MIE566: Decision making Under Uncertainty

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Project Part1

Team Member

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Problem Statement:

In this scenario, an individual investor must decide how to allocate their $1,000,000 investment portfolio between stocks and bonds. The investor has four key options: invest heavily in stocks, invest heavily in bonds, split the investment 70-30 in favour of stocks, or split the investment 70-30 in favour of bonds. Additionally, the investor can choose to pay for financial advice at a cost of $15,000, which provides market analysis to inform their decision. This decision is complex due to uncertainties tied to market conditions.

The investor faces subjective uncertainties, such as stock market performance and geopolitical risks, and objective ones like bond yields and central bank interest rates. The decision-making process uses Bayesian analysis, allowing the investor to update beliefs as new information (e.g., market analysis) becomes available. Risk tolerance plays a critical role, with higher risk tolerance favouring stocks and a more conservative approach focusing on bonds. By modelling these decisions, the investor can assess trade-offs between returns and risks, balancing subjective judgments with objective data.

Probability tables

Bond Yield Category	**Probability**
Low (below 2%) =1%	30%
Medium (2-4%) =3%	50%
High (above 4%) =5%	20%

Interest Rate	**Probability**
Low Interest Rate (<2%)	20%
Medium Interest Rate (2-4%)	50%
High Interest Rate (>4%)	30%

Stock Market Crash	Probability
No Market Crash	95%
Market Crash	5%

Stock Market Performance Category	Probability
High Performance (10%)	30%
Medium Performance (5%)	50%
Low Performance (-2%)	20%

Geopolitical Risk	Probability
Low Geopolitical Risk	30%
Moderate Geopolitical Risk	50%
High Geopolitical Risk	20%

Conditional Probabilities for Market Analysis Results given Market Performance:

	Market Performance		
Market Analysis Result	**High**	**Medium**	**Low**
High	70%	50%	10%
Medium	20%	40%	30%
Low	10%	10%	60%

Decision Nodes:

- **Market Allocation Decision (D1):**
    - The investor has four alternatives: After analysing the market conditions and potential outcomes, the investor could decide how to allocate the investment
        1. Split 90% in stocks and 10% in bonds. d1
        2. Split 90% in bonds and 10% in stocks. d2
        3. Split 70% in stocks and 30% in bonds. d3
        4. Split 70% in bonds and 30% in stocks. d4

    This node influences Risk Adjustment and the utility.

- **Pay for Financial Advice Decision (D2):**
    - The investor chooses whether to pay for financial advice (market analysis) to inform their market allocation decision.
        1. Yes
        2. No

    This node influences Risk Adjustment, Market Analysis Result, Market Allocation, and the utility.

- **Risk Adjustment Decision (D3)**:
    - The investor has to adjust the allocation of investment immediately in case of unexpected event, such as change in Central Bank Interest Rate or Geopolitical Events

1. Increase risk tolerance (more exposure to stocks):

   Increase investment in stocks by 10% and decrease in bond by 10%

2. Decrease risk tolerance (more exposure to bonds):

   Increase investment in stocks by 10% and decrease in bond by 10%

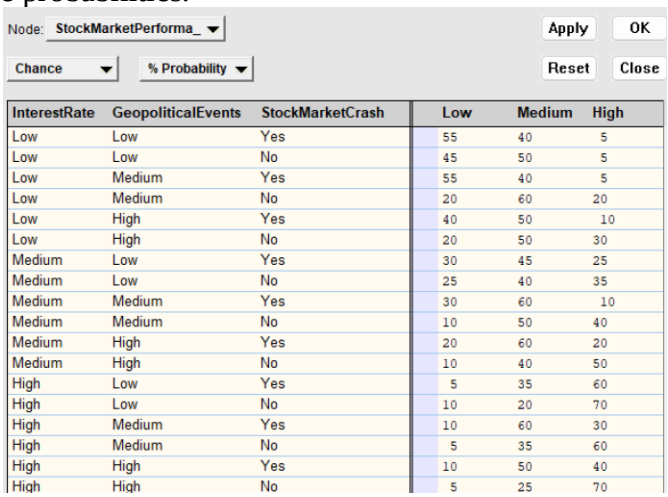
3. Maintain the current allocation

This node influences just the **utility**.

Uncertainty Nodes:

1) Stock Market Performance (C1): This node models the uncertainty in stock market returns. Historical trends and expert forecasts inform the probabilities:

- High (10%): Strong market growth.
- Medium (5%): Stable conditions.
- Low (-2%): Market downturn.



InterestRate	GeopoliticalEvents	StockMarketCrash	Low	Medium	High
Low	Low	Yes	55	40	5
Low	Low	No	45	50	5
Low	Medium	Yes	55	40	5
Low	Medium	No	20	60	20
Low	High	Yes	40	50	10
Low	High	No	20	50	30
Medium	Low	Yes	30	45	25
Medium	Low	No	25	40	35
Medium	Medium	Yes	30	60	10
Medium	Medium	No	10	50	40
Medium	High	Yes	20	60	20
Medium	High	No	10	40	50
High	Low	Yes	5	35	60
High	Low	No	10	20	70
High	Medium	Yes	10	60	30
High	Medium	No	5	35	60
High	High	Yes	10	50	40
High	High	No	5	25	70

This node directly influences **utility.** These probabilities were subjectively assigned based on expert analysis of current economic forecasts and historical data on stock market cycles. This node influences the utility directly, as stock performance impacts portfolio returns.

2) Bond Yields (C2): Based on **U.S. Treasury data** and **Federal Reserve policies**, bond yield probabilities reflect economic cycles (US Department of the treasury, 2023):

- **Low Yield (1%)**: 30% (economic slowdowns).
- **Medium Yield (3%)**: 50% (stable conditions).
- **High Yield (5%)**: 20% (growth/inflation).

Node: BondYield | Apply | OK | Reset | Close

Chance | % Probability

InterestRate	GeopoliticalEvents	Low	Medium	High
Low	Low	55	40	5
Low	Moderate	40	50	10
Low	High	20	60	20
Medium	Low	10	70	20
Medium	Moderate	10	60	30
Medium	High	10	50	40
High	Low	5	45	50
High	Moderate	5	35	60
High	High	5	25	70

These probabilities reflect typical market behaviour influenced by central bank decisions. The methodology involved analysing historical yield trends and economic cycles These yield probabilities impact **utility**.

3) **Market Analysis Result (C3):** if the investor chooses to pay for financial advice, they receive market analysis that provides insights into market conditions with possible outcomes:

- **High (favouring stocks)**: The analysis suggests strong stock market performance.
- **Medium (neutral recommendation)**: The analysis indicates balanced market conditions with no clear advantage for stocks or bonds.
- **Low (favouring bonds)**: The analysis indicates a downturn in stock market performance, favouring a heavier investment in bonds.
- **NA (No financial advice chosen)**: No market analysis is taken into consideration, and the investor makes decisions without additional information.

This node influences both **Risk Adjustment** and the **Market Allocation Decision**, guiding the investor's allocation based on expert market analysis. The methodology here relies on subjective probabilities, as financial advice varies based on the advisor's interpretation of current market trends.

Node: MarketAnalysisResult | Apply | OK | Reset | Close

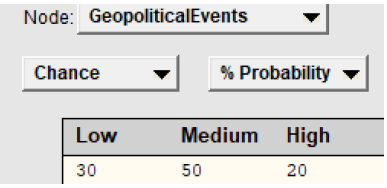
Chance | % Probability

PayFinancialAdvice	StockMarketPerformance	Low	NA	Medium	High
Yes	Low	60	0	30	10
Yes	Medium	10	0	40	50
Yes	High	10	0	20	70
No	Low	0	100	0	0
No	Medium	0	100	0	0
No	High	0	100	0	0

4) **Geopolitical Events (C4):** This reflects uncertainties in global events affecting markets:

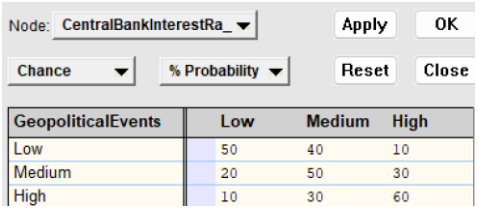
- **Low (25%)**: Stability in global political and economic relations
- **Moderate (50%)**: uncertainties, such as trade tensions or regional conflicts, that may affect market confidence.
- **High (25%)**: Significant disruptions such as wars or sanctions, leading to major market disruptions.

This node affects **Stock Market Performance**, **Interest Rates**, **Bond Yields**, and **Risk Adjustment**.



5) **Central bank Interest Rates (C5):** This node models uncertainties around central bank policies, reflecting inflation control:

- **Low (<2%)**: Stimulate economy (boost stocks, lower bonds).
- **Moderate (2-4%)**: Balanced.
- **High (>4%)**: Combat inflation (lower stocks, raise bonds).



The probabilities for interest rates were derived from historical data on central bank actions and forecasts from economic experts. This node affects **Stock Market Performance**, **Bond Yields**, and **Risk Adjustment**.

6) **Stock Market Crash (C6)**

This node captures the potential for a significant stock market crash. Given current economic forecasts, the likelihood of a crash is low, but still relevant to consider. The outcomes are:

- **No (95%)**: Reflects normal market conditions with typical fluctuations.
- **Yes (5%)**: Represents a sharp decline in stock prices, leading to major losses in stock-heavy portfolios.

The probability of a crash was assigned based on subjective judgment, informed by historical data and the current low likelihood of a crash. However, crashes, when they occur, can be catastrophic for stock-heavy investments. This node influences **Stock Market Performance** directly.

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Outcome Node:

- **Portfolio Return/Utility (U):**
    - The investor's portfolio return depends on Market Allocation Decision (D1), Pay for Financial Advice(D2), Risk Adjustment(D3), Stock market performance (C1), Bond yields (C2)

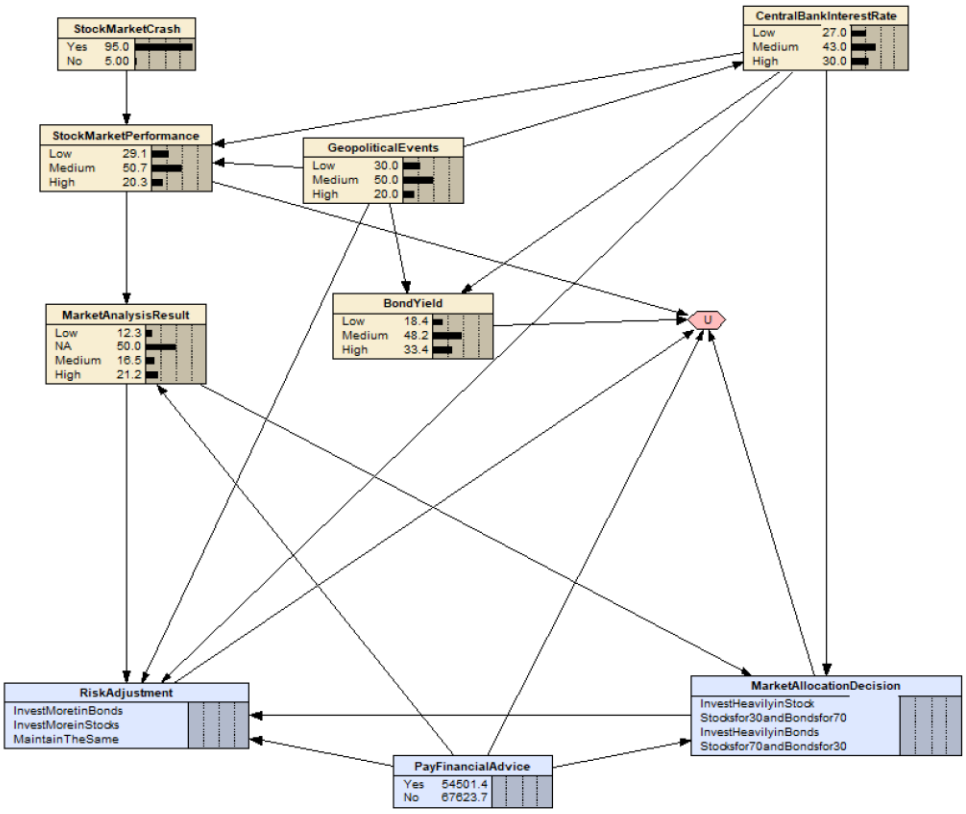
Utility Function:

PortfolioReturn(U)=1,000,000((%ReturnfromBond)(%InvestinginBonds)+(%ReturnfromStocks)(%InvestinginStocks)) -15,000(if PayforFinancialAdvice==Yes)

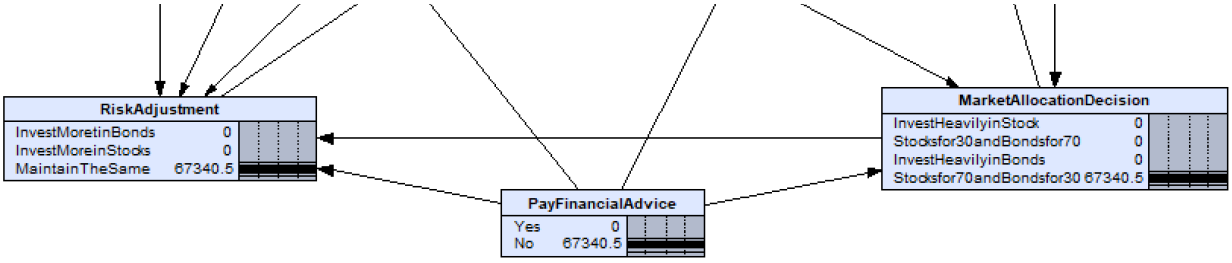
Influence Diagram

The influence diagram for this decision problem includes key decision nodes, chance nodes, and an outcome node (utility). The primary decision is the Market Allocation decision, where the investor chooses how to allocate their $1,000,000 portfolio between

stocks and bonds. Supporting this decision are two other decision nodes: the choice to Pay for Financial Advice (which provides additional market analysis) and Risk Adjustment (where the investor can increase, decrease, or maintain their risk tolerance based on the market conditions). The chance nodes represent the key uncertainties that affect the investor's decision. These include Stock Market Performance, Bond Yields, Geopolitical Risk, Interest Rates, and the probability of a Stock Market Crash. Each of these nodes is carefully modelled based on both subjective and objective data, reflecting historical trends and expert forecasts.



Best Outcome:



Risk Adjustment: Maintain The Same

Pay for Financial Advice: No

Market Allocation Decision: Invest 70% in Stocks and30% in Bonds

Summary:

In conclusion, to maximize the expected portfolio return(outcome) of this investment, the decision maker (the investor) should not pay for Financial Advice, not adjust the allocation of the portfolio, and invest 70% in Stocks and 30% for Bonds; consequently, the expected return of this decision is $67340.5.

However, it's important to note that this model simplifies real-world market dynamics. Uncertainties like geopolitical risk and stock market performance are modelled based on subjective probabilities, which, while informed by historical data and expert judgment, cannot perfectly predict future events. Additionally, behavioural factors such as emotional decision-making, which often play a role in real-world investing, are not explicitly modelled. Despite these limitations, the model provides valuable insights into optimal investment strategies under uncertainty.

References

US Department of the treasury. (2023). *Interest rate statistics.* From US Department of the treasury: https://home.treasury.gov/policy-issues/financing-the-government/interest-rate-statistics