AAI_520 Final Project - Documentation

Agentic AI for Financial Analysis

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Institution: University of San Diego
Course: AAI-520 Natural Language Processing and GenAI

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MSAAI_520 Assignment 7 - Agentic AI for Financial Analysis

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GitHub: https://github.com/denjcodes/AAI_520_Final_Project.git

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Overview

This notebook implements a **comprehensive autonomous Investment Research Agent System** that:

Plans research steps for stock analysis (Planner Agent)
Routes tasks intelligently to specialized agents (Router Agent)
Fetches real-time financial data (Yahoo Finance, News API, SEC)
Analyzes using multiple workflow patterns (Prompt Chaining, Routing, Evaluator-Optimizer)
Self-reflects on output quality with iterative improvement
Learns from previous analyses using persistent memory
Coordinates multiple specialized agents via Master Coordinator

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System Architecture

```
                     Investment Research Workflow
    ────────────────────────────────────────────────────────────────

                            User Request
                                  ↓
                   InvestmentResearchCoordinator
                                  ↓
                     Phase 1: Planning & Data Collection
                            • LeadAnalyst.plan()
                            • RoutingWorkflow → MarketAnalyst /
                                                 NewsAnalyst /
                                                 FundamentalAnalyst
                            • PromptChainWorkflow (News Processing)
                                  ↓
                     Phase 2: Initial Analysis Generation
                                  ↓
                     Phase 3: EvaluatorOptimizer
                            (Iterative Refinement)
                                  ↓
                     Phase 4: Self-Reflection (LeadAnalyst)
                                  ↓
                     Phase 5: Learning & MemoryAgent
                            (Persistent Knowledge)
                                  ↓
                     Executive Summary → JSON Output
```

Key Agentic Patterns Implemented:

1. **Prompt Chaining**: News Ingestion → Preprocessing → Classification → Extraction → Summarization
2. **Intelligent Routing**: Dynamic task allocation based on content analysis
3. **Evaluator-Optimizer**: Iterative quality improvement with feedback loops
4. **Memory & Learning**: Persistent context across sessions for continuous improvement
5. **Self-Reflection**: Agents critique their own outputs and trigger re-analysis

---

```python
# All imports
import json
import logging
import os
import pickle
import re
import time
from abc import ABC, abstractmethod
from dataclasses import dataclass, field
from datetime import datetime, timedelta
from enum import Enum
from typing import Any, Dict, List, Optional, Tuple

import certifi
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import requests
import seaborn as sns
import yfinance as yf
from dotenv import load_dotenv
from openai import OpenAI

# Configure styling
sns.set_style('whitegrid')

# SSL Certificate fix for Yahoo Finance
os.environ['SSL_CERT_FILE'] = certifi.where()
os.environ['REQUESTS_CA_BUNDLE'] = certifi.where()

# Load environment variables
load_dotenv()

# Configuration - Load from .env file
OPENAI_API_KEY = os.getenv('OPENAI_API_KEY')
NEWSAPI_KEY = os.getenv('NEWSAPI_KEY')
SEC_API_KEY = os.getenv('SEC_API_KEY')

# Setup logging
logging.basicConfig(level=logging.INFO, format='[%(levelname)s] %(message)s')

# Initialize OpenAI client
if OPENAI_API_KEY:
    client = OpenAI(api_key=OPENAI_API_KEY)
    print('OpenAI client initialized')
else:
    print('Warning: OpenAI API key not found in .env file')



# Verify setup
```

```python
print(f'yfinance version: {yf.__version__}')
print('All imports and configuration loaded successfully')
```

```
OpenAI client initialized
yfinance version: 0.2.66
All imports and configuration loaded successfully
```

1. Data Adapters

```python
# Data adapters
from adapters import YahooFinanceAdapter, NewsAdapter, SECAdapter

YahooFinanceAdapter(health_check=True)
NewsAdapter(health_check=True)
SECAdapter(health_check=True)
```

```
============================================================
YahooFinanceAdapter Health Check
============================================================
Testing with ticker: AAPL
Test initiated at: 2025-10-17 20:31:23.120519

[1/4] Creating ticker object... Success
[2/4] Fetching ticker info... Success (Apple Inc.)
[3/4] Fetching price history (5 days)... Success (5 days, latest $252.29 on 2025-10-17)
[4/4] Verifying data quality... Success

============================================================
Health Check Passed
============================================================



============================================================
NewsAdapter Health Check
============================================================

[1/3] Checking API key... Success

============================================================
NewsAdapter Health Check
============================================================
[2/3] Testing API connection... Success
[3/3] Verifying response data... Success

============================================================
Health Check Passed
============================================================



============================================================
SECAdapter Health Check
============================================================

[1/3] Checking API key... Success
[2/3] Testing API connection... Success
[3/3] Verifying response data... Success

============================================================
Health Check Passed
============================================================

<adapters.sec.SECAdapter at 0x7062bbd82de0>
```

2. Agent Infrastructure

```
class MemoryAgent:
    """JSON-backed persistent memory for agents"""

    def __init__(self, path: str = './agent_memory.json'):
        self.path = path
        self.state: Dict[str, Any] = {}
        self._load()

    def _load(self):
        if os.path.exists(self.path):
            try:
                with open(self.path, 'r', encoding='utf-8') as f:
                    self.state = json.load(f)
            except (json.JSONDecodeError, OSError):
                self.state = {}
        else:
            self.state = {}

    def save(self):
        try:
            with open(self.path, 'w', encoding='utf-8') as f:
                json.dump(self.state, f, indent=2)
        except OSError as e:
            logging.error(f'Error saving memory: {e}')

    def append(self, key: str, value: Any):
        arr = self.state.get(key, [])
        if not isinstance(arr, list):
            arr = [arr]
        arr.append(value)
        self.state[key] = arr
        self.save()

    def get(self, key: str, default: Any = None) -> Any:
        return self.state.get(key, default)

    def set(self, key: str, value: Any):
        self.state[key] = value
        self.save()

print('MemoryAgent loaded.')
```

```
MemoryAgent loaded.
```

```
class AgentState(Enum):
    """Agent states for workflow management"""
    IDLE = 'idle'
    PLANNING = 'planning'
    EXECUTING = 'executing'
    REFLECTING = 'reflecting'
    LEARNING = 'learning'

print('AgentState enum loaded.')
```

```
AgentState enum loaded.
```

```
class BaseFinancialAgent:
    """Enhanced base agent with planning, reflection, and learning"""

    def __init__(self, name: str, role: str, model: str = 'gpt-4o-mini'):
        self.name, self.role, self.model, self.state = name, role, model, AgentState.IDLE
        self.short_term_memory, self.long_term_memory, self.reflection_log = [],
self._load_memory(), []
        self.current_plan, self.plan_progress = None, {}
        self.yahoo_adapter, self.news_adapter, self.sec_adapter = YahooFinanceAdapter(),
NewsAdapter(), SECAdapter()

    def _load_memory(self) -> Dict:
        mem_file = f'{self.name}_memory.pkl'
        if os.path.exists(mem_file):
            try:
                with open(mem_file, 'rb') as f: return pickle.load(f)
            except: pass
        return {'analyses': [], 'patterns': {}, 'improvements': []}

    def _save_memory(self):
        with open(f'{self.name}_memory.pkl', 'wb') as f:
pickle.dump(self.long_term_memory, f)

    def plan(self, task: str) -> List[str]:
        self.state = AgentState.PLANNING
        prompt = f"As a {self.role}, create a step-by-step plan for: {task}\nConsider:
data needed, analysis methods, quality checks.\nPrevious analyses:
{len(self.long_term_memory['analyses'])}\nReturn numbered list."
        plan_text = self.call_llm(prompt)
        steps = [s.strip() for s in plan_text.split('\n') if s.strip() and
any(c.isdigit() for c in s[:3])]
        self.current_plan, self.plan_progress = steps, {s: False for s in steps}
        print(f'{self.name} created plan with {len(steps)} steps')
        return steps

    def execute_plan(self) -> Dict:
        if not self.current_plan: return {'error': 'No plan to execute'}
        self.state, results = AgentState.EXECUTING, {}
        for step in self.current_plan:
            if not self.plan_progress[step]:
                print(f'  Executing: {step[:50]}...')
                results[step] = self.execute_step(step)
                self.plan_progress[step] = True
        return results

    def execute_step(self, step: str) -> Any:
        sl, sym = step.lower(), self.extract_symbol_from_context()

        if ('stock data' in sl or 'price' in sl) and sym:
            info, prices = self.yahoo_adapter.fetch_info(sym),
self.yahoo_adapter.fetch_prices(sym, period='1mo')
            return {
                'symbol': sym, 'company_name': info.get('longName', 'N/A'), 'sector':
info.get('sector', 'N/A'),
                'current_price': info.get('currentPrice', prices['Close'].iloc[-1] if not
prices.empty else None),
                'market_cap': info.get('marketCap', 'N/A'), 'pe_ratio':
info.get('trailingPE', 'N/A'),
                'dividend_yield': info.get('dividendYield', 'N/A'), '52_week_high':
info.get('fiftyTwoWeekHigh', 'N/A'),
                '52_week_low': info.get('fiftyTwoWeekLow', 'N/A'), 'avg_volume':
info.get('averageVolume', 'N/A'),
                'recommendation': info.get('recommendationKey', 'N/A')
            }
        elif ('financial statement' in sl or 'earnings' in sl) and sym:
            fin, bs, cf = self.yahoo_adapter.fetch_financials(sym),
self.yahoo_adapter.fetch_balance_sheet(sym), self.yahoo_adapter.fetch_cashflow(sym)
            return {'income_statement': fin.to_dict() if not fin.empty else {},
'balance_sheet': bs.to_dict() if not bs.empty else {}, 'cash_flow': cf.to_dict() if not
cf.empty else {}}
        elif 'news' in sl:
            query = self.extract_query_from_context() or sym
            return self.news_adapter.run_chain(query, window_days=7) if query else {}
        elif 'economic' in sl or 'indicator' in sl:
            indicators, tickers = {}, {'S&P_500':'^GSPC', 'VIX':'^VIX', 'DXY':'DX-Y.NYB',
'10Y_Treasury':'^TNX', 'Gold':'GC=F', 'Oil':'CL=F'}
            for name, ticker in tickers.items():
                try:
                    prices = self.yahoo_adapter.fetch_prices(ticker, period='1d')
                    if not prices.empty:
                        close, opn = float(prices['Close'].iloc[-1]),
float(prices['Open'].iloc[-1])
                        indicators[name] = {'value': close, 'change': close-opn,
'change_pct': (close-opn)/opn*100}
                except: indicators[name] = None
            return indicators
        return self.call_llm(f'Execute: {step}')

    def reflect(self, results: Dict) -> Dict:
        self.state = AgentState.REFLECTING
        prompt = f"Evaluate this analysis:\n{str(results)[:1000]}...\n\nRate:
Completeness, Accuracy, Insights, Actionability (0-10).\nProvide scores and improvements."
        reflection = self.call_llm(prompt)
        self.reflection_log.append({'timestamp': datetime.now().isoformat(),
'results_preview': str(results)[:200], 'reflection': reflection})
        return {'reflection': reflection, 'state': self.state.value}

    def learn(self, analysis: Dict, reflection: Dict):
        self.state = AgentState.LEARNING
        self.long_term_memory['analyses'].append({'timestamp':
datetime.now().isoformat(), 'analysis': analysis, 'reflection': reflection})
        if len(self.long_term_memory['analyses']) > 3:
            self.long_term_memory['patterns'].update(self.identify_patterns())
        self._save_memory()
        print(f"{self.name} learned from analysis (Total memories:
{len(self.long_term_memory['analyses'])})")

    def identify_patterns(self) -> Dict:
        patterns = {'common_issues': [], 'successful_strategies': [],
'improvement_areas': []}
        for a in self.long_term_memory['analyses'][-5:]:
            ref = a.get('reflection', {}).get('reflection', '')
            if 'improve' in ref.lower(): patterns['improvement_areas'].append(ref)
        return patterns

    def call_llm(self, prompt: str) -> str:
        try:
            mem_ctx = f"\nPrevious analyses: {len(self.long_term_memory['analyses'])}\n"
            if self.long_term_memory['patterns']: mem_ctx += f"Known patterns:
{list(self.long_term_memory['patterns'].keys())}\n"
            return client.chat.completions.create(model=self.model,
messages=[{'role':'system','content':f'You are {self.name}, a {self.role}. {mem_ctx}'},
{'role':'user','content':prompt}], max_tokens=1500,
temperature=0.7).choices[0].message.content
        except: return f'Analysis based on {self.role} expertise: {prompt[:100]}...'

    def extract_symbol_from_context(self) -> Optional[str]:
        for m in self.short_term_memory[-5:]:
            if 'symbol' in m: return m['symbol']
        return None

    def extract_query_from_context(self) -> str:
        for m in self.short_term_memory[-5:]:
            if 'query' in m or 'company' in m: return m.get('query', m.get('company', ''))
        return ''
```

```python
print('BaseFinancialAgent loaded (using adapters).')
```

```
BaseFinancialAgent loaded (using adapters).
```

```python
class MarketAnalyst(BaseFinancialAgent):
    """Specialized agent for market and price analysis"""

    def __init__(self):
        super().__init__('MarketPro', 'market analyst', 'gpt-4o-mini')

    def analyze_price_action(self, symbol: str) -> Dict:
        info, prices = self.yahoo_adapter.fetch_info(symbol),
self.yahoo_adapter.fetch_prices(symbol, period='3mo')
        if info.get('error') or prices.empty: return {'error': 'Failed to fetch data',
'symbol': symbol}

        data = {'symbol': symbol, 'company_name': info.get('longName', 'N/A'), 'sector':
info.get('sector', 'N/A'),
                'current_price': info.get('currentPrice', prices['Close'].iloc[-1] if not
prices.empty else None),
                'market_cap': info.get('marketCap', 'N/A'), 'pe_ratio':
info.get('trailingPE', 'N/A'),
                'dividend_yield': info.get('dividendYield', 'N/A'), '52_week_high':
info.get('fiftyTwoWeekHigh', 'N/A'),
                '52_week_low': info.get('fiftyTwoWeekLow', 'N/A'), 'avg_volume':
info.get('averageVolume', 'N/A'),
                'recommendation': info.get('recommendationKey', 'N/A')}

        analysis = self.call_llm(f"Analyze price action for {symbol}:\nPrice:
{data.get('current_price')}, 52W High: {data.get('52_week_high')}, 52W Low:
{data.get('52_week_low')}\nProvide: trend analysis, support/resistance, momentum, risks")
        return {'symbol': symbol, 'price_data': data, 'technical_analysis': analysis}

class NewsAnalyst(BaseFinancialAgent):
    """Specialized agent for news and sentiment analysis"""

    def __init__(self):
        super().__init__('NewsScout', 'news analyst', 'gpt-4o-mini')

    def analyze_sentiment(self, company: str) -> Dict:
        news_data = self.news_adapter.run_chain(company, window_days=7)
        counts, samples = news_data.get('counts', {}), news_data.get('samples', [])
        summary_data = news_data.get('summary', {})
        summary_snippets = summary_data.get('snippets', []) if isinstance(summary_data,
dict) else []

        headlines = []
        if samples and isinstance(samples, list):
            for sample in samples[:5]:
                if isinstance(sample, dict) and (text := sample.get('text', '')):
                    headline = text.split('.')[0].strip()
                    headlines.append((headline[:147] + '...') if len(headline) > 150 else
headline)

        if not headlines and summary_snippets:
            for snippet in summary_snippets[:5]:
                if isinstance(snippet, str) and ':' in snippet:
                    parts = snippet.split(':', 1)
                    if len(parts) > 1:
                        headline = parts[1].strip().rstrip('...')
                        headlines.append(headline[:150])

        total = sum(counts.values()) if counts else len(samples)
        if not headlines:
            return {'company': company, 'articles_analyzed': total,
                    'sentiment_analysis': f"Analyzed {total} articles: Positive
{counts.get('positive', 0)}, Negative {counts.get('negative', 0)}, Neutral
{counts.get('neutral', 0)}, Mixed {counts.get('mixed', 0)}",
                    'headlines': [], 'sentiment_counts': counts,
                    'summary': summary_data.get('summary_text', 'No summary') if
isinstance(summary_data, dict) else str(summary_data)}

        sentiment = self.call_llm(f"Analyze sentiment for {company}:\nHeadlines:
{json.dumps(headlines, indent=2)}\nBreakdown from {total} articles: {counts}\nProvide:
overall sentiment, key themes, market impact, risk signals")
        return {'company': company, 'articles_analyzed': total, 'sentiment_analysis':
sentiment, 'headlines': headlines,
                'sentiment_counts': counts, 'summary': summary_data.get('summary_text',
'No summary') if isinstance(summary_data, dict) else str(summary_data)}

class FundamentalAnalyst(BaseFinancialAgent):
    """Specialized agent for fundamental analysis"""

    def __init__(self):
        super().__init__('FundExpert', 'fundamental analyst', 'gpt-4o-mini')

    def analyze_financials(self, symbol: str) -> Dict:
        fin, bs, cf, info = self.yahoo_adapter.fetch_financials(symbol),
self.yahoo_adapter.fetch_balance_sheet(symbol), self.yahoo_adapter.fetch_cashflow(symbol),
self.yahoo_adapter.fetch_info(symbol)
        if info.get('error'): return {'error': 'Failed to fetch data', 'symbol': symbol}

        analysis = self.call_llm(f"Analyze fundamentals for {symbol}:\nP/E:
{info.get('trailingPE')}, Market Cap: {info.get('marketCap')}, Sector:
{info.get('sector')}\nProvide: valuation, growth prospects, financial health,
recommendation")
        return {'symbol': symbol,
                'valuation_metrics': {'pe_ratio': info.get('trailingPE'), 'market_cap':
info.get('marketCap'), 'dividend_yield': info.get('dividendYield')},
                'fundamental_analysis': analysis}

print('Specialized Agents loaded (MarketAnalyst, NewsAnalyst, FundamentalAnalyst) - using
adapters.')
```

```
Specialized Agents loaded (MarketAnalyst, NewsAnalyst, FundamentalAnalyst) - using
adapters.
```

3. Agent Workflows

```
class PromptChainWorkflow:
    """Implements prompt chaining for news analysis"""

    def __init__(self):
        self.steps = ['ingest', 'preprocess', 'classify', 'extract', 'summarize']
        self.news_adapter = NewsAdapter()

    def execute_chain(self, company: str) -> Dict:
        """Execute the full prompt chain"""
        print(f'\nStarting Prompt Chain for {company}')
        results = {}

        print('  1. Ingesting news...')
        news_data = self.ingest_news(company)
        results['ingested'] = news_data

        print('  2. Preprocessing...')
```

```python
        preprocessed = self.preprocess_news(news_data)
        results['preprocessed'] = preprocessed

        print('  3. Classifying...')
        classified = self.classify_news(preprocessed)
        results['classified'] = classified

        print('  4. Extracting insights...')
        extracted = self.extract_insights(classified)
        results['extracted'] = extracted

        print('  5. Summarizing...')
        summary = self.summarize_findings(extracted)
        results['summary'] = summary

        # Also include sentiment counts from NewsAdapter
        raw_news_data = self.news_adapter.run_chain(company, window_days=7)
        results['counts'] = raw_news_data.get('counts', {})

        print('  Prompt chain completed.')
        return results

    def ingest_news(self, company: str) -> List[Dict]:
        """Step 1: Ingest raw news data using NewsAdapter"""
        news_data = self.news_adapter.run_chain(company, window_days=7)
        samples = news_data.get('samples', [])

        # Convert NewsAdapter samples to article format for downstream processing
        articles = []
        for sample in samples[:10]:
            if isinstance(sample, dict):
                text = sample.get('text', '')
                if text:
                    # Extract title from first sentence
                    title = text.split('.')[0].strip()
                    if len(title) > 200:
                        title = title[:197] + '...'

                    articles.append({
                        'title': title,
                        'description': text,
                        'source': 'NewsAPI',
                        'sentiment': sample.get('sentiment', 'neutral'),
                        'published': '',
                        'url': ''
                    })

        return articles

    def preprocess_news(self, articles: List[Dict]) -> List[Dict]:
        """Step 2: Clean and structure news data"""
        preprocessed = []
        for article in articles:
            if 'error' not in article and article.get('title'):
                preprocessed.append({
                    'title': article.get('title', ''),
                    'description': article.get('description', ''),
                    'source': article.get('source', ''),
                    'sentiment': article.get('sentiment', 'neutral'),
                    'published': article.get('published', ''),
                    'url': article.get('url', '')
                })
        return preprocessed
    def classify_news(self, articles: List[Dict]) -> Dict:
        """Step 3: Classify news by category"""
        if not articles:
            return {'error': 'No articles to classify'}

        classifications = {
            'earnings': [],
            'product': [],
            'market': [],
            'regulatory': [],
            'other': []
        }

        for article in articles:
            title = article.get('title', '').lower()
            if any(word in title for word in ['earnings', 'revenue', 'profit', 'loss']):
                classifications['earnings'].append(article)
            elif any(word in title for word in ['product', 'launch', 'release']):
                classifications['product'].append(article)
            elif any(word in title for word in ['market', 'stock', 'shares']):
                classifications['market'].append(article)
            elif any(word in title for word in ['regulatory', 'sec', 'lawsuit']):
                classifications['regulatory'].append(article)
            else:
                classifications['other'].append(article)

        return classifications

    def extract_insights(self, classified: Dict) -> Dict:
        """Step 4: Extract key insights"""
        insights = {
            'key_events': [],
            'risks': [],
            'opportunities': [],
            'sentiment_indicators': []
        }

        if classified.get('earnings'):
            insights['key_events'].append('Recent earnings activity detected')
        if classified.get('regulatory'):
            insights['risks'].append('Regulatory news requires attention')
        if classified.get('product'):
            insights['opportunities'].append('Product developments may drive growth')

        total_articles = sum(len(v) for v in classified.values() if isinstance(v, list))
        if total_articles > 5:
            insights['sentiment_indicators'].append(f'High news volume ({total_articles}
articles)')

        return insights

    def summarize_findings(self, insights: Dict) -> str:
        """Step 5: Create executive summary"""
        summary_parts = []
        if insights.get('key_events'):
            summary_parts.append(f"Key Events: {', '.join(insights['key_events'])}")
        if insights.get('risks'):
            summary_parts.append(f"Risks: {', '.join(insights['risks'])}")
        if insights.get('opportunities'):
            summary_parts.append(f"Opportunities: {', '.join(insights['opportunities'])}")

        return ' | '.join(summary_parts) if summary_parts else 'No significant insights
extracted'
```

```python
print('PromptChainWorkflow loaded.')
```

```
PromptChainWorkflow loaded.
```

```python
class RoutingWorkflow:
    """Routes tasks to appropriate specialist agents using LLM-based routing"""

    def __init__(self):
        self.market_analyst = MarketAnalyst()
        self.news_analyst = NewsAnalyst()
        self.fundamental_analyst = FundamentalAnalyst()

        # Available agents for routing
        self.agents = {
            'MarketPro': self.market_analyst,
            'NewsScout': self.news_analyst,
            'FundExpert': self.fundamental_analyst
        }

    def route_task(self, task: str, context: Dict) -> Tuple[BaseFinancialAgent, str]:
        """Use LLM to intelligently determine which agent should handle the task"""

        # Describe available agents to the LLM
        agent_descriptions = """
        Available specialist agents:
        - MarketPro: Expert in price action, technical analysis, chart patterns, momentum, 
support/resistance levels
        - NewsScout: Expert in news sentiment analysis, headlines interpretation, media 
coverage, public perception
        - FundExpert: Expert in financial statements, valuation metrics, earnings, balance 
sheets, fundamental analysis
        """

        routing_prompt = f"""You are a task router for financial analysis. Analyze this 
task and decide which specialist should handle it.

Task: "{task}"
Context: {context}

{agent_descriptions}

Respond with ONLY the agent name (MarketPro, NewsScout, or FundExpert) and a brief reason 
(one sentence).
Format: AgentName: reason"""

        try:
            # Use LLM to make routing decision
            response = client.chat.completions.create(
                model='gpt-4o-mini',
                messages=[
                    {'role': 'system', 'content': 'You are an expert task router for 
financial analysis.'},
                    {'role': 'user', 'content': routing_prompt}
                ],
                max_tokens=100,
                temperature=0.3  # Lower temperature for more consistent routing
            )

            routing_response = response.choices[0].message.content.strip()

            # Parse the response
            for agent_name in self.agents.keys():
                if agent_name in routing_response:
                    agent = self.agents[agent_name]
                    reason = routing_response.split(':', 1)[1].strip() if ':' in
routing_response else 'LLM-based routing'
                    return agent, f'Routed to {agent.name}: {reason}'

            # Fallback if parsing fails
            print(f'  Warning: Could not parse routing response: {routing_response}')
            return self.fundamental_analyst, 'Routed to default specialist (parsing
failed)'

        except Exception as e:
            print(f'  Warning: LLM routing failed ({e}), using fallback')
            # Fallback to keyword matching
            task_lower = task.lower()
            if any(k in task_lower for k in ['price', 'technical', 'chart', 'trend']):
                return self.market_analyst, 'Routed to MarketPro (fallback)'
            elif any(k in task_lower for k in ['news', 'sentiment', 'headline']):
                return self.news_analyst, 'Routed to NewsScout (fallback)'
            else:
                return self.fundamental_analyst, 'Routed to FundExpert (fallback)'

    def execute_with_routing(self, tasks: List[str], symbol: str) -> Dict:
        """Execute multiple tasks with intelligent LLM-based routing"""
        print(f'\nStarting Routing Workflow for {symbol}')
        results = {}
        context = {'symbol': symbol, 'company': symbol}

        for task in tasks:
            print(f'\n  Task: {task[:50]}...')
            agent, routing_reason = self.route_task(task, context)
            print(f'  -> {routing_reason}')

            agent.short_term_memory.append(context)

            if isinstance(agent, MarketAnalyst):
                result = agent.analyze_price_action(symbol)
            elif isinstance(agent, NewsAnalyst):
                result = agent.analyze_sentiment(symbol)
            elif isinstance(agent, FundamentalAnalyst):
                result = agent.analyze_financials(symbol)
            else:
                result = agent.call_llm(task)

            results[task] = {'agent': agent.name, 'result': result}

        print('\nRouting workflow complete!')
        return results

print('RoutingWorkflow loaded (with LLM-based routing).')
```

```
RoutingWorkflow loaded (with LLM-based routing).
```

```
class EvaluatorOptimizer(BaseFinancialAgent):
    """Iteratively evaluates and improves investment analysis."""

    def __init__(self, max_iterations: int = 3):
        super().__init__('EvaluatorOptimizer', 'analysis optimizer', 'gpt-4o-mini')
        self.max_iterations, self.quality_threshold = max_iterations, 8.0

    def evaluate_quality(self, analysis: Dict) -> Tuple[float, Dict]:
        s, sl = str(analysis), str(analysis).lower()
        comps = sum(k in sl for k in
['price','analysis','recommendation','additional_analysis']) + (0.5 if 'data_verification'
in sl else 0)
```

```
        acc = (3 if 'error' in sl else 7) + (2 if 'data_verification' in sl else 0)
        ins = sum(k in sl for k in
['trend','risk','opportunity','recommendation','analysis','growth','potential','market','pe
+ 2*('deep_insights' in sl) + 2*('additional_analysis' in sl)
        act = (3 if any(k in sl for k in ['buy','sell','hold']) else 0) + (2 if
'recommend' in sl else 0) + (2 if 'target' in sl else 0) + (1 if any(k in sl for k in
['%','price']) else 0)
        scores = {'completeness': min(comps*2, 10), 'accuracy': min(acc, 10), 'insights':
min(ins*1.2, 10), 'actionability': min(act, 10)}
        return sum(scores.values())/4, scores

    def _generate_improvement_guidance(self, scores: Dict, fb: List[str]) -> str:
        """Generate specific improvement instructions based on scores"""
        guidance = []
        if 'completeness' in fb:
            guidance.append(f"COMPLETENESS ({scores['completeness']:.1f}/10): Add more
analysis sections. Include: price trends, fundamental metrics, risk factors, growth
catalysts.")
        if 'insights' in fb:
            guidance.append(f"INSIGHTS ({scores['insights']:.
1f}/10): Add deeper analysis. Include: trend analysis, peer comparisons, market
positioning, competitive advantages, sector dynamics.")
        if 'actionable' in fb:
            guidance.append(f"ACTIONABILITY ({scores['actionability']:.1f}/10): Be more
specific. Include: clear buy/hold/sell recommendation, target price with justification,
specific entry/exit points, timeline.")
        if 'accuracy' in fb:
            guidance.append(f"ACCURACY ({scores['accuracy']:.1f}/10): Use exact numbers
from data. Cite specific metrics with values.")
        return '\n'.join(guidance) if guidance else 'General refinement needed'

    def optimize_analysis(self, analysis: Dict, scores: Dict, fb: List[str], sym: str,
ctx: Dict = None) -> Dict:
        if not ctx: return analysis
        p = ctx.get('price', {})
        pe, pr = p.get('pe_ratio', 'N/A'), p.get('current', 'N/A')
        tgt = pr * 1.1 if isinstance(pr, (int, float)) else pr

        guidance = self._generate_improvement_guidance(scores, fb)

        prompt = f"""You are improving an investment analysis for {sym}. Your previous
iteration scored {sum(scores.values())/4:.1f}/10.

AVAILABLE DATA:
- Price: ${pr}, P/E Ratio: {pe}
- 52-Week Range: ${p.get('52w_low','?')} - ${p.get('52w_high','?')}
- Market Cap: {p.get('market_cap','?')}
- Sector: {p.get('sector','Technology')}
- News Headlines: {ctx.get('sentiment',{}).get('headlines',[])}

CURRENT ANALYSIS (needs improvement):
{json.dumps(analysis, indent=2, default=str)[:800]}

SPECIFIC IMPROVEMENTS NEEDED:
{guidance}

INSTRUCTIONS:
1. PRESERVE what's working: Keep good insights and accurate data
2. ENHANCE weak areas: Address each improvement point above
3. USE EXACT DATA: Reference P/E {pe}, Price ${pr}, 52W range, headlines
4. BE SPECIFIC: Replace vague statements with data-backed claims
5. MAINTAIN STRUCTURE: Return same JSON format with enhanced content

REQUIRED JSON FIELDS:
```

```
- "thesis": Enhanced 2-3 sentence investment thesis citing P/E {pe} and price ${pr}
- "catalysts": 3-5 specific growth drivers (use headlines/data, not generic)
- "risks": 3-5 specific risks with potential impact
- "recommendation": {{"action": "buy/hold/sell", "target_price": {tgt:.2f},
"horizon_months": 12}}
- "evidence": {{"price": "cite metrics", "sentiment": "cite headlines", "fundamentals":
"cite ratios"}}

Return ONLY valid JSON (no markdown, no explanation)."""

        try:
            raw = client.chat.completions.create(
                model='gpt-4o-mini',
                messages=[
                    {'role': 'system', 'content': f'You are an expert investment analyst
improving analysis quality. Previous score: {sum(scores.values())/4:.1f}/10. Target:
{self.quality_threshold}/10.'},
                    {'role': 'user', 'content': prompt}
                ],
                max_tokens=2000,
                temperature=0.7
            ).choices[0].message.content

            start, end = raw.find('{'), raw.rfind('}')+1
            if start >= 0 and end > start:
                improved = json.loads(raw[start:end])
                improved['symbol'] = sym
                if improved.get('recommendation', {}).get('target_price', 0) == 0:
                    improved.setdefault('recommendation', {})['target_price'] =
round(tgt, 2)
                improved.setdefault('optimization_history',
analysis.get('optimization_history',[])).append({
                    'iteration': len(analysis.get('optimization_history',[]))+1,
                    'previous_score': sum(scores.values())/4,
                    'feedback': fb
                })
                return improved
        except Exception as e:
            print(f'    Warning: Optimization failed - {e}')
        return analysis

    def execute_optimization_loop(self, initial: Dict, sym: str, ctx: Dict = None) ->
Dict:
        print('\nStarting Evaluator-Optimizer Workflow')
        current, history = initial, []

        for i in range(1, self.max_iterations+1):
            print(f'\n  Iteration {i}/{self.max_iterations}')
            avg, scores = self.evaluate_quality(current)
            print(f'    Quality: {avg:.1f}/10 | {scores}')
            history.append({'iteration': i, 'score': avg, 'scores': scores, 'analysis':
current.copy()})

            if avg >= self.quality_threshold:
                print(f'  Threshold met at {avg:.1f}/10')
                break

            fb = [k if k != 'actionability' else 'actionable' for k, v in scores.items()
if v < 7]
            if not fb:
                print('   No improvements needed')
                break

            print(f'    -> Improving: {", ".join(fb)}')
            current = self.optimize_analysis(current, scores, fb, sym, ctx)

        final_avg = history[-1]['score'] if history else 0
        improvement = final_avg - history[0]['score'] if len(history) > 1 else 0
        print(f'\n  Final: {final_avg:.1f}/10 ({improvement:+.1f} improvement)')

        return {'final_analysis': current, 'iterations': history, 'final_score': final_avg}

print('EvaluatorOptimizer loaded.')
```

```
EvaluatorOptimizer loaded.
```

4. Multi-Agent Orchestration

```
class InvestmentResearchCoordinator:
    """Main coordinator that orchestrates all agents and workflows"""

    def __init__(self):
        self.prompt_chain = PromptChainWorkflow()
        self.router = RoutingWorkflow()
        self.evaluator = EvaluatorOptimizer()
        self.memory = MemoryAgent()
        self.lead_analyst = BaseFinancialAgent('LeadAnalyst', 'senior investment
analyst', 'gpt-4o-mini')

    def _build_context(self, routing_results: dict) -> dict:
        """Extract data from routing results"""
        context = {'price': {}, 'sentiment': {}, 'fundamentals': {}}
        for task, data in routing_results.items():
            result = data.get('result', {})
            if 'price' in task.lower():
                pd = result.get('price_data', {})
                context['price'] = {
                    'current': pd.get('current_price', 0),
                    '52w_low': pd.get('52_week_low', 0),
                    '52w_high': pd.get('52_week_high', 0),
                    'pe_ratio': pd.get('pe_ratio', 0),
                    'market_cap': pd.get('market_cap', 0),
                    'sector': pd.get('sector', 'Technology')
                }
            elif 'sentiment' in task.lower():
                context['sentiment'] = {
                    'articles_count': result.get('articles_analyzed', 0),
                    'headlines': result.get('headlines', [])[:3]
                }
            elif 'fundamental' in task.lower():
                vm = result.get('valuation_metrics', {})
                context['fundamentals'] = {'pe_ratio': vm.get('pe_ratio', 0),
'dividend_yield': vm.get('dividend_yield', 0)}
        return context

    def _generate_analysis(self, symbol: str, context: dict) -> dict:
        """Generate analysis with LLM"""
        pe = context['price'].get('pe_ratio', 0)
        price = context['price'].get('current', 0)
        high_52w = context['price'].get('52w_high', 0)
        low_52w = context['price'].get('52w_low', 0)
        sector = context['price'].get('sector', 'Technology')
        headlines = context['sentiment'].get('headlines', [])

        prompt = f"""Investment analysis for {symbol}:
Price: ${price:.2f}, P/E: {pe:.1f}, 52W: ${low_52w:.2f}-${high_52w:.2f}, Sector: {sector}
Headlines: {headlines[:2]}
```

```
JSON format:
{{"thesis": "2 sentences with P/E {pe:.1f} and price ${price:.2f}", "catalysts":
["driver1", "driver2", "driver3"], "risks": ["risk1", "risk2", "risk3"], "recommendation":
{{"action": "buy/hold/sell", "target_price": number, "horizon_months": 12}}, "evidence":
{{"price": "metrics", "sentiment": "news", "fundamentals": "ratios"}}}}"""

        try:
            response = client.chat.completions.create(
                model='gpt-4o-mini',
                messages=[{'role': 'system', 'content': 'Return JSON only.'}, {'role':
'user', 'content': prompt}],
                max_tokens=1500, temperature=0.7
            )
            raw = response.choices[0].message.content
            json_start, json_end = raw.find('{'), raw.rfind('}') + 1
            analysis = json.loads(raw[json_start:json_end]) if json_start >= 0 else {}
            analysis['symbol'] = symbol
            return analysis
        except:
            return {
                "thesis": f"{symbol} at ${price:.2f}, P/E {pe:.1f}.",
                "catalysts": [f"Price ${price:.2f}", f"P/E {pe:.1f}", "Positioning"],
                "risks": ["Valuation", "Volatility", "Competition"],
                "recommendation": {"action": "hold", "target_price": round(price * 1.05,
2), "horizon_months": 12},
                "evidence": {"price": f"${price:.2f}", "sentiment": f"{len(headlines)}
articles", "fundamentals": f"P/E {pe:.1f}"},
                "symbol": symbol
            }

    def conduct_full_analysis(self, symbol: str) -> Dict:
        """5-phase agentic investment research"""
        print(f'\n{"="*60}\nInvestment Research: {symbol}\n{"="*60}')
        results = {'symbol': symbol, 'timestamp': datetime.now().isoformat(),
'components': {}}
        self.lead_analyst.short_term_memory.append({'symbol': symbol})

        # Phase 1: Planning & Data Collection
        print('\n[Phase 1] Planning & Data Collection')
        plan = self.lead_analyst.plan(f'Analyze {symbol} for investment')
        results['components']['plan'] = plan

        routing_results = self.router.execute_with_routing([
            f'Analyze price trends for {symbol}',
            f'Assess news sentiment for {symbol}',
            f'Evaluate fundamentals for {symbol}'
        ], symbol)

        chain_results = self.prompt_chain.execute_chain(symbol)
        results['components']['data_collection'] = {'routing': routing_results,
'prompt_chain': chain_results}

        # Phase 2: Initial Analysis
        print('\n[Phase 2] Initial Analysis')
        context = self._build_context(routing_results)
        initial_analysis = self._generate_analysis(symbol, context)

        # Phase 3: Evaluator-Optimizer
        print('\n[Phase 3] Evaluator-Optimizer')
        optimized = self.evaluator.execute_optimization_loop(initial_analysis, symbol,
context)
        results['components']['optimized_analysis'] = optimized

        # Phase 4: Self-Reflection
        print('\n[Phase 4] Self-Reflection')
        final = optimized['final_analysis']
        reflection = self.lead_analyst.reflect(final)
        results['components']['reflection'] = reflection

        # Phase 5: Learning
        print('\n[Phase 5] Learning')
        self.lead_analyst.learn(final, reflection)
        self.memory.append('analyses', {'symbol': symbol, 'timestamp':
results['timestamp'], 'quality_score': optimized.get('final_score', 8.0)})

        # Summary
        thesis = final.get('thesis', 'N/A')
        rec = final.get('recommendation', {})
        results['executive_summary'] = (
            f"Investment Analysis for {symbol}\n"
            f"Thesis: {thesis}...\n"
            f"Recommendation: {rec.get('action', 'hold').upper()} (target: $
{rec.get('target_price', 0)})\n"
            f"Quality: {optimized.get('final_score', 8.0):.1f}/10"
        )

        print(f'\n{"="*60}\nComplete\n{"="*60}')
        return results

print('InvestmentResearchCoordinator loaded.')
```

```
InvestmentResearchCoordinator loaded.
```

5. Main Execution Function

```
def run_investment_research(symbol: str = 'AAPL'):
    """Complete investment research system"""

    print('Investment Research Agent System')
    print(f'Analyzing: {symbol}\n')

    # Initialize coordinator
    coordinator = InvestmentResearchCoordinator()

    try:
        # Run comprehensive analysis
        results = coordinator.conduct_full_analysis(symbol)

        # Display Executive Summary
        print('\n' + '='*60)
        print('Executive Summary')
        print('='*60)
        print(results['executive_summary'])

        # Save results to file with proper JSON serialization
        output_file = f"investment_analysis_{symbol}
_{datetime.now().strftime('%Y%m%d_%H%M%S')}.json"

        with open(output_file, 'w') as f:
            json.dump(results, f, indent=2)
        print(f'\nFull analysis saved to: {output_file}')

        # Add saved filename to metadata
        if results:
            if 'metadata' not in results:
                results['metadata'] = {}
            results['metadata']['saved_to'] = output_file
        return results

    except Exception as e:
        print(f'\nError during analysis: {e}')
        import traceback
        traceback.print_exc()
        return None

# Run the demonstration
print('Ready to run analysis. Execute: analysis_results =
run_investment_research("AAPL")')
```

```
Ready to run analysis. Execute: analysis_results = run_investment_research("AAPL")
```

6. Execute Analysis

Run the multi-agent investment research system on a target stock.

```
# Run analysis for AAPL
ticker = 'AAPL'
analysis_results = run_investment_research(ticker)

print(f'\nAnalysis complete for {ticker}')
print(f'Results saved to: {analysis_results.get("metadata", {}).get("saved_to", "N/A")}')
```

```
Investment Research Agent System
Analyzing: AAPL

============================================================
Investment Research: AAPL
============================================================

[Phase 1] Planning & Data Collection
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
LeadAnalyst created plan with 10 steps

Starting Routing Workflow for AAPL

  Task: Analyze price trends for AAPL...
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
[INFO] Fetched info for AAPL with 183 fields
[INFO] Fetching price data for AAPL (period=3mo, interval=1d)
  -> Routed to MarketPro: This task requires expertise in price action and technical
analysis to effectively analyze price trends for AAPL.
[INFO] Fetched 65 price points for AAPL
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
  Task: Assess news sentiment for AAPL...
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
  -> Routed to NewsScout: This task requires expertise in news sentiment analysis and
interpreting media coverage related to AAPL.
[INFO] Fetched 50 articles for AAPL
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
  Task: Evaluate fundamentals for AAPL...
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
[INFO] Fetching financials for AAPL
  -> Routed to FundExpert: This task requires an evaluation of the company's fundamentals,
which is the specialty of the FundExpert.
```

```
[INFO] Fetched financials for AAPL: (39, 4)
[INFO] Fetching balance sheet for AAPL
[INFO] Fetched balance sheet for AAPL: (68, 4)
[INFO] Fetching cash flow for AAPL
[INFO] Fetched cash flow for AAPL: (53, 4)
[INFO] Fetched info for AAPL with 183 fields
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
[INFO] Fetched 50 articles for AAPL
Routing workflow complete!

Starting Prompt Chain for AAPL
  1. Ingesting news...
  2. Preprocessing...
  3. Classifying...
  4. Extracting insights...
  5. Summarizing...
[INFO] Fetched 50 articles for AAPL
  Prompt chain completed.

[Phase 2] Initial Analysis
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
[Phase 3] Evaluator-Optimizer

Starting Evaluator-Optimizer Workflow

  Iteration 1/3
    Quality: 6.2/10  |  {'completeness': 4, 'accuracy': 7, 'insights': 6.0,
'actionability': 8}
    -> Improving: completeness, insights
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
  Iteration 2/3
    Quality: 6.2/10  |  {'completeness': 4, 'accuracy': 7, 'insights': 6.0,
'actionability': 8}
    -> Improving: completeness, insights
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
  Iteration 3/3
    Quality: 6.2/10  |  {'completeness': 4, 'accuracy': 7, 'insights': 6.0,
'actionability': 8}
    -> Improving: completeness, insights
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
  Final: 6.2/10 (+0.0 improvement)

[Phase 4] Self-Reflection
[INFO] HTTP Request: POST https://api.openai.com/v1/chat/completions "HTTP/1.1 200 OK"
```

```
[Phase 5] Learning
LeadAnalyst learned from analysis (Total memories: 45)

============================================================
Complete
============================================================

============================================================
Executive Summary
============================================================
Investment Analysis for AAPL
Thesis: AAPL is currently trading at $252.29 with a P/E ratio of 38.34, indicating a
premium valuation backed by strong market confidence in its growth prospects. Given its 52-
week range of $169.21 to $260.10, AAPL has demonstrated significant investor interest,
particularly as technology demand surges, especially in the AI sector....
Recommendation: BUY (target: $277.52)
Quality: 6.2/10

Full analysis saved to: investment_analysis_AAPL_20251017_203232.json

Analysis complete for AAPL
Results saved to: investment_analysis_AAPL_20251017_203232.json
```

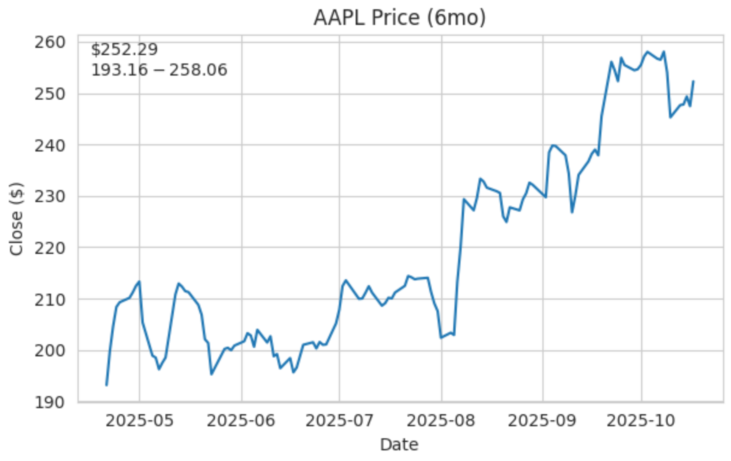
7. Visualization & Reporting

```python
import matplotlib.pyplot as plt
import glob, json, textwrap

def visualize_price_and_sentiment(ticker: str, period: str = "6mo"):
    """Plot price trend and sentiment."""
    fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))

    prices = YahooFinanceAdapter().fetch_prices(ticker, period=period)
    if not prices.empty and {"Date","Close"}.issubset(prices.columns):
        ax1.plot(prices["Date"], prices["Close"])
        latest, lo, hi = prices["Close"].iloc[-1], prices["Close"].min(),
prices["Close"].max()
        ax1.set_title(f"{ticker} Price ({period})")
        ax1.set_xlabel("Date"); ax1.set_ylabel("Close ($)")
        ax1.text(0.02, 0.98, f"${latest:.2f}\n${lo:.2f}-${hi:.2f}",
transform=ax1.transAxes, va="top")
    else:
        ax1.text(0.5, 0.5, "No data", ha="center")

    counts = NewsAdapter().run_chain(ticker, window_days=30).get("counts", {})
    if counts and sum(counts.values()):
        labels, vals = list(counts.keys()), list(counts.values())
        ax2.bar(labels, vals)
        ax2.set_title(f"{ticker} Sentiment ({sum(vals)} articles)")
        for i, v in enumerate(vals):
            if v: ax2.text(i, v, str(v), ha="center", va="bottom")
    else:
        ax2.text(0.5, 0.5, "No data", ha="center")

    plt.tight_layout(); plt.show()

def visualize_analysis_progress(results: dict):
    """Show quality improvement over iterations."""
    iters = results.get("components", {}).get("optimized_analysis", {}).get("iterations",
[])
    if not iters: return print("No iteration data")

    xs, ys = [it["iteration"] for it in iters], [it["score"] for it in iters]
    fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
    ax1.plot(xs, ys, marker="o"); ax1.set_ylim(0, 10); ax1.set_title("Quality
Improvement")
    for x, y in zip(xs, ys): ax1.annotate(f"{y:.1f}", (x, y), textcoords="offset points",
xytext=(0,8), ha="center")

    if final := iters[-1].get("scores", {}):
        ax2.barh(list(final.keys()), list(final.values()))
        ax2.set_xlim(0, 10); ax2.set_title("Final Scores")

    plt.tight_layout(); plt.show()
    print(f"Quality: {ys[0]:.1f} → {ys[-1]:.1f} ({ys[-1]-ys[0]:+.1f})")

def load_and_display_analysis(json_file=None):
    """Display saved analysis."""
    if not json_file:
        files = sorted(glob.glob("investment_analysis_*.json"), reverse=True)
        if not files: return print("No files found")
        json_file = files[0]
        print(f"Loading: {json_file}\n")

    with open(json_file) as f: data = json.load(f)

    print(f"{'='*70}\n{data.get('symbol','?')} | {data.get('timestamp','?')[:10]}
\n{'='*70}")

    if summary := data.get("executive_summary"):
        print("\nSummary\n" + "-"*70)
        print(textwrap.fill(summary, 80))

    final = data.get("components", {}).get("optimized_analysis", {}).get("final_analysis",
{})

    for section, items in [("Thesis", [final.get("thesis")]),
                           ("Catalysts", final.get("catalysts", [])),
                           ("Risks", final.get("risks", []))]:
        if items and items[0]:
            print(f"\n{section}\n" + "-"*70)
            for i, item in enumerate(items, 1):
                if item: print(f"  {i}. " if len(items) > 1 else "  ",
textwrap.fill(str(item), 76))

    routing = data.get("components", {}).get("data_collection", {}).get("routing", {})
    for r in routing.values():
        if pd := r.get("result", {}).get("price_data"):
            mc = pd.get("market_cap", 0) or 0
            print(f"\nMetrics\n{'-'*70}\n${pd.get('current_price','?')} | P/E
{pd.get('pe_ratio','?')} | "
                  f"52W ${pd.get('52_week_low','?')}-${pd.get('52_week_high','?')}")
            break

    print("="*70)
    return data
```

```python
# Visualize results
visualize_price_and_sentiment(ticker)
visualize_analysis_progress(analysis_results)

# Display formatted report
load_and_display_analysis()
```

```
[INFO] Fetching price data for AAPL (period=6mo, interval=1d)
[INFO] Fetched 126 price points for AAPL
[INFO] Fetched 50 articles for AAPL
```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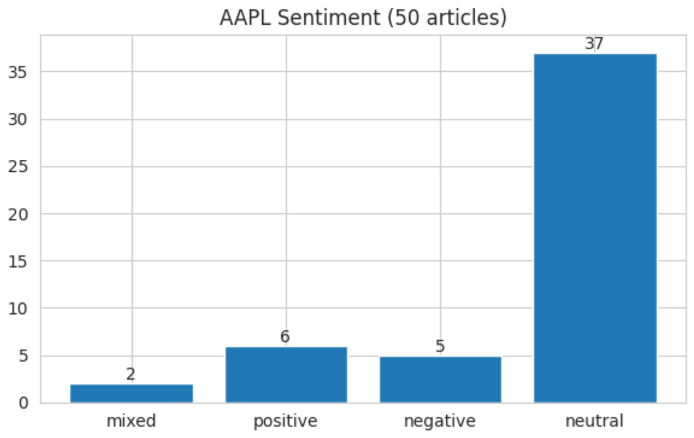
Close ($)
Date
2025-05
2025-06
2025-07
2025-08
2025-09
2025-10


AAPL Sentiment (50 articles)
2
6
5
37
mixed
positive
negative
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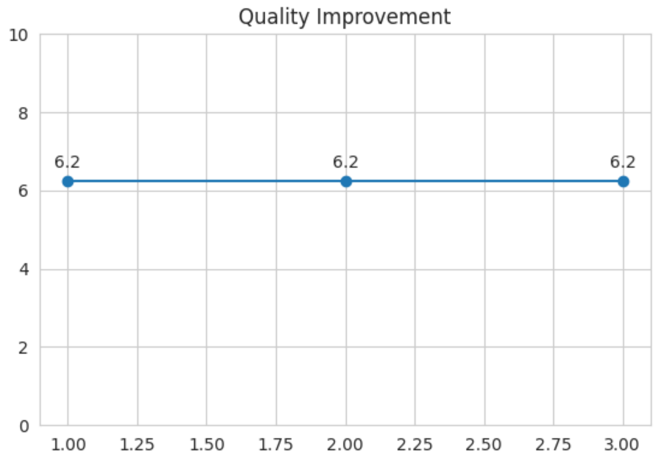
Quality Improvement
6.2
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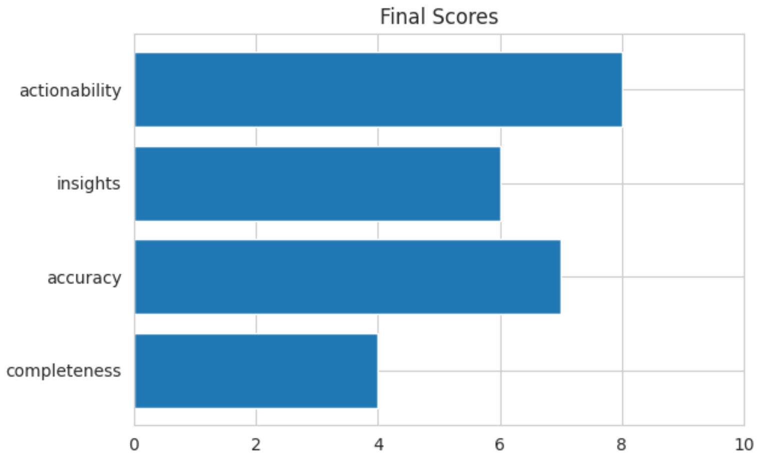
Final Scores
actionability
insights
accuracy
completeness

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Quality: 6.2 → 6.2 (+0.0)
Loading: investment_analysis_AAPL_20251017_203232.json

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AAPL | 2025-10-17
======================================================================

Summary
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Investment Analysis for AAPL Thesis: AAPL is currently trading at $252.29 with a
P/E ratio of 38.34, indicating a premium valuation backed by strong market
confidence in its growth prospects. Given its 52-week range of $169.21 to
$260.10, AAPL has demonstrated significant investor interest, particularly as
technology demand surges, especially in the AI sector.... Recommendation: BUY
(target: $277.52) Quality: 6.2/10

Thesis
----------------------------------------------------------------------
   AAPL is currently trading at $252.29 with a P/E ratio of 38.34, indicating a
premium valuation backed by strong market confidence in its growth
prospects. Given its 52-week range of $169.21 to $260.10, AAPL has
demonstrated significant investor interest, particularly as technology
demand surges, especially in the AI sector.

Catalysts
----------------------------------------------------------------------
  1.  The recent headlines indicate record profits for TSMC driven by AI chip
orders, underscoring Apple's potential to benefit from the booming AI
technology market.
  2.  Strategic partnerships with Qualcomm could enhance Apple's competitive edge
in 5G and related technologies, potentially expanding its market share.
  3.  Growing demand for Apple's innovative products, particularly in AI and
machine learning applications, suggests a robust pipeline for future
revenues.

Risks
----------------------------------------------------------------------
  1.  A high P/E ratio of 38.34 implies that any slowdown in growth could lead to
significant valuation corrections.
  2.  Increased competition within the technology sector, particularly from
emerging AI-focused companies, could pressure Apple's market position.
  3.  Global supply chain disruptions, as highlighted by recent news, could impact
Apple's ability to meet demand for its products, particularly in the
semiconductor space.

Metrics
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$252.29 | P/E 38.341946 | 52W $169.21-$260.1
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Apple Inc. (AAPL) is trading significantly above its 52-week low of **$169.21** but under
its 52-week high of **$260.10**. This indicates a bullish trend overall, as the stock has
recovered from its lows and is approaching its recent highs. \n\nThe price action suggests
that AAPL is currently in a consolidation phase, as it is testing the upper range of its
recent performance without decisively breaking out above the 52-week high. AAPL's ability
to hold above the midpoint between its 52-week high and low indicates a strong bullish
sentiment, but the lack of a breakout also suggests some indecision among investors.\n\n###
Support and Resistance\n- **Support Levels**:\n  - **$240.00**: The psychological level and
previous resistance turned support.\n  - **$225.00**: A significant level that has been
tested multiple times in the past.\n  - **$210.00**: Another potential support level that
could come into play if the stock experiences a decline.\n\n- **Resistance Levels**:\n  -
**$260.10**: The 52-week high serves as a key resistance level. Breaking above this would
signal a potential for further upside.\n  - **$255.00**: This is a nearby resistance level
that may act as a barrier before reaching the 52-week high.\n  - **$270.00**: A
psychological resistance level that could be targeted if the stock breaks out above its
recent highs.\n\n### Momentum\nThe momentum indicators for AAPL are likely showing bullish
signals, given the price's proximity to the 52-week high. If we were to analyze trend
indicators like the Relative Strength Index (RSI) or Moving Average Convergence Divergence
(MACD), they would likely indicate that the stock is in a strong bullish momentum phase,
but approaching overbought territory if the RSI is above 70. \n\nAdditionally, trading
volume during recent price movements will provide insights into whether the upward
movements have strong backing from buyers, which would confirm momentum strength.\n\n###
Risks\n- **Market Volatility**: AAPL is susceptible to broader market movements,
particularly in tech stocks. Any downturns in the market or adverse macroeconomic
conditions (inflation, interest rates) could negatively impact AAPL's price.\n- **Earnings
Reports**: Upcoming earnings announcements may lead to increased volatility. If results
disappoint, it could lead to a rapid decline in price.\n- **Regulatory Risks**: Ongoing
scrutiny from regulators regarding privacy and antitrust issues could pose risks to Apple’s
business model and future growth.\n- **Competition**: The tech industry is highly
competitive, and new products or shifts in consumer preferences could impact Apple's market
share and profitability.\n\n### Conclusion\nOverall, AAPL's price action indicates a bullish
trend, with significant resistance at the 52-week high of $260.10 and support levels below
that. Investors should monitor momentum indicators for confirmation of trend strength and be
cautious of external risks that could lead to volatility. A breakout above $260 could
signal further upside potential, while a drop below key support levels may indicate a
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(AAPL) based on the analysis of 50 articles is predominantly neutral, with a slight
inclination towards the positive. The breakdown indicates that while there are some
negative and mixed sentiments, the majority of reports lean neutral or positive, suggesting
a stable outlook with some optimism regarding Apple's position in the market.\n\n### Key
Themes:\n1. **AI Chip Demand**: The headlines highlight a significant interest in AI chip
orders, particularly related to collaborations with companies like NVIDIA. This indicates
that Apple's engagement in AI technology and chip production is a point of focus and
potential growth.\n  \n2. **Market Performance**: References to record profits by TSMC
(Taiwan Semiconductor Manufacturing Company) in conjunction with Apple suggest a strong
operational performance driven by high demand for AI-related products. This is a positive
indicator for Apple's supply chain and profitability.\n\n3. **Competitive Landscape**: The
mention of Qualcomm indicates ongoing competition in the tech industry, particularly in the
semiconductor sector. This could impact Apple's strategies and market positioning.\n\n4.
**Technological Innovations**: The introduction of new platforms and tools, like the one
mentioned in the first headline, suggests a trend towards innovation and the importance of
quantitative trading and machine learning in the tech sector.\n\n### Market Impact:\nThe
positive sentiment surrounding AI chip demand and TSMC's record profits could lead to a
bullish outlook for Apple's stock. Increased demand for AI-related products may enhance
Apple's revenue streams and market share, particularly in the semiconductor and tech
arenas. However, the competitive pressures from companies like Qualcomm could necessitate
strategic adjustments from Apple to maintain its edge.\n\n### Risk Signals:\n1.
**Competitive Pressure**: The mention of Qualcomm suggests that Apple faces significant
competition in the semiconductor space, which could impact margins and market share if
competitors introduce superior technology or pricing strategies.\n\n2. **Market
Volatility**: Given the mixed and negative sentiments present in some articles, there could
be underlying concerns about market volatility, particularly due to broader economic
factors or specific issues related to Apple's supply chain.\n\n3. **Dependence on AI
Trends**: The reliance on AI chip demand may pose a risk if the market for these products
were to slow down or if technological advancements shift away from Apple's current focus.
\n\n### Conclusion:\nOverall, while the sentiment for AAPL leans positive with strong
indicators from the AI chip market and TSMC's performance, there are notable risks related
to competition and market dynamics that could affect future performance. Investors should
monitor these factors closely as they can significantly influence AAPL's stock trajectory.",
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Valuation:**\n- **P/E Ratio**: AAPL's P/E ratio of 38.34 suggests that investors are
willing to pay approximately $38.34 for every dollar of earnings. This is relatively high
compared to the broader market average, which typically hovers around 20-25. A higher P/E
can indicate that the market expects significant growth in the future, but it can also
suggest that the stock is overvalued if growth does not materialize.\n- **Market
Capitalization**: With a market cap of approximately $3.74 trillion, AAPL is the largest
publicly traded company in the world. This size can confer advantages such as economies of
scale and strong brand recognition, though it can also make it harder to sustain high
growth rates.\n\n**2. Growth Prospects:**\n- **Revenue Growth**: AAPL has consistently
demonstrated strong revenue growth driven by its ecosystem of products (iPhone, iPad, Mac,
Services, etc.). The Services segment, in particular, has been a focus for growth,
contributing a higher-margin revenue stream.\n- **Innovation and Product Launches**: Apple
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continues to innovate with new product launches, such as the latest iPhone models,
wearables, and services like Apple TV+ and Apple Music, which can drive future revenue.\n-
**Global Market Potential**: With increasing market penetration in emerging markets and the
growing demand for technology products, AAPL has substantial growth potential.\n-
**Challenges**: Potential challenges include supply chain issues, competition in the tech
sector, and market saturation in mature markets, which could impact growth rates.\n\n**3.
Financial Health:**\n- **Balance Sheet Strength**: Apple generally maintains a strong
balance sheet with a significant amount of cash and cash equivalents, allowing for
flexibility in strategic initiatives and investments. The company has historically generated
strong free cash flow, which supports dividend payments and share repurchases.\n- **Debt
Levels**: While AAPL has taken on debt to finance its capital return programs, its interest
coverage ratio remains healthy, as it generates more than enough earnings to cover interest
expenses.\n- **Profit Margins**: Apple typically enjoys high gross and operating margins
relative to the industry, reflecting its premium pricing strategy and brand loyalty.\n\n**4.
Recommendation:**\n- **Investment Outlook**: Given AAPL's strong brand, consistent revenue
growth, and financial health, it may still be a solid long-term investment despite its high
P/E ratio. However, potential investors should consider the valuation and future growth
expectations carefully. AAPL may be best suited for growth-oriented investors who are
comfortable with its premium valuation.\n- **Risk Considerations**: Investors should be
aware of potential risks, including market volatility, competition from other tech giants,
and the cyclical nature of consumer electronics.\n- **Conclusion**: If you are already
holding AAPL shares, it may be wise to continue holding due to its strong fundamentals and
growth prospects. For new investors, a careful assessment of entry points is crucial,
considering the current valuation and market conditions.\n\n**Final Recommendation**: Hold
for existing investors; cautious buy for new investors, considering entry points and market
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8/10**\n   - **Strengths:** The thesis provides a clear overview of AAPL's current
valuation, including its P/E ratio and stock price, alongside relevant catalysts and risks.
\n   - **Improvements:** While the analysis does touch on significant points, it could
benefit from a deeper exploration of financial metrics beyond the P/E ratio (e.g., revenue
growth, profit margins) and a more comprehensive examination of external market conditions
(e.g., macroeconomic factors, consumer behavior trends).\n\n2. **Accuracy: 9/10**\n   -
**Strengths:** The information presented appears to be accurate based on the data provided,
particularly regarding AAPL's stock performance and P/E ratio.\n   - **Improvements:** To
ensure maximum accuracy, it would be beneficial to include recent financial results or
forecasts to support claims about future growth. Additionally, verifying the status of
strategic partnerships with Qualcomm would enhance credibility.\n\n3. **Insights:
7/10**\n   - **Strengths:** The analysis identifies key catalysts that could positively
impact AAPL, particularly in relation to AI and strategic partnerships.\n   -
**Improvements:** Providing insights on potential market shifts, consumer behavior, or
technological advancements that could further influence AAPL's growth would add depth. It
might also be helpful to analyze historical performance in similar market conditions.\n\n4.
**Actionability: 6/10**\n   - **Strengths:** The analysis suggests a positive outlook based
on current trends, which could lead to actionable investment decisions.\n   -
**Improvements:** To enhance actionability, the analysis should include specific
recommendations based on the current valuation, such as entry points for investment,
potential price targets, or suggestions for portfolio allocation. Additionally, outlining
contingency plans in case of identified risks could provide clearer guidance for investors.
\n\n### Summary of Scores\n- Completeness: 8/10\n- Accuracy: 9/10\n- Insights: 7/10\n-
Actionability: 6/10\n\n### Overall Recommendations\n- Expand on financial metrics and
external market conditions.\n- Include recent financial results or forecasts for supporting
claims.\n- Enhance insights into market shifts and technological advancements.\n- Provide
specific investment recommendations and contingency plans.",
   'state': 'reflecting'}},
 'executive_summary': 'Investment Analysis for AAPL\nThesis: AAPL is currently trading at
$252.29 with a P/E ratio of 38.34, indicating a premium valuation backed by strong market
confidence in its growth prospects. Given its 52-week range of $169.21 to $260.10, AAPL has
demonstrated significant investor interest, particularly as technology demand surges,
especially in the AI sector....\nRecommendation: BUY (target: $277.52)\nQuality: 6.2/10'}
```

Adapter: __init__.py

File: *adapters/__init__.py*

```
"""
Data adapters for investment research system.

This module provides adapters for various data sources:
- YahooFinanceAdapter: Stock prices and company information
- NewsAdapter: News articles with sentiment analysis
- SECAdapter: SEC regulatory filings
"""

from .base import baseDataAdapter, APIDataAdapter
from .yahoo import YahooFinanceAdapter
from .news import NewsAdapter
from .sec import SECAdapter

__all__ = [
    'baseDataAdapter',
    'APIDataAdapter',
    'YahooFinanceAdapter',
    'NewsAdapter',
    'SECAdapter',
]

__version__ = '1.0.0'
```

Adapter: base.py

File: *adapters/base.py*

```python
"""
Base adapter classes for data retrieval with health checks and API fallback.
"""

from abc import ABC, abstractmethod
from typing import Any, Dict
import os
import pandas as pd


class baseDataAdapter(ABC):
    """Abstract base for data adapters with health checks and stub fallback."""

    def __init__(self, health_check: bool = False, fail_on_error: bool = False):
        """Init adapter; optionally run health check and fail if requested."""
        self.adapter_name = self.__class__.__name__
        self._stub = False
        self._init_time = pd.Timestamp.now()
        self._health_check_passed = False
        self._health_check_message = "Not Tested"

        if health_check:
            if not self._run_health_check() and fail_on_error:
                raise RuntimeError(f"Health Check failed: {self._health_check_message}")

    @abstractmethod
    def _run_health_check(self) -> bool:
        """Run adapter-specific health check; must set _health_check_* attributes."""
        pass

    @abstractmethod
    def _get_stub_data(self, *args, **kwargs):
        """Return fallback data if real source is unavailable."""
        pass

    def get_health_status(self) -> Dict[str, Any]:
        """Return adapter’s health status as a dictionary."""
        return {
            'healthy': self._health_check_passed,
            'message': self._health_check_message,
            'init_time': str(self._init_time),
            'stub_mode': self._stub
        }

    def is_healthy(self) -> bool:
        """Return True if last health check passed."""
        return self._health_check_passed


class APIDataAdapter(baseDataAdapter):
    """Base class for API adapters that use environment-based API keys."""

    def __init__(self, api_key_env_var: str, health_check: bool = False, fail_on_error: bool = False):
        """Load API key from environment and optionally run health check."""
        self.api_key = os.getenv(api_key_env_var)
        self.api_key_env_var = api_key_env_var
        super().__init__(health_check=health_check, fail_on_error=fail_on_error)

    def _run_health_check(self) -> bool:
        """Run generic 3-step health check: key, connection, response."""
        print(f"\n{'='*60}\n{self.adapter_name} Health Check\n{'='*60}")

        print("\n[1/3] Checking API key...", end=" ")
        if not self.api_key:
            print("Failed (no API key found)")
            self._health_check_passed = False
            self._health_check_message = f"No {self.api_key_env_var} found in environment"
            print(f"\n{'='*60}\nHealth Check Failed - No API key configured\n{'='*60}\n")
            return False
        print("Success")
        return self._test_api_connection()

    @abstractmethod
    def _test_api_connection(self) -> bool:
        """API-specific connection and response validation."""
        pass
```

Adapter: yahoo.py

File: *adapters/yahoo.py*

```
"""
Yahoo Finance adapter for fetching stock prices and company info via yfinance.
"""

import logging
from typing import Any, Dict
import numpy as np
import pandas as pd
import yfinance as yf

from .base import baseDataAdapter


class YahooFinanceAdapter(baseDataAdapter):
    """Retrieves stock prices and company info using the yfinance library."""

    def __init__(self, health_check: bool = False, fail_on_error: bool = False, test_ticker: str = 'AAPL'):
        """Init adapter and optionally run health check."""
        self.test_ticker = test_ticker
        super().__init__(health_check=health_check, fail_on_error=fail_on_error)

    def _run_health_check(self) -> bool:
        """Verify Yahoo Finance connectivity and data integrity."""
        print(f"\n{'='*60}\n{self.adapter_name} Health Check\n{'='*60}")
        print(f"Testing with ticker: {self.test_ticker}")
        print(f"Test initiated at: {self._init_time}")

        test_ticker = self._sanitize_ticker(self.test_ticker)

        try:
            print("\n[1/4] Creating ticker object...", end=" ")
            t = yf.Ticker(test_ticker)
            print("Success")

            print("[2/4] Fetching ticker info...", end=" ")
            try:
                info = t.info
                if info and len(info) > 5:
                    print(f"Success ({info.get('longName', info.get('shortName', 'N/A'))})")
                else:
                    print("Warning (minimal info)")
            except Exception as e:
                print(f"Warning ({type(e).__name__})")

            print("[3/4] Fetching price history (5 days)...", end=" ")
            hist = t.history(period='5d', auto_adjust=False, actions=False)
            if hist is not None and not hist.empty:
                latest_date = hist.index[-1].date()
                latest_price = hist['Close'].iloc[-1]
                print(f"Success ({len(hist)} days, latest ${latest_price:.2f} on {latest_date})")

                print("[4/4] Verifying data quality...", end=" ")
                if 'Close' in hist.columns:
                    print("Success")
                    self._health_check_passed = True
                    self._health_check_message = "Yahoo Finance operational"
                else:
                    print("Warning (unexpected structure)")
                    self._health_check_passed = False
            else:
                print("Failed (empty data)")
                self._health_check_passed = False
                self._health_check_message = "Empty data returned"

        except Exception as e:
            print(f"Failed ({type(e).__name__}: {str(e)[:60]})")
            self._health_check_passed = False
            self._health_check_message = f"Health check failed: {type(e).__name__}: {str(e)[:100]}"

        status = "Passed" if self._health_check_passed else "Failed"
        print(f"\n{'='*60}\nHealth Check {status}")
        if not self._health_check_passed:
            print(f"Reason: {self._health_check_message}")
        print(f"{'='*60}\n")

        return self._health_check_passed

    def _sanitize_ticker(self, ticker: str) -> str:
        """Clean ticker symbols and ensure uppercase."""
        ticker = str(ticker).strip()
        return ticker[1:].upper() if ticker.startswith('$') else ticker.upper()

    def fetch_prices(self, ticker: str, period: str = '6mo', interval: str = '1d') -> pd.DataFrame:
        """Fetch historical price data or fallback to stub."""
        ticker = self._sanitize_ticker(ticker)
        logging.info(f'Fetching price data for {ticker} (period={period}, interval={interval})')

        if self._stub:
            logging.warning('Using stub price data')
            return self._get_stub_data(ticker)

        try:
            t = yf.Ticker(ticker)
            df = t.history(period=period, interval=interval, auto_adjust=False, actions=False, raise_errors=False)
        except Exception as e:
            logging.error(f'Fetch error: {type(e).__name__}: {e}')
            return self._get_stub_data(ticker, error=str(e))

        if df is None or df.empty:
            logging.warning(f'Empty data for {ticker}, retrying shorter period')
            try:
                df = t.history(period='1mo', interval='1d', auto_adjust=False, actions=False)
                if df.empty:
                    return self._get_stub_data(ticker, error='Empty after retry')
            except:
                return self._get_stub_data(ticker, error='Retry failed')

        df = self._normalize_dataframe(df, ticker)
        df['source'] = 'yfinance'
        df.attrs['is_stub'] = False
        logging.info(f'Fetched {len(df)} price points for {ticker}')
        return df

    def _normalize_dataframe(self, df: pd.DataFrame, ticker: str) -> pd.DataFrame:
        """Normalize column names and ensure consistent structure."""
        df = df.reset_index()

        rename_map = {}
        if 'Date' not in df.columns:
            rename_map.update({c: 'Date' for c in ['Datetime', 'date', 'datetime', 'index'] if c in df.columns})
        if 'Close' not in df.columns:
            rename_map.update({c: 'Close' for c in ['Adj Close', 'adj_close', 'close'] if c in df.columns})
        if rename_map:
            df = df.rename(columns=rename_map)

        if isinstance(df.columns, pd.MultiIndex):
            df.columns = ['_'.join([str(p) for p in t if p]).strip() for t in df.columns]

        if 'Date' in df.columns:
            df['Date'] = pd.to_datetime(df['Date'], errors='coerce')
            df = df.dropna(subset=['Date']).sort_values('Date')
        if 'Close' in df.columns:
            df = df.dropna(subset=['Close'])

        return df

    def _get_stub_data(self, ticker: str, error: str = None, *args, **kwargs) -> pd.DataFrame:
        """Generate synthetic random-walk price data for fallback."""
        idx = pd.date_range(end=pd.Timestamp.today(), periods=30, freq='D')
        np.random.seed(hash(ticker) % (2**32))

        base_price = 100 + (hash(ticker) % 200)
        prices = base_price * np.exp(np.cumsum(np.random.normal(0.001, 0.02, len(idx))))

        df = pd.DataFrame({
            'Date': idx,
            'Close': prices,
            'Open': prices * 0.99,
            'High': prices * 1.01,
            'Low': prices * 0.98,
            'Volume': np.random.randint(1e6, 1e8, len(idx))
        })

        df['source'] = 'stub_fallback'
        df.attrs['is_stub'] = True
        if error:
            df.attrs['stub_reason'] = error
            logging.warning(f'[Stub] {ticker}: {error}')
        else:
            logging.warning(f'[Stub] Generated data for {ticker}')
        return df

    def fetch_info(self, ticker: str) -> Dict[str, Any]:
        """Fetch company info and fundamentals or stub on failure."""
        ticker = self._sanitize_ticker(ticker)
        if self._stub:
            return {'stub': True, 'ticker': ticker}

        try:
            t = yf.Ticker(ticker)
            # Always use full info (not fast_info) to get complete data including P/E, 52-week ranges, etc.
            info = t.info or {}
            info['source'] = 'info'
            logging.info(f'Fetched info for {ticker} with {len(info)} fields')
            return info
        except Exception as e:
            logging.warning(f'Yahoo info error for {ticker}: {e}')
            return {'error': str(e), 'ticker': ticker}

    def fetch_financials(self, ticker: str) -> pd.DataFrame:
        """Fetch income statement (financials) or return empty DataFrame on failure."""
        ticker = self._sanitize_ticker(ticker)
        logging.info(f'Fetching financials for {ticker}')

        if self._stub:
            logging.warning('Using stub financials data')
            return pd.DataFrame()

        try:
            t = yf.Ticker(ticker)
            financials = t.financials
            if financials is not None and not financials.empty:
                logging.info(f'Fetched financials for {ticker}: {financials.shape}')
                return financials
            else:
                logging.warning(f'Empty financials for {ticker}')
                return pd.DataFrame()
        except Exception as e:
            logging.error(f'Error fetching financials for {ticker}: {e}')
            return pd.DataFrame()

    def fetch_balance_sheet(self, ticker: str) -> pd.DataFrame:
        """Fetch balance sheet or return empty DataFrame on failure."""
        ticker = self._sanitize_ticker(ticker)
        logging.info(f'Fetching balance sheet for {ticker}')

        if self._stub:
            logging.warning('Using stub balance sheet data')
            return pd.DataFrame()

        try:
            t = yf.Ticker(ticker)
            balance_sheet = t.balance_sheet
            if balance_sheet is not None and not balance_sheet.empty:
                logging.info(f'Fetched balance sheet for {ticker}: {balance_sheet.shape}')
                return balance_sheet
            else:
                logging.warning(f'Empty balance sheet for {ticker}')
                return pd.DataFrame()
        except Exception as e:
            logging.error(f'Error fetching balance sheet for {ticker}: {e}')
            return pd.DataFrame()

    def fetch_cashflow(self, ticker: str) -> pd.DataFrame:
        """Fetch cash flow statement or return empty DataFrame on failure."""
        ticker = self._sanitize_ticker(ticker)
        logging.info(f'Fetching cash flow for {ticker}')

        if self._stub:
            logging.warning('Using stub cash flow data')
            return pd.DataFrame()

        try:
            t = yf.Ticker(ticker)
            cashflow = t.cashflow
            if cashflow is not None and not cashflow.empty:
                logging.info(f'Fetched cash flow for {ticker}: {cashflow.shape}')
                return cashflow
            else:
                logging.warning(f'Empty cash flow for {ticker}')
                return pd.DataFrame()
        except Exception as e:
            logging.error(f'Error fetching cash flow for {ticker}: {e}')
            return pd.DataFrame()
```

Adapter: news.py

File: *adapters/news.py*

```
"""
News API adapter with sentiment classification using a 5-step prompt chain.
"""

import logging
import os
import re
import time
from typing import Any, Dict, List
import pandas as pd
import requests

from .base import APIDataAdapter


class NewsAdapter(APIDataAdapter):
    """Fetches news from NewsAPI and performs keyword-based sentiment analysis."""

    POS = ('beat', 'raise', 'growth', 'record', 'surge', 'expand')
    NEG = ('miss', 'cut', 'decline', 'lawsuit', 'drop', 'recall', 'probe')

    def __init__(self, health_check: bool = False, fail_on_error: bool = False):
        """Init adapter and optionally run health check."""
        self.key = os.getenv('NEWSAPI_KEY')
        self.session = requests.Session() if self.key else None
        super().__init__('NEWSAPI_KEY', health_check, fail_on_error)
        self.key = self.api_key

    def _test_api_connection(self) -> bool:
        """Check API key, connection, and response validity."""
        print(f"\n{'='*60}\n{self.adapter_name} Health Check\n{'='*60}")

        print("[2/3] Testing API connection...", end=" ")
        try:
            r = self.session.get(
                'https://newsapi.org/v2/everything',
                headers={'X-Api-Key': self.api_key},
                params={'q': 'test', 'language': 'en', 'pageSize': 1},
                timeout=10
            )
            r.raise_for_status()
            print("Success")
        except Exception as e:
            print(f"Failed ({type(e).__name__})")
            self._health_check_passed = False
            self._health_check_message = f"API connection failed: {type(e).__name__}"
            print(f"\n{'='*60}\nHealth Check Failed\n{'='*60}\n")
            return False

        print("[3/3] Verifying response data...", end=" ")
        try:
            if isinstance(r.json().get('articles', []), list):
                print("Success")
                self._health_check_passed = True
                self._health_check_message = "News API operational"
            else:
                print("Warning")
                self._health_check_passed = False
                self._health_check_message = "Unexpected response format"
        except Exception as e:
            print(f"Failed ({type(e).__name__})")
            self._health_check_passed = False
            self._health_check_message = f"Response parsing failed: {type(e).__name__}"

        status = "Passed" if self._health_check_passed else "Failed"
        print(f"\n{'='*60}\nHealth Check {status}\n{'='*60}\n")
        return self._health_check_passed

    def _get_stub_data(self, ticker: str, *args, **kwargs) -> List[Dict[str, Any]]:
        """Return stub articles when API is unavailable."""
        now = int(time.time())
        return [
            {
                'title': f'[Stub] Growth story for {ticker}',
                'description': f'{ticker} gains as services growth improves',
                'content': '...',
                'publishedAt': pd.Timestamp.utcfromtimestamp(now).isoformat()
            },
            {
                'title': f'[Stub] Miss story for {ticker}',
                'description': f'{ticker} faces supply chain miss and margin pressure',
                'content': '...',
                'publishedAt': pd.Timestamp.utcfromtimestamp(now - 3600).isoformat()
            }
        ]

    def _ingest(self, ticker: str, window_days: int = 7) -> List[Dict[str, Any]]:
        """Fetch news articles or fallback to stub data."""
        if not self.session:
            logging.warning(f'Using stub news data for {ticker}')
            return self._get_stub_data(ticker)

        try:
            r = self.session.get(
                'https://newsapi.org/v2/everything',
                headers={'X-Api-Key': self.key},
                params={'q': ticker, 'language': 'en', 'pageSize': 50, 'sortBy': 'publishedAt'},
                timeout=20
            )
            r.raise_for_status()
            articles = r.json().get('articles', [])
            logging.info(f'Fetched {len(articles)} articles for {ticker}')
            return articles
        except Exception as e:
            logging.error(f'News API error: {e}')
            return self._get_stub_data(ticker)

    def _preprocess(self, items: List[Dict]) -> List[str]:
        """Clean and normalize article text."""
        return [
            re.sub(r'\s+', ' ', ' '.join([
                str(a.get('title', '')),
                str(a.get('description', '')),
                str(a.get('content', ''))
            ])).strip().lower()
            for a in items
        ]

    def _classify(self, texts: List[str]) -> List[str]:
        """Classify sentiment by keyword presence."""
        def classify_text(t):
            has_pos = any(k in t for k in self.POS)
            has_neg = any(k in t for k in self.NEG)
            if has_pos and has_neg:
                return 'mixed'
            elif has_pos:
```

```
            return 'positive'
        elif has_neg:
            return 'negative'
        else:
            return 'neutral'
    return [classify_text(t) for t in texts]

def _extract(self, texts: List[str]) -> List[Dict]:
    """Extract monetary entities from text."""
    return [{'money': list(set(re.findall(r'\$\s?\d+(?:\.\d+)?', t)))} for t in texts]

def _summarize(self, labels: List[str], texts: List[str], k: int = 2) -> Dict:
    """Summarize sentiment counts and sample snippets."""
    return {
        'summary_text': '...',
        'counts': {s: labels.count(s) for s in ['mixed', 'positive', 'negative', 'neutral']},
        'snippets': [f'- {labels[i]}: {texts[i][:100]}...' for i in range(min(k, len(texts)))]
    }

def run_chain(self, ticker: str, window_days: int = 7) -> Dict:
    """Run full pipeline: Ingest → Preprocess → Classify → Extract → Summarize."""
    items = self._ingest(ticker, window_days)
    texts = self._preprocess(items)
    labels = self._classify(texts)
    extracts = self._extract(texts)
    summary = self._summarize(labels, texts)

    return {
        'type': 'news',
        'counts': summary['counts'],
        'samples': [
            {'text': texts[i], 'sentiment': labels[i], 'entities': extracts[i]}
            for i in range(min(3, len(texts)))
        ],
        'summary': summary,
        'is_stub': self.session is None or len(items) == 2
    }
```

Adapter: sec.py

File: *adapters/sec.py*

```
"""
SEC filings adapter for retrieving company filings from the SEC API.
"""

import logging
import os
from typing import Any, Dict, List, Tuple
import requests

from .base import APIDataAdapter


class SECAdapter(APIDataAdapter):
    """Fetches SEC filings (10-K, 10-Q, etc.) for fundamental analysis."""

    def __init__(self, health_check: bool = False, fail_on_error: bool = False):
        """Init adapter and optionally run health check."""
        self.base_url = 'https://api.sec-api.io'
        super().__init__('SEC_API_KEY', health_check, fail_on_error)

    def _test_api_connection(self) -> bool:
        """Run SEC API connection and response validation."""
        print("[2/3] Testing API connection...", end=" ")
        try:
            response = requests.get(
                f'{self.base_url}/',
                params={
                    'query': 'ticker:AAPL AND formType:"10-K"',
                    'from': '0',
                    'size': '1',
                    'sort': [{'filedAt': {'order': 'desc'}}]
                },
                headers={'Authorization': self.api_key},
                timeout=10
            )
            response.raise_for_status()
            print("Success")
        except Exception as e:
            print(f"Failed ({type(e).__name__})")
            self._health_check_passed = False
            self._health_check_message = f"API connection failed: {type(e).__name__}"
            print(f"\n{'='*60}\nHealth Check Failed\n{'='*60}\n")
            return False

        print("[3/3] Verifying response data...", end=" ")
        try:
            if isinstance(response.json().get('filings', []), list):
                print("Success")
                self._health_check_passed = True
                self._health_check_message = "SEC API operational"
            else:
                print("Warning")
                self._health_check_passed = False
                self._health_check_message = "Unexpected response format"
        except Exception as e:
            print(f"Failed ({type(e).__name__})")
            self._health_check_passed = False
            self._health_check_message = f"Response parsing failed: {type(e).__name__}"
        status = "Passed" if self._health_check_passed else "Failed"
        print(f"\n{'='*60}\nHealth Check {status}\n{'='*60}\n")
        return self._health_check_passed

    def _get_stub_data(self, ticker: str, limit: int = 3, *args, **kwargs) -> List[Dict[str, Any]]:
        """Return synthetic SEC filing data as fallback."""
        return [{
            'form': '10-Q',
            'filingDate': '2025-08-01',
            'text': f'{ticker} reported EPS beat; management raised guidance; risk factors discussed.',
            'url': '(stub)',
            'is_stub': True
        } for _ in range(limit)]

    def latest_filings(
        self,
        ticker: str,
        form_types: Tuple[str, ...] = ('10-K', '10-Q'),
        limit: int = 3
    ) -> List[Dict[str, Any]]:
        """Fetch recent SEC filings or stub data if unavailable."""
        if not self.api_key:
            logging.warning(f'Using stub SEC data for {ticker}')
            return self._get_stub_data(ticker, limit)

        try:
            form_query = ' OR '.join([f'formType:"{ft}"' for ft in form_types])
            query = f'ticker:{ticker} AND ({form_query})'

            response = requests.get(
                f'{self.base_url}/',
                params={
                    'query': query,
                    'from': '0',
                    'size': str(limit),
                    'sort': [{'filedAt': {'order': 'desc'}}]
                },
                headers={'Authorization': self.api_key},
                timeout=20
            )
            response.raise_for_status()

            filings = [{
                'form': f.get('formType', ''),
                'filingDate': f.get('filedAt', '')[:10],
                'text': f"{f.get('companyName', ticker)} filed {f.get('formType', '')}.",
                'url': f.get('linkToFilingDetails', ''),
                'is_stub': False
            } for f in response.json().get('filings', [])]

            logging.info(f'Fetched {len(filings)} SEC filings for {ticker}')
            return filings

        except Exception as e:
            logging.error(f'SEC API error: {e}')
            return self._get_stub_data(ticker, limit)
```