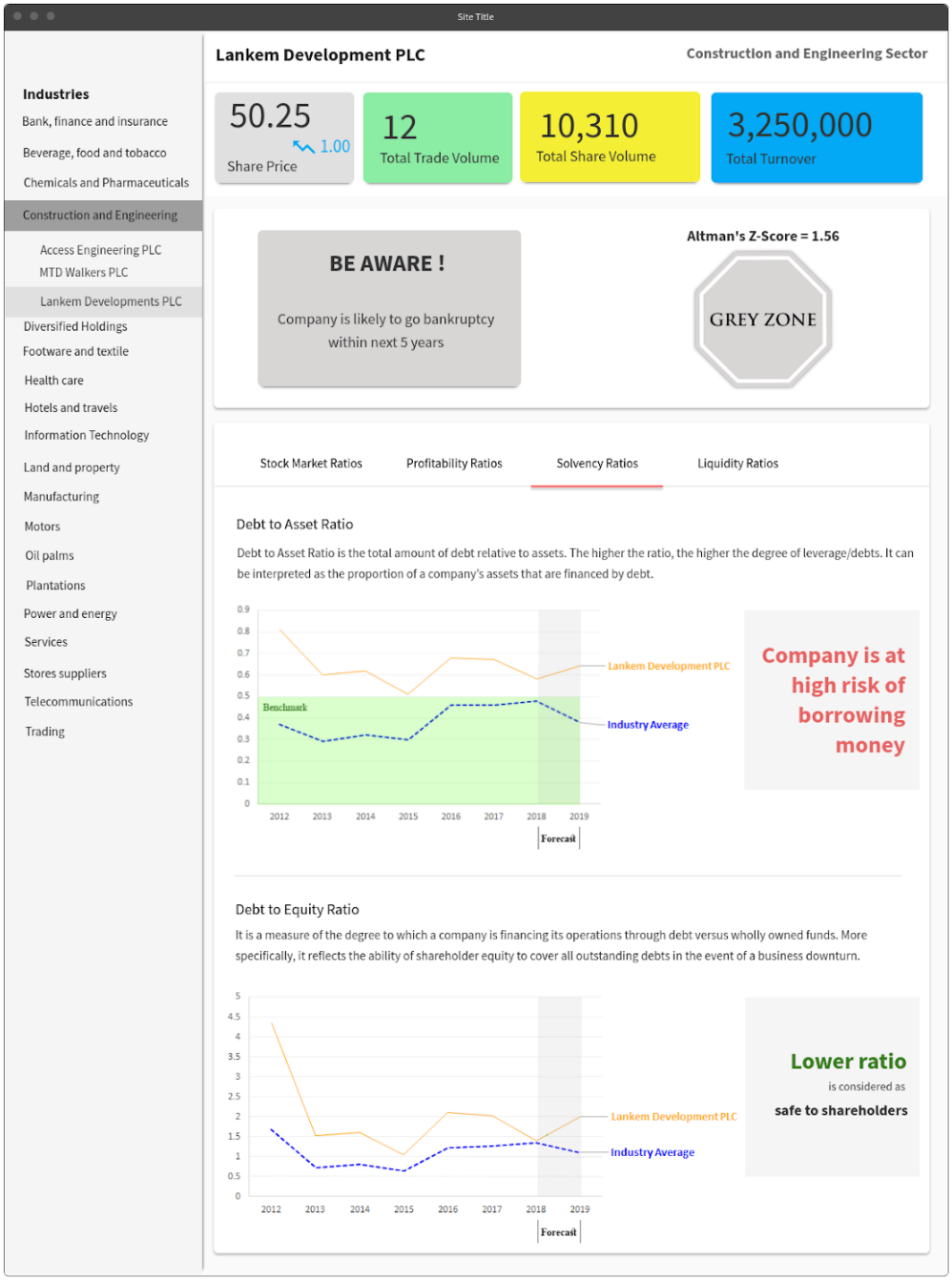


Lankem Development PLC – Stock market ratio

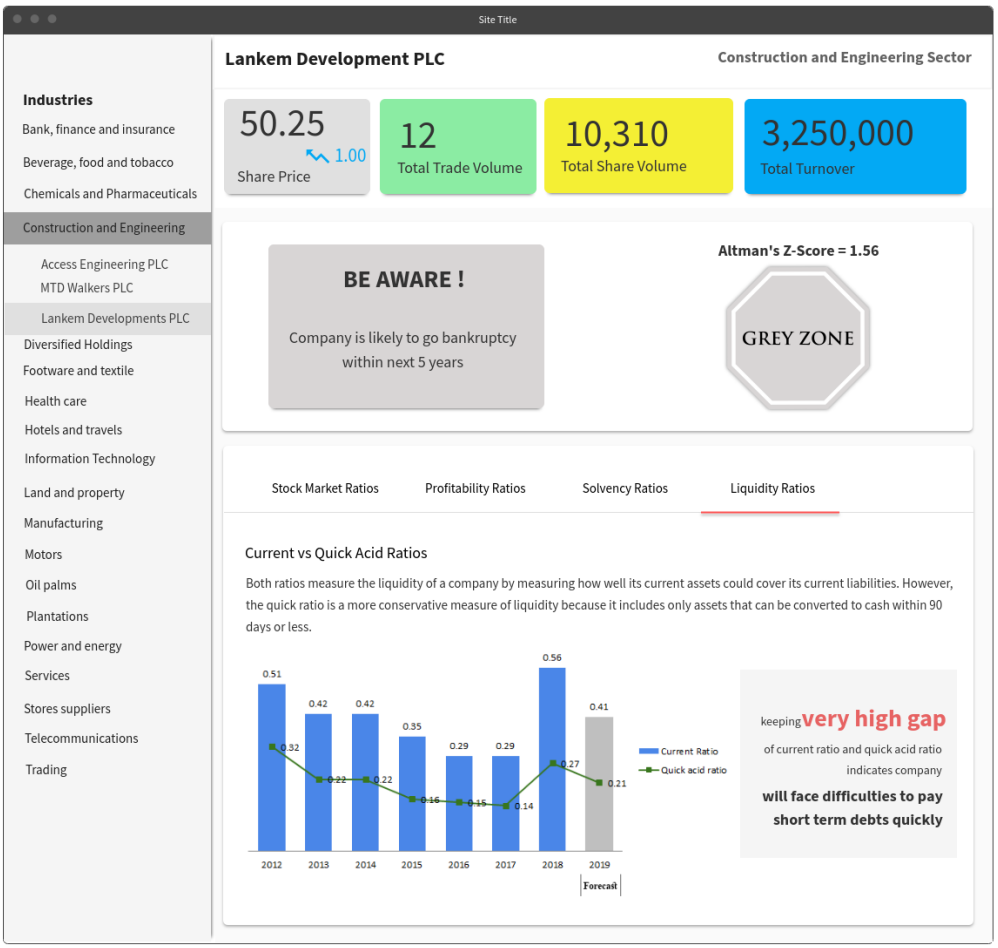
Lankem Development PLC – Profitability ratio



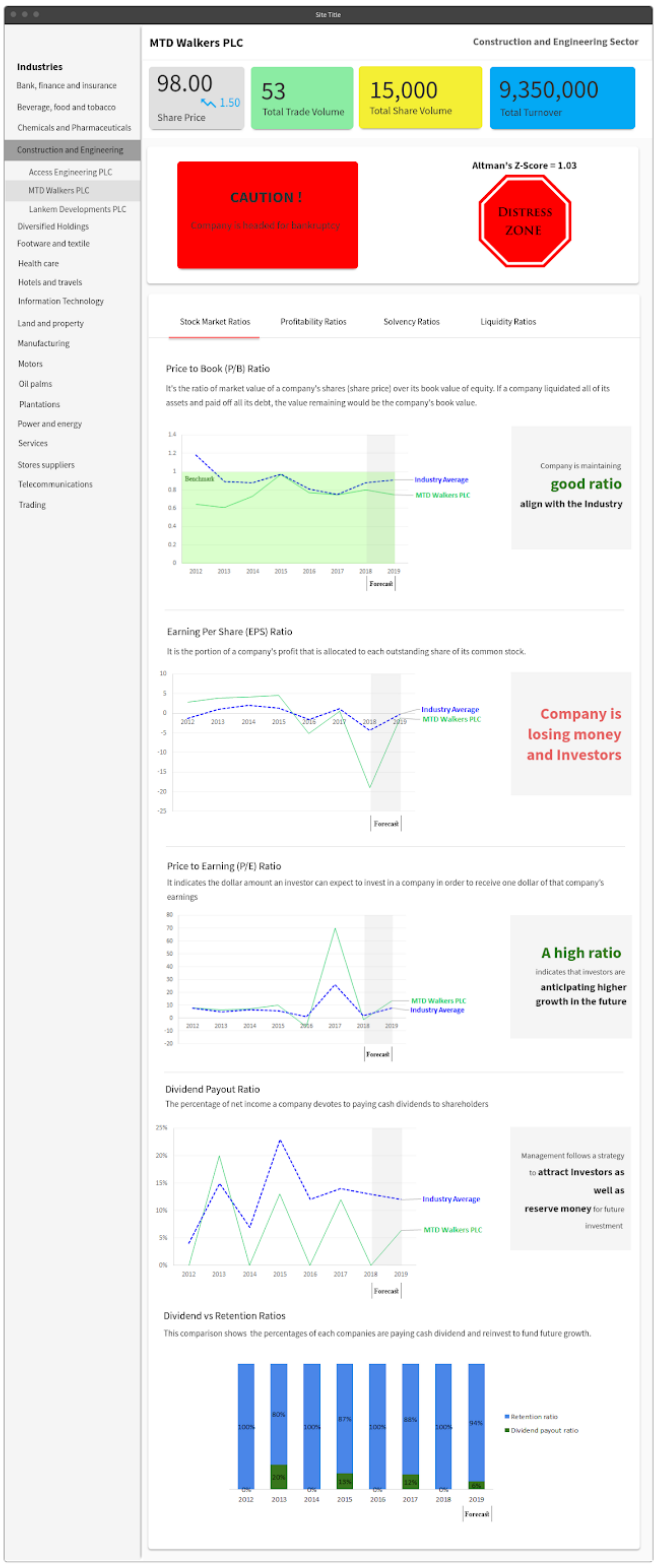
Lankem Development PLC – Solvency ratio



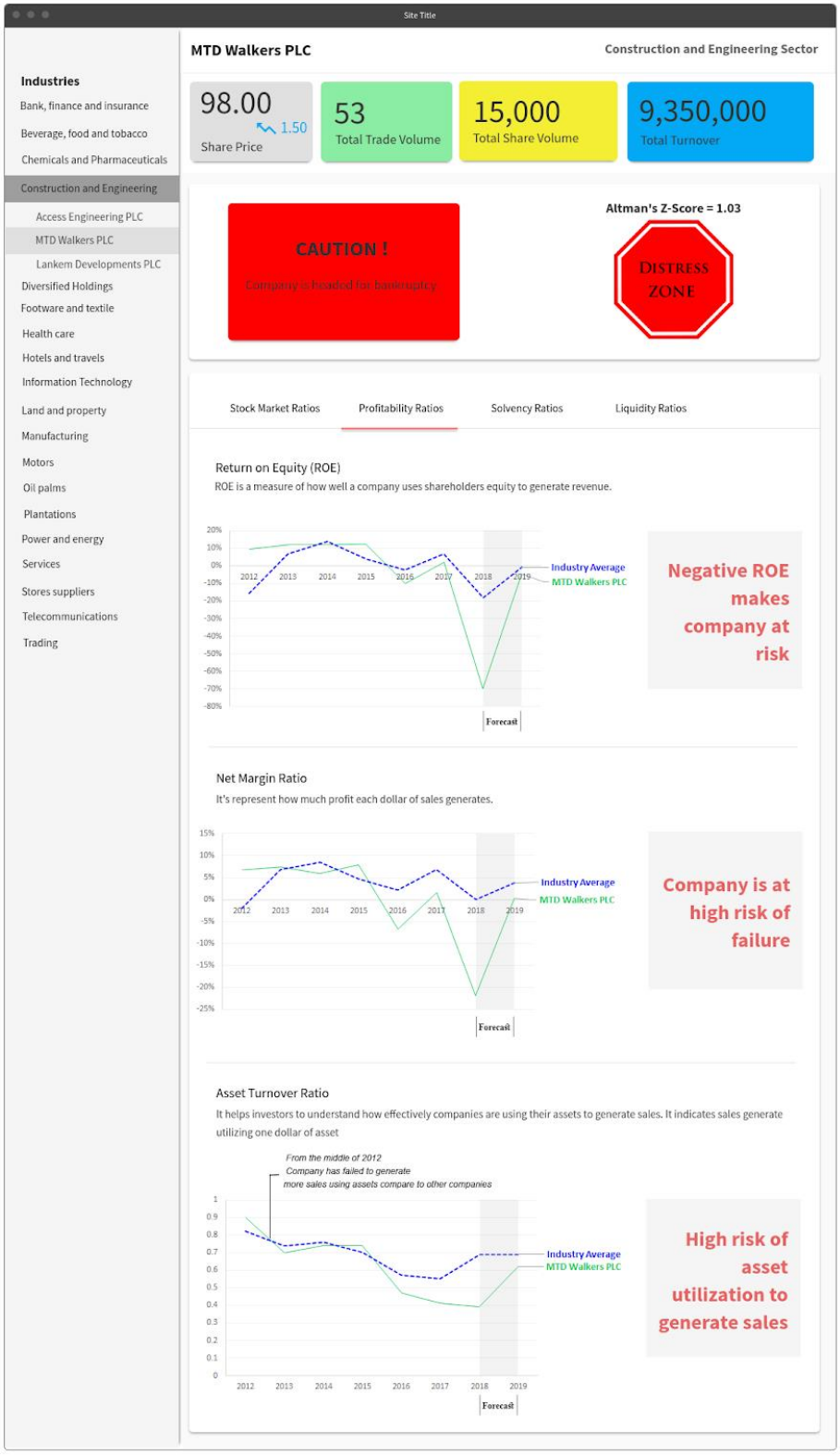
Lankem Development PLC – Liquidity ratio



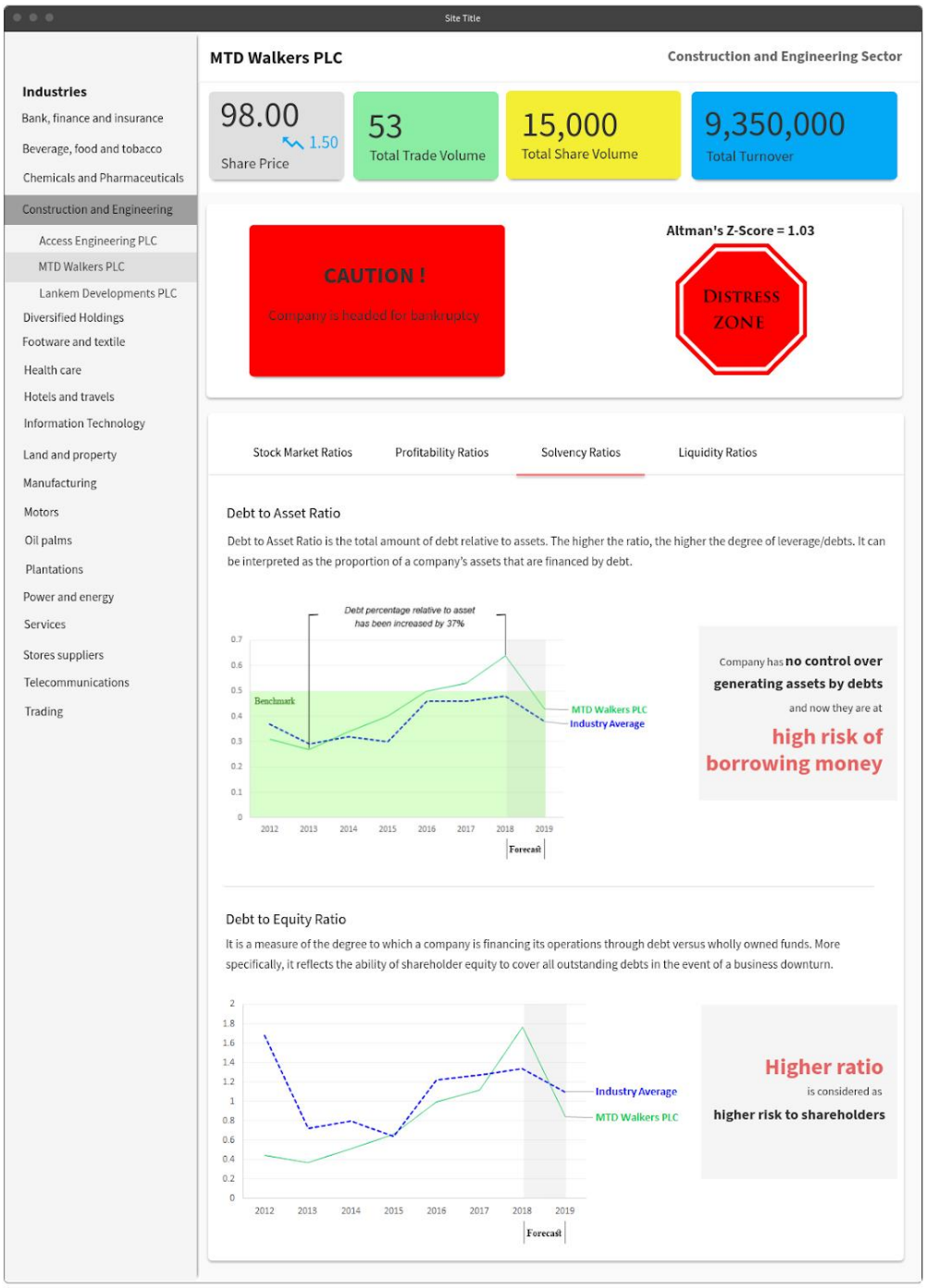
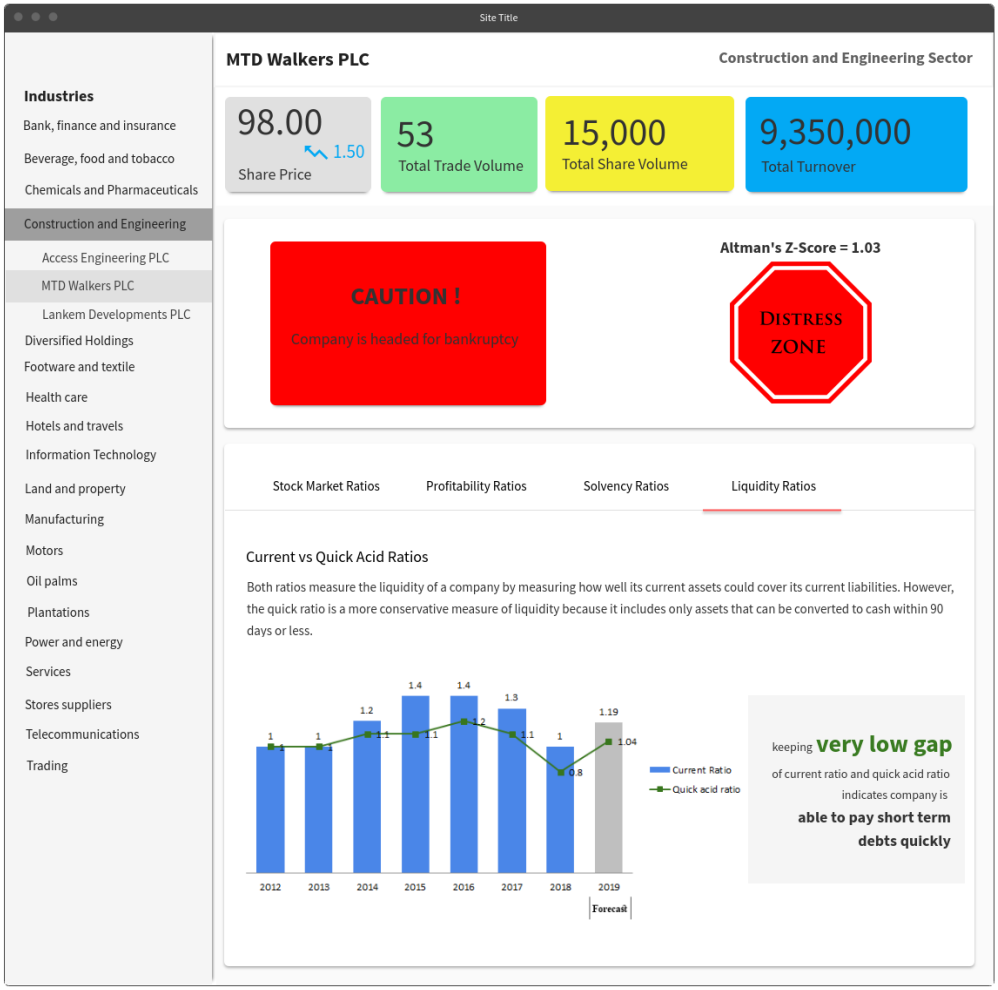
MTD Walkers PLC – Stock market ratio



MTD Walkers PLC – Profitability ratio



MTD Walkers PLC – Solvency ratio



MTD Walkers PLC – Liquidity ratio