# Research on Stock

**Purpose:**
=> Build a smart portfolio management system using Reinforcement Learning (RL)
=> Include stocks as a major asset class within the multi-agent system

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**About Stocks:**
A **stock** represents ownership in a company and constitutes a claim on part of the company's assets and earnings. Investors use individual stocks to target specific industries, growth stories, or income strategies.
**Example Stocks:**

- **AAPL** – Apple Inc.
- **MSFT** – Microsoft Corporation
- **GOOGL** – Alphabet Inc.

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**Market Regime Awareness via Stocks:**
Use stock performance and technical indicators to detect regimes:

| Regime | Stock Signals |
|---|---|
| Bull | Major indices (e.g., S&P 500, NASDAQ) ↑, VIX ↓ |
| Bear | Major indices ↓, defensive stocks ↑, VIX ↑ |
| Sideways | Low volatility, unclear directional trend |

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**Types of Stock Agents:**

| Agent Type | Stock Category | Example Tickers | Purpose |
|---|---|---|---|
| Index Agent | Blue-chip indices | AAPL, MSFT, JNJ | Capture broad market trends |
| Growth Agent | High-growth tech | TSLA, NVDA, SHOP | Alpha-seeking, momentum strategy |
| Dividend Agent | Income-focused stocks | T, VZ, KO, PFE | Yield harvesting, low volatility |
| Defensive Agent | Consumer staples/utilities | PG, XEL, WMT | Market hedge, safe-haven exposure |
| Small-Cap Agent | Emerging businesses | PLTR, UPST, RIVN | High-risk/high-reward |
| Thematic Agent | ESG, AI, Fintech | AI, SQ, CRWD | Trend-following |

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**Building the Multi-Agent System (Step-by-Step)**

**=> Step 1: Assign One Agent per Stock Category**

- Growth Agent follows fast-growing tech firms like TSLA or NVDA
- Dividend Agent monitors high-yield stocks like KO or PFE
- Defensive Agent watches non-cyclicals like PG or WMT

**=> Step 2: What Info Does Each Agent See?**

Each stock agent consumes:

- Historical stock prices (OHLCV)
- Technical indicators (RSI, MACD, Moving Averages)
- Volatility (Beta, ATR)
- News sentiment (from APIs like NewsAPI)
- Macro signals (Fed announcements, CPI data, etc.)

This info represents the **state** for each agent.

**=> Step 3: What Can Each Agent Do?**

Actions include:

- Allocate a % of portfolio to the stock (e.g., 30% to AAPL)
- Hold cash (risk-off mode)
- Rebalance or switch between stocks

**=> Step 4: How Do Agents Learn?**

Agents use reward signals like:

- Portfolio return – Volatility penalty
- Alpha over benchmark (e.g., SPY)
- Diversification bonus (if applicable)

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**Data Sources and APIs for Stock Information**

| API/Source | Purpose | Notes |
|---|---|---|
| **Yahoo Finance API** | Historical prices, volume, corporate data | Free via yfinance Python library |
| **Alpha Vantage** | Stock prices, fundamentals, indicators | Free tier available, requires API key |
| **IEX Cloud** | Real-time quotes, market depth | High-quality US market data |
| **Polygon.io** | Minute-level data, news | Paid tiers available for institutional-grade data |
| **Finnhub** | Financials, sentiment, earnings calendar | Good for alternative data |
| **NewsAPI** | Headlines from financial media | Combine with NLP models for sentiment signals |

| API/Source | Purpose | Notes |
|---|---|---|
| **Quandl (now Nasdaq Data Link)** | Fundamental and macroeconomic data | Used for high-level regime signals |

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**Why It Matters for Our Project**
Stocks offer:

- **Granular exposure** to company-level fundamentals
- **Higher alpha potential** with careful stock picking
- **Complementarity** with ETFs, bonds, and crypto
- **Market signal generation** via broad indices or specific sector leaders

# Research on ETFs

## Purpose:

=> Building a smart portfolio management system using Reinforcement Learning (RL)

## New Requirements:

=> The system should manage different types of assets like stocks, ETFs, crypto, bonds, etc.

=> Use multiple agents, each focusing on different asset types.

## About ETF:

An ETF (Exchange-Traded Fund) is like a basket of investments that you can buy or sell just like a stock. One ETF may contain many companies.

Example:
SPY = 500 big US companies (like Apple, Microsoft).

TLT = long-term government bonds.

GLD = gold.

## Market Regime Awareness via ETFs:

Use ETFs as regime proxies to classify market conditions:

| Regime | ETF Signal |
|---|---|
| Bull | SPY ↑, QQQ ↑, TLT ↓ |
| Bear | SPY ↓, VIX ↑, GLD ↑ |
| Sideways | Low volatility across SPY, QQQ, VIX |

## Types of ETF:

| Agent Type | ETF Category | Example Tickers | Purpose |
|---|---|---|---|
| Equity Agent | Broad Market | SPY, VTI | Stocks |
| Sector Agent | Sectoral | XLK, XLF, XLE | Technology, Finance, Energy |
| Bond Agent | Fixed Income | TLT, IEF, AGG | Interest rate exposure |
| Commodity Agent | Commodities | GLD, USO, SLV | Hedge strategies |
| Crypto Agent | Crypto ETFs | BTCC, BITO | Track Bitcoin price |
| Volatility Agent | VIX Products | VXX, UVXY | Market fear & hedging |
| Thematic Agent | Innovation | ARKK, KOMP | Trend-following strategies |

## Building the Multi-Agent System (Step-by-Step)

=> Step 1: Assign One Agent per ETF Type
Imagine you have a team of robots (agents):

One robot focuses on stock ETFs like SPY, QQQ

Another robot watches bond ETFs like TLT

Another follows crypto ETFs like BITO

Another one tracks gold or oil ETFs like GLD, USO

Each robot will learn how to invest smartly in its own type of ETFs.

=> Step 2: What Info Does Each Agent See?
Each agent needs to understand the market, so you'll show it:

Past prices of its ETF

Moving averages (price trends)

Volatility (how risky it is)

News sentiment (e.g., tweets saying "market is crashing!")

Market mood (bullish, bearish, etc.)

This collection of info is called the state of the market.

=> Step 3: What Can Each Agent Do?
Each agent can:

Decide how much money to put in its ETF (e.g., 50% in SPY, 50% in QQQ)

Do nothing if the market looks risky

These are its actions.

=> Step 4: How Do Agents Learn What's Right?
They learn using a reward system, like how a child learns from consequences.

Example:

If the ETF goes up after an agent invests → it gets a reward

If it picks a bad time → it gets penalized

Reward = Good returns - Too much risk

## Canadian ETF Market:

| Aspect | Canadian Market Snapshot |
|---|---|
| First ETF | Toronto 35 Index Participation Fund (1990) |
| Toal AUM | Over $400 billion CAD as of 2024 |
| Key Providers | BlackRock (iShares), BMO, Vanguard, Horizons, CI Global |
| Exchange | Toronto Stock Exchange (TSX) |
| Growth | Rapid growth in low-cost, thematic, and crypto-linked ETFs |
| Fees | Typically lower MER (Management Expense Ratio) than mutual funds |

## Why It Matters for our Project

The Canadian market offers:

=> A wide range of ETFs across sectors and asset classes

=> Access to crypto via TSX-listed ETFs (BTCC, ETHH)

=> Liquidity and low fees – good for realistic backtesting or paper trading

=> Regime-awareness options: We can compare Canadian sectors like energy (ZEO) or banks (ZEB) to detect trends.

| ETF Ticker | Description |
|---|---|
| ZCN | Broad Canadian stock index (S&P/TSX) |
| XIC | iShares Canadian Composite Index |
| ZEB | Canadian Banks ETF |
| XBB | Canadian Aggregate Bond Index |

| | |
|---|---|
| BTCC | Bitcoin ETF (Purpose) |
| VDY | High Dividend Yield Index |
| ZCLN | BMO Clean Energy Index ETF |

## Data Sources (for training our agents)

Yahoo Finance (ZCN.TO, XIC.TO, etc.)

TMX Money (https://money.tmx.com)

ETF provider websites (BMO, iShares, etc.)

## Data Collection Sources for ETFs:

Data Source besides “yfinance”
1. Alpha Vantage (Free, API key required)
🔗 [https://www.alphavantage.co](https://www.alphavantage.co)
What it provides:
=> Daily OHLCV for ETFs (same as stocks)
=> Technical indicators (e.g., RSI, MACD)
=> Real-time data (with delay on free tier)
Example API Call:
https://www.alphavantage.co/query?function=TIME_SERIES_DAILY&symbol=SPY&apikey=your_api_key

Pros:
=>Free with 500 calls/day
=> Includes tech indicators
Cons:
> 5 calls/minute rate limit
=> Output in JSON (needs parsing)

##2. IEX Cloud (Freemium)
🔗 [https://iexcloud.io](https://iexcloud.io)
What it provides:
=> OHLCV data

=> ETF price quotes and fundamentals
Example:
https://cloud.iexapis.com/stable/stock/SPY/chart/1y?token=YOUR_TOKEN
Pros:
=> Clean API
=> Supports JSON + CSV
=> Better docs than Alpha Vantage
Cons:
=> Limited free calls
=> U.S. ETFs only

##3. Polygon.io (Freemium)
🔗 [https://polygon.io](https://polygon.io)
What it provides:
=> Historical OHLCV
=> Real-time updates (paid)
=> Market-wide ETF/stock data
Sample Endpoint:
https://api.polygon.io/v2/aggs/ticker/SPY/range/1/day/2022-01-01/2023-01-01?apiKey=YOUR_KEY
Pros:
=> Fast, reliable
=> Suitable for high-frequency use
Cons:
=> Most features are paid
=> U.S. market focus

##4. Tiingo (Freemium)
🔗 [https://api.tiingo.com](https://api.tiingo.com)
What it provides:
=> Daily OHLCV
=> Technicals, real-time prices
Example:
plaintext
https://api.tiingo.com/tiingo/daily/SPY/prices?token=YOUR_API_KEY
Pros:
=> CSV/JSON options
=> Good ETF coverage
Cons:
=> Limited free quota
##5. Quandl (now Nasdaq Data Link)
🔗 [https://data.nasdaq.com](https://data.nasdaq.com)
What it provides:
=> U.S. ETF data

=> Economic and sector metrics
Example:
https://data.nasdaq.com/api/v3/datasets/EOD/SPY.json?api_key=YOUR_KEY
## Summary: Best Alternatives to `yfinance` for ETFs

| Source | Free? | Real-Time | Best For |
| --- | --- | --- | --- |
| Alpha Vantage | | ⏳ Delayed | Beginners, historical data |
| IEX Cloud | | | Clean JSON, U.S. ETFs |
| Polygon.io | | | Fast, scalable solutions |
| Tiingo | | | Easy CSV export |
| Nasdaq/Quandl | | ⏳ Delayed | Fundamentals + ETF history |

## References:


Exchange-Traded Fund (ETF): What It Is and How to Invest
ETF Facts - Canadian Securities Administrators
Global Corporate Actions Data for ETFs | ETF Data | Listed Funds including Distributions, Payments | Datarade


# Research on Crypto APIs and Market Indicators

- **What is Cryptocurrency?**

Cryptocurrency is a type of **digital or virtual money** that uses cryptography for security. Unlike traditional money issued by governments (like rupees or dollars), cryptocurrencies are **decentralized**—meaning they are not controlled by any central authority like a bank or government.
The most well-known cryptocurrency is **Bitcoin**, created in 2009. Since then, many others have been created, such as **Ethereum, Binance Coin, Solana, and Dogecoin**.

- **How Does It Work?**

Cryptocurrencies run on a technology called **blockchain**—a digital ledger that records all transactions across a network of computers. Each transaction is verified and added to the blockchain, making it **secure, transparent, and permanent**.

- The crypto market has **grown rapidly** over the past decade. Bitcoin started with almost no value, but now it's worth **tens of thousands of dollars**.
- Cryptocurrency prices **change very quickly**, which means there's a high risk—but also a high chance of a reward. This **volatility** makes crypto attractive for traders but risky for beginners.

**MARKET INDICATORS:**

Market indicators are tools used to **analyze cryptocurrency price movements**, trading volume, volatility, and investor sentiment. They help traders make smarter decisions by identifying market trends and potential entry/exit points.

**1. Price-Based Indicators**

- **Moving Averages (MA)**: Show average price over time; help identify uptrends/downtrends.
- **RSI (Relative Strength Index)**: Ranges from 0–100; >70 = overbought, <30 = oversold.
- **MACD**: Tracks momentum using two moving averages; shows buy/sell signals.

**2. Volume-Based Indicators**

- **OBV (On-Balance Volume)**: Combines price and volume to show buying/selling pressure.
- **Volume Oscillator**: Measures volume strength to indicate rising or falling interest.

**3. Volatility Indicators**

- **Bollinger Bands**: Wide bands = high volatility; narrow bands = low volatility.
- **ATR (Average True Range)**: Measures how much price moves; higher ATR = higher risk.

**4. Sentiment Indicators**

- **Fear & Greed Index**: Ranges from 0 (fear) to 100 (greed); gauges market emotion.
- **Social Media Trends**: Tracks hype across platforms; spikes may signal breakouts.

**There are many more indicators than the above stated.We Use Indicators because** They help in

- Understanding market trends
- Reducing emotional trading
- Improving timing of trades

To pull crypto data we are going to use API of some websites which can provide access to real-time and past crypto data. Some of them are

**yfinance** (Yahoo Finance Python Library) : Free Python package to access financial data, including some major cryptocurrencies

Binance API for real-time market data.

CoinMarketCap API, CoinGecko API, CoinDesk

Refrences:

1) https://www.kraken.com/learn/crypto-technical-indicators
2) https://www.tokenmetrics.com/blog/best-indicators-for-crypto-trading-and-analysis
3) https://coinmarketcap.com/charts/cmc100/
4) https://www.gemini.com/cryptopedia/crypto-indicators-token-metrics-crypto-fear-and-greed-index
5) https://pypi.org/project/yfinance/

# Research on Multi Agent RL

Algorithms where multiple small tasks are accomplished by agents in a shared environment to complete one bigger task. Each agent learns to make decisions based on its observation rewards and behavior of other agents in some cases.
There are two or more agents involved and the interaction between them is cooperative, competitional or mixed.
Type of Interactions

1. Cooperative
   Agents work together to accomplish common goals
2. Competitional
   Agents have opposing goals
3. Mixed
   Mixed between cooperation and competition

Key Challenges

1. Non-Stationarity
   With changes in other agent's behavior, the shared environment becomes more unpredictable
2. Credit Assignment
   It's hard to determine which agent had higher contribution in group reward setting while contributing to single goal
3. Scalability
   As the agents grow joint action space grows exponentially
4. Partial Observability
   Agent may lack full visibility of the environment or each other

**Meta-RL**
Meta RL is a field where agents learn how to quickly learn new tasks. Instead of taring for a single task, Meta-RL trains the agent to adapt quickly to new tasks using a small amount of data or experience.
Difference between traditional RL and Meta-RL
Traditional RL

- An agent trains for millions of steps on one task
- If the task changes (even slightly), training must start from scratch

Meta-RL

- The agent it trained on distribution of tasks
- At test time, it can quickly adapt to new but related tasks

How it works

1. Gradient-Based Meta-RL (Model-Agnostic Meta-Learning)
2. Recurrent Meta-RL (RNN-based)

Meta-RL Structure

- Meta Training Phase
  Training many tasks from task distribution
  Learn a policy or algorithm that can adapt
- Meta-Testing Phase
  Give new task, it adapts quickly using only a few episodes

Benefits

1. Sample efficiency
2. Generalization
3. Task adaptation

Challenges

1. Require many diverse training tasks
2. Computationally intensive
3. Defining task distribution can be tricky

**Contextual Bandits**
Agents learn to choose the best action for a given context to maximize the rewards over time.
Its balance between Exploration and Exploitation

- Exploration: Try new actions to learn
- Exploitation: Use bets known action for a context

How it works
Context □ Action □ Reward

1. Agents see the context

2. Chooses an action
3. Gets reward
4. Updates the strategy for future similar contexts

Common Algorithms

1. Epsilon-Greedy
2. LinUCB
3. Thompson Sampling
4. Neural Bandits

Benefits

- Fast to train, easy to update
- Doesn’t need full environment modeling like RL
- Strong for personalized experiences

Challenges

- No long-term planning
- Assuming action doesn’t affect future context
- May struggle with high dimensional contexts

**Why Contextual Bandit > Meta-RL in our case?**

1. Sample and effective for Policy Selection
2. Fast Decision making
3. Easier to Train and Debug
4. Integrates well with Sentiment + Macro Context

# Research on Paper Trading API and options


PAPER TRADING API and OPTIONS.pdf

# Research on Impact of Social Media Sentiments on the Stock Market

**Introduction**

In today's digital era, social media platforms have become pivotal in shaping public opinion and investor behavior. Platforms like Twitter, Reddit, and TikTok serve as real-time sources of information, where sentiments expressed can significantly influence stock market dynamics. The rapid dissemination of opinions, news, and rumors through these channels has introduced a new dimension to market volatility and investor decision-making.

**Understanding Social Media Sentiment**

Social media sentiment refers to the collective emotions and opinions expressed by users on social platforms regarding specific topics, companies, or financial instruments. Analyzing this sentiment involves assessing whether the public discourse is positive, negative, or neutral. Advanced techniques, including natural language processing (NLP) and machine learning algorithms, are employed to quantify and interpret these sentiments. For instance, studies have demonstrated that Twitter sentiment can be a significant predictor of stock market trends, highlighting the platform's influence on investor behavior .arXiv

**Case Studies Illustrating Impact**

**The GameStop Phenomenon**

A notable example of social media's impact on the stock market is the GameStop (GME) short squeeze in early 2021. Retail investors congregating on Reddit's r/WallStreetBets forum orchestrated a massive buying spree, propelling GME's stock price from under $20 to over $400 within weeks. This event underscored the power of collective action facilitated by social media, challenging traditional market dynamics and causing significant losses for hedge funds with short positions .Time

**Influence of Finfluencers**

The rise of financial influencers, or "finfluencers," on platforms like TikTok and Instagram has further exemplified social media's sway over the stock market. These individuals, often lacking formal financial credentials, can amass large followings and influence investment decisions through their content. Their recommendations have been linked to significant stock price movements, emphasizing the need for critical evaluation of information sources in the digital age .The Insurance Universe

**Mechanisms of Influence**

**Rapid Information Dissemination**

Social media enables instantaneous sharing of information, allowing news, rumors, and opinions to spread rapidly among investors. This immediacy can lead to swift market reactions, as seen in various instances where tweets or posts have triggered significant stock price fluctuations .

**Herd Behavior and Sentiment Contagion**

The phenomenon of herd behavior, where individuals mimic the actions of a larger group, is amplified on social media platforms. Positive sentiments can lead to increased buying activity, while negative sentiments may trigger widespread selling. This sentiment contagion can result in heightened market volatility and price swings .ScienceDirect

**Predictive Analytics and Algorithmic Trading**

Investment firms are increasingly incorporating social media sentiment analysis into their trading algorithms. By leveraging AI and big data analytics, these firms aim to predict market movements based on public sentiment trends. Such strategies have shown promise in enhancing the accuracy of market forecasts and informing investment decisions .

**Challenges and Considerations**

**Misinformation and Market Manipulation**

The unregulated nature of social media allows for the rapid spread of misinformation, which can mislead investors and distort market perceptions. Coordinated efforts to manipulate stock prices through false or exaggerated claims pose significant risks to market integrity .ScienceDirect

**Short-Term Impact and Volatility**

While social media sentiment can influence immediate stock price movements, its effects are often short-lived. Studies have indicated that the impact of social media sentiment on stock returns tends to diminish over time, with fundamental factors eventually prevailing .ScienceDirect

**Ethical and Regulatory Implications**

The growing influence of social media on financial markets raises ethical and regulatory concerns. Issues such as the spread of unverified information, potential conflicts of interest, and the need for investor protection necessitate the development of appropriate regulatory frameworks .

**Conclusion**

Social media has undeniably transformed the landscape of stock market investing. Its capacity to shape investor sentiment and influence market dynamics underscores the importance of understanding and monitoring online discourse. While it offers valuable insights and democratizes information access, it also presents challenges that require careful navigation. Investors and regulators alike must remain vigilant, ensuring that the integration of social media into financial markets promotes transparency, fairness, and stability.

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# Research on the explainability of model with LLMs

Stock Portfolio Allocation and Risk Management using FinRL/Reinforcement Learning

- **Action rationale**: Why did the RL agent choose a particular asset allocation?
- **Policy interpretation**: What is the strategy or behavior learned by the agent?
- **Risk assessment**: How are risk measures like volatility, Sharpe ratio, and drawdowns being handled?
- **State-action importance**: What market states most influence decisions?

**. Techniques for Explainability with LLMs**

**a. Natural Language Explanations from Logs**

Use LLMs to turn logs from your environment into explanations. For example:

- Track states (market conditions), actions (buy/sell/hold), and rewards.
- Feed sequences into an LLM to generate descriptions:
- Implement Explainable AI (XAI) in stock trading RL model, we need to analyze and interpret the decisions made by the PPO agent
- Use **SHAP** (SHapley Additive exPlanations) to understand feature contributions for the Q-network or policy network.
- Convert SHAP values into natural language summaries with LLMs

```
shap_summary = shap_explainer.shap_values(state)
prompt = f"""
Given these SHAP values for input features: {shap_summary},
explain how they influenced the agent's decision.
"""
```

**c. State Clustering + LLM Interpretation**

- Cluster similar states (e.g., bull, bear, volatile).
- Use LLMs to describe agent behavior in each cluster.

**. Visualization + LLM Commentary**

Combine plots (portfolio value, risk metrics, allocation changes) with LLM-generated summaries.
Example: “This dip in the portfolio coincides with increased volatility in the market. The agent responded by reallocating to lower-risk assets.”

**. Explain Risk Management Policies**

Use LLMs to interpret how your RL agent complies with risk controls:

- Maximum drawdown enforcement
- Portfolio diversification
- Stop-loss triggers

## . Visualization + LLM Commentary

- Combine plots (portfolio value, risk metrics, allocation changes) with LLM-generated summaries.
- Example: "This dip in the portfolio coincides with increased volatility in the market. The agent responded by reallocating to lower-risk assets."

**. Explain Risk Management Policies**

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- Stop-loss triggers

**LLMs and tools we can combine**

| | |
|---|---|
| Open Ai GPT-4 | General purpose explainability,financial narrative |
| Gemini | Regulatory compliance and wise decision |
| Meta LlaMa3 | Open source research prototypes |

## References

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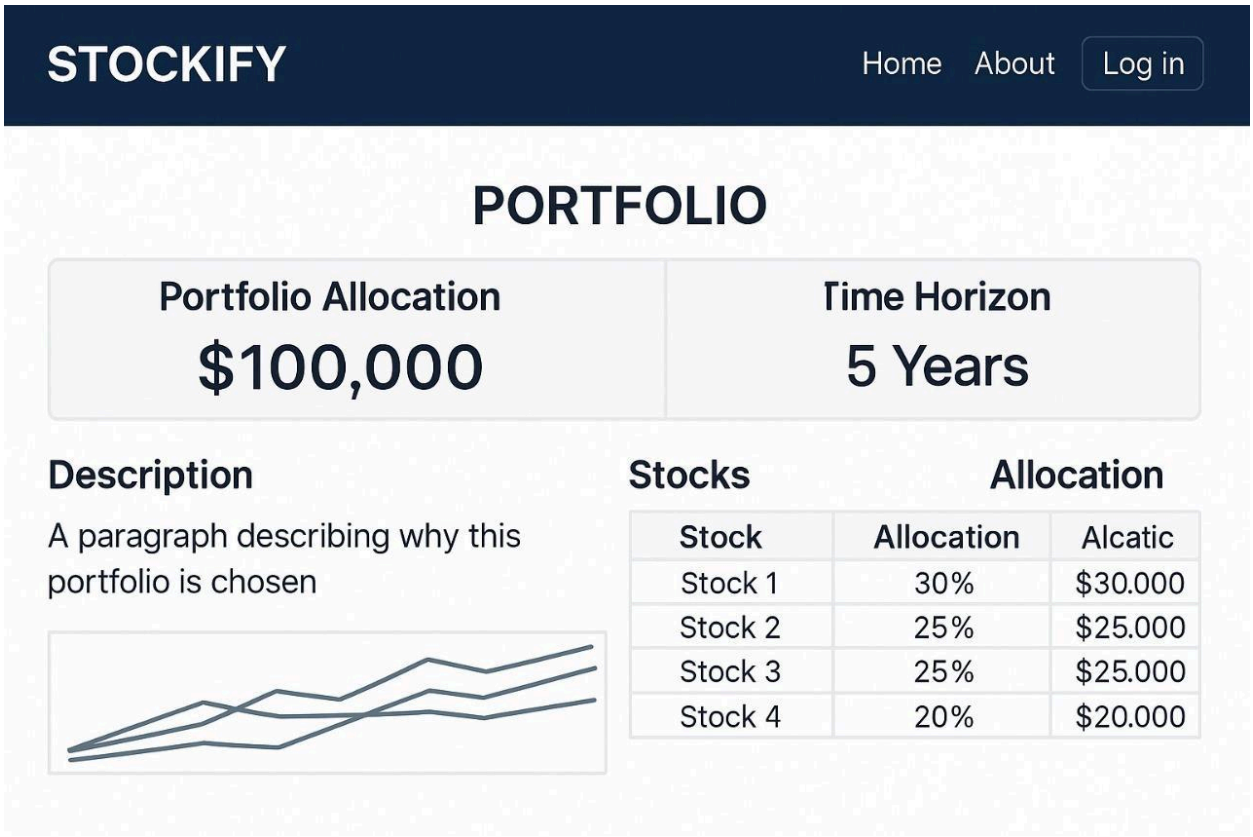
# Wireframe




Research on