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Customized Investment Plans Using CAPM and HRP

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ABSTRACT
During the past few months, a lot of people, mostly millennials, have begun to invest money as they have realized its importance and power. An investment in the right combination of stock can go a long way. In the current scenario, the new investors are playing it smart by choosing safe options like mutual funds. But in reality, a diversified portfolio, though a little riskier than the former, guarantees better returns. Our project is based on helping these investors make wise decisions as per their requirements and make sure they receive the maximum returns given their preferred level of risk. We plan on making this process of making a portfolio easy for these investors. The market that is being considered is National Stock Exchange (NSE). The stocks that will be examined will be those enlisted in the NSE. We will be predicting the stock growth using appropriate methods and using this data for further steps. The stock growth prediction has been done using multiple approaches. Seeking the user's point of view is extremely important if we want to build a customized portfolio, hence he/she will have to take a small quiz to throw some light on his/her expectations from the portfolio. The portfolio will be built based on the user preferences. Following this, risk minimization will be done using various methods. The agenda is to produce a portfolio that gives maximum returns for the specified risk level. The project has been programmed in Python using a number of libraries and extensions. This project is still in the research and testing stages. It is highly recommended not to take the following findings as investment advice.

Keywords
AI/ML, Portfolio, RNN (Recurrent Neural Network), OHLC (Open-High-Low-Close) chart, Linear Regression (LR), STD_DEV (Standard Deviation) Random Forest (RF), Deep Neural Network (DNN), Genetic Algorithm (GA), Generalized Autoregressive Conditional Heteroskedasticity (GARCH), Long-Short Term Memory (LSTM), Prophet, P/E ratio, D/E ratio, CAPM, Black-Litterman, Hierarchical Risk Parity

1. INTRODUCTION
Financial literacy is an important form of education that all people must be taught both in educational institutions and at home. Unfortunately, this is not being given enough significance. It involves learning about efficient ways to handle money and use it tactically to multiply it. One of the important aspects of it is investment. In a nutshell, investing means lending money that you will not use to others who need it. In turn, they give you a share of it. The same concept applied on a large scale adds complexity to it. It is basically done to gain profit or to generate additional income at a future point of time. It is observed that from past years there has been a tremendous increase in the number of people who have started investing. People work hard for the money and that money should also work hard for them in times of need.

Investing is an important task that needs a wise plan. Numerous people turn to stock market to assist purchase of real-estate, send children to college, or construct a retirement settlement egg. But unlike banks where there is a fixed rate of interest, federal deposits and insurance plans, the value of stocks, mutual funds fluctuate rapidly based on the market condition. Nobody can ensure that the investors can make money from their investments. Even the brokers without doing systematic analysis of the risks, returns and future of that particular investment field cannot make a proper choice. So, the investors just cannot simply invest without knowing the risks and future of their choices. Many approach brokers and may end up making bad choices. This may majorly affect those who are new to investing. Thus, there is a high demand for concrete investment plans that can address these issues.

Many existing applications assist people in making their investment in a particular field. These applications provide plans without considering the financial goals of the investors. So, there is a high need for customized investment plans. Making a personalized plan requires more than setting up an investment account. In order to make the right choice, one must comprehend where he/she is at and what he/she wishes to attain with the investment. It is essential to understand the investor's goals to build a portfolio that is well-suited to their needs. Additionally, centering on the things that one can control himself/herself could be the key to investment victory.

2. LITERATURE SURVEY

2.1 An Exploratory Study on Investment Behavior of Investors - Mark KY Mak1 and WH Ip2
The paper is based on analyzing the difference between actual and desired financial outcomes. The significant predictors of investment behavior are investors' psychological, societal and geographic factors. Thus, the financial service providers can predict the investors' behavior in the investment and make market decisions. Some of the key attributes influencing financial investment behavior are key psychological attributes, geographical attributes and societal attributes. As investor behavior needs to be analyzed, a relatively huge test measure is preferred to obtain valid results. The analysis is sharply focused on investor behavior only considering a single company and does not talk about the kind of product the investor prefers. The population factors such as age group and sex have not been contemplated while studying the investors' behavior. The

regression analysis was done over 142496 samples but the empirical results did not represent all the East Asian investors and a very small number of cases were considered. Further scope would be collection of more financial transaction data and investor behavior from other Hong Kong companies to produce a more realistic and general result.

Considering the real-world challenges, the study has identified that (i) geographic, psychological and societal factors influence the investment behavior (ii) main attributes that affect the investment pattern in East Asia include income, education etc. The results of the regression can be used to build a predicting model which would be an efficient manner to understand the investors' behavior.

2.2 Research Paper on Investment Awareness Among Indian Working Women with Reference to Pune - Prof. Priya Vasagadekar

This paper focuses on exploring the financial mindset of working women in Pune. This research talks about the monetary decisions that women make in order to make profits out of money. The objectives of the study are discovering the speculation propensities of the working women in Pune, exploring the role of the Indian woman in financial speculations and knowing the common financial choices of Indian women. The socio-demographic characteristics that affect the analysis are self-standing variables and investment habits, investment awareness and risk bearing capacity are reliant variables. Since the data collected is of short duration and from a constrained topographical region, the research performed might not be in-depth. Some data given by the interviewees may not be accurate as not all of them will consent to disclose their financial details. So, the data used for this analysis is assumed to be authentic with no evidence to prove the same.

Women in the current generation are becoming more financially independent and stronger than ever. It is nice to see that some women are aware of the steps they need to take to become self-sustained. But since all of them are not financially educated, they are forced to take care of their own portfolios and hence cannot reap the full benefits of investing.

2.3 International Asset Pricing and Portfolio Diversification with Time-varying Risk - Giorgio de Santis and Bruno Gerard

The aim of the paper is used to check the performance of Capital Asset Pricing Model (CAPM) in an international and national setting. It is stated that the international markets are correlated and move in a predictable way but the national market is the polar opposite of it. It has been believed that a diversified portfolio often fetches the best results. But in this study, it has been observed that a decline in the US markets affects the internationally diversified portfolio as well. Hence, it may not be the best choice after all. The main objective of this paper is about the international diversification by US investors. In this paper, CAPM model is tested in an international setting, and is used to analyze the effects on international portfolio diversification. GARCH parameterization has been used, which can be applied to various assets at the same time.

Country specific scenarios have considered only the USA; other regions have not been included. There is not enough conclusive proof to tell that national markets are not affected by the international markets. International market risk is predictable as the markets are holistic, whereas national markets are still a mystery. Hence, CAPM alone cannot be used to alleviate risks.

2.4 Stock Price Correlation Coefficient Prediction with ARIMA-LSTM Hybrid Model - Hyeong Kyu Choi

Foreseeing the cost relationship between two resources for future is vital in portfolio optimization. The ARIMA demonstrates coordinate propensities within the information and passes the leftover findings to the LSTM layer. The ARIMA-LSTM crossover can be tried against many conventional models. The objective of the study is to find correlation between the stocks in a portfolio. A combination model of the ARIMA and LSTM is utilized to anticipate future correlation coefficients of stocks that are randomly selected from the S&P500 corporations. The analysis considers only two stocks at a time i.e., correlation between only two stocks can be calculated. If used in a portfolio, the method needs to be repeated for each pair of companies.

The reason for the study was to propose an architecture that performs better than traditional financial models. The ARIMA-LSTM hybrid was employed to channel out linearity in the ARIMA modeling step and anticipate nonlinearity within the LSTM RNN. The testing comes about showing that the ARIMA-LSTM hybris exhibits better performance than traditional financial models.

2.5 Portfolio Selection - Harry Markowitz

This paper was written by Harry Markowitz in 1952, which fetched him a Noble prize in 1990. This is considered as a ground-breaking theory in the world of finance and economics as other fascinating studies that came after this were built on this very idea. One of the assumptions of this paper is that investors always go for the minimum risk combination of stocks. The main idea of Markowitz's Modern Portfolio Theory (MPT) is that risks and returns are directly related. The theory claims that the overall risk can be hedged by means of diversification. Diversification means including stocks that belong to uncorrelated sectors.

MPT involves creating a correlation matrix of all the stocks in the portfolio. The weight matrix is initially assigned randomly. Linear algebra techniques are used to find out the optimized weights to ensure minimal risk, i.e., Global Minimum variance portfolio. Modern Portfolio Theory, besides it being recognized worldwide, has been adopted by many investment institutions, but it has also been criticized by others as it assumes ideal world conditions, hence is rendered moot in real-market conditions.

2.6 Stock Chart Pattern Recognition with Deep learning - Marc Velay and Fabrice Daniel

This paper is based on the concept of evaluating the performance of CNN and LSTM for recognizing frequently encountered chart patterns in a stock OHLC chart. It provides two common patterns, the technique used to make the training set, the neural networks architectures and the accuracies obtained. This study has chosen bounds which are capable of decreasing the type I error, false positives, to about 0. In turn, they have a higher type II error rate. This sort of error infers missed openings, leading to risky decisions.

A recognizer is used to initially recognize the edges in the patterns. The dataset is built using the previously mentioned method. This is then used to train the AlexNet CNN to recognize patterns in the real-world dataset. It has been found that the LSTM accomplished the most precise rates. Patterns such as

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bearish flag, double bottom, double top, tea cup etc., can be recognized using this model.

2.7 A Machine Learning Framework for Stock Selection - XingYu Fu, JinHong Du, YiFeng Guo, MingWen Liu, Tao Dong, XiuWen Duan

This paper highlights how to apply ML calculations to recognize "good" stocks from the "bad" stocks. In this, 244 specialized properties are constructed to characterize each stock and rank stocks according to the return-to-volatility ratio. Any trading strategy involves three major steps, listing the best performing stocks, allocating money to each stock and time at which the capital must be traded. LR, RF, DNN and Stacking are used as training algorithms. GA is used for feature selection. The accuracy was checked by validating on the East Asian market dataset. Stacking strategy exhibits the best accuracy when compared to other models. There's a hitch within the statistical assessment strategy, i.e., stocks that drop within the two-tailed region are chosen. Hence, a more realistic evaluation is needed. The portfolio constructed has perfect stocks, which is not possible in real life.

It can be concluded that the stacking technique is advantageous as the stock can be classified using two different approaches. This guarantees different ML models packed into an orchestrated model which performs better than each individual component.

3. PROPOSED METHODOLOGY

Increasing number of people have started to invest in stocks, mutual funds, gold and silver etc. Thus, customized plans are very much beneficial for people without experience in such fields. This project individually designs the portfolio containing stocks according to the user needs and financial goals. It manages the investment of a single user by recommending the portfolio that best meets his/her monetary needs. It can be used by anybody from any industry who wants to invest. Information about the user's financial goals and desired time horizon will be useful. Moreover, focusing on things that one can control is a key to investment success. The methodology can be roughly described as follows:

- All stock tickers listed under the NSE are web scraped sector-wise.
- Once the tickers are scraped, the stocks that agree with the chosen investment strategy are retained and the rest are eliminated. This is done by finding out the required stock ratios and performing a few calculations.
- After filtering out the stocks, the risk is found out using Unsystematic risk formula and returns are found out using CAPM and Naïve methods.
- Methods to predict the growth of any company given the ticker symbol are framed. Here, GARCH, LSTM and Prophet models will be used for the same.
- Since a customized portfolio is being created, the user will have to answer a questionnaire stating their expectations.
- Now that all required input is ready, the portfolio is generated initially allocating equal weights to all stocks in the portfolio.
- Portfolio optimization methods such as Black-Litterman and Hierarchical Risk Parity are used to assign the weights that are most profitable. The data flow diagram is as follows:

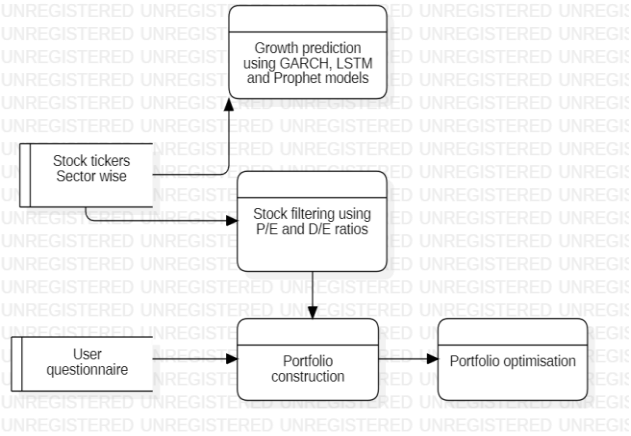

Figure 1: Data Flow Diagram

3.1 Stock Growth Prediction

3.1.1 GARCH Model

The generalized autoregressive conditional heteroskedasticity predicts the volatility of stock price. It is used to forecast volatility. It aims to minimize errors in forecasting by accounting for errors in prior forecasting and enhancing the accuracy of ongoing predictions.

The GARCH (1,1) is the best model for measuring volatility of returns. In GARCH (α, β), α corresponds to the lag version of time series and β corresponds to the lag version of volatility. The two important Python libraries are arch model and pandas data reader. Arch model library, which allows us to run GARCH processes and Pandas data reader library to get stock price data. The GARCH (1,1) model looks at the time series of current day as the function of the random error of the present day and time series and volatility of previous day.

$$a_t = \varepsilon_t \sqrt{\alpha + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2}$$

$$= \varepsilon_t \sigma_t$$

Where,

a_t = The value of time series of current day

ε_t = Random error of present day

σ_t is made up of two different components:

1. The value of time series of previous day (a_{t-1})
2. volatility of previous day (σ_{t-1})

3.1.2 LSTM Model

The LSTM model is one of the deep learning algorithms. Due to the feedback connection in its architecture, it is an RNN. This has the ability to process the entire chain of data points which makes it different from the conventional neural network. It includes a cell, input, output and the forget gates. The cell stores the facts over a time period and the 3 gates adjust the flow of data in and out of the cell. The input gate controls the extent of flow of data into the cell, the forget gate controls the volume of utilization of preceding values and the output gate controls the volume of utilization of the data within the cell to compute the output activation cost. There are different versions of the LSTM model like GRU (Gated Recurrent Unit). GRU has no output gate.

LSTM is the best suited model for time series data prediction. The two important Python libraries that can be used to fetch the stock data are nsepy and Tensorflow libraries. Nsepy fetches the data and Tensorflow is for the backend process. All the fetched data needs to be pre-processed and trained well to give the best result. Once the model is compiled the test data will be fed to make the predictions. Since there are training and testing datasets it is possible to calculate the error as well as accuracy. As the R-square value is quite good, this model is appropriate for the stock prediction.

3.1.3 Prophet Model

The Prophet Model was developed by Facebook and is one of the most popular models among the forecasting models. It is a highly optimized model and used in all business forecasting tasks. It does the prediction extremely fast as it does not involve any pre-processing of the data. It can handle missing values as well as outliers. It does not make use of training and testing data instead all the data that is fetched will be used to fit the model. It also gives an idea about the confidence intervals when the predictions are visualized. The mathematical equation is $f(t)=a(t)+b(t)+c(t)+d(t)$ where a(t) denotes the trend, b(t) denotes the seasonality component, c(t) indicates the holiday effect and d(t) is the error term. Important characteristics of the Prophet Model are as follows:

- It can draw weekly, yearly and seasonal observations with just few months of data
- Important holidays that occur at irregular intervals can be known in advance
- The trend that changes over a period after the product launch can be captured
- The model comes with a default setting and parameter tuning is not required to give the best result. So, it requires much less effort to use this model.
- Once the data is fetched from Yahoo Finance website or Python library, the data is made to fit the model. It prefers using simple and flexible regression models like curve fitting instead of traditional time series models. The components like trend, weekly, yearly, seasonal factors can also be visualized for better understanding.

3.2 User Questionnaire

Before building a portfolio, it is important to understand the investor's monetary goals to construct a portfolio that caters to their needs. In order to gain a better insight of the user's investing personality, he/she will have to take a short quiz answering a few questions. The questions are as follows:

i. How much money are you willing to invest?

This will make sure that all the stocks being chosen will be well within the price that the investor is willing to pay.

Input must be in terms of INR.

ii. What is your investment horizon?

The investment horizon is the time period for which the user is willing to hold the stock. This gives a broader idea about the user's reason for investing. If the investor wants to avail capital in a short span of time to buy something in the near future, this will be a short time horizon. The time can be somewhere around 1-4 years. The investor cannot afford to take risk and at the same time wants to gain profit. This leads to choosing stock with low-risk rates, which means the returns will be low as well.

If the user just wants to invest as a second source of income, this will be considered as a long-term horizon. The time period can be anything greater than 5 years. This allows the portfolio to include risky stock with attractive returns. Though it is not generally preferred, since the horizon is long, it allows even the most volatile stock to recuperate and generate massive returns. The hidden hero here is compounding, which is nothing but reinvesting the principal amount each time along with the interest. The returns are fairly high irrespective of the stability of the market in the long-term.

iii. What is your risk-tolerance level?

This will further make the stock selection process easy as it gives a clear idea about the risk level that the investor is willing to take. The options available are as follows:

- Low tolerance (0-33%)
- Moderate tolerance (33-66%)
- High tolerance (66-99%)

The percentage essentially denotes the volatility of the stock. Keeping the investor's risk tolerance in mind, a portfolio will be created that will have an overall risk similar to the one specified by the investor.

iv. Is there a particular field that you want to invest in?

The user can choose a particular field such as agriculture, banking, transport, technology etc, that he/she wants to invest in. At least one stock from the chosen field will be included in the portfolio.

3.3 Stock Filtering

Broadly, there are four types of investment strategies that are popularly used: Value, Growth, Momentum and Dollar-cost averaging. Each strategy attracts a different audience according to their investment style. Since long-term and/or low risk investment is being considered here, it is best to use value investing as it involves choosing undervalued stocks that are expected to grow eventually. When the investor is looking to make money, they tend to choose the top performers or overvalued stock. While the calculations may seem to produce a profit, the volatility of such stocks pose a high risk.

Having chosen the strategy, the stocks that meet the criteria need to be picked out. We have considered all stocks that are enlisted in NSE by each sector. The filtering process will be done using P/E and D/E ratios as explained below.

3.3.1 D/E Ratio

D/E ratio or the Debt-to-Equity ratio is the relationship between total liabilities to shareholder's equity. Shareholder's equity denotes the total assets owned by the company. As much as it is important to generate returns, it is crucial to hedge the risks. This can be done by choosing companies that are relatively less risky. These companies tend to have a lesser D/E ratio than the others. D/E ratio helps in analyzing the strategies of the company. High D/E ratio indicates high risk which means the company is borrowing more and is in debt. Low D/E ratio means the company's equity is in excess and has less debts. So, the companies with D/E ratio greater than the average are filtered out and those with less than the average are considered for portfolio creation.

There is no definite or expected P/E ratio. The companies need to be compared with their peers in the same sector before making any decisions.

The procedure followed is as follows:

i. In each sector, the average D/E ratio is found out for all companies.

ii. All those companies with D/E ratio greater than average are removed and those with D/E less than average are considered.

3.3.2 P/E Ratio

P/E ratio or the Price-to-Earnings ratio is the relationship between a company's stock cost to the earnings/profit per share. This ratio helps the investors to know the value of the company in the market. It essentially tells the amount the investors are willing to pay for each rupee (or dollar) the company earns. Earnings of the company play an important role in valuing a company's stock. The investor comes to know about the profitability of the company currently as well as in future. The investing strategy that is being used is Value investing. This is the strategy in which undervalued stocks are chosen over overvalued. This is a safe method for investors looking at a long-time horizon. Similar to the D/E ratio, the companies with lower-than-average P/E ratio are considered for the portfolio because of the Value investing strategy and the rest are eliminated.

3.4 Returns Portfolio

Once the stocks have been filtered out, the attributes related to the stock need to be found out. A data frame is created to add the various values related to the stock. The attributes that are being calculated are returns using CAPM and Naïve methods, risk using Unsystematic risk formula, price of the stock, P/E and D/E ratios. The returns are calculated using the following methods:

3.4.1 Capital Asset Pricing Model (CAPM)

CAPM model is used to establish a relation between the risks and returns involved in an investment. The CAPM was introduced by William F. Sharpe, Jack Treynor, Jan Mossin and John Lintner building on the well-known work of Harry Markowitz on diversification and Modern Portfolio Theory. The CAPM gives the overall rate of returns which is the sum of risk-free rate and market risk rate. It takes risk-free rate, market returns and beta into consideration.

Beta is a constant that measures stock volatility with respect to the market. The formula is as follows:

$R_a = R_{rf} + \beta (R_m - R_{rf})$

Where,

R_a = Total return

R_{rf} = Risk-free rate of return

β = Beta

R_m = Market return

In the calculations performed, R_{rf} has been assumed as zero.

3.4.2 Naïve Returns Calculation

Naïve returns is a simple calculation to find the returns. The returns are simply subtracted for the required intervals. For example, if 1-year returns need to be calculated, the difference in stock price on the 1st of January, 2021 with stock price on 1st January, 2020 is calculated and divided by the latter. The similar approach is followed for time periods of 2 and 5 years.

3.5 Risk Portfolio

3.5.1 Systematic and Unsystematic Risk

Risk involved with a stock is a combination of systematic and unsystematic risks. Systematic risk is the risk that is involved with the market whereas unsystematic risk is unique to the company or the industry. This is a diversifiable risk, but systematic risk is not. Unsystematic risk for each company is calculated using the following formula.

Formula:

Total risk = Systematic (Market) risk + Unsystematic_risk

Market_risk = Beta * STD_DEV(Market)

Unsystematic_risk = STD_DEV(Company) – Market_risk

3.6 Portfolio Construction

Once the stocks returns and risks are calculated, the portfolio can be constructed. A portfolio can be described in many ways; when it comes to describing it in terms of the number of stocks it must contain, it can be classified as diversified or concentrated. A diversified portfolio is always preferred as the risks will be diversified as well along with the stocks itself. This is the kind of portfolio that does not need constant supervision, hence is considered safe in a way.

Popular opinion suggests that one stock should not make up more than 8% of the overall portfolio. According to this statement, a portfolio should contain 16-18 companies.

A major way of diversifying is by choosing stock from industries that are directly unrelated, such as agriculture and technology. This is to make sure that a loss in one market does not affect the other. If in fact stocks from both the industries are included, then the risks will be considerably less. To apply this variety of diversification, stocks are chosen randomly and made sure they belong to different markets.

Another way of describing a portfolio is by the kind of stocks it includes. The types of portfolios in this category are Aggressive, Defensive, Income, Speculative and Hybrid. Defensive type of portfolio is being used as this considers stocks with lesser beta value i.e., less risky stock.

Keeping all the mentioned metrics in mind, 16-18 stocks are chosen randomly from the previously generated data frame.

Initially, the same weightage is assigned to each stock in the portfolio. Optimal weights will be applied in the next phase using multiple methods.

3.7 Portfolio Optimization

Once the stocks have been chosen, it is now important to decide the weightage of each stock to ensure optimal returns. This can be done by using the following methods:

3.7.1 Black-Litterman Model

Black-Litterman was developed in Goldman Sachs in 1990 by Fisher Black and Robert Litterman. It begins assuming that the stock will perform like it has in the past. It integrates CAPM with Bayesian statistics and Markowitz's Modern Portfolio Theory (MPT). This method was created after it was realized that Markowitz's MPT fails in practice.

It can be broken down to prior, likelihood and posterior similar to Bayesian statistics. In prior, the market conditions are mapped. In likelihood, the investor's views on the growth of each stock and the confidence of their views. Posterior integrates both prior and likelihood to construct the final formula.

The investor views and confidence intervals are assigned randomly if the investor has no prior experience.

3.7.2 Hierarchical-Risk Parity Model

Hierarchical Risk Parity model is based on the machine learning algorithm of tree clustering. Given a portfolio, the correlation between all the stocks is calculated and clustered accordingly. After this, the stocks are rearranged according to their similarity. This process is matrix seriation. In recursive bisection, the weights

are allocated according to the results obtained from the previous steps.
The portfolios will be generated using both the methods. The portfolio with the maximum returns will be presented to the user along with the expected performance.

4. RESULTS AND DISCUSSION

Stock growth prediction is done using three different models, namely GARCH, LSTM and Prophet. The predictions are quite accurate and gave good results. The plots are displayed for user reference and the user can make use of it as per their preference. User questionnaire is used to map the user's financial goals in order to build a portfolio well suited to their needs. Stocks are filtered according to value investing strategy. During portfolio creation, the stocks are chosen randomly from uncorrelated markets and assigned equal weightage. Portfolio optimization is done using Black-Litterman model and Hierarchical Risk Parity, where the optimal weights are associated to ensure minimal risk. Once the portfolio creation is completed, it is recommended to the investor.

5. CONCLUSION AND SCOPE

5.1 Conclusion

Stock Prediction: Using time-series models such as Time series LSTM, GARCH, FB Prophet model
Stock filtering using P/E and D/E ratio
Returns portfolio: Using CAPM and Naïve methods
Risk portfolio: Using unsystematic risk formula
Portfolio construction: Using Black-Litterman, Hierarchical Risk Parity.

5.2 Future Work

An ideal portfolio consists of stocks, bonds and mutual funds in ratios according to the investor's risk tolerance. Some portfolios include gold and cryptocurrency as well. Future work entails analysis on mutual funds as well to build a market-ready portfolio. Upcoming work will consider these investment options as well.

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APPENDIX

A. Abbreviations and Acronyms

ARIMA: Auto-Regressive Integrated Moving Average model
LSTM: Long Short-Term Memory
GARCH: Generalized Autoregressive Conditional Heteroskedasticity
ETS: Error Trend and Seasonality, or exponential smoothing
GRU: Gated Recurrent Unit
AI/ML: Artificial Intelligence
RNN: Recurrent Neural Network
OHLC: Open-High-Low-Close
LR: Linear Regression
STD_DEV: Standard Deviation
RF: Random Forest
DNN: Deep Neural Network
GA: Genetic Algorithm

B. *Definitions*

Portfolio: A portfolio is a collection of stock, mutual funds, equity funds, debt funds, bonds etc., that an individual has invested capital in.

Stocks: A stock is an agreement that represents the ownership of a fraction of a corporation. This entitles the proprietor of the stock to a proportion of the company's assets and profits.

C. Equations

C.1 $a_t = \varepsilon_t \sqrt{\alpha + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2} = \varepsilon_t \sigma_t$
Where,
a_t = The value of time series of current day
ε_t = Random error of present day
σ_t is made up of two different components:
1. The value of time series of previous day (a_{t-1})
2. volatility of previous day (σ_{t-1})

C.2 f(t)=a(t)+b(t)+c(t)+d(t) where a(t) denotes the trend, b(t) denotes the seasonality component, c(t) indicates the holiday effect and d(t) is the error term.

C.3 $R_a = R_{rf} + \beta (Rm - R_{rf})$
Where,
R_a = Total return
R_{rf} = Risk-free rate of return
β = Beta
Rm = Market return

C.4
Totalrisk=Systematic (Market) risk+Unsystematic_risk
Market_risk = Beta * STD_DEV(Market)
Unsystematic_risk = STD_DEV(Company) – Market_risk

REFERENCES

[1] Marc Velay and Fabrice Danie. 2018. Stock chart pattern recognition with deep learning, Artificial Intelligence Department of Lusis, Paris, France fabrice.daniel@lusis.fr http://www.lusis.fr(June .2018)

[2] Mark KY Mak1 and WH Ip2. 2017. An exploratory study of investment behaviour of investors- International Journal of Engineering Business Management,vol. 9, [a] The Author(s), (Jan 2017), 1-12, DOI=10.1177/1847979017711520

[3] Giorgio de Santis and Bruno Gerard. International Asset Pricing and Portfolio Diversification with Time-Varying

Risk, The Journal of Finance, Wiley Vol. 52, No. 5, (Dec 1997), 1881-1912

[4] Tavel Hyeong Kyu Choi. Stock Price Correlation Coefficient Prediction with ARIMA-LSTM Hybrid Model, B.A Student Dept. of Business Administration Korea University Seoul, Korea imhgchoi@korea.ac.kr ,arXiv:1808.01560v5 [cs.CE], (1 Oct 2018).

[5] XingYu Fu, JinHong Du, YiFeng Guo, MingWen Liu, Tao Dong, XiuWen Duan. A Machine Learning Framework for Stock Selection, Likelihood Technology, ShiningMidas Private Fund, Sun Yat-sen University, arXiv:1806.01743v2 [q-fin.PM], (8 Aug 2018).

[6] Forman Harry Markowitz The Rand Corporation. Portfolio Selection, The Journal of Finance, Wiley, Vol. 7, No. 1 (Mar., 1952), 77-91.

[7] Aditya Vyas. The Hierarchical Risk Parity Algorithm: An Introduction.

[8] Aditya Vyas. Bayesian Portfolio Optimization: Introducing the Black-Litterman Model.

[9] Types of Portfolio Investment, Angel One (13th Nov, 2022).

[10] How many stocks should you have in your portfolio, Finology Blog (4th June, 2021).

[11] How to compare stocks of same sector? Team Groww, (24th Nov, 2021).

