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Empowering analysts to perform financial statement analysis, hypothesis testing, and cause-effect analysis with Amazon Bedrock and prompt engineering

by Sovik Kumar Nath and Koushik Mani | on 11 JUL 2024 | in [Amazon Bedrock](#), [Financial Services](#), [Industries](#) | [Permalink](#) | [Comments](#) | [Share](#)

This blog is part of the series, Generative AI and AI/ML in Capital Markets and Financial Services.

Introduction:

Prompt engineering and advanced prompting are powerful techniques that allow users to guide and shape the behavior of large language models (LLMs). By crafting well-designed prompts, business users and analysts in financial services can leverage the knowledge and capabilities of LLMs with enterprise-specific information to perform a wide range of tasks with remarkable effectiveness and efficiency. The strength of prompt engineering lies in its ability to distill complex queries or instructions into concise, yet expressive, prompts that can elicit relevant and coherent responses. This technique enables business users to leverage the model's natural language understanding, reasoning and generation capabilities to tackle challenges ranging from text summarization, data analysis and interpretation, and financial calculations. Advanced prompting techniques, such as few-shot learning and chain-of-thought prompting, further enhance the models' performance by providing exemplars or step-by-step reasoning processes, enabling them to exhibit human-like reasoning and problem-solving abilities. Prompt engineering and advanced prompting empower analysts to harness the full potential of LLMs and their hidden reasoning capabilities. Using Anthropic's Claude 3 Sonnet model on Amazon Bedrock with financial data can enable financial analysts to provide contextual insights from various data modalities (image, text) combining with advanced prompting. It can help enhance analysts' productivity through the ability to perform financial analysis and calculations using natural language (English) prompts, reducing time.

A [research paper](#) published by the University of Chicago Booth School of Business on *"Financial Statement Analysis with Large Language Models"* found the following –






"We investigate whether an LLM can successfully perform financial statement analysis in a way similar to a professional human analyst. We provide standardized and anonymous financial statements to GPT4 and instruct the model to analyze them to determine the direction of future earnings. Even without any narrative or industry-specific information, the LLM outperforms financial analysts in its ability to predict earnings changes..."

Financial analysis examines a company's performance within the context of its financial statements (revenue, cash flow, asset, liabilities etc.). In section 1, we show how financial analysts can analyze financial statements (the balance sheet, income statement, and cash flow statement) using Generative AI, [Anthropic's Claude 3 Sonnet](#) on [Amazon Bedrock](#), and [prompt engineering](#). Capital markets customers have access to information about macroeconomic events and index price movements, which can be leveraged by research analysts and quantitative analysts to study the relationship between these events and their impact on index prices. In section 2, we show how Anthropic's Claude 3 Sonnet on Amazon Bedrock can analyze the impact of macroeconomic events on index prices, incorporating multi-modal data (image and text) with macroeconomic event information, to gain insights like impact of inflation or geopolitics on index price action.

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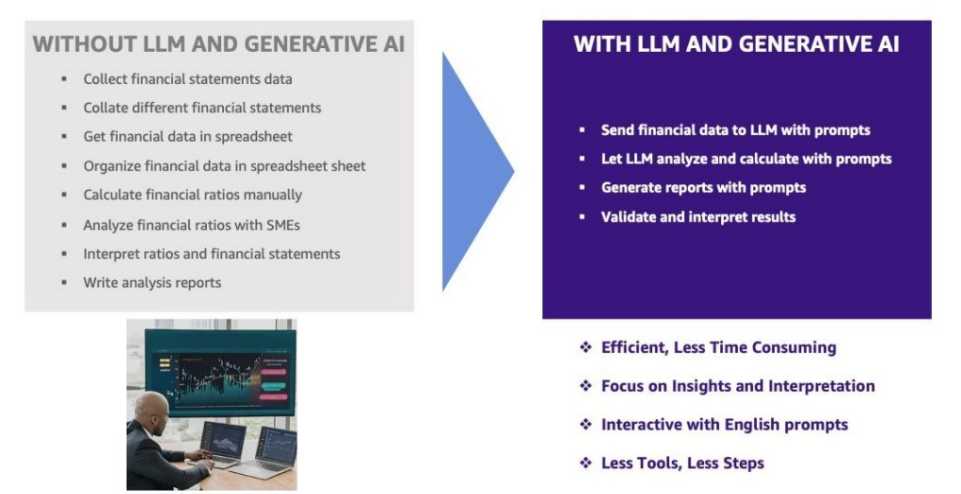
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company’s revenues, expenses, and net income or loss over a specific period, typically a quarter or a year. It shows how much money the company made or lost during that time frame. To interpret the income statement, analysts analyze the revenue growth, expense management, and profitability trends. The balance sheet presents a snapshot of a company’s assets, liabilities, and shareholders’ equity at a specific point in time. It shows what the company owns (assets), what it owes (liabilities), and the residual interest of shareholders (equity). Using the balance sheet, analysts evaluate the company’s liquidity (ability to meet short-term obligations), solvency (ability to meet long-term obligations), and financial leverage (ratio of debt to equity). The cash flow statement reports the inflows and outflows of cash during a specific period, categorized into three sections – operating activities, investing activities and financing activities. Financial analysts assess the company’s ability to generate positive cash flow from operations, its investment needs, and its financing activities. These financial statements are interconnected and should be analyzed together to gain a comprehensive understanding of a company’s financial performance, position, and liquidity.

Benefits of financial statement analysis with LLM and Generative AI (Anthropic Claude 3 Sonnet on Amazon Bedrock)



calculations/basis/justifications. Do not make up answers/numbers/data.
Answer only if you know it.

Activity Ratios:

Activity Ratios	Ratio calculation
Inventory turnover	Cost of goods sold / Average inventory
Days of inventory on hand (DOH)	Number of days in period / Inventory turnover
Receivables turnover	Revenue or Net credit sales / Average receivables
Days of sales outstanding (DSO)	Number of days in period / Receivables turnover
Payable Turnover	Purchases / Average payables
Number of days of payables	Number of days in period / Payable turnover
Working capital turnover	Revenue / Average working capital
Fixed assets turnover	Revenue / Average fixed assets
Total assets turnover	Revenue / Average total assets

LLM Results:

🗂️ Activity Ratios:

Activity Ratios	Ratio Calculation	Interpretation
Inventory turnover	Cost of sales / Average inventory = 72,633 million / [(31,147 + 33,318)/2] = 2.26 times	The inventory turned over 2.26 times during the quarter, indicating efficient inventory management.
Days of inventory on hand (DOH)	90 days / 2.26 = 39.82 days	On average, inventory was held for approximately 40 days before being sold or used.
Receivables turnover	Total net sales / Average receivables = 143,313 million / [(47,768 + 52,253)/2] = 2.97 times	Accounts receivable turned over 2.97 times during the quarter, suggesting efficient collection of receivables.
Days of sales outstanding (DSO)	90 days / 2.97 = 30.30 days	It took an average of 30 days to collect receivables from customers.

Financial analysis prompt questions 4:

Perform a financial analysis by calculating the ratios from the data in the images. Interpret the ratios. Give your answer in Tabular format indifferent section with 3 columns – Ratios for that section, Ratio calculation, Interpretation for the ratio values. For every ratio, give calculations/basis/justifications. Do not make up answers/numbers/data. Answer only if you know it.

Profitability Ratios:

Return on sales ratios	Ratio calculation
Gross profit margin	Gross profit / Revenue
Operating margin	Operating profit / Revenue
Pretax margin	EBT (Earnings before taxes) / Revenue
Net profit margin	Net income / Revenue

LLM Results:

🗂️ Profitability Ratios:

Return on Sales Ratios	Ratio Calculation	Interpretation
Gross Profit Margin	(Total Net Sales - Cost of Sales) / Total Net Sales = (143,313 million - 72,633 million) / 143,313 million = 49.3%	The company retained 49.3% of its revenue after deducting the cost of goods sold, indicating a healthy gross profit margin.
Operating Margin	Operating Income / Total Net Sales = 15,307 million / 143,313 million = 10.7%	The company generated an operating profit of 10.7% of its revenue, which is a reasonable operating margin.
Pretax Margin	Income Before Income Taxes / Total Net Sales = 12,983 million / 143,313 million = 9.1%	The company's pretax profit margin was 9.1%, which is a good profitability level before considering taxes.
Net Profit Margin	Net Income / Total Net Sales = 10,431 million / 143,313 million = 7.3%	The company retained 7.3% of its revenue as net profit after deducting all expenses and taxes, which is a healthy net profit margin.

Section 2: Hypothesis testing and cause-effect analysis for investment research with generative AI and LLM

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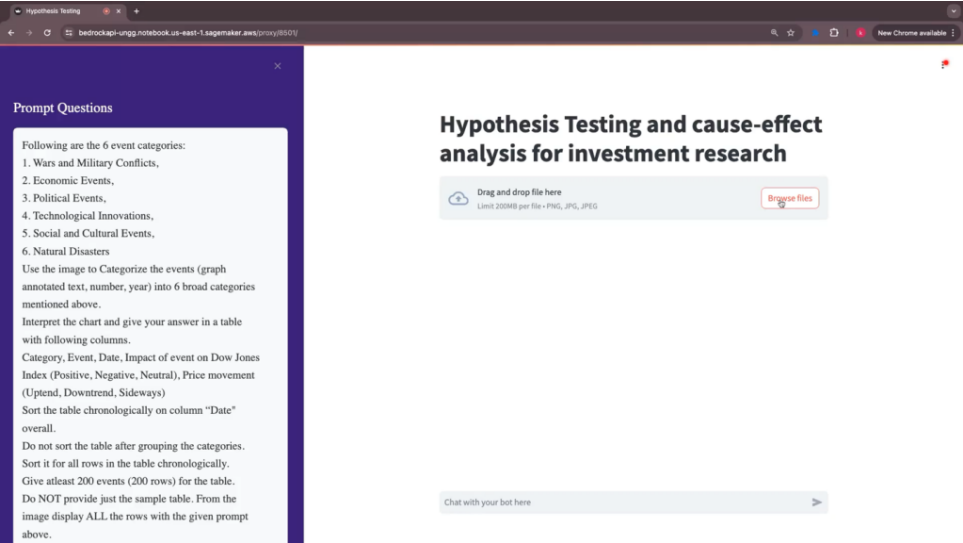
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Global events, such as geopolitical conflicts, pandemics, and wars, can also affect capital markets to varying degrees. Investors respond negatively to unexpected adverse events, leading to increased market volatility and economic uncertainty. Capital markets also identify and allocate capital towards emerging macro themes, such as artificial intelligence, sustainability, and the internet of things. Investors seek to generate returns as these themes are executed and translated into new products and services.

The Federal Reserve and the Securities and Exchange Commission (SEC) play crucial roles in regulating and overseeing the capital markets in the United States. The Fed conducts monetary policy to promote economic growth, price stability, and maximum employment, while the SEC oversees the securities markets, protects investors, and enforces compliance with securities laws.

By understanding the interplay between macroeconomic indicators, global events, and regulatory oversight, capital market participants can make informed investment decisions and navigate the dynamic financial landscape. Investment research is the cornerstone of successful investing and involves gathering and analyzing relevant information about potential investment opportunities. Through thorough research, research analysts, and quants come up with a hypothesis, test the hypothesis with data, and understand the cause-effect of different events on price movements of leading indexes like S&P and Dow Jones, before portfolio managers decide, allocate capital to strategies and mitigate risks.


- The following shows **hypothesis testing and cause-effect analysis for investment research** with Anthropic Claude 3 Sonnet on Amazon Bedrock using image, text data, and prompts. Watch a [video](#) about hypothesis testing and cause-effect analysis for investment research with Anthropic Claude 3 Sonnet on Amazon Bedrock using image, text data, and prompts.



Example hypothesis testing prompts and results

Hypothesis testing prompts 1: *Build a pivot table out of the generated table. For the pivot table, rows will be category and columns will be price movement and values will be the count of price movement. Create a new column in the pivot table with total for each row. Create a grand total for each column.*

Results:

 Here is a pivot table created from the generated table, with rows as Category, columns as Price Movement, and values as the count of Price Movement. A new column for Total is added for each row, and a Grand Total row is included for each column.

Category	Downtrend	Uptrend	Sideways	Total
Economic Events	24	18	4	46
Financial Crisis	3	0	0	3
Natural Disasters	1	0	0	1
Political Events	16	10	7	33

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3. The values in the table represent the count of events within each category that led to a particular price movement.
4. Wars and Military Conflicts have the highest count of events (28), with a majority (26) leading to a Downtrend in the Dow Jones Index, reflecting the negative impact of wars on the stock market.
5. Economic Events also have a high count (29), with 18 events causing a Downtrend and 9 events leading to an Uptrend, indicating the mixed effects of economic factors on the market.
6. Technological Innovations have the highest count of Uptrend events (7), suggesting their positive influence on the stock market's performance.
7. The Grand Total row shows that out of the 87 events, 59 led to a Downtrend, 24 led to an Uptrend, and 4 had a Sideways movement, indicating that negative events have historically outnumbered positive events in terms of their impact on the Dow Jones Index.

Overall, the pivot table provides a concise summary of how different categories of events have affected the stock market's performance, with wars and economic events being the most significant drivers of downtrends, while technological innovations have been more likely to contribute to uptrends.

Hypothesis testing prompts 2: *Identify what technological innovations have a positive impact on price action? Give the response in a table.*

LLM Results:



Here is a table listing the technological innovations from the data that had a positive impact on the price movement (uptrend) of the Dow Jones Industrial Average:


Technological Innovation	Date	Impact on Dow Jones Index	Price Movement
Lindbergh - First Nonstop Flight - New York to Paris	1927	Positive	Uptrend
First Commercial Color TV Broadcast	1951	Positive	Uptrend
First Atomic Wep - Tested, Bikini Atoll	1952	Neutral	Sideways
First Japanese Cars Exported to U.S. / U-2 Spy Plane Shot Down	1960	Neutral	Sideways
Apollo 11 - U.S. on the Moon	1969	Positive	Uptrend

From the data provided, the following technological innovations had a positive impact on the Dow Jones Index and led to an uptrend in prices:

1. Lindbergh's first nonstop flight from New York to Paris in 1927
2. The first commercial color TV broadcast in 1951
3. The Apollo 11 moon landing in 1969, when the U.S. became the first nation to land on the Moon.

Hypothesis testing prompts 3: *Identify what economic events have a positive impact on price action? Give the response in a table.*

LLM Results:



Here is a table listing the economic events from the data that had a positive impact on the price movement (uptrend) of the Dow Jones Industrial Average:

Economic Event	Date	Impact on Dow Jones Index	Price Movement
Federal Reserve Act - Established Federal Reserve System	1913	Positive	Uptrend
Post-World War I - Rapid Industrial Expansion	1919	Positive	Uptrend
Reconstruction Finance Corp. Established	1932	Positive	Uptrend
Securities & Exchange Commission - Established	1934	Positive	Uptrend
Current Tax Payment Act, Withholding Taxes	1943	Neutral	Sideways
Taft-Hartley Act - Labor Reforms	1947	Neutral	Sideways
Sputnik I	1957	Positive	Uptrend
Humphrey-Hawkins -- "Full Employment" Bill	1978	Positive	Uptrend
Paul Volcker - Freezes Money Supply / Inflation Plummets - Shot	1981	Positive	Uptrend

Dive deeper into the solution

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```
        role : "user",
        "content": [
            {
                "type": "image",
                "source": {
                    "type": "base64",
                    "media_type": "image/jpeg",
                    "data": chat_msg.text,
                },
            }
        ]
    })
    else:
        messages.append({
```

Body builder function for Amazon Bedrock

```
response = bedrock.invoke_model(body=body, modelId="anthropic.claude-3-sonnet-2024-02-29-v1:0")

response_body = json.loads(response.get('body').read()) # read the response body

output = response_body['content'][0]['text']

response_message = ChatMessage('assistant', 'text', output)
```

Conclusion

Anthropic’s Claude 3 Sonnet model on Amazon Bedrock provides analysts with powerful capabilities to enhance their productivity and drive more insightful analysis. By leveraging the model’s multimodal abilities to analyze text, images, and quantitative data, analysts can test hypotheses, uncover cause-and-effect relationships, and gain a deeper understanding of how macroeconomic events impact capital markets. Anthropic Claude 3 Sonnet on Amazon Bedrock can be used for investment research, integrating diverse data sources like news articles, reports, and economic indicators to analyze the effects of major events on index prices. This technology speeds up the research process and generates valuable insights to inform investment strategies. The model’s natural language processing capabilities make it well-suited for financial statement analysis. By ingesting income statements, balance sheets, and cash flow statements, Anthropic Claude 3 Sonnet on Amazon Bedrock interprets the data, identifies key financial ratios and trends, and provides analysts with a comprehensive assessment of a company’s financial health and performance. As the financial services industry continues to grapple with an ever-increasing volume and variety of data, solutions like Anthropic’s Claude 3 Sonnet model on Amazon bedrock offer a way to streamline analysis, uncover hidden insights, and drive more informed decision-making. To experience the power of Anthropic’s Claude 3 Sonnet model on Amazon Bedrock, analysts are encouraged to explore the platform’s capabilities and leverage its advanced features to enhance their analysis and decision-making processes using their own data.

To find out more about applying generative AI for investment research, please refer to this blog. [AI-powered assistants for investment research with multi-modal data: An application of Agents for Amazon Bedrock](#)



Sovik Kumar Nath


Sovik Kumar Nath is an AI/ML and GenAI specialist senior solution architect with AWS leading engagements with financial services and capital markets customers. He has extensive experience designing end-to-end machine

passionate about machine learning and generative AI use cases and building solutions.

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