

CS787 Project Report

AlphaAgents

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Abstract

This project explores the use of a Large Language Model based multi-agent system to support stock investment decision-making. The framework enables multiple specialized agents to independently analyze a stock from different financial perspectives and then collaborate through structured discussion to reach a unified recommendation. By integrating diverse viewpoints such as fundamentals, valuation, sentiment, and technical indicators, the system aims to produce more balanced and well-reasoned conclusions compared to a single-model approach. When tested on real market data, the multi-agent collaboration generated investment decisions that were more transparent and better supported by evidence. The results demonstrate the potential of coordinated agent-based reasoning for improving equity research and portfolio management.

1 Introduction

Equity portfolio management requires analyzing large amounts of financial information and forming decisions based on diverse and often fast-changing data sources. Traditionally, this work is carried out by human analysts who must interpret financial reports, market sentiment, price trends, and economic indicators to recommend investment actions. However, the volume and complexity of information involved can make the process demanding and susceptible to human limitations, such as cognitive bias, emotional influence, and inconsistent judgment.

Recent advancements in artificial intelligence, particularly Large Language Models, have created opportunities to support and enhance equity research by enabling automated reasoning over unstructured financial data. In addition, multi-agent systems have emerged as a promising approach for complex decision-making, where multiple AI agents collaborate using different analytical perspectives rather than relying on a single model.

Motivated by these developments, this project investigates whether a coordinated multi-agent framework can contribute to more reliable and transparent investment decisions. The goal is to evaluate how combining multiple viewpoints can strengthen the investment process and provide a structured, explainable alternative to both manual decision-making and single-model AI outputs. Through experiments on real stock data, the project aims to explore the practical

value of collaborative agentic reasoning in supporting equity research and portfolio management.

2 Methodology

2.1 Multi-agent System for Equity Research

Equity research involves collecting and analyzing a wide range of financial information, such as company financial statements, historical stock performance, market sentiment, and technical indicators. Working with such diverse data can be complex and time-consuming, and decisions may be influenced by individual interpretation or bias. To address these challenges, this project implements a multi-agent system using Large Language Models to assist in stock evaluation and investment decision-making.

In this system, multiple AI agents analyze the same stock independently from different financial perspectives and contribute their reasoning to a shared decision process. A moderator agent coordinates a structured discussion, allowing each analyst to justify and refine their conclusions, and a final conclusion agent produces a unified buy or sell recommendation based on the collective insights. This collaborative approach aims to create more transparent and well-supported investment decisions by combining diverse viewpoints rather than relying on a single analytical source.

The key responsibilities of each agent in the system are as follows:

- **Fundamental Agent:** The Fundamental Analyst evaluates a company's financial health using its most recent financial reports. The agent extracts key metrics such as revenue growth, profitability, debt levels, cash flow, and risk factors through natural language queries on structured financial documents. Based entirely on this evidence, it forms a data-driven assessment of performance and provides a justified Buy or Sell recommendation.
- **Sentiment Agent:** The Sentiment Analyst examines recent news articles, analyst opinions, and corporate disclosures to assess market perception of the stock. By identifying major themes, risks, and opportunities within current reporting, the agent determines the overall sentiment as positive, negative, or neutral and recommends a Buy or Sell position based on likely market reaction.
- **Valuation Agent:** The Valuation Agent evaluates a stock by analyzing historical price performance and

volatility to understand its risk-return profile. Using financial metrics such as annualized returns, annualized volatility, and trend consistency, the agent determines whether the stock is fairly priced relative to its historical behavior. By interpreting long-term valuation patterns and market expectations, the agent forms an evidence-based perspective on the stock's investment attractiveness and provides a justified Buy or Sell recommendation grounded in quantitative analysis.

- **Technical Agent:** The Technical Agent focuses on price action and market psychology to identify potential trading opportunities. The agent reviews technical indicators including moving averages, RSI, and MACD, along with chart formations and momentum signals, to assess short- and medium-term market direction. Through analysis of support and resistance levels, trend reversals, and breakout patterns, the agent predicts likely price movements and offers a trading-oriented recommendation such as Buy or Sell supported by technical evidence.

2.1.1 System Data Description. The system utilizes multiple financial data sources, each made available only to the agent responsible for its corresponding analytical role. The key data features and their allocation across agents are summarized in Table 1.

Feature	Availability	Description
Ticker	All Agents	Unique symbol of a publicly traded company's stock.
Price (Open, High, Low, Close)	Valuation Agent & Technical Agent	Initial, highest, lowest, and final trading prices within a given period.
Volume	Valuation Agent	Total number of shares traded during a specific period.
Balance Sheet Data and Uploaded Financial PDFs	Fundamental Agent	Structured financial statement data obtained from yfinance for evaluating financial health.
News Articles	Sentiment Agent	Financial news fetched using Google News & Bing News scrapers.

Table 1. Feature description

2.1.2 Role Prompting: Role prompting is a prompt-engineering method where an agent is given a specific role or context to produce more relevant and focused outputs. In our system, we applied role prompting by clearly defining the objectives of each agent, improving task-specific reasoning and accuracy.

- **Valuation Agent:** "As a valuation equity analyst, your primary responsibility is to analyze the valuation trends of a given asset or portfolio over an extended time horizon. You must analyze historical valuation data, identify trends and patterns in valuation metrics over time, and interpret the implications of these trends for investors or stakeholders."
- **Sentiment Agent:** "As a sentiment equity analyst, your primary responsibility is to analyze financial news, analyst ratings, and disclosures related to the underlying security. You must interpret their implications and assess the sentiment for investors or stakeholders."
- **Fundamental Agent:** "As a fundamental financial equity analyst, your primary responsibility is to analyze the most recent Financial report provided for a company. You have access to a powerful tool that extracts relevant information from the Financial. Your analysis should be based solely on the information retrieved using this tool. You can interact with the tool using natural language queries, and it will return relevant text snippets and data points from the Financial Reports. Keep checking if you have answered the users' question to avoid looping."
- **Technical Agent:** "You are an expert technical analyst with deep knowledge of chart patterns, technical indicators, and market psychology. You use historical price data to identify trends and potential entry/exit points."

2.1.3 Agent Tools: Each agent in the system is supported with dedicated tools and data sources designed specifically for its analytical role. The tools utilized by each agent are described below:

- **Valuation Agent**
 - Computes annualized return and annualized volatility using recent historical stock price data.
 - Annualized return $R_{\text{annualized}}$ is calculated as:

$$R_{\text{annualized}} = (1 + R_{\text{cumulative}})^{\frac{252}{n}} - 1,$$

where $R_{\text{cumulative}}$ represents the cumulative return and n is the number of observed trading days.

- Annualized volatility $\sigma_{\text{annualized}}$ is derived from daily log-return volatility:

$$\sigma_{\text{annualized}} = \sigma_{\text{daily}} \times \sqrt{252}.$$

- **Sentiment Agent**
 - Automatically gathers recent financial news related to the target stock.
 - Extracts and summarizes textual content from collected articles for sentiment evaluation.
 - Produces sentiment-oriented insights based on market commentary, analyst opinions, and corporate announcements.
- **Fundamental Agent**

- Uses fundamental_analysis_tool to retrieve and summarize the latest balance sheet data from the yfinance API.
- Enables automated interpretation of financial metrics such as profitability, liquidity, leverage, and cash flow.
- Utilizes a Retrieval-Augmented Generation tool (CustomRagTool) to query uploaded financial PDF documents through semantic chunking and vector search.
- Returns relevant context segments to support detailed, evidence-based decision making.

- **Technical Agent**

- Computes core technical indicators including SMA, EMA, RSI, and MACD directly from historical stock price data.
- Analyzes momentum trends, support/resistance levels and breakout signals.
- Uses an integrated signal-generation tool to produce consolidated trading recommendations such as BUY or SELL.

2.1.4 Multi-Agents Collaboration: To coordinate the four specialist agents, a dedicated Moderator agent is employed to manage the interaction and ensure that each analyst contributes its perspective in an organized manner. After all individual analyses are presented, a Conclusion agent consolidates insights from all agents to generate a unified investment decision.

- **Moderator Prompt:** "You are a neutral and fair investment debate moderator with deep market experience. You ensure that each agent has the chance to present their case and that the debate remains productive. Each agent should provide their opinion on what the strategy should be, and all of them must come to a final consensus that they agree on."
- **Conclusion agent Prompt:** "You are a neutral and fair investment analyst with deep market experience. After the debate, analyze the discussion carefully and provide a final investment decision."

2.1.5 Multi-Agent Debate Mechanism. The system conducts a structured debate using a Round-Robin process, where each agent presents and defends its position sequentially while responding to peer analyses. The Moderator ensures balanced participation and guides the discussion toward consensus.

Prompt: "Moderate a structured debate between the Fundamental Analyst, Sentiment Analyst, Technical Analyst and Valuation Analyst. Each analyst independently proposes a BUY or SELL position, defends their reasoning, challenges opposing views, and responds to critiques. Ensure each analyst has at least two turns to speak. The goal is to highlight the strengths

and weaknesses of each position and move toward a consensus recommendation."

2.2 Multi-Agent Workflow

Once the system is executed with a selected stock ticker, the multi-agent workflow begins by sequentially activating each specialist agent to independently analyze the stock from its respective financial perspective. Each agent produces an evidence-based BUY or SELL opinion along with a confidence score derived from its analytical tools and data sources. After the completion of individual analyses, the Moderator agent initiates a structured debate in which every agent is required to defend and justify its position while challenging conflicting viewpoints. The moderator ensures equal participation and keeps the discussion focused on achieving convergence rather than unilateral decisions.

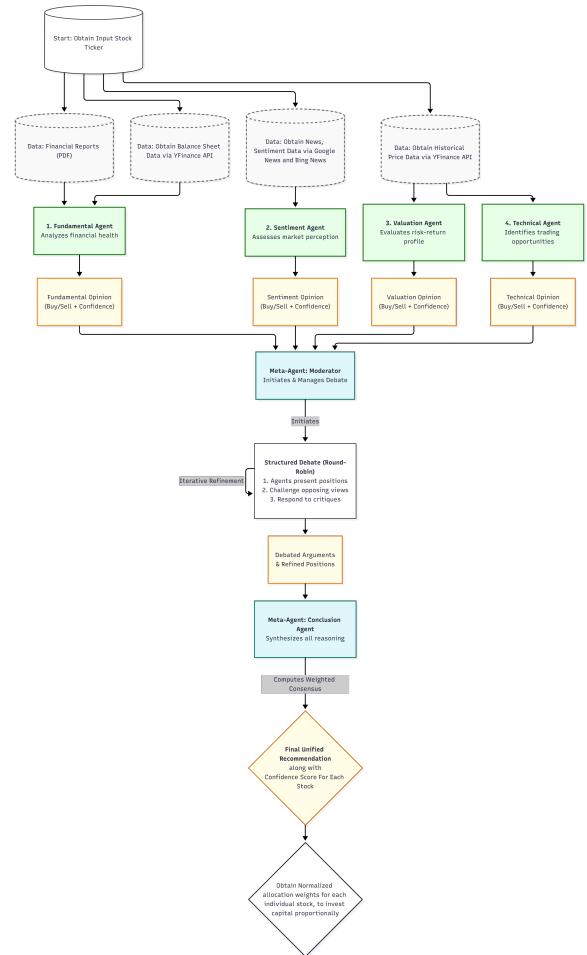


Figure 1. Workflow of the proposed Architecture

Following the debate, the Conclusion agent synthesizes the reasoning and confidence scores provided by all four analysts and computes a weighted consensus decision. This final output consists of a unified BUY or SELL recommendation

along with a numerical confidence score between -1 and $+1$, reflecting the collective judgment rather than the dominance of any single perspective. Through this workflow, the system emulates real-world investment committee dynamics, enabling transparent, explainable, and collaboratively reasoned decision-making.

3 Evaluation Metrics

In finance, portfolio evaluation is fundamentally two-fold: we seek to (i) increase mean returns and (ii) reduce variance. To assess our AlphaAgent portfolio against the benchmark, we therefore compare both its relative return and its volatility over time. Volatility is measured as the standard deviation of daily portfolio values.

Additionally, we report the Sharpe Ratio, which jointly captures return and risk. Following the formulation used in the reference paper, the Sharpe Ratio is defined as:

$$S = \frac{R_p - R_f}{\sigma_p}, \quad (1)$$

where R_p is the portfolio return, R_f is the risk-free rate, and σ_p is the standard deviation of portfolio returns.

For rolling analysis, we use the windowed Sharpe measure:

$$S_{\text{rolling}}(t) = \frac{\bar{R}_{p,t-w+1:t} - R_f}{\sigma_{p,t-w+1:t}}, \quad (2)$$

where \bar{R} and σ denote the mean and standard deviation computed over a sliding window of size w .

This framework allows us to evaluate whether the AlphaAgent portfolio offers higher returns, lower risk, or superior risk-adjusted performance relative to the benchmark.

4 Results

- **Weight Allocation Result:** The valuation agent effectively mirrors the benchmark, making no independent adjustments to the stock selection. In contrast, the fundamental agent broadens the selection beyond the benchmark, reflecting a more diversified and fundamentals-driven approach. The combined multi-agent output is more selective than the fundamental agent alone, showing how coordinated reasoning helps refine and consolidate decisions while still maintaining wider coverage.
- **Backtest Result:** From the backtest, the multi-agent portfolio finished the period with roughly 1.2% higher cumulative return compared to the benchmark. In terms of risk-adjusted performance, its final rolling Sharpe ratio was about 0.20 higher than the baseline, indicating a modest but meaningful improvement in reward relative to volatility.

The standard deviation of daily returns for the multi-agent portfolio (0.0234) is almost identical to the benchmark

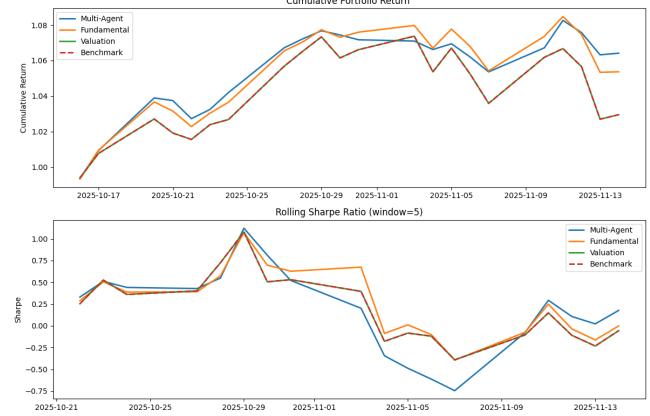


Figure 2. the multi-agent portfolio outperforms both single-agent portfolios in terms of cumulative return and rolling Sharpe ratio

(0.0235). Since volatility remains the same while mean return is higher, the basic mean-variance objective is satisfied.

5 Conclusion

The project demonstrates a multi-agent framework where separate fundamental, sentiment, technical and valuation agents collaborate to evaluate equities. Their coordinated reasoning produces more consistent and interpretable stock assessments by combining different analytical viewpoints and reducing individual bias. Although not a complete portfolio-optimization system, the approach acts as a strong base for building more advanced agent-driven investment tools and is easily scalable and can allow for more diverse agents in the future.

Backtesting shows that structured agent debate strengthens the reliability of decisions, particularly when signals disagree or when some agents have limited information. The recorded interaction history also offers clear insight into why the system reached specific conclusions, helping address the typical opacity of AI-driven financial models.

The debate process works like an investment committee, where different views are compared and resolved before making a decision. This makes the framework useful for supporting or automating human-guided decisions. With stronger infrastructure and cleaner data pipelines, it can scale into a transparent tool for large scale portfolio management.

References

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