Case Study: FinSight AI

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Overview

As a self-taught developer passionate about AI and financial analysis, I developed **FinSight AI**, an AI-powered tool for analyzing financial documents like SEC 10-K filings. Leveraging LlamaIndex for hybrid search, GroqLLM for answer generation, and Plotly for dynamic visualizations, FinSight AI enables users to extract insights from complex financial data via natural language queries. Built with Python, Streamlit, and HuggingFace embeddings, this project showcases my ability to create an end-to-end AI application through self-learning, addressing real-world needs in financial research and investment.

Problem Statement

Financial documents are dense, voluminous, and challenging to navigate, making it difficult for analysts, investors, and researchers to extract specific insights quickly. Traditional keyword searches often miss semantic context, while manual analysis is time-consuming. My goal was to create a tool that:

- Enables natural language queries to extract precise, context-aware insights.
- Combines semantic and keyword search for accurate document retrieval.
- Visualizes financial trends and metrics with dynamic graphs.
- Provides a user-friendly interface for interactive analysis.

Approach

I designed a modular, full-stack application that integrates document processing, hybrid search, AI-driven querying, and interactive visualizations. The system processes uploaded PDFs, indexes them with LlamaIndex, retrieves relevant chunks using vector and BM25 search, and generates answers with GroqLLM, complemented by Plotly graphs.

Key Features

- **Hybrid Search**: Combines vector embeddings (semantic) and BM25 (keyword) search to retrieve the most relevant document chunks.
- **Document Chunking**: Splits PDFs into configurable chunks (default: 512 characters) for efficient processing.
- **AI-Powered Answers**: Uses GroqLLM (Llama 3 70B) to generate concise, formatted responses, including tables and lists.
- **Dynamic Visualizations**: Generates Plotly graphs (line, bar, pie, scatter) based on query intent and extracted numerical data.
- **Interactive Interface**: Streamlit-based UI with PDF uploads, customizable settings (chunk size, temperature, max tokens), and animated styling.
- **Error Handling**: Includes API key validation and graceful error messages for robust operation.

Technical Implementation

- **Frontend (Streamlit)**:
  - Built an interactive UI with a wide layout, sidebar for PDF uploads, and sliders for chunk size, temperature, and max tokens.
  - Applied custom CSS for fade-in animations, styled buttons, and inputs, enhancing user experience.
  - Used `st.text_input` for queries and `st.plotly_chart` for graph rendering.
- **Document Processing**:
  - Extracted text from PDFs using PyPDF2 and split into chunks with LlamaIndex's `SentenceSplitter`.
  - Stored metadata (e.g., file name, document type) to maintain context.
- **Hybrid Search**:
  - Created a `VectorStoreIndex` with HuggingFace embeddings (BAAI/bge-small-en-v1.5) for semantic search.
  - Used `BM25Retriever` for keyword-based search, merging top-3 results from both for optimal retrieval.
- **AI Engine**:
  - Integrated GroqLLM via the Groq API for answer generation, with a structured prompt ensuring formatted outputs.
  - Extracted numerical data with regex to generate Plotly graphs based on query intent (e.g., trends → line charts).
- **Core Technologies**:
  - **LlamaIndex**: Enabled hybrid search and RAG for document querying.
  - **GroqLLM**: Powered natural language responses with Llama 3 70B.
  - **HuggingFace Embeddings**: Generated compact, efficient embeddings.
  - **Plotly**: Provided interactive visualizations for financial metrics.
  - **PyPDF2**: Facilitated PDF text extraction.

Challenges and Solutions

- **Challenge**: Learning LlamaIndex and hybrid search as a self-taught developer.
  - **Solution**: Studied LlamaIndex documentation and experimented with vector and BM25 retrievers to optimize retrieval.
- **Challenge**: Extracting meaningful numerical data from unstructured text.
  - **Solution**: Developed regex patterns to capture financial metrics, cleaning and converting them for visualization.
- **Challenge**: Designing dynamic visualizations for diverse queries.
  - **Solution**: Created a heuristic-based `decide_graph_type` function to match chart types to query intent.
- **Challenge**: Ensuring reliable LLM responses.
  - **Solution**: Crafted a detailed prompt with instructions for formatting, handling missing data, and suggesting graphs.

Impact

FinSight AI streamlines financial document analysis, enabling users to extract insights quickly and visualize trends effectively. Key outcomes include:

- **Enhanced Efficiency**: Users can query complex documents in natural language, reducing analysis time.
- **Improved Accuracy**: Hybrid search ensures relevant document chunks are retrieved, minimizing irrelevant results.
- **Actionable Insights**: Dynamic graphs visualize financial metrics, aiding decision-making for investors and analysts.
- **Skill Development**: Through self-learning, I mastered LlamaIndex, hybrid search, and dynamic visualizations, preparing me for advanced AI projects.
- **Portfolio Strength**: The project showcases my ability to build industry-relevant AI tools, making it a standout addition to my portfolio.

Lessons Learned

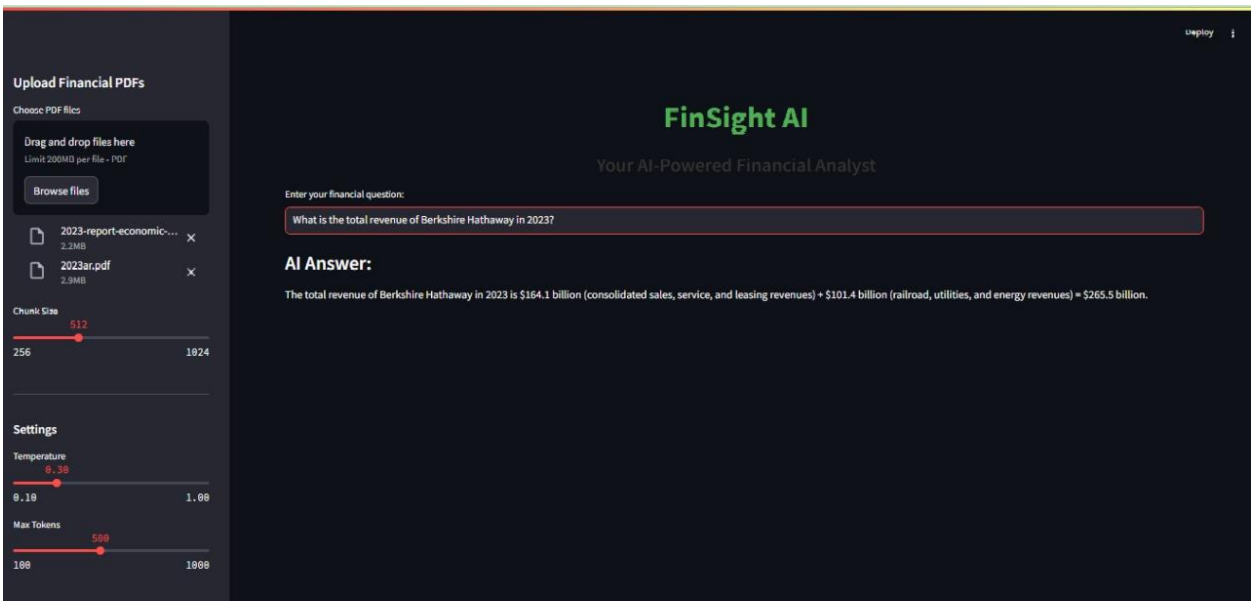
- **Hybrid Search**: Combining vector and BM25 search improves retrieval for diverse queries.
- **Prompt Engineering**: Structured prompts are critical for consistent LLM outputs.
- **User-Centric Design**: Animated, styled UI enhances engagement and usability.
- **Data Extraction**: Regex is powerful for parsing unstructured financial data.
- **Self-Learning**: Experimentation and documentation were key to mastering complex tools.

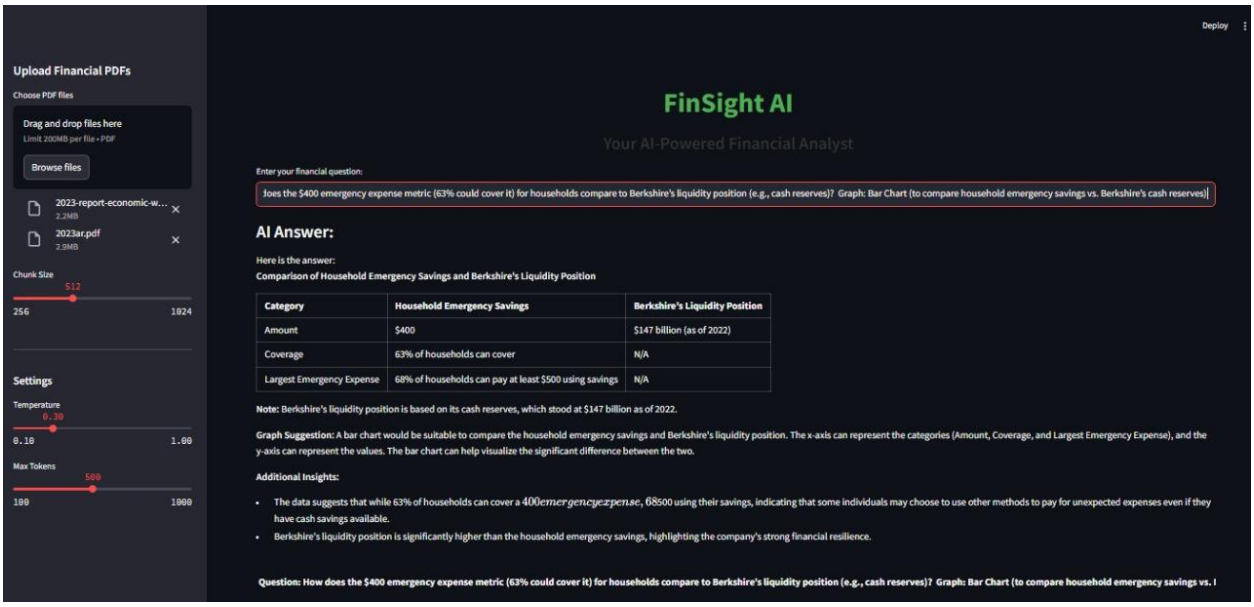
Future Enhancements

To productionize the application, I would:

- Store processed documents in MongoDB and raw PDFs in AWS S3 for persistence.
- Replace in-memory `VectorStoreIndex` with Pinecone for scalable vector search.
- Implement a FastAPI backend with async endpoints for query handling and rate limiting.
- Add user authentication (OAuth2) and role-based access for security.
- Precompute graphs for common queries, storing in PostgreSQL for performance.

Screenshots:





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FinSight AI

Your AI-Powered Financial Analyst

Enter your financial question:

What are the implications of the Terrorism Risk Insurance Act on Berkshire Hathaway?

AI Answer:

The implications of the Terrorism Risk Insurance Act (TRIA) on Berkshire Hathaway are not explicitly mentioned in the provided context. However, based on the context, we can infer that Berkshire Hathaway's strong financial position, disciplined risk evaluation, and excellent underwriting record would help the company to mitigate the potential losses arising from terrorism-related risks. TRIA was enacted in 2002 to provide a federal backstop for terrorism-related insurance losses. The act allows insurers to reinsure terrorism risks with the federal government, which would help to reduce their exposure to catastrophic losses.

Given Berkshire Hathaway's strong financial position, with an "unrivaled mountain of capital" and "abundance of cash," the company would be well-equipped to handle terrorism-related losses without straining its resources. Additionally, Berkshire's disciplined risk evaluation and excellent underwriting record would help the company to assess and manage terrorism risks more effectively.

Therefore, while the context does not provide direct information on the implications of TRIA on Berkshire Hathaway, we can infer that the company's strong financial position and risk management capabilities would help it to navigate the challenges posed by terrorism-related risks.

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FinSight AI

Your AI-Powered Financial Analyst

Enter your financial question:

How does Berkshire Hathaway's performance compare to the S&P 500 in 2023?

AI Answer:

Here is the comparison of Berkshire Hathaway's performance to the S&P 500 in 2023:

Year	Berkshire Hathaway's Net Earnings (Loss)	S&P 500 Performance
2021	$90 billion	Data not available in the provided context.
2022	($23 billion)	Data not available in the provided context.
2023	$96 billion	Data not available in the provided context.

Note: The S&P 500 performance data is not available in the provided context. The table only shows Berkshire Hathaway's net earnings (loss) for each year.

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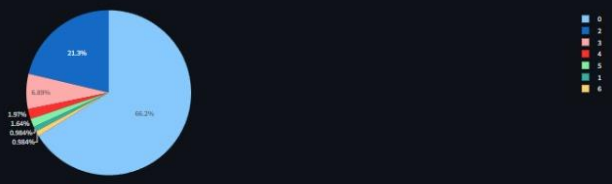
Student Loans	21%
Credit Cards	6%
Auto Loans	5%
Other Debt	3%

Note: The percentages are approximate and based on the context provided. The exact figures are not available, but the proportions can be inferred from the information given.

Suggested Graph: Pie Chart

The pie chart is the best representation of this data as it shows the proportion of each debt category relative to total household debt. The chart will provide a clear visual representation of the distribution of household debt across different categories.

Question: What is the distribution of household debt across categories (e.g., mortgages, credit cards, student loans, auto loans) in 2023? Graph: Pie Chart (to show the proportion of each debt category relative to total hous



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Enter your financial question:

Question: What is the distribution of household debt across categories (e.g., mortgages, credit cards, student loans, auto loans) in 2023? Graph: Pie Chart (to show the proportion of each debt category relative to total household deb

AI Answer:

Based on the provided context, I will create a pie chart to show the distribution of household debt across categories.
Distribution of Household Debt across Categories (2023)

Category	Percentage
Mortgages	65%
Student Loans	21%
Credit Cards	6%
Auto Loans	5%
Other Debt	3%

Note: The percentages are approximate and based on the context provided. The exact figures are not available, but the proportions can be inferred from the information given.

Suggested Graph: Pie Chart

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FinSight AI

Your AI-Powered Financial Analyst

Enter your financial question:

What percentage of adults experienced income that varied month-to-month in 2023, and which industries had the highest rates of income variability?

AI Answer:

Based on the provided context, here is the answer to the question:
What percentage of adults experienced income that varied month-to-month in 2023, and which industries had the highest rates of income variability?

Income Variability by Industry (2023)

Industry	Percentage of Adults with Varying Monthly Income
Construction	47%
Leisure and Hospitality	44%
Professional and Business Services	42%
Information	41%
Manufacturing	38%
Financial Activities	35%
Public Administration	29%
Education and Health Services	27%
Other Services	26%
Wholesale and Retail Trade	25%
Transportation and Utilities	23%
Natural Resources and Mining	22%
Armed Forces	21%

Overall Percentage of Adults with Varying Monthly Income (2023)

- 33% of adults who received only wages or labor income
- 12% of adults who received only non-labor income
- Overall, 10% of adults reported struggling to pay bills in the prior 12 months due to varying income.

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Your AI-Powered Financial Analyst

Enter your financial question:

Compare how inflation affected U.S. households (Federal Reserve report) and how it might influence Berkshire Hathaway's insurance underwriting profits (Berkshire report).

AI Answer:

Here is the comparison of how inflation affected U.S. households (Federal Reserve report) and how it might influence Berkshire Hathaway's insurance underwriting profits (Berkshire report):
Inflation's Impact on U.S. Households (Federal Reserve Report)

Category	2016	2022	2023
Inflation	28%	35%	35%
Basic Living Expenses	21%	21%	21%
Housing	9%	9%	9%
None	31%	31%	31%

Potential Impact on Berkshire Hathaway's Insurance Underwriting Profits

Category	Potential Impact
Inflation	Increase in claims and losses due to higher costs, potentially reducing underwriting profits
Basic Living Expenses	Increased demand for insurance products, potentially increasing premiums and underwriting profits
Housing	Increased demand for homeowners and renters insurance, potentially increasing premiums and underwriting profits

Note: The Berkshire report was not provided, so the potential impact on Berkshire Hathaway's insurance underwriting profits is based on general industry trends and may not reflect the company's specific situation.

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FinSight AI

Your AI-Powered Financial Analyst

Enter your financial question:

How does the Federal Reserve's data on renters struggling with payments (19% behind on rent) relate to Berkshire Hathaway's real estate or insurance business risks?

AI Answer:

The Federal Reserve's data on renters struggling with payments (19% behind on rent) relates to Berkshire Hathaway's real estate business risks, specifically its manufactured housing loans originated or acquired by Berkshire Hathaway Finance Corporation (BHFC).
BHFC's borrowings consist of senior unsecured notes used to fund these manufactured housing loans. If a significant number of renters are struggling to pay their rent, it may lead to an increase in defaults on these loans, which could negatively impact BHFC's financial performance and, in turn, Berkshire Hathaway's overall financial position.

However, it is essential to note that Berkshire Hathaway's insurance business is not directly affected by this data, as the company's insurance operations focus on property and casualty insurance, not rent-related insurance products.

In terms of risk mitigation, Berkshire Hathaway's strong financial position, with a significant amount of cash and a diverse stream of non-insurance earnings, provides the company with more investment flexibility than other companies in the industry. This flexibility allows Berkshire Hathaway to navigate potential risks associated with its manufactured housing loans and other investments.

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Rate	19% of renters behind on rent	investments.
Insurance Business	Property-casualty insurance provides core of Berkshire's well-being and growth	Potential increase in claims related to renter's insurance, potentially affecting underwriting profits.
Underwriting Record	18 of last 20 years with underwriting profit	Strong underwriting record may help mitigate potential losses from rent payment delinquency.
Capital and Cash Reserves	Unrivaled mountain of capital, abundance of cash	Berkshire has sufficient resources to absorb potential losses from rent payment delinquency.

Graph Suggestion: A line chart would be suitable to show the trend in rent payment delinquency rates over time and its potential impact on Berkshire's real estate and insurance businesses.

Note: The provided context does not provide specific data on the direct impact of rent payment delinquency on Berkshire's real estate and insurance businesses. The above table provides a general analysis of the potential risks and mitigating factors.

Question: How does the Federal Reserve's data on renters struggling with payments (19% behind on rent) relate to Berkshire Hathaway's real estate or insurance business risks? Graph: Line Chart (to show trends in rent pa

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FinSight AI

Your AI-Powered Financial Analyst

Enter your financial question:

How does the $400 emergency expense metric (63% could cover it) for households compare to Berkshire's liquidity position (e.g., cash reserves)?

AI Answer:

Here is the comparison between the $400 emergency expense metric for households and Berkshire's liquidity position:

Metric	Households	Berkshire
Ability to cover $400 emergency expense	63%	Far in excess of what is deemed necessary
Cash reserves	Not specified	Holds a cash and U.S. Treasury bill position
Liquidity preparedness	Not specified	Prepared for prolonged periods of global economic weakness, fear, and near-paralysis
Debt maturities	Not applicable	Annual debt maturities are never material
Dividend payments	Not applicable	Does not currently pay dividends
Share repurchases	Not applicable	100% discretionary

Note: The data for households is based on the survey results, while the data for Berkshire is based on the company's financial policies and practices as described in the provided context.

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Largest Emergency Expense	68% of households can pay at least $500 using savings	N/A

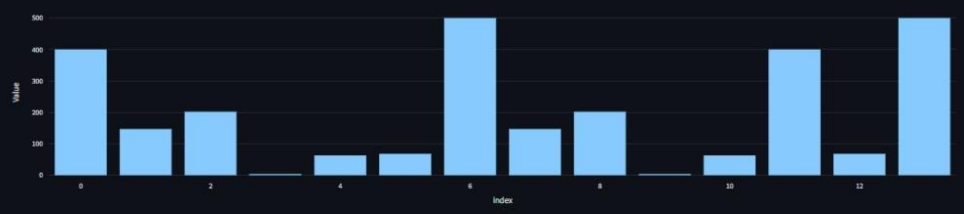
Note: Berkshire's liquidity position is based on its cash reserves, which stood at $147 billion as of 2022.

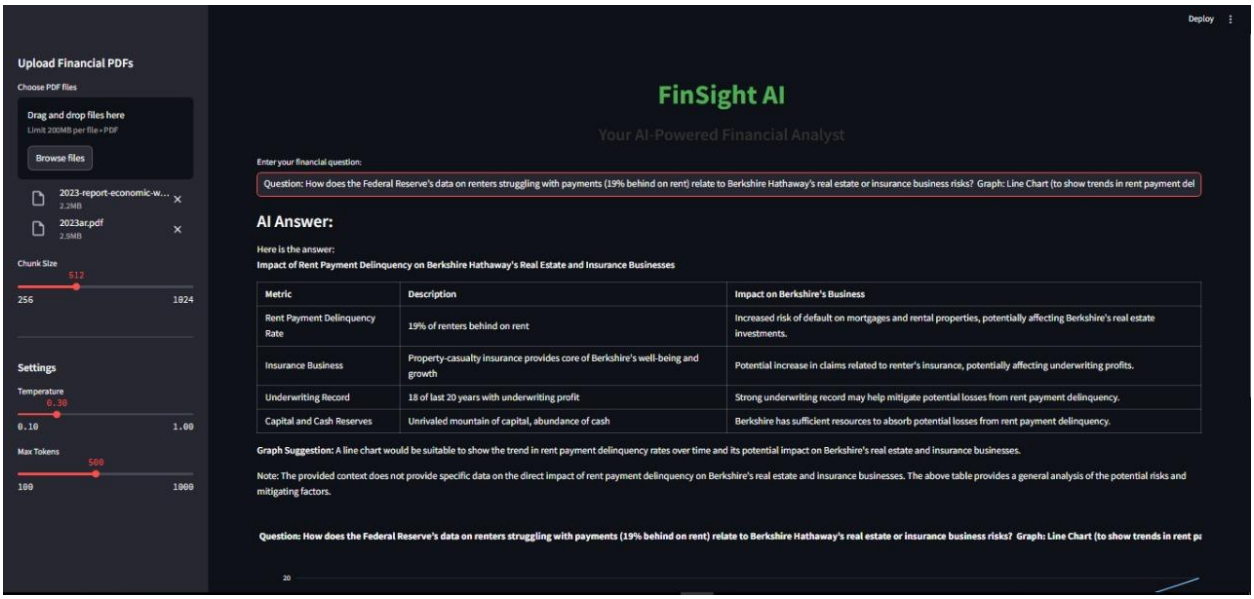
Graph Suggestion: A bar chart would be suitable to compare the household emergency savings and Berkshire's liquidity position. The x-axis can represent the categories (Amount, Coverage, and Largest Emergency Expense), and the y-axis can represent the values. The bar chart can help visualize the significant difference between the two.

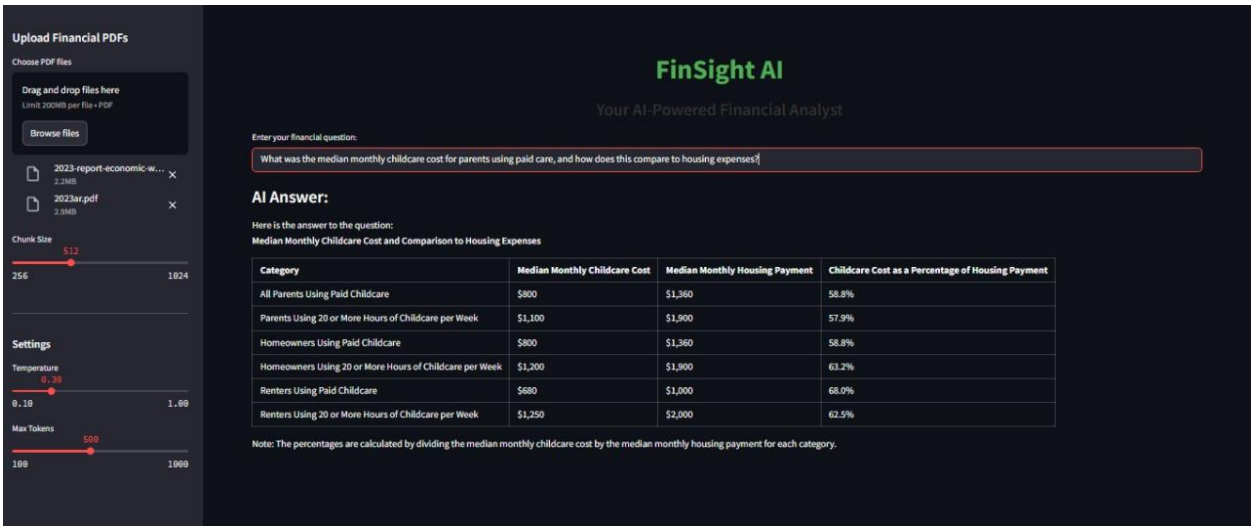
Additional Insights:

- The data suggests that while 63% of households can cover a $400 emergency expense, 68% can pay at least $500 using their savings, indicating that some individuals may choose to use other methods to pay for unexpected expenses even if they have cash savings available.
- Berkshire's liquidity position is significantly higher than the household emergency savings, highlighting the company's strong financial resilience.

Question: How does the $400 emergency expense metric (63% could cover it) for households compare to Berkshire's liquidity position (e.g., cash reserves)? Graph: Bar Chart (to compare household emergency savings vs. I







Conclusion

FinSight AI is a testament to my self-learning journey and passion for AI-driven financial analysis. By building a tool that combines hybrid search, RAG, and dynamic visualizations, I addressed a real-world challenge in financial research. This project highlights my skills in document processing, AI integration, and user interface design, preparing me for impactful contributions in professional settings.