

# **Modern Portfolio Theory**

## **Master's Project Report**

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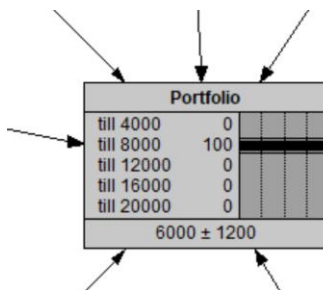
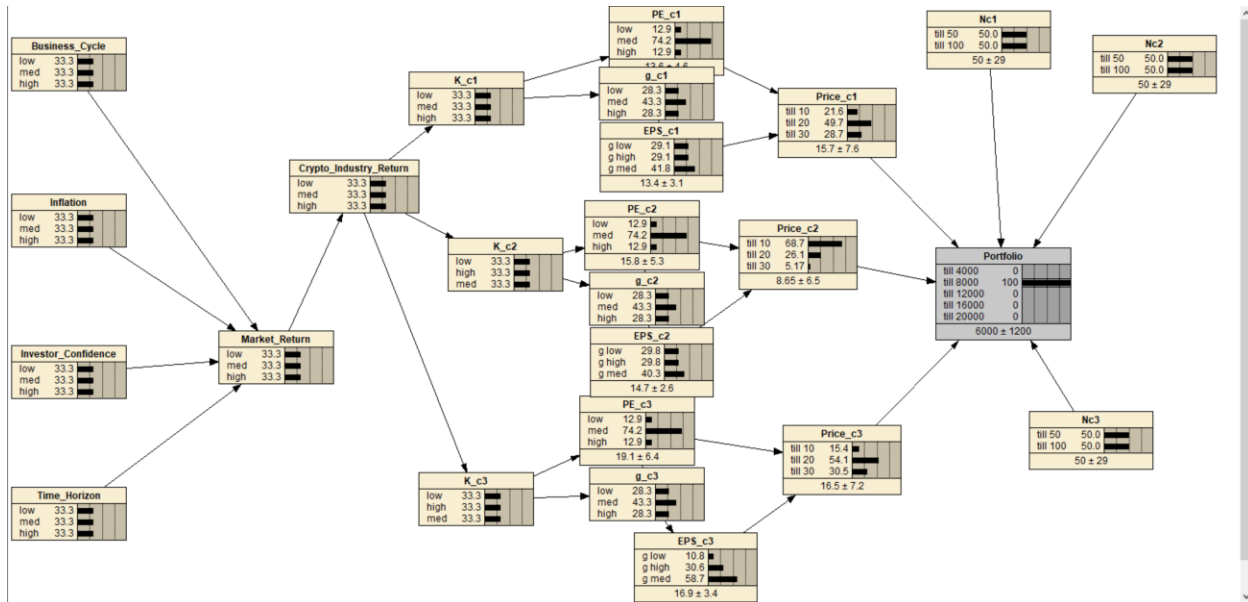
## Probabilistic Methods for Financial and Marketing Informatics

Modern Portfolio Theory (MPT), a hypothesis put forth by Harry Markowitz in his paper "Portfolio Selection," (published in 1952 by the *Journal of Finance*) is an investment theory based on the idea that risk-averse investors can construct portfolios to optimize or maximize expected return based on a given level of market risk, emphasizing that risk is an inherent part of higher reward. It is one of the most important and influential economic theories dealing with finance and investment.

Also called "portfolio theory" or "portfolio management theory," MPT suggests that it is possible to construct an "efficient frontier" of optimal portfolios, offering the maximum possible expected return for a given level of risk. It suggests that it is not enough to look at the expected risk and return of one particular stock. By investing in more than one stock, an investor can reap the benefits of diversification, particularly a reduction in the riskiness of the portfolio. MPT quantifies the benefits of diversification, also known as not putting all of your eggs in one basket.

# Deliverable

A Bayesian network that gives the “Portfolio” distribution of how much returns to expect with what amount of risk given a number of share of each company in the portfolio. Alternatively, The portfolio node can also be used to set expected return values at their corresponding risks to get the optimal distribution in the portfolio.



This is the final node, which gives the portfolio values.

Example - \$6000 is the expected return with a variance or risk of \$1200.

# Parameters

**Risk Factors** – There are multiple market risk factors that must consider if one has to predict future market trend and **market returns**. Time slice considered for calculations is one month.

For this project, I have considered 4 most essential market Risk factors.

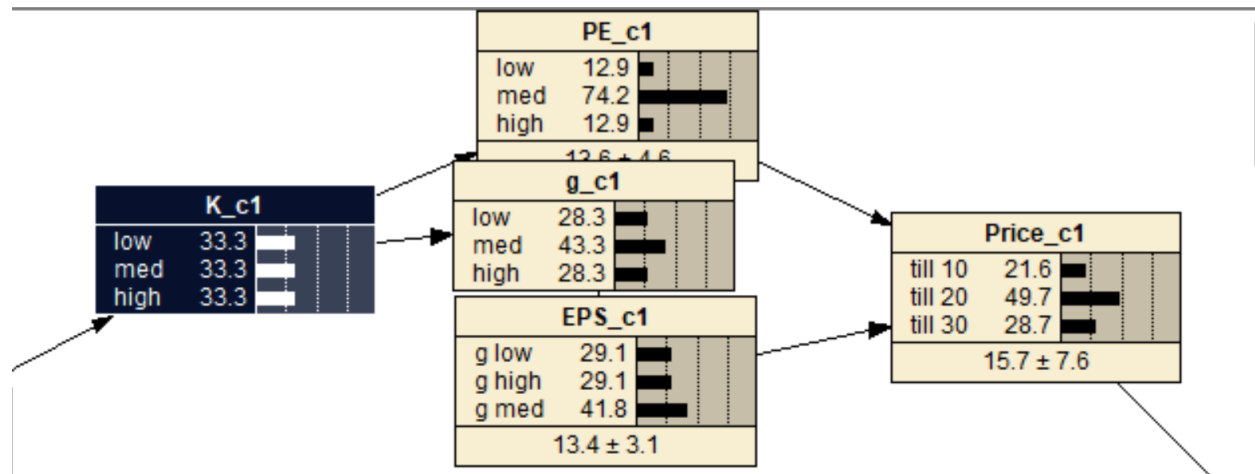
- 1.) Business Cycle – It is the difference between the expected values of the business index at the end of a month and start of the month.
- 2.) Inflation – It is the difference between the actual inflation at the end of the month and the inflation predicted at the starting of the month.
- 3.) Investment Confidence – It is the difference between the end of month rate of return of risk prone corporate bonds and the end of month rate of return on government bonds.
- 4.) Time horizon - It is the difference between the end of month return 20-year government bonds and 30-day Treasury bill.

**Market portfolio** - Market portfolio can be considered as the superset and guiding factor for a **particular industry or sector** portfolios. It consists of a various factor of Market Indices.

For the project and for simplicity sake, let us just consider that the market can be categorized based on return values and variance(risk).

**Industry return** – Like the Market portfolio, it is categorized, for the particular industry, you wish to work on. For our case, it is Cryptocurrency.

**Price of a stock** – There are different factors that combined to form the price of a stock node. They are structured as follows.



**K – required rate of return :**

It is the minimum rate of return required of a stock so as to an investor would consider investing in the stock given a risk as compared to investing in the market portfolio and risk-free assets.

**PE – P/E ration:**

It is the ration of the price (Intrinsic value) per share to the Earning per share of the stock as predicted by investment researchers.

**G – annual growth rate of the company** – dividends grow at this rate per year.

**EPS – Expected earning per share :**

EPS of a company is the ration of the total earnings of the company to the number of outstanding shares of the stock in the company.

**Price :**

This is the current intrinsic price of a share.

$$\text{Price} = \text{PE} * \text{EPS}$$

# Implementation

The entire project has been implemented as a **Bayesian network**.

## **Why Bayesian network :**

A Bayesian network gives the liberty of fixing node values and using them as evidence, hence accessing values and variances at different levels in the whole system.

This essentially provides the user to operate at multiple sub-levels and of course use the final “Portfolio” node for the MPT objective as well as fixing a return that the user wants for a fixed risk and have the corresponding number of shares to invest in different stocks in the portfolio.

## **Netica:**

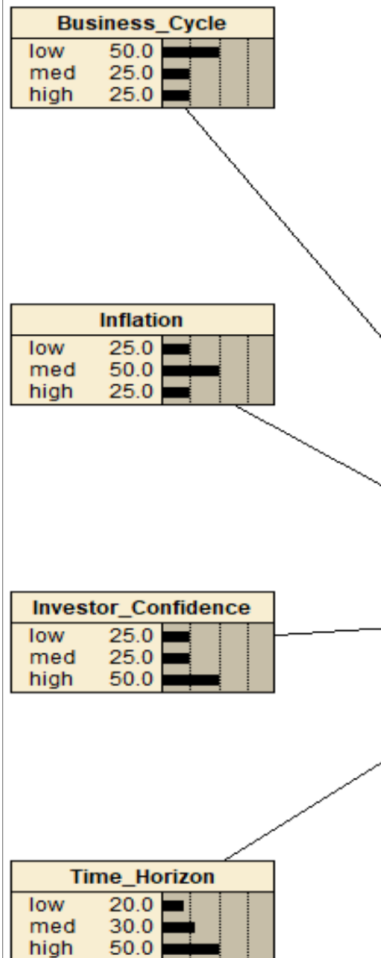
The project is built on a tool called Netica.

Netica is a super tool to build and implements belief/ Bayesian network and Influence diagram.

<https://www.norsys.com/netica.html>

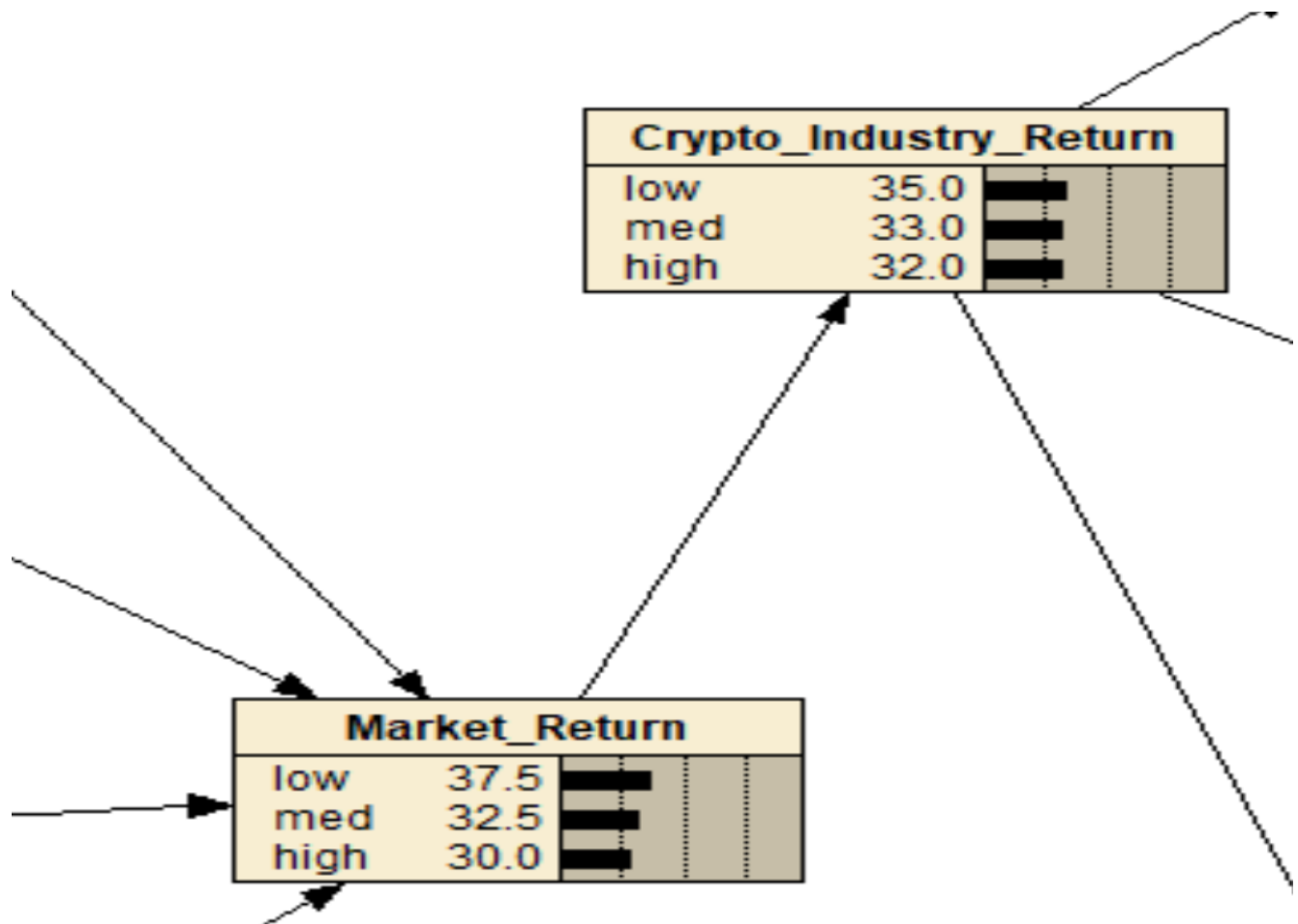
# The Network

Now let us see how the previously explained parameters are constructed into the network.



All the four Risk factors are to be obtained from previous year data. The values are discretized into low, medium and high category ranges. The probability was set as per the number of months out of the total observed months that the values fell into.

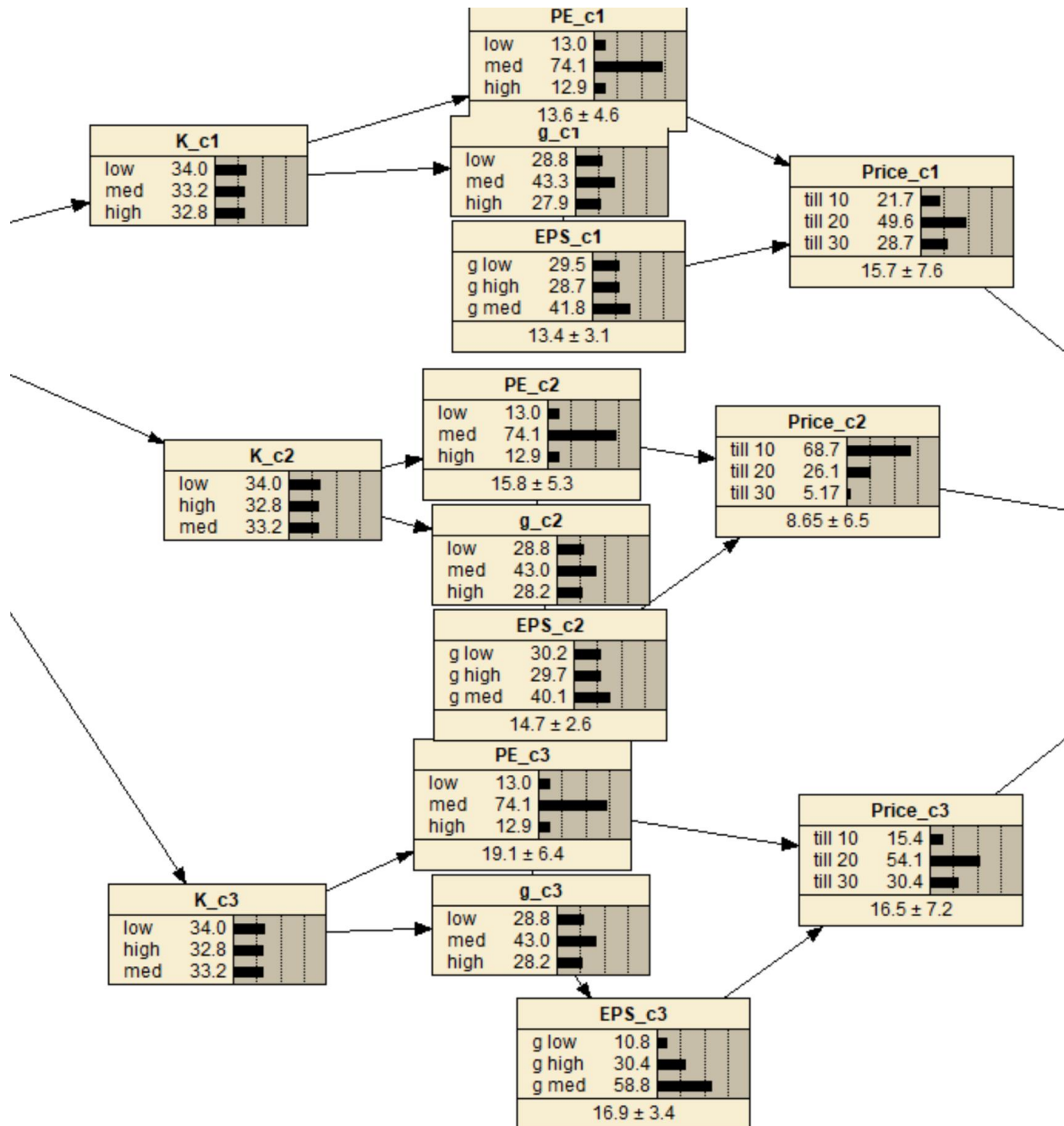




**Market Return** – the risk factors cause or affect the Market return, thus the arrows from Risk factors to this node.

As like risk factors, the market return values were taken from past years. Then given the 81 combinations ( $3 \times 3 \times 3 \times 3$ ) of the 4 Risk factor values, the CPT(conditional probability) values are set into low, medium and high category ranges.

**Crypto\_Industry\_Return** – A particular industry is independent of the Risk factors given the Market Return. As like Market Return node, the CPT(conditional probability) values are set into low, medium and high category ranges.

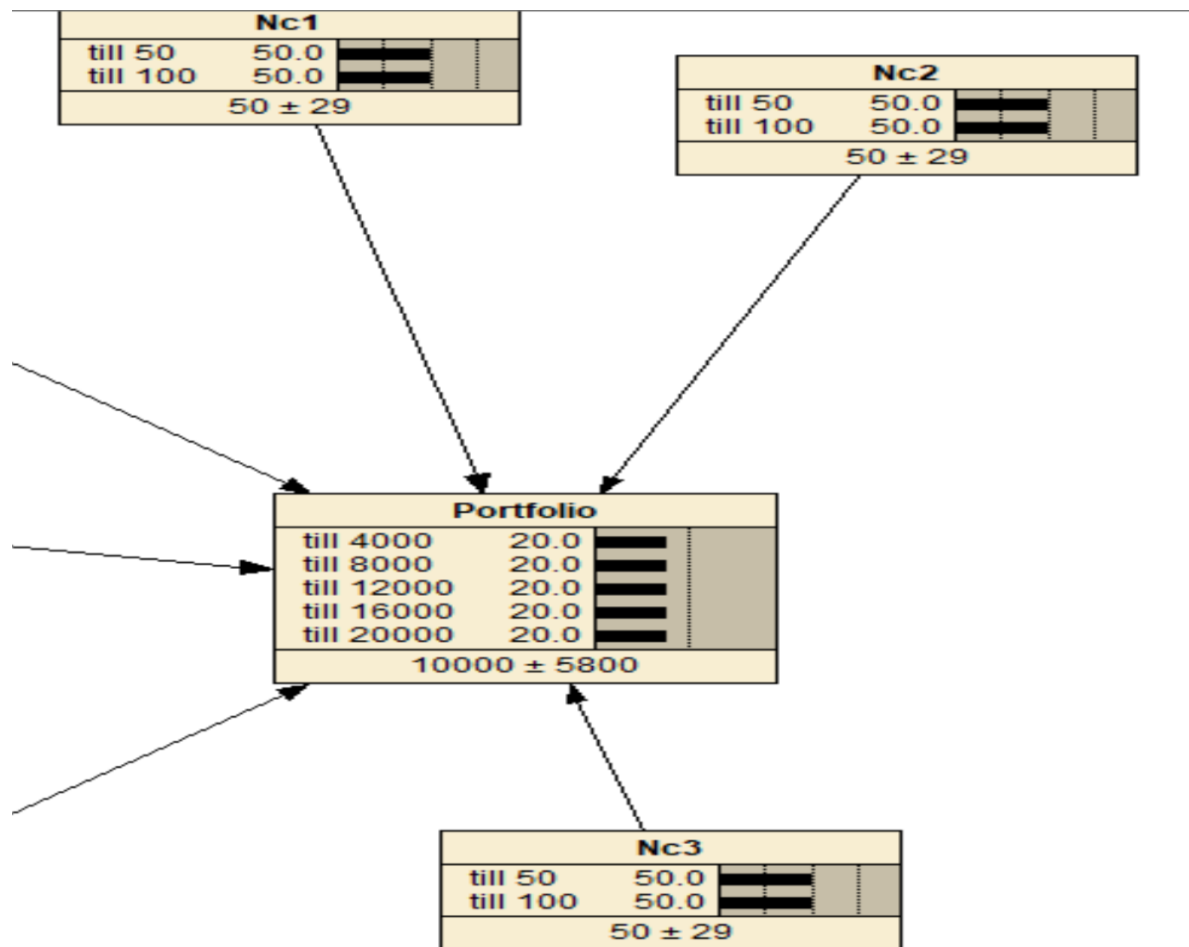


This is the price sub-set part of the network previously explained, for three different companies.

All of them is categorized into low, medium and high.

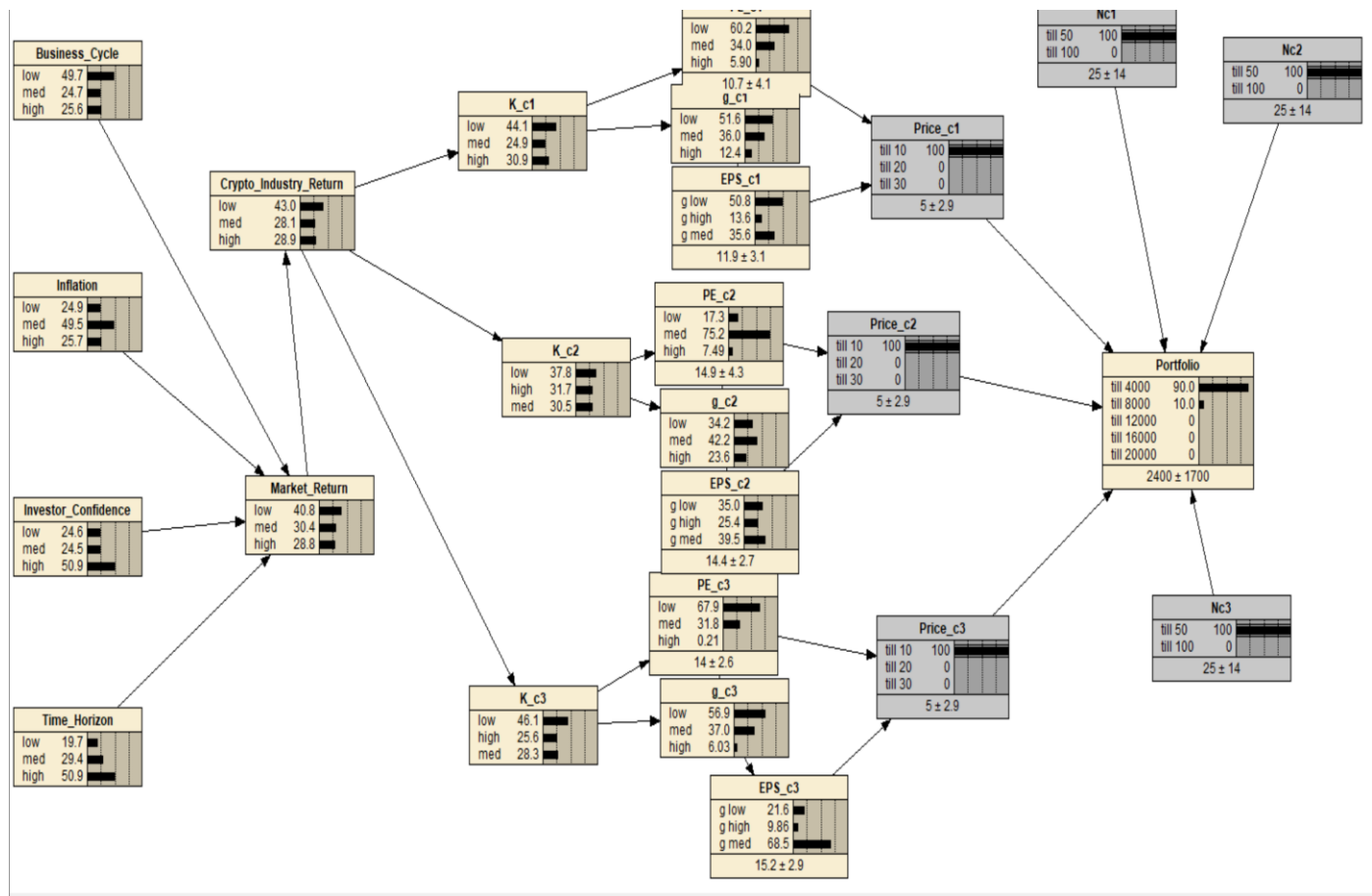
“g” is a normal discrete node.

“PE” and “EPS” are continuous nodes, as both of them contains values with variance.



The **Nc** nodes show the number of shares to be bought for each stock C1, C2, and C3.

Portfolio node is the ultimate node which gives you the expected return and the risk associated with it.



An example with evidence as in the picture gives an expected return of \$2400 and a risk of + or - \$1700.

# References

The network and parameters are based on the book –

**Probabilistic Methods for Financial and Marketing Informatics**

by Richard E. Neapolitan, and Xia Jiang

MPT information is influenced from –

<https://www.investopedia.com/terms/m/modernportfoliotheory.asp>

Data is partially taken from –

<https://finance.yahoo.com/cryptocurrencies>