Asset Management

PROJECT PLAN

Team 13
Principal Global Investors - Client
Chinmay Hedge – Faculty Advisor

Carter Scheve — *Communications Lead*
Nathan Hanson — *Project Progress Tracker/Manager*
Caleb Utesch — *Meeting Scribe*
Jack Murphy — *Research Analyst*
Samuel Howard — *Lead Engineer*
Alex Mortimer — *Project Manager*

sddec18-13@iastate.edu
http://sddec18-13.sd.ece.iastate.edu/

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List of Symbols

No symbols that need to be further defined were used in this document.

List of Definitions

PGI: Principal Global Investors

BK_P: Book to Price - used to help demonstrate value

X12M_Ret: Investment's Twelve-Month Return - used to demonstrate momentum

1 Introductory Material

1.1 Acknowledgement

Our clients at Principal have extensive experience in big data analysis and machine learning and have made it clear that they will are willing to help us in any way possible. They have already helped by providing access to learning resources such as tutorials and readings on topics like the ones mentioned above.

Our faculty advisor, Chinmay Hedge, will also be a valuable asset to developing the proposed product. As an expert in data processing and machine learning, he provides advice and guidance towards what we need to learn to deliver a successful product.

1.2 Problem Statement

Investment analysis at Principal Financial Group currently relies on human calculation, using a variety of models and inputs. These statistical models are proven and effective, although the dependence upon human-given inputs and calculations is both inefficient and unreliable. Various steps of the statistical analysis process can be automated through software. This would remove most of the potential for human error, expedite the decision making process, and reduce overhead costs by making accurate statistical modeling and prediction more accessible.

Our proposed solution makes use of our background in computational sciences to implement a software approach to multi-factor statistical analysis. We aim to create a system which aids in the creation and management of an investment portfolio based upon well-defined statistical models and machine learning algorithms, which consistently outperforms the market. Such a system would not only increase profits for portfolio owners, but it would also reduce risk by eliminating erroneous human action and increasing decision-making speed in a volatile stock market.

1.3 Operating Environment

The product is expected to be run on a device using Python version 3.6 or higher. Additional libraries required include Scikit-learn, Pandas, and Numpy. No environmental hazards are expected beyond those inherent in running a computer.

1.4 Intended Users and Intended Uses

Our product has two potential user groups. The first is the investment analysts at Principal, who have little to no experience with programming techniques. The other user group is the data analysts that are employed by Principal, who have a large amount of programming experience, along with statistical analysis and data mining.

The ideal intended use of our final product will be to provide a forecasting model that can predict with 50-60% accuracy whether a factor will outperform the current market. Another potential use of our final product could come even if our models are unsuccessful in predicting market behavior. Not being able to generate accurate models with the data that we were given is telling enough, and could be further analyzed to identify potential changes that would be beneficial to make in Principal's current forecasting model.

1.5 Assumptions and Limitations

Assumptions:

- Provided data will be of a consistent format
- Provided data will be valid and accurate
- Data will be open and accessible
- Users will have a working understanding of input and output data

Limitations:

- Tools used to research and produce model shall not exceed $50
- The model shall be written primarily in Python
- Final predictive model must use machine learning techniques

1.6 Expected End Product and Other Deliverables

Table 1 - Expected Deliverables

Deliverable	**Description**
Software Models	The main deliverable of our project is a series of software models used to predict stock market factor performance. These models include a system to input data, train the model, and display their results in a human-readable manner.
Model Analysis	The secondary deliverable is an analysis of the model's performance throughout time. We will note how different market conditions affect the accuracy of the model. Additionally, special note will be made for performance for major events, such as the 2008 stock market crash.
Documentation	The last deliverable will be the documentation of the design process used for each model. Additionally, we will include the reasoning behind each model selection and tuning process. This is to help the client investigate methods for future growth and development.

All deliverables are expected by early December.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

The objective of the proposed project of Asset Management is of two parts. One is a simulation/model to be produced. The goal here is to create a model that can (help) predict performance of certain sets of stocks. This is the backbone of the second and more indirect part of the objective, which more of a service. We will provide this model to our clients and portfolio managers will use it to help serve their clients in a more accurate way. We are providing a product and the backbone of a service for our clients to provide.

2.2 Functional Requirements

- Models report processing time and accuracy
- Results are displayed in a human-readable format
- Models only use data from a certain time period to predict future behaviors
    - Example: The model does not use stock market data from 2005 to make predictions on the stock market for 2002
- Summary of models gives concrete statistics for performance of each individual model, along with a comparison of each and a recommendation for which to use in similar future tasks.

2.3 Constraint Consideration

There are no specific design standards for machine learning that we know of or that will benefit us. Since that is almost all of our design, this leaves us with only implementation standards. Since we are programming in Python, we need to have standards that deal with developing in Python. We will be using Python version 3. This affects the specific syntax of our implementation and is needed to ensure common code is able to be compiled on all of our team's machines. Our other standard we will be using for the most part is PEP8. This is a naming convention and style guide used by many Python programmers. It is well developed and allows for a standard of clean and readable code. This ensures that common code retains readability and can be developed by all team members smoothly. It will also ensure time and comprehension of code reviews by team members.

2.4 Previous Work And Literature

Investment analysis is a task that has been taken on by many thousands of intelligent minds over the course of time. Every investor that has worked in the stock market has tried to find the pattern of growth and success to gain an advantage in future deals. From what we have learned from research on the topic, other companies in the industry have software systems to help predict the behavior of stocks that still rely on human analysis for their larger-scale decisions.

Our product is different from projects like these in the sense that ours analyzes the success and overall performance of individual factors of investments, instead of an entire investment's overall success. In addition to the individual models, we will deliver analyses for each model, describing its effectiveness in the market along with its advantages and shortcomings.

Much of the knowledge we have gained has been through tutorial websites, such as kaggle.com or datacamp.com. These have been effective in enhancing our comprehension of machine learning because they allow for practice with realistic problems. This research has enabled us to eliminate certain machine learning models that proved to not be feasible for our project.

Our research has resulted in a more targeted approach to data analysis. For example, we have chosen to implement a custom train-test split method, including a buffer between the end of the data used for algorithm training and the beginning of the data used for testing the trained algorithm. Through research and advice from our client, it was clear the continuous chronological nature of the data would have a significant effect on the accuracy of the trained algorithm.

Our research does not include any domains pertaining to finance, stocks, investments, or other related fields. This is for two reasons; the main reason is based on a request from our client. They stated that it would be best for the project if we did not research into the metrics and notions behind the data given. Their reasoning is that we have a fresh set of eyes that do not have bias toward any piece of the data. The second reason is that we need to tune our focus to other places. We do not have any substantial experience or knowledge on the subject of data analytics and machine learning. We only have a limited amount of time for research, and delving further into machine learning versus the financial domain is going to have a bigger impact on the success of our project.

2.5 Proposed Design

As we discussed with our client, there are many solutions and many ways to come to a solution. Thus, to cover our bases and help our clients feel better, we are going to design a few solutions that differ a little bit. Since the problem is open-ended and our client is okay with us doing this, we are going to have 3-5 different analytic models. Each model will do the same thing: give predictions on the success of stocks in the near future. The differences of each model and possible solution are contained in the implementation. There are many types of models that are well known that we will use to our advantage. Each one will differ in what data we put into it, and how we tweak the internals.

One strength of using several different models is that it makes it easier to find potential errors in our predictions. Being able to analyze results from several different models at a time can greatly help us pinpoint where we might be going wrong and what we can change in order to produce a final model that is as useful as possible. To put it shortly, there is really only one direction we can go about solving this, which is a constraint from

our client. Our designs are not high level, but the designs are what we plan out when we are testing and analyzing data. There are almost no alternatives. Our client has given us enough creative room and time so that whatever we come up with will be a solution in some way. There is a possibility we fail in designing any possible solution. In this case, we will gain valuable insight from that and report those results.

2.6 Technology Considerations

The proposed technology to be used for our system is Python, a high-level scripting language that has been long used by statisticians for modeling and analysis. Python is a very strong choice for the system being developed; it has access to a multitude of extensive open-source mathematical modeling and statistical analysis libraries. Not only are these libraries specifically developed for purposes very similar to our own, but they are also available free of charge. Python is strong for nearly every aspect of our proposed solution. It offers utilities for easy collection and interpretation of data, as well as graphical modeling of said data.

One of the utilities that we will be using is scikit-learn, a widely used machine learning library. Another utility is NumPy, a very popular library used for scientific computing. Another library we will use is called Pandas. This is a scientific computing and data modeling library that, like NumPy, will help us organize and manipulate our data for our models to consume. The third is Matplotlib, the standard utility used for generating graphs and charts. It also provides various interfaces for manipulation of data for statistical analysis purposes that we will be utilizing. As far as software languages go, Python is the best tool to approach this problem.

The biggest weakness that we may encounter is a lack of experience with the technology. Each of us has stronger backgrounds with other software technologies. This, however, is relatively straightforward to overcome, as a general experience with other languages and software libraries makes it easy to learn and utilize new tools.

Alternative tools at our disposal include the R programming language, which is a language designed specifically for statistical modeling. While we gave this some consideration, both our client and faculty advisor suggested that we focus our efforts on Python. To our knowledge, there are not any other relevant technologies outside of the Python environment that will contribute valuable resources to our project.

2.7 Safety Considerations

There are no safety concerns with the applicable product.

2.8 Statement of Work

Research

1. Objective - The objective of this task is to gain the necessary knowledge in order to provide the optimal model for our project.
2. Approach - The approach involves using the resources available from Principal to research machine learning and model forecasting.
3. Expected Results - The expected results from our research will be comprehension of machine learning algorithms in order to effectively use them in our models.

Model Development

1. Objective - The objective of model development is to provide a working model that will be able to effectively forecast stock market trends.
2. Approach - The approach will involve taking our information gained from research and implementing it into a working model.
3. Expected Results - A working model that can successfully forecast stock market trends with 50-55% accuracy based on given data would be an expected and desired result.

Testing

1. Objective - The objective of testing will be to thoroughly test and analyze our developed models to see if the desired result is achieved.
2. Approach - tuning the various parameters in our models to analyze the results.
3. Expected Results - Many of the initial results will probably not be what we need them to be at, but further testing will hopefully provide information to feasibly predict trends in the market.

2.9 Possible Risks And Risk Management

One of the main risks involves a lack of knowledge in the area of machine learning, since most of us have no previous experience working in the area. This project will be a good chance for us to gain knowledge and experience in machine learning, but initially it will be difficult to adjust with the amount of learning required. There is also the risk that the models we develop will not provide sufficient information for Principal to properly predict future outcomes from our research. This risk has been discussed with the client, and they have reiterated that even poor results like these will help them to understand what data can be used for predictions and what is beyond current capabilities.

As far as risk management techniques, we are looking to implement a risk management log that will allow us to identify and track possible risks for this project. Currently there is no financial cost for implementing this project. There is a financial risk in the future for Principal if our models incorrectly predict the stock market, but of course increasing our model accuracy will help to mitigate this risk.

2.10 Project Proposed Milestones and Evaluation Criteria

The first key milestone in our proposed project will most likely be if and when we begin to produce models that are useful in identifying patterns in the data we were given. Throughout our project implementation we will be making many different statistical models based on the data we've been given. Once we begin to notice patterns or trends within the different parameters as they relate to the given factors, our strategy will most likely begin to change significantly based on these identified patterns.

Testing any patterns we identify will involve modifying parameter values that are used as input for our model. We will need to check with multiple different input values for any parameters involved that the output that is being produced is at least close to what we would expect it to be. If multiple input values don't give outputs close to what we expect them to be, then this most likely an indication that the pattern we thought we identified might not be accurate.

2.11 Project Tracking Procedures

Our team uses the Gitlab project tracking software to monitor project progress. This is a great choice, as the system incorporates work tasks, TODO items, and progress reports in a clear, concise, effective format that bolsters our work environment.

2.12 Expected Results and Validation

The desired outcome of our project is to deliver a software tool that analyzes performance reports on past investments and generates relatively accurate predictions for investments moving forward. This will be used to monitor the pool of investments on the market and inform the user about those that could soon become profitable or dangerous to own.

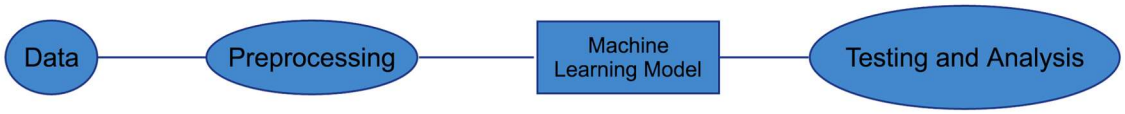
To confirm that our solution works at a satisfactory level in the industry, we will run several tests with a multitude of data sets containing information on investment performance from the past two decades. After running the data through our program, we will compare the output to the actual results for the investments and find the level of accuracy attained. The major requirement we need to meet is to produce more profitable portfolios than what the asset managers working at PGI do regularly. There is no finite level of accuracy that defines a successful model, but instead depends upon whether we can improve the current system. The tests we run will clearly display whether our models are performing better than the asset managers at Principal by comparing the net worth change over certain periods. If we are more successful than the results from the experts' portfolios, and the results can be easily interpreted, we will consider that to be a successful product.

2.13 Test Plan

Our plan for testing is fairly straightforward. We will run a large amount of simulated investment environments with our software, monitoring the success of each at several different time periods. With all of that data, we can then compare each of the models and modeling techniques to establish which works best for this type of analysis. This will be valuable information for our client, and will allow them to carry on the work after our project terminates.

The major baseline for our testing results will be whether our models outperform the portfolio managers at PGI, the overall goal for the product. A model that can predict investment performance better than the experts at PGI will be considered a success.

Figure 1 - Graph of the project process

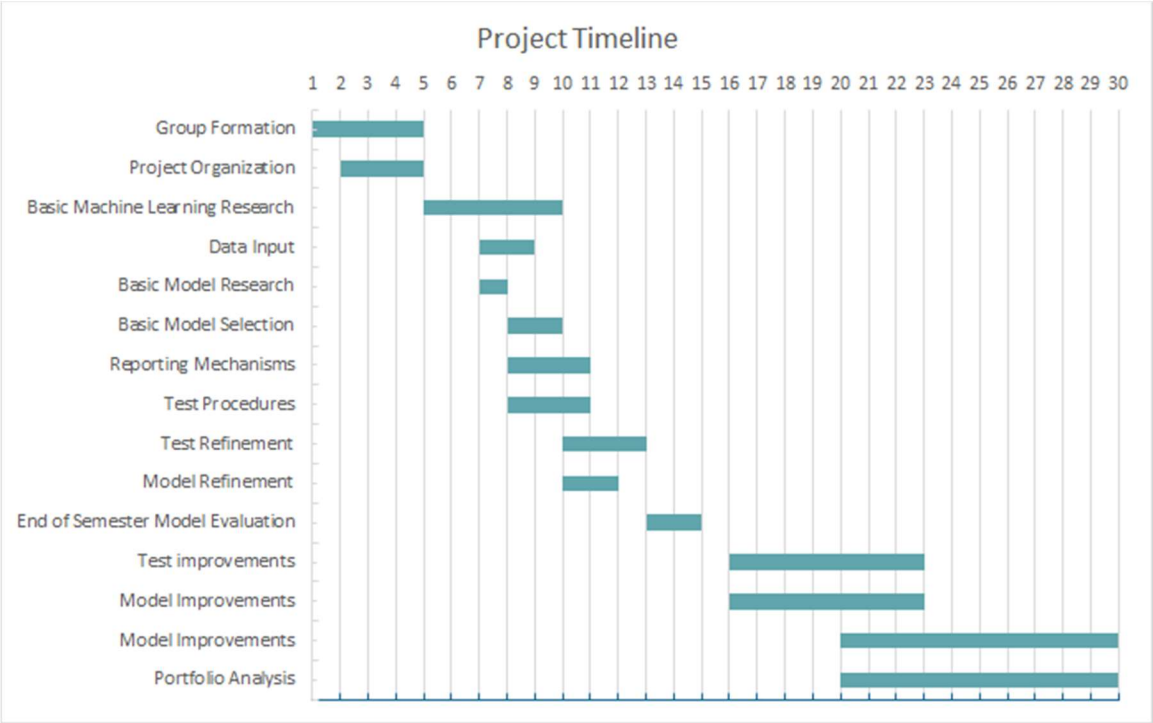


This diagram gives a general overview of the process involved with testing and analyzing the various models. The data provided by Principal will be imported, processed, and used to train the models. Model performance will then be tested and analyzed. Each of these steps will need to be consistently followed to allow for proper tuning of the models. The full testing and analysis details can be found in sections 3.3 and 3.4 in the accompanying design document.

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

Figure 2 - Timeline of Tasks



3.1.1 First Semester

The first semester will be composed of background research, exploratory data analysis, and preliminary model selection. We will be poking around the data, trying to see which predictors work best, and try and reason why for each. Datasets with many different variables, like stock market data, is incredibly hard to visualize, so we will find the best through trial and error.

3.1.2 Second Semester

The second semester will be taken up with taking the best model(s) found previously, and refining it. We will try to make the models 'better' according to whatever standards we decide upon when refining our tests. Near the end of the semester we will do the portfolio analysis, which entails seeing how good our model would do throughout the time period presented in the dataset. Special note will be taken for periods of volatility, such as the 2008 stock market crash. The analysis, model, and documentation will be presented to the client at the end of this semester.

3.2 Feasibility Assessment

This project is somewhat of a challenge to assess; however, we see the plan as quite feasible. We want the project to succeed to the fullest. The success of this project would equate to this state: a set of models that have a relatively high accuracy in forecasting the market for a certain set of stocks. These models will be available to people within PGI to use at their disposal. There is a substantial amount of challenges, but all of the challenges have been enumerated and planned for to the best of our ability. The first challenge is the barrier to basic understanding for this area of expertise. Most of the group currently has little to no experience in machine learning and data analysis. We also have some barrier to understanding the tools that we will be using to develop and test the models.

Another challenge will be in the development of our models. The big question is concerned with how accurate we can get with the models and how influential they will be on the current strategies of investment analysis. The challenge is that there are many ways in which a model can be influenced, so we need to identify the most influential ones. A lot of parts of the development of this project initially seem to be challenges, but minor ones at best. The major ones are listed here, and we expect to overcome them as they come up. Luckily, there is no expected financial cost to this project, as previously stated.

3.3 Personnel Effort Requirements

Table 2 - Personnel Effort Requirements

Planning and Documentation	Developing a project plan and design document, as well as other documents such as a risk management log and project timeline, will enable us to stay on track throughout the duration of this project. Our goal is to make these documents detailed and clear in order to limit the amount of roadblocks going forward.
Research	Quite a bit of our effort will be spent in research. In order to develop a successful model, a significant amount of research will need to be done. Research will be focused on machine learning and exploratory data analysis.
Issue Tracking	Gitlab will be used for issue tracking of our project. Proper use of Gitlab will be imperative for our success in this project. Each team member will be able to post issues as well as set the necessary date for completion.
Model Development	Since developing several viable and accurate models is the overall end goal of our project, model development will most likely be where the bulk of our software development efforts go towards. This includes testing out different machine learning algorithms with our proposed models, as well as the work associated with creating the models themselves.
Testing	Once models are developed, extensive testing will need to be done. This will most likely be handled by each group member as there will likely be more than one model to test.

3.4 Other Resource Requirements

This project is purely software related, which implies that we will not need any hardware resources. We have confirmed this to be true. Aside from resources we already have, namely computers, there are no resources that we need to complete the project.

3.5 Financial Requirements

The nature of the project makes it so that there are very little, if any, financial dependencies. For each part: learning, developing, testing, and deploying is predicted to cost no money at. However, we do allow a little bit of money as a just in case. There are some places for learning and testing that might cost money, but other than that, we see no cost incurrence in the future for this project.

4 Closure Materials

4.1 Conclusion

The stock market is largely regarded as unpredictable. However, companies like PGI are striving to utilize every tool they can to provide consistent performance on their investments. One of their strategies is to analyze patterns in different factors of stock. Factor analysis at Principal is largely done by humans, which can be inaccurate, biased, and above all, inefficient. We hope to develop a useful resource that will be widely utilized at Principal. In our work, we expect to provide insight on the viability of various statistical models based on factor analysis through software tools.

Our approach is proposed in two phases: research and development. More specifically, our work will consist of a lot of experimentation as we research our domain. As we are doing research into these topics, we are planning to run structured experiments, testing to get a better understanding of them in relation to our dataset. The development phase will consist of experimentation as well. Our process will take a while since we want to get the best set of models we can. As we develop and test our models, we will be experimenting with different settings, calculations, features, and parameters.

The solution that is proposed: use a complex machine learning and regression model. We have 4 different models that we are using as predictive analyzers. Some of these models will be used to predict exact performance, while others will be used to predict relative performance in the market. Each may use different data sets to achieve the highest and most realistic accuracy. . We will use a complex “voting” system between these models to determine actions that will be taken on the aforementioned portfolios.

Our software solution is anticipated to provide valuable insights into future performance of the stock market.

Software tools used to produce reliable analysis have already been used in high-volume stock trading and many other areas in the financial industry. By introducing our tool to Principal's business model, we have the potential to greatly add to the company's reputation of being a leader in investment strategies, along with their overall value.

4.1 References

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4.3 Appendices

No additional information needed in appendices.