FINAL TECHNICAL REPORT

ON

ADVANCED FINANICAL QUESTION ANSWERING CHATBOT: INVESTO

TEAM A2

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BY

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ABSTRACT

In today's financial world, over 1 million financial documents are produced by listed companies across the globe for their shareholders. This wealth of information makes it challenging for user to go through and make an informed investment decision. This challenge is further compounded by limited accessibility to these documents and the complexity of financial terminology used within them.

In response, our team, Fickle Nickel, is to develop an advanced Financial Question Answering system which will help an individual to assist with investment and speed up investment decision-making. We aim to build a chatbot, Investo, where it can automate the key information from financial reports and provide both numeric and visual information to the queries from the user.

The project involves implementing state-of-the-art Natural Language Processing (NLP) techniques to build a Financial Question Answering system. This includes training models on the given datasets, developing an intuitive user interface, and conducting thorough testing to ensure reliability. The scope extends to handling a variety of financial questions related to reports, statements, and market analysis, handling variations in questions & content.

By using the NLP, our FQA system can quickly extract relevant information from financial reports, reducing the time required for investment decision-making. The system enhances decision accuracy by providing precise and reliable answers to complex financial queries. Users experience increased efficiency in information retrieval, allowing them to focus on strategic aspects of investment analysis. The project promotes wider access to financial insights, catering to both seasoned professionals and those with limited financial expertise, fostering a more inclusive investment environment.

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1. INTRODUCTION

In the dynamic landscape of finance, over 1 million financial documents are produced by listed companies across the globe for their shareholders. This wealth of information makes it challenging for any individual to go through and make an informed investment decision. A total of 100 trillion dollars are invested in the listed companies and over 10 million+ trading decisions are made each day. An individual who is interested in investment need to go through every financial report among different years of different companies of different sector. Moreover, there will be lack of accessibility to different financial report. Thus, there is a critical need for advanced technologies to automate the extraction of key information from financial reports and provide accurate responses to queries, thereby enhancing the efficiency and accuracy of investment decision-making.

Financial data is vast and complex, encompassing a wide range of documents such as annual reports, quarterly filings, earnings statements, and market analyses. Extracting meaningful insights from these documents requires advanced computational techniques capable of understanding and interpreting financial language and concepts. Understanding financial report and market trend is essential for an investor to make decision regarding asset allocation, risk management, and portfolio optimization. However, the size and complexity of financial report make all this difficult. Analysing the report on manual mode is a time-consuming thing. Moreover, the interpretation of financial reports often requires domain-specific knowledge and expertise, further limiting accessibility to financial insights.

In this project, we develop an advanced Financial Question Answering chatbot investo using the given datasets, to provide timely and accurate responses to queries based on financial reports enhancing the efficiency of investment decision-making. Leveraging state-of-the-art technologies in Natural Language Processing (NLP) and machine learning, our FQA system

aims to provide timely and accurate responses to queries based on financial reports, enhancing the efficiency and accuracy of investment decision-making.

The project involves implementing state-of-the-art Natural Language Processing (NLP) techniques to build a Financial Question Answering system. This includes training models on the given datasets, developing an intuitive user interface, and conducting thorough testing to ensure reliability. The scope extends to handling a variety of financial questions related to reports, statements, and market analysis, handling variations in questions & content. The system achieves a predetermined accuracy/performance metrics threshold on a standardized test set that is comparable with other solutions available in the market on such performance metrics. Average response time for queries falls below the specified threshold. The UI allows for taking financial data and questions and displays answer those questions allowing for follow-up questions. The system can handle context and conversations and answer financial questions from a dialogue displaying understanding of domain specific nuances.

Users can quickly extract relevant information from financial reports, reducing the time required for investment decision-making. The system enhances decision accuracy by providing precise and reliable answers to complex financial queries. Users experience increased efficiency in information retrieval, allowing them to focus on strategic aspects of investment analysis. The project promotes wider access to financial insights, catering to both seasoned professionals and those with limited financial expertise, fostering a more inclusive investment environment.

2. LITERATURE REVIEW

2.1. Designing a Dutch financial chatbot

Wetstein (2017) conducted a study on designing a Dutch financial chatbot, focusing on building a chatbot capable of answering highly complex questions in the financial domain. By comparing different models, including vector space and machine learning approaches, Wetstein demonstrated the feasibility of developing a chatbot to provide high-quality answers in the banking context.

He contributes to this body of knowledge through a comprehensive investigation into the development of chatbot systems capable of handling highly complex questions within a well-defined domain. By leveraging a combination of Natural Language Processing (NLP) techniques and machine learning algorithms, Wetstein explores various chatbot implementations, including vector space models and machine learning approaches. The study emphasizes the importance of selecting appropriate models and techniques to ensure the delivery of high-quality responses to user queries.

Among the implemented models, the combination of a vector space model and a machine learning model emerges as the most effective, successfully answering 23% of user questions with a 74% accuracy rate. This hybrid approach demonstrates the potential of integrating NLP and machine learning techniques to address the complexities inherent in answering intricate questions. Furthermore, the study highlights the necessity of ongoing research efforts to enhance Dutch NLP pipelines and explore generative-based chatbot architectures to further improve system performance and capabilities. In summary, Wetstein's research underscores the significance of chatbot technology in addressing the challenges posed by unstructured data, particularly within the context of highly specialized domains like finance. By advancing our understanding of effective chatbot design and implementation strategies, this study contributes

valuable insights to the broader discourse on leveraging artificial intelligence for text-based data analysis and decision support.

2.2. Effectiveness of an Intelligent Question Answering System for Teaching Financial Literacy: A Pilot Study

Jayaraman and Black (2021) contribute to this burgeoning field with their pilot study focused on the effectiveness of an IQA system for teaching financial literacy. Despite the widespread utilization of question answering systems in diverse fields, their application in the financial literacy domain remains relatively unexplored. The IQA system developed in this study incorporates state-of-the-art NLP techniques, leveraging Google's Bidirectional Encoder Representations from Transformers (BERT) model. Comprising three modules—question answering, evaluation, and feedback—the system serves a dual purpose: as a practice tool for learners and as a scaffolding tool for facilitating answers to queries. Notably, the research findings reveal significant learning gains, with an effect size of 1.89, indicating the system's efficacy in improving students' understanding of personal finance concepts. Participants perceive the IQA system as beneficial for self-paced learning, error correction, and comprehension reinforcement, highlighting its potential as a supportive learning tool in financial education.

2.3. Chatbot as Finance Expert (CaIFE): When Finance Meets Artificial Intelligence

Khan and Rabbani (2021) present a compelling case for leveraging chatbots as efficient tools for addressing customer queries and complaints within the Islamic finance domain. With the increasing demand for accessible and timely solutions, financial institutions have turned to chatbots to provide round-the-clock assistance to customers. The proposed "Chatbot as Islamic Finance Expert" (CaIFE) exemplifies this trend, offering an interactive platform for users to engage with a machine learning-powered chatbot specializing in Islamic finance and banking. By harnessing the knowledge accumulated through machine learning algorithms, CaIFE

effectively addresses user inquiries in real-time, thereby enhancing the accessibility and efficiency of Islamic finance services.

This study highlights the transformative potential of AI-driven chatbots in streamlining customer interactions and improving service delivery within specialized domains like Islamic finance. By providing insights into the design, functionality, and limitations of CaIFE, Khan and Rabbani offer valuable contributions to the discourse on AI applications in finance and banking. Moving forward, further research is warranted to explore the scalability and efficacy of chatbot solutions across diverse financial contexts, while also addressing concerns related to privacy, security, and user trust in AI-driven financial services.

2.4. Toward a Chatbot for Financial Sustainability

Hwang and Kim (2021) contribute to the ongoing discourse on the application of artificial intelligence (AI) in the financial sector by examining the effectiveness of chatbot technology in promoting financial sustainability. The study synthesizes existing literature on chatbots and customer service, exploring theories related to the acceptance of innovative technologies within the industry. Through methodological analysis, the research investigates the impact of chatbots on bank revenues, with a particular focus on customer age classification and transaction types.

The findings reveal nuanced insights into the role of chatbots in enhancing bank profitability. While new product-oriented funds or housing subscription savings may be better suited for traditional customer service interactions, chatbots demonstrate a positive impact on banks' net income when used for existing product services. Moreover, the study highlights the propensity for small banking transactions to be processed through chatbot systems, leading to cost savings and improved profitability. Through empirical analysis of AI-based chatbot systems, the research underscores their potential to strengthen financial soundness and streamline customer service processes.

2.5. Text-Based Chatbot in Financial Sector: A Systematic Literature Review

Wube et al. (2022) conducted a systematic literature review focusing on text-based chatbots in the financial sector, aiming to enhance customer relationships and address external challenges and requirements. The study provides a comprehensive overview of the implementation and adoption of chatbot technology in financial services, emphasizing its role in addressing customer inquiries and streamlining service delivery processes through machine learning algorithms.

The literature review encompasses various aspects of chatbots in the financial sector, including implementation strategies, adoption intentions, attitudes towards use and acceptance, as well as user experiences related to perception, expectation, and trust. Additionally, the study examines the management of security and privacy vulnerabilities associated with chatbots, highlighting the importance of safeguarding sensitive financial information.

Key findings from the review underscore the potential of text-based chatbots to improve customer engagement and satisfaction in financial services. However, the study also identifies several challenges and open issues, such as security concerns and the need for ongoing research to address evolving user expectations and technological advancements.

Overall, Wube et al.'s systematic literature review provides valuable insights into the current state of text-based chatbots in the financial sector, offering a foundation for future research directions aimed at optimizing chatbot functionalities and addressing emerging challenges to ensure their successful evolution and widespread adoption.

3. METHODS

We, Fickle Nickel, as a team have taken on the task to create a chatbot that will answer financial questions from the user. In the context of a financial report, engage in a conversation with a user, addressing their queries and facilitating a dialogue to expedite the decision-making process related to investments. And for that purpose, our team will aim to build a chatbot which will be able sustain a conversation and pass suggestions as well.

The primary objective of implementing a financial chatbot is to enhance user experience and streamline financial interactions. The chatbot serves as a valuable tool within the industry by providing efficient and personalized support for users engaging with financial data and reports.

3.1. Market research

Recognizing the importance of thorough groundwork, our team initiated the project with extensive research aimed at understanding the intricacies of product market fit. This involved exploring why such a product was necessary, how customers would benefit from it, and identifying existing similar products in the market. Additionally, our team delved into the challenges posed by the vast volume of financial documents, with over 1 million produced annually, each spanning 150 to 200 pages. To streamline data acquisition, we meticulously identified the necessary information for the chatbot from this vast pool of documents. From a curated list of companies spanning the globe, we compiled a comprehensive list of 50 entities. Diligently visiting their official websites, we accessed a wealth of financial data, laying a robust foundation for the project's subsequent phases.

3.2. Financial terminologies

Our next goal was having a detailed knowledge about the financial terminologies used in the financial report. This was our one of the challenges. Having a different background was a

challenge for us. To learn about this terminology, we have made a documentation about this terminology and how we calculate these things.

Market capitalization:

According to FINRA (2022), Market capitalization, or market cap, is a measure of a company's size. It refers to the total worth of a company's outstanding stock, which includes both publicly traded and restricted shares held by company officers and insiders.

Revenue:

According to Chopra (2023), Denotes the income generated by an individual or entity through the sale of goods or services provided.

Gross profit:

According to Indeed (2023), Gross profit, also referred to as gross income, represents the earnings a company retains after subtracting expenses related to the production of its diverse goods and services.

Net income (NI)

According to Kenton (2023), Also termed net earnings, is derived by subtracting various expenses such as cost of goods sold, selling, general and administrative costs, operating expenses, depreciation, interest, taxes, and other expenditures from total sales.

Earnings per share (EPS)

According to TD (n.d.), to assess a company's worth or the value of its shares. EPS is computed by dividing the net profit of a company by the total number of common shares outstanding.

EBITDA

According to Square (n.d.), EBITDA assesses a company's ability to manage daily operations, including crucial expenses like cost of goods sold, offering a precise snapshot of its status and potential.

Shareholder equity (SE)

According to Hayes (2023), Shareholder equity (SE) represents a company's net worth and signifies the total amount that would be distributed to shareholders in the event of liquidation after settling all debts.

Cash flow from operations

According to Seth, S. (2023), Cash flow from operations Represents the segment of a company's cash flow statement that illustrates the cash generated from its day-to-day operating activities over a period. Investing Cash Flow, a vital component of a company's cash flow statement, indicates the expenditure on business investments within a specified timeframe.

Cash flow from financing activities (CFF)

According to Murphy (2022), Cash flow from financing activities (CFF) is a segment of a company's cash flow statement that reveals the net cash flows employed to support the business.

Current ratio

According to Indeed Editorial Team (2022), The current ratio serves as a liquidity gauge, reflecting a debtor's capability to settle their debts.

Debt-to-equity (D/E)

According to Fernando (2023) The debt-to-equity (D/E) ratio is a vital metric for assessing a company's financial leverage, calculated by dividing total liabilities by shareholder equity.

Return on equity (ROE)

According to Fernando (2024) Return on equity (ROE) is a crucial financial performance indicator obtained by dividing net income by shareholders' equity.

Return on assets (ROA)

According to Hargrave (2024) Return on assets (ROA) is a financial ratio that demonstrates a company's profitability in relation to its total assets.

Return on investment (ROI)

According to Fernando (2023), Return on investment (ROI) serves as a performance metric utilized to evaluate the efficiency or profitability of an investment, or to compare the effectiveness of multiple investments.

Net profit margin

According to Murphy (2022), The net profit margin, it referred to as the net margin, is a percentage of revenue used to measure net income or profit.

Free cash flow per share (FCF)

According to Kenton (2021), Free cash flow per share (FCF), it represents a gauge of a company's financial adaptability, derived by dividing free cash flow by the total number of outstanding shares.

Return on tangible equity (ROTE)

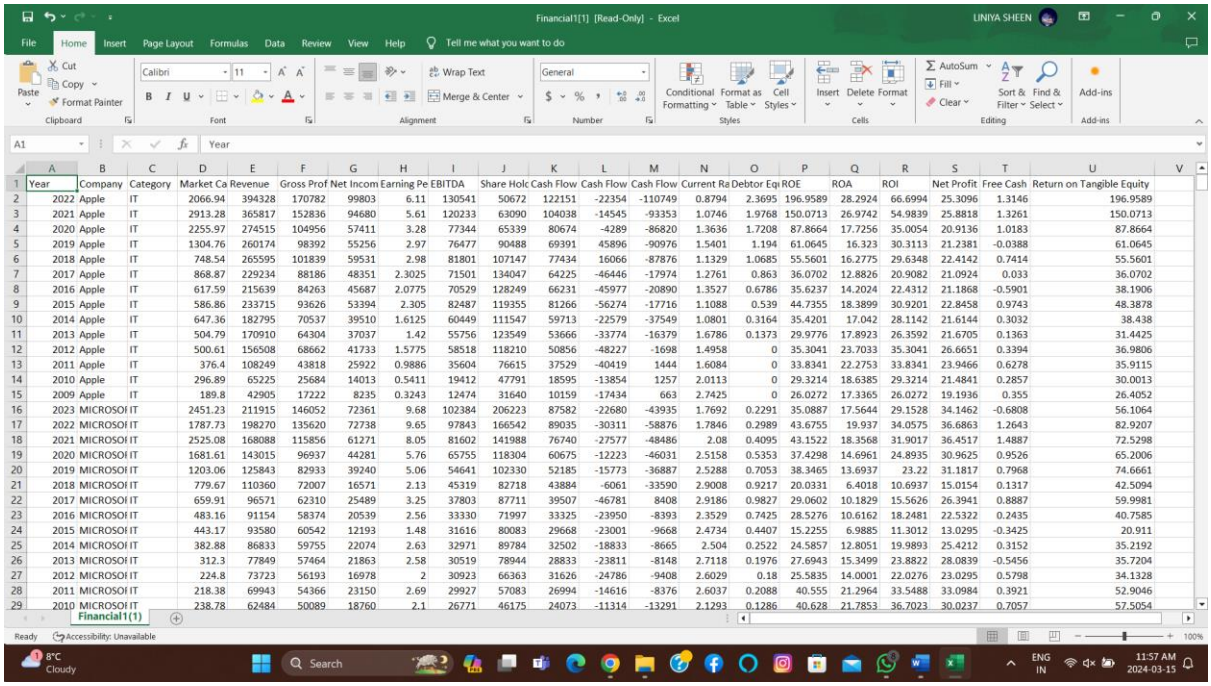
According to Wall Street Prep. (2023) Return on tangible equity (ROTE) is a crucial metric for evaluating a company's performance, particularly in the analysis of financial institutions like banks and insurance companies.

3.3. **Datasets**

The primary step in developing our financial question answering system involved the collection of datasets according to the requirements of our chatbot. To ensure the accuracy and accessibility of our model, we took financial reports from multiple companies across various industries which was a lot of data to deal with. We discussed this with our project advisor, he provided us a dataset in form of JSON file. However, the project encountered a significant pivot when initial attempts to utilize the dataset in form of JSON file which proved challenging. The data to our understanding was too random and did not provide us with enough tangible information that we can play around with. We need to bend and manipulate the data in a calculative form to synthesize the data for the user query. Undeterred by this setback, the team swiftly adapted our approach and explored alternative avenues for acquiring the requisite data.

Our persistence led us to discover the Macrotrends website, a treasure trove of financial data. Through meticulous manual extraction, our team successfully obtained data in the form of Excel files, which served as the cornerstone of Investo's dataset. The wide range of financial metrics in our dataset enhances not only the efficiency of our model but also provide an insightful response to user queries. It has company’s profitability and other data so our chatbot with necessary information can address user’s quires very accurately.

Macrotrend provided us with numeric structure of a data which we can use and build our chatbot around it. So, we did finally go with a numeric set of data which contains data of around 50 companies and around 16 different financial terms. These data were set around the timeframe of 2009-2022. So, that is a lot of data across the rows and columns. Now that we got the data that leaves us with the data cleaning.



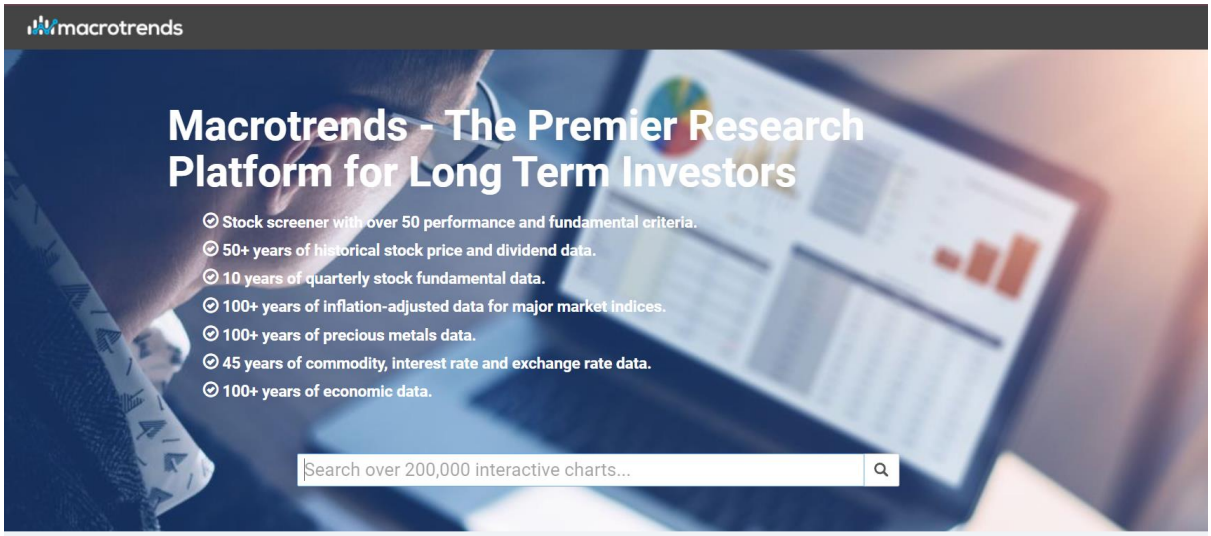
Year	Company	Category	Market Ca	Revenue	Gross Prof	Net Incom	Earning Pe	EBITDA	Share Holc	Cash Flow	Cash Flow	Cash Flow	Current Ra	Debtor Eq	ROE	ROA	ROI	Net Profit	Free Cash	Return on Tangible Equity
2022	Apple	IT	2066.94	394328	170782	99803	6.11	130541	50672	122151	-22354	-110749	0.8794	2.3695	196.9589	28.2924	66.6994	25.3096	1.3146	196.9589
2021	Apple	IT	2913.28	365817	152836	94680	5.61	120233	63090	104038	-14545	-93353	1.0746	1.9768	150.0713	26.9742	54.9839	25.8818	1.3261	150.0713
2020	Apple	IT	2255.97	274515	104956	57411	3.28	77344	65339	80674	-4289	-86820	1.3636	1.7208	87.8664	17.7256	35.0054	20.9136	1.0183	87.8664
2019	Apple	IT	1304.76	260174	98392	55256	2.97	76477	90488	69391	45896	-90976	1.5401	1.194	61.0645	16.323	30.3113	21.2381	-0.0388	61.0645
2018	Apple	IT	748.54	265595	101839	59531	2.98	81801	107147	77434	16066	-87876	1.1329	1.0685	55.5601	16.2775	29.6348	22.4142	0.7414	55.5601
2017	Apple	IT	868.87	229234	88186	48351	2.3025	71501	134047	64225	-46446	-17974	1.2761	0.863	36.0702	12.8826	20.9082	21.0924	0.033	36.0702
2016	Apple	IT	617.59	215639	84263	45687	2.0775	70529	128249	66231	-45977	-20890	1.3527	0.6786	35.6237	14.2024	22.4312	21.1868	-0.5901	38.1906
2015	Apple	IT	586.86	233715	93626	53394	2.305	82487	119355	81266	-56274	-17716	1.1088	0.539	44.7355	18.3899	30.9201	22.8458	0.9743	48.3878
2014	Apple	IT	647.36	182795	70537	39510	1.6125	60449	111547	59713	-22579	-37549	1.0801	0.3164	35.4201	17.042	28.1142	21.6144	0.3032	38.438
2013	Apple	IT	504.79	170910	64304	37037	1.42	55756	123549	53666	-33774	-16379	1.6786	0.1373	29.9776	17.8923	26.3592	21.6705	0.1363	31.4425
2012	Apple	IT	500.61	156508	68662	41733	1.5775	58518	118210	50856	-48227	-1698	1.4958	0	35.3041	23.7033	35.3041	26.6651	0.3394	36.9806
2011	Apple	IT	376.4	108249	43818	25922	0.9886	35604	76615	37529	-40419	1444	1.6084	0	33.8341	22.2753	33.8341	23.9466	0.6278	35.9115
2010	Apple	IT	296.89	65225	25684	14013	0.5411	19412	47791	18595	-13854	1257	2.0113	0	29.3214	18.6385	29.3214	21.4841	0.2857	30.0013
2009	Apple	IT	189.8	42905	17222	8235	0.3243	12474	31640	10159	-17434	663	2.7425	0	26.0272	17.3365	26.0272	19.1936	0.355	26.4052
2023	MICROSOI	IT	2451.23	211915	146052	72361	9.68	102384	206223	87582	-22680	-43935	1.7692	0.2291	35.0887	17.5644	29.1528	34.1462	-0.6808	56.1064
2022	MICROSOI	IT	1787.73	198270	135620	72738	9.65	97843	166542	89035	-30311	-58876	1.7846	0.2989	43.6755	19.937	34.0575	36.6863	1.2643	82.9207
2021	MICROSOI	IT	2525.08	168088	115856	61271	8.05	81602	141988	76740	-27577	-48486	2.08	0.4095	43.1522	18.3568	31.9017	36.4517	1.4887	72.5298
2020	MICROSOI	IT	1681.61	143015	96937	44281	5.76	65755	118304	60675	-12223	-46031	2.5158	0.5353	37.4298	14.6961	24.8935	30.9625	0.9526	65.2006
2019	MICROSOI	IT	1203.06	125843	82933	39240	5.06	54641	102330	52185	-15773	-36887	2.5288	0.7053	38.3465	13.6937	23.22	31.1817	0.7968	74.6661
2018	MICROSOI	IT	779.67	110360	72007	16571	2.13	45319	82718	43884	-6061	-33590	2.9008	0.9217	20.0331	6.4018	10.6937	15.0154	0.1317	42.5094
2017	MICROSOI	IT	659.91	96571	62310	25489	3.25	37803	87711	39507	-46781	8408	2.9186	0.9827	29.0602	10.1829	15.5626	26.3941	0.8887	59.9981
2016	MICROSOI	IT	483.16	91154	58374	20539	2.56	33330	71997	33325	-23950	-8393	2.3529	0.7425	28.5276	10.6162	18.2481	22.5322	0.2435	40.7585
2015	MICROSOI	IT	443.17	93580	60542	12193	1.48	31616	80083	29668	-23001	-9668	2.4734	0.4407	15.2255	6.9885	11.3012	13.0295	-0.3425	20.911
2014	MICROSOI	IT	382.88	86833	59755	22074	2.63	32971	89784	32502	-18833	-8665	2.504	0.2522	24.5857	12.8051	19.9893	25.4212	0.3152	35.2192
2013	MICROSOI	IT	312.3	77849	57464	21863	2.58	30519	78944	28833	-23811	-8148	2.7118	0.1976	27.6943	15.3499	23.8822	28.0839	-0.5456	35.7204
2012	MICROSOI	IT	224.8	73723	56193	16978	2	30923	66363	31626	-24786	-9408	2.6029	0.18	25.5835	14.0001	22.0276	23.0295	0.5798	34.1328
2011	MICROSOI	IT	218.38	69943	54366	23150	2.69	29927	57083	26994	-14616	-8376	2.6037	0.2088	40.555	21.2964	33.5488	33.0984	0.3921	52.9046
2010	MICROSOI	IT	238.78	62484	50089	18760	2.1	26771	46175	24073	-11314	-13291	2.1293	0.1286	40.628	21.7853	36.7023	30.0237	0.7057	57.5054

Appendices A

The dataset contains of financial parameters including market capitalization, revenue, gross profit, net income, earnings per share (EPS), Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA), shareholder equity, cash flows from operating, investing, and financing activities, current ratio, debt-to-equity ratio, return on equity (ROE), return on assets (ROA), return on investment (ROI), net profit margin, free cash flow per share, and return on tangible equity. Each of these metrics provides valuable insights into a company's financial health, performance, and operational efficiency.

3.4. **Macrotrends**

To ensure the reliability and accuracy of our dataset, we sourced the financial reports from a reputable and credible platform known as Macrotrends.



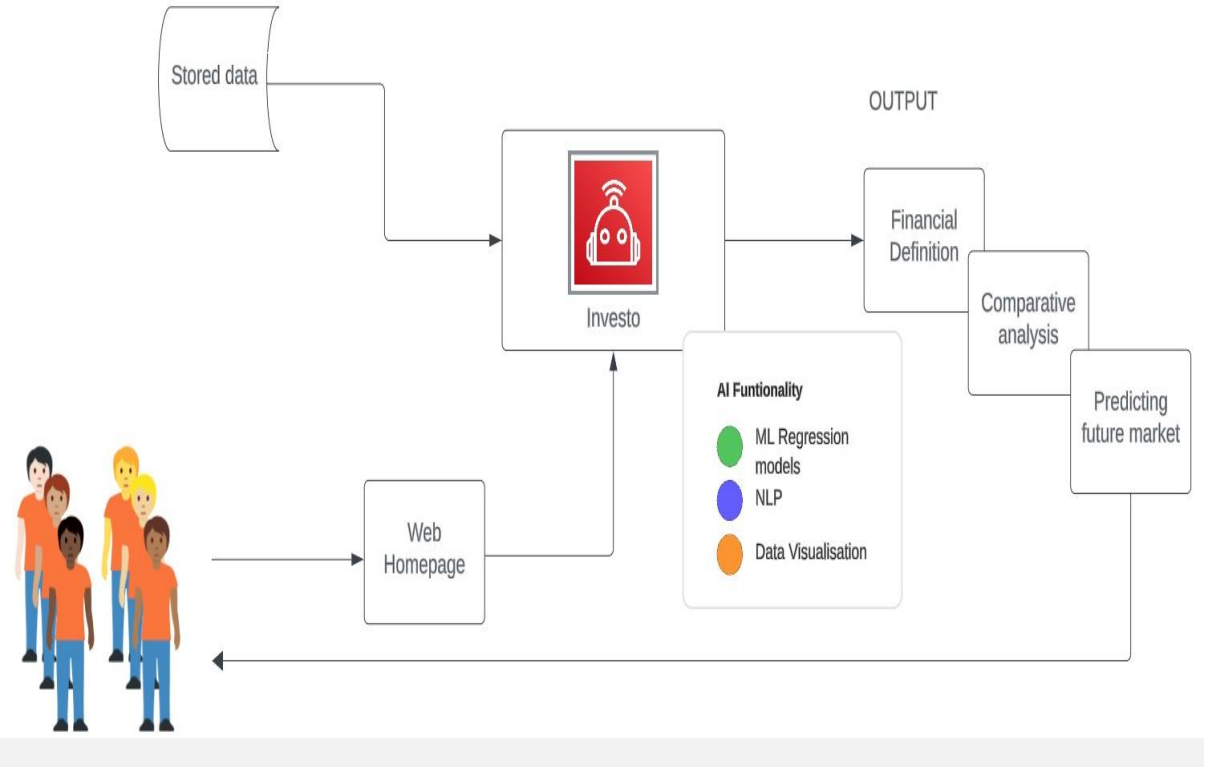
Appendices B

Macrotrends is renowned for its comprehensive collection of financial data from various publicly traded companies, making it an ideal resource for our dataset needs. By leveraging the wealth of information available on Macrotrends, we were able to compile a comprehensive dataset that reflects the diverse landscape of financial reporting across industries and companies.

4. PROJECT PROTOTYPE

After extensive brainstorming and careful consideration of various ideas, our team diligently finalized our dataset and moved forward to develop a project prototype. This pivotal phase involved synthesizing insights gathered from our research efforts and selecting the most promising avenues to pursue. With our dataset meticulously curated and refined, we embarked on the exciting journey of bringing our project to life through the creation of a prototype. This prototype serves as a tangible manifestation of our vision, providing a glimpse into the innovative capabilities of our solution. Leveraging our collective expertise and collaborative spirit, we are eager to refine and iterate upon this prototype, ultimately delivering a robust and

impactful solution to meet the needs of our users.



Appendices C

4.1. Cleaning and modifying dataset

Now that we got the data that leaves us with the data cleaning. We got the data, but we still had to format to our liking. The idea was to get a specific block of data based on the user query. To make our life easier, we had to transpose the data in such a way that the years came into the rows and the financial terms came into column. We had to use the data in an iterative method. So, if any data was repeating, we thought it to be easier if we put the numeric value that is the "years" in the rows. After transposing, we still had to deal with NAN values which stands for null values. These values occurred because some companies were not in business at that timeframe. So, we got rid of all those empty blocks of data. We did not fill those columns up because to our understanding it will compromise the density of data we had. If we came up with those numbers, these data would not have been representative of the market. Another form

of formatting we had to perform was, the financial term “Market Cap” in our data was in billions USD. But we converted it into millions USD so that we could use millions of USD as a universal unit for our model. Now with the data cleaning and formatting part is completed we can dive into the model building.

5. MODEL BUILDING

At the beginning of the AIP, when we chose this project, we had a clear view of the goal we were trying to achieve. So, according to our plan, there were three parts of the model that we were going to develop. We are going elaborate on this at the later point of this report.

5.1. Phase 1-Basic model Building

Our project was to build a chatbot which can answer financial questions in a conversational manner. That means this chatbot will be not only be able to navigate through data but also engage the user into more conversations. We used Python programming language for the model building. We used Microsoft Excel for the basic data cleaning and handling. This is a classic NLP (Natural Language Processing) problem. So, we approached this problem with NLP methodologies. To deal with the conversational idea, we tried to use pre-trained RAG models. According to Lewis et al. (2021), RAG models, short for Retrieval-augmented generation models, harness the capabilities of both pretrained dense retrieval (DPR) and sequence-to-sequence models. These models first retrieve relevant documents using DPR, then pass them to a sequence-to-sequence model for further processing. The model then integrates both retrieval and generation processes to produce the final outputs. By initializing and fine-tuning both the retriever and sequence-to-sequence modules from pretrained models, RAG models adapt to downstream tasks effectively, ensuring both retrieval and generation aspects are optimized.

5.2. Challenges faced leading to change in Approach

Running RAG model was troublesome for us. Because of the lack in computational power, we were not able to run this model. This model requires transformers and large language models (LLM)'s. As a result, our personal computer could not handle such computation for conversational techniques.

5.3. Phase 2- Model Building

Upon further discussion with our team and project advisor, we decided that rather than using a pre - trained model, we will develop our own conversational model. Our model will be simple but functional such as that can be handled by our personal computer. After searching for various techniques, we came up with a solution called "Cosine similarity". Cosine Similarity is a classic NLP approach for question answering chatbot. According to Miesle (2023), "Cosine similarity is a mathematical metric used to measure the similarity between two vectors in a multi-dimensional space, particularly in high-dimensional spaces, by calculating the cosine of the angle between them." Cosine similarity is a unique solution and very light weighted method. For cosine similarity to work we must provide the model a reference which the model can take in account when it is providing us with the response.

We stared to build a mapping sequence for our model. This mapping sequence can be used as a reference to generate answers to our query. In this mapping sequence, we have three columns. First column is our supposed questions that user can ask. This column consists of various kinds of questions that can be asked from a user perspective. The second column of the mapping is the responses that we want our program to spit out. This column consists of responses to the general queries and function names that we want to initialize when the program finds a specific keyword in the user query. The third column in our mapping sequence is the intent of the question and responses. The intent can be either general financial queries, a specific function or greetings. So, that is how we classified our responses.

As mentioned earlier, there can be three kinds of queries a user can ask to the chatbot as our understanding. The first kind is the general queries which are the general financial queries like definitions, pure numbers based on specific companies and years. The second kind is the statistical kind of question which is the future projection or growth of a company. The third kind is the unmapped queries which are those questions that are out of bound for our chatbot. These are three points of queries we were trying to cover. For the first kind of queries, we used a retrieval-based technique which will retrieve the data based on the specific query. This will satisfy the queries such as "what is revenue for apple in 2015?". The second kind of queries, we used linear regression to project the future growth of the companies. It will answer the question such as "what is the future growth of the revenue for Apple in the next 5 years?". The third kind queries are the out of bound questions. So, our bot can handle all these kinds of questions.

5.4. **Challenges faced during model building**

But model building did not come without bugs. In the next paragraph, we will try to describe a little bit about the bugs we fixed. The first problem we had is with the mapping. Our chatbot was not able to get the answers from the mappings. So, we had to fix that with changing the parameters of the search in our code. We also had to replace 5 of the company names and their data with other companies because those company names were not fetching from the mapping itself. Another problem we faced was, the integration of the model with our Streamlit UI. According to Javadyan (n.d.) "Streamlit lets you transform Python scripts into interactive web apps in minutes, instead of weeks. Build dashboards, generate reports, or create chat apps. Once you've created an app, you can use our Community Cloud platform to deploy, manage, and share your app". Because streamlit is compatible with python, it was easier to deploy it online. But we solved all these bugs in the code and handed it over to UI to our team.

6. UI AND WEB DESIGNING

6.1. Exploration of Web Development Technologies

Initially, our team attempted to research a variety of web development technologies commonly used in the industry, including:

Frontend Frameworks: Examples include React.js, Vue.js, and Angular.js. These frameworks offer robust tools and libraries for building dynamic and interactive user interfaces. They provide features such as component-based architecture, state management, and routing capabilities. However, they often require a steep learning curve and may be challenging for developers with limited experience in front-end development.

Backend Technologies: Options such as Node.js with Express.js or Django with Python are commonly used for building server-side logic and handling data processing and storage. While these technologies offer scalability and flexibility, they typically require knowledge of server-side programming and may involve complex setup and configuration.

6.2. Exploration of User Interface Design Technologies

In parallel, we researched various user interface design technologies and frameworks to ensure a seamless and visually appealing user experience. Examples include:

UI/UX Design Tools: Tools such as Figma, Sketch, and Adobe XD offer powerful features for creating wireframes, prototypes, and high-fidelity designs. These tools enable designers to iterate rapidly and collaborate effectively on UI/UX projects. However, they may have a learning curve for beginners and may not integrate seamlessly with development workflows.

6.3. Decision to Use Streamlit

Given the team's limited familiarity with web development and user interface design technologies, as well as the project's emphasis on simplicity and ease of deployment, we

decided to leverage Streamlit for building the financial Q&A chatbot UI. Here's a comparative analysis of different options and why Streamlit was chosen:

Simplicity and Ease of Use: Compared to traditional web development frameworks and UI design tools, Streamlit offers a streamlined and intuitive approach to building interactive web applications. Its Python-based API allows developers to create UI components and define application logic using familiar syntax and conventions. This simplicity reduces the learning curve and enables rapid prototyping and iteration.

Declarative Syntax: Streamlit's declarative syntax makes it easy to define UI elements and their interactions without the need for complex configuration or boilerplate code. Developers can create dynamic interfaces by simply writing Python code, eliminating the need to switch between multiple languages or frameworks.

Built-in Deployment Support: One of the key advantages of Streamlit is its built-in support for deploying web applications online. With just a few commands, developers can deploy their Streamlit apps to various hosting platforms, such as Heroku, AWS, or Streamlit Sharing. This streamlined deployment process simplifies the operational overhead and ensures seamless accessibility for end users.

Growing Ecosystem and Community: Streamlit has a vibrant ecosystem and active community of developers, which provides access to a wide range of extensions, plugins, and resources. The availability of pre-built components and community-contributed examples accelerates development and encourages collaboration among developers.

Focus on Data Science and Machine Learning: Streamlit is particularly well-suited for data science and machine learning applications, with built-in support for data visualization, interactive widgets, and integration with popular libraries like Pandas, Matplotlib, and

TensorFlow. This alignment with our project requirements made Streamlit a natural choice for building the financial Q&A chatbot UI.

By choosing Streamlit as the development platform for our project, we were able to leverage its simplicity, ease of use, and built-in deployment capabilities to overcome the challenges posed by our limited familiarity with web development and user interface design technologies. Streamlit's intuitive API and Python-based syntax enabled us to focus on delivering value to our users without being hindered by technical complexities, ultimately leading to the successful development and deployment of our financial Q&A chatbot UI Investo.

6.4. Implementation Challenges with Streamlit

In our exploration and utilization of Streamlit for building the financial Q&A chatbot UI, we encountered several challenges along the way. Here's how we navigated through these obstacles:

Adding the Logo: Incorporating our branding elements, such as the logo, into the Streamlit UI posed a challenge initially. We had to explore different approaches and customizations within Streamlit to seamlessly integrate the logo into the chatbot interface.

Adding Clear Chat Button: Implementing features like a clear chat button required us to delve into Streamlit's customization options and explore ways to add interactivity to the UI. We experimented with Streamlit's widgets and event handling mechanisms to enable users to clear the chat history effortlessly.

Showing the Graphs:

Exploration of External Libraries: Initially, we explored using external Python libraries like Matplotlib for generating graphs within our Streamlit application. While Matplotlib offers

extensive capabilities for data visualization, we encountered compatibility issues and challenges with integrating Matplotlib plots into the Streamlit UI.

Integration Challenges: Integrating Matplotlib plots into the Streamlit UI required additional code complexity and customizations to ensure proper rendering and interaction. However, despite our efforts, we faced difficulties in achieving consistent and reliable graph display using external libraries.

Utilizing Streamlit's Built-in Functions: To streamline the graph rendering process and mitigate compatibility issues, we decided to leverage Streamlit's built-in functions for data visualization. Streamlit provides convenient APIs for generating various types of plots, including line charts, bar graphs, scatter plots, and more, directly within the application interface.

Seamless Integration: By utilizing Streamlit's built-in functions for graph generation, we were able to seamlessly integrate dynamic graphs into our application without relying on external libraries. This approach simplified the development process and ensured compatibility with the Streamlit framework, resulting in consistent and reliable graph rendering.

Enhanced User Experience: Leveraging Streamlit's built-in functionalities for graph visualization not only resolved the bugs related to graph rendering but also enhanced the overall user experience. Streamlit's intuitive APIs and seamless integration capabilities allowed us to create interactive and visually appealing graphs that effectively conveyed financial data to users.

By transitioning to Streamlit's built-in graph visualization functions, we successfully addressed the bugs related to graph rendering within our application. This approach not only provided a more robust solution but also improved the development workflow and enhanced the user experience of our financial Q&A chatbot UI.

7. INTEGRATION OF STREAMLIT UI AND MODEL

Compatibility Issues with ipynb Files: Initially, we encountered compatibility issues when attempting to run Streamlit directly from Jupyter Notebook (.ipynb) files. To address this challenge, we had to convert our codebase to Python (.py) files, enabling seamless integration between the Streamlit UI and the underlying machine learning model. This transition required careful consideration of dependencies and code organization to ensure smooth execution.

8. DEPLOYMENT TO THE CLOUD

The idea of the whole chatbot would be rendered moot if we could not use it from the internet directly. We used GitHub to deploy it to the internet. Streamlit gives us the option to make the tool online deployed. We created a GitHub repository to store all the files necessary for the project. We logged into the streamlit with our GitHub. And we directed it to our project repository and deployed it to the cloud.

Appendices D

8.1. Deployment Challenges using Streamlit Cloud

Configuration Setup: Deploying our application using Streamlit Cloud necessitated configuring settings and dependencies to ensure compatibility with the hosting environment. We had to familiarize ourselves with Streamlit Cloud's deployment process and adapt our application accordingly to meet the platform's requirements.

Ensuring Consistent Performance: Achieving consistent performance across different environments and user interactions was crucial for delivering a seamless user experience. We conducted thorough testing and optimization to address performance bottlenecks and ensure reliable performance, particularly during peak usage periods.

Types of bugs encountered during deployment:

Here's a detailed overview of the bugs we encountered and how we addressed them:

State Management Bugs with st.session_state():

Managing the state of the application across different sessions using st.session_state() presented some challenges. We encountered bugs related to maintaining the state of user inputs, widget selections, and application variables between sessions.

To address these issues, we carefully reviewed our implementation of st.session_state() and identified areas where state management could be improved. We optimized our code to ensure consistent behavior across sessions and implemented error handling mechanisms to catch any unexpected state-related bugs.

Widget Interaction Bugs:

Bugs related to widget interactions, such as dropdown menus, sliders, and buttons, were also encountered during development. These bugs manifested as unexpected behavior or errors when users interacted with the UI elements.

We debugged these issues by closely examining our widget callbacks and event handling mechanisms. We identified and fixed errors in our event-driven logic, ensuring that widget interactions triggered the intended actions and updates within the application.

Graph Rendering Bugs:

Rendering dynamic graphs within the Streamlit UI occasionally led to bugs related to data visualization and plotting. These bugs manifested as inconsistencies in graph rendering, incorrect data display, or performance issues.

We addressed these bugs by optimizing our graph rendering code, optimizing data processing pipelines, and ensuring compatibility with the chosen data visualization libraries which are built-in in streamlit. Additionally, we conducted extensive testing to identify and resolve any rendering-related issues before deployment.

Compatibility Bugs with Streamlit Versions:

Incompatibilities between different versions of Streamlit occasionally resulted in bugs and errors during development. These compatibility issues arose when transitioning between Streamlit versions or when relying on deprecated features.

To mitigate these bugs, we carefully monitored updates and releases from the Streamlit team and ensured that our codebase remained compatible with the latest stable version. We updated deprecated features and adjusted our code as needed to maintain compatibility with the Streamlit framework.

Deployment Bugs on Streamlit Cloud:

Bugs specific to the deployment environment on Streamlit Cloud were also encountered during the deployment phase. These bugs included issues with environment configuration, package dependencies, and resource allocation.

We addressed these deployment bugs by thoroughly testing our application on the Streamlit Cloud platform and troubleshooting any errors encountered during the deployment process. We adjusted configuration settings, resolved package conflicts, and optimized resource utilization to ensure a smooth deployment experience.

By actively addressing these bugs and issues throughout the development lifecycle, we were able to enhance the stability, reliability, and performance of our financial Q&A chatbot UI built with Streamlit. Our commitment to rigorous testing, continuous improvement, and collaborative problem-solving enabled us to deliver a high-quality user experience to our audience.

9. WIX WEBSITE

After conducting thorough research and evaluating various website-building platforms, including WordPress, Squarespace, and Weebly, our team determined that Wix was the optimal choice for our project. We were particularly drawn to Wix's user-friendly interface and robust features, which made it the ideal platform for creating and customizing our website to meet our specific needs.

9.1. Some key reasons why Wix emerged as the best option for our project include

Ease of Use: Wix's intuitive drag-and-drop editor allowed us to effortlessly design and customize our website without requiring extensive technical expertise. This streamlined the development process and enabled us to focus on creating compelling content and functionality.

Customization Options: With a vast selection of professionally designed templates and a wide range of customization options, Wix provided us with the flexibility to tailor our website to our unique specifications. We were able to incorporate our branding elements seamlessly and create a visually appealing and cohesive online presence.

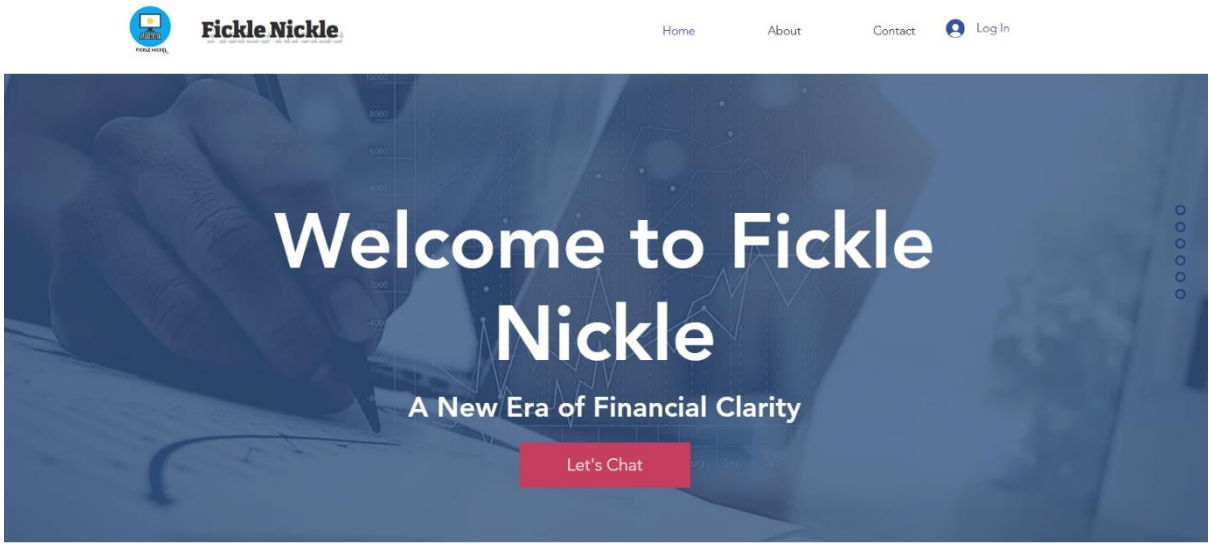
Integration Capabilities: Wix offers seamless integration with a variety of third-party tools and applications, making it easy to incorporate additional features and functionality into our website. This allowed us to seamlessly integrate our chatbot and other project-related components, enhancing the overall user experience.

Mobile Responsiveness: Wix's built-in mobile optimization features ensured that our website looked great and functioned smoothly across all devices, including smartphones and tablets. This helped us reach a wider audience and provided users with a consistent and engaging experience regardless of the device they were using.

Reliable Hosting: Wix provides reliable hosting services, ensuring that our website remains accessible and performs optimally at all times. This alleviated concerns about downtime or slow loading speeds, allowing us to focus on delivering valuable content to our audience.

9.2. Content On WIX

Our website serves as a central hub housing essential project component, including our chatbot, project documents, a comprehensive list of companies from which our dataset was sourced, and information about our team members. Notably, we integrated our chatbot seamlessly into the website using a prominent button labeled "Let's Chat," which directs users to our Streamlit Cloud platform, ensuring a seamless and intuitive user experience. Through Wix, we have successfully created a dynamic and user-friendly platform that enhances accessibility and engagement for our audience.



Appendices E

10. PROJECT MANAGEMENT

Effective project management was paramount in ensuring the success of our model-building endeavor. To streamline our workflow and optimize task allocation, we adopted agile methodologies. By embracing agile principles, we were able to remain flexible and responsive to evolving project requirements, ultimately enhancing our ability to deliver results efficiently. Leveraging Jira as our project management tool, we meticulously organized and assigned tasks among team members. This facilitated clear communication, promoted collaboration, and ensured that all project objectives were met within the designated timeframe.

Version Control and Collaboration:

GitHub emerged as our go-to platform for version control and collaboration throughout the project lifecycle. Serving as a centralized repository for storing project files, GitHub enabled seamless collaboration among team members. Its intuitive interface and robust version control features allowed us to manage code changes effectively, track revisions, and address issues promptly. Moreover, GitHub's collaborative functionalities empowered team members to

review, comment on, and contribute to the project codebase, fostering a culture of collaboration and knowledge sharing.

Deployment:

One of the key advantages of GitHub was its seamless integration with deployment platforms such as Streamlit Cloud. After developing and testing our chatbot locally, we leveraged GitHub to deploy our bot on Streamlit Cloud. This integration streamlined the deployment process, allowing us to transition our bot from a local environment to a production environment seamlessly. Notably, GitHub's ability to modify code directly from the platform post-deployment provided us with unparalleled flexibility and agility in managing and updating our deployed application. This ensured that our chatbot remained accessible to users while allowing us to implement iterative improvements and address user feedback in real-time.

In conclusion, the combination of agile project management methodologies, Jira for task management, GitHub for version control and collaboration, and Streamlit Cloud for deployment played a pivotal role in the success of our model-building project. These tools empowered us to effectively manage our project, collaborate efficiently, and deploy our solution with ease, ultimately delivering value to our users and stakeholders.

11. CONCLUSION

In wrapping up, this project has been a journey of exploration and innovation in the realm of financial analysis and artificial intelligence. From the inception of the idea to the implementation of advanced machine learning algorithms, every step has been guided by a commitment to excellence and a vision for a smarter, more accessible financial future.

Through meticulous data gathering and analysis, we've delved into the intricate world of stock valuation, risk assessment, and investment strategy. Our efforts culminated in the development of a sophisticated chatbot system, poised to assist users in navigating the complexities of the financial landscape with ease. Throughout the project, we employed various evaluation metrics such as ROUGE and BLEU scores to assess the performance of the chatbot and ensure its effectiveness in generating accurate and contextually relevant responses.

By integrating cutting-edge technologies with real-world financial data, we've created a platform that not only empowers users with actionable insights but also fosters meaningful engagement and interaction. From parsing financial metrics to crafting intuitive user experiences, each aspect of the project has been meticulously designed to deliver tangible value to our users and stakeholders alike.

As we conclude this project, we reflect on the strides we've made and the challenges we've overcome. Moving forward, we remain steadfast in our pursuit of innovation, continuously seeking new ways to leverage technology for the betterment of financial decision-making.

In essence, this project represents more than just a culmination of efforts—it's a testament to our vision for a smarter, more connected future. As we embark on the next chapter of our journey, we do so with optimism and determination, fuelled by the belief that the intersection of finance and technology holds boundless potential for positive change.

12. RECOMMENDATION

Investo is currently in its early stages, with a plethora of potential features and enhancements awaiting integration into the platform. Notably, one of our primary challenges lies in the limited scope of available data. Presently, we have been operating with data sets encompassing 51 companies spanning the timeframe of 2009 to 2022. However, our prospects are marked by the promise of boundless data accessibility. Leveraging API keys and diverse data sources, we can ensure a continuous influx of the latest data to address evolving user inquiries. Furthermore, our model exhibits adaptability to a wide array of data inputs, facilitating seamless integration of additional datasets.

Looking ahead, we envision the implementation of subscription-based access to our platform as a viable avenue for sustainability. Through tiered package plans, users would gain access to enhanced features and refined data analytics, incentivizing investment in the platform. This strategic approach would enable us to further refine our models, delivering increasingly precise and comprehensive insights to our user base.

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14. APPENDICES

Appendix A: Screenshot of our datasets

Appendix B: Macrotrends (the site we used to collect our data)

Appendix C: Architecture of our project

Appendix D: QR code of our chatbot

Appendix E: Screenshot of our website