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Quant Quarterly

NC STATE UNIVERSITY

Financial Mathematics

Contents

Message from the Director

Dr. Tao Pang
Ph.D., CFA, FRM
Professor and Director

The year of 2022 continues to be a challenge year due to the COVID-19 impacts, high inflation, and the volatile financial markets. Despite this, our program continues to grow and improve.

In fall, 2022, the program welcomed the largest cohort in over 5 years with 33 new students joining the program from around the world, including countries such as the United States, India, and China. Students came from diversified academic backgrounds, such as Economics, Finance, Engineering, Mathematics, Statistics, Computer Sciences, Business Management, and many more. While several students came with previous working experiences, many students joined us right after completing other degrees.

Our program rankings continue to be very strong. In 2022, the Risk.net ranking for our program is #6 globally, only next to Princeton, Baruch, UC Berkely among all programs from the US. In 2023, the Quantnet ranking for our program is #13. Our December 2021 and May 2022 graduates have a very strong placement record, with employers like Credit Suisse, Wells Fargo, PwC, CITI, Truist, Freddie Mac, Fannie Mae, BlackRock, and SAS. The internship record for summer 2022 was also very strong. About 76% of our students secured summer internship offers from companies such as Bank of America, JP Morgan Chase, Morning Star, EY, Amazon, and Walmart.

The program also welcomed two new staff members this year. Mr. Patrick Roberts joined the program in March 2022 as the new Career Service Director. Mr. Roberts has over a decade of experience in career services and connecting students to successful employment. He holds a master's degree in higher education administration from Buffalo State College. Ms. Susan Uy joined the program in May 2022 as the Program Specialist, a position that was newly created to better serve the student body. Ms. Uy is an alumna of NC State, having earned a bachelor's degree in Chemistry. She came to our program after a successful career in graduate student support with NC State's Computer Science Department as well as the Mechanical and Aerospace Department.

We created the Alumni Advisory Board earlier this year. The board members are Graham Carroll (Class'19, MS Capital Management), Erica Isabella (Class'17, McKinsey), Rohit Khurana (Class'19, Crisil), Zheng Liu (Class'20, Wells Fargo), Garrett Mills (Class'19, Bank of America), Venkatesh Nayak (Class'18, Blackrock) and Matthew Puksta (Class'20, Silicon Valley Bank). The board provides feedback on job trends and curriculum, summer project ideas, and professional advice to students on job searching. Providing high quality education and best services to our students is our top priority, and students' success is our success.

Together, we can make it!

About Career Services

Patrick Roberts
Director of Career Services

As the career services director for the Master of Financial Mathematics (MFM) program at NC State, I am thrilled to be working with such academically focused and career driven students. Having over a decade of experience in the field of career services, I have had the opportunity to work with a variety of students, employers, and alumni partners to deliver developmental programs that enhance education and solidify career outcomes. In addition to my previous role as Associate Director of Career Services at East Carolina University, I was also fortunate to be elected President of the North Carolina Association of Colleges and Employers. These experiences have strengthened my professional network and I am excited to bring my background to assist the students at NC State. From my experience, what students contribute both inside and outside of the classroom directly correlates to their success when seeking both internships and full-time roles. I always advise students to begin thinking of the MFM program as a savings account, the more time and effort you put into your career development along with your coursework and group projects, the more you will be able to take advantage of these experiences upon graduation and beyond.

A key aspect of the MFM program is that career development is integrated within the curriculum starting in the first semester course FIM 500. As the instructor my goal is to set students up for success through career exercises and programs. This course includes technical trainings, an industry focused group project, mock interviews, and lectures on topics such as resume writing, job searching, networking, LinkedIn, and interview preparation.

Students in the MFM program also benefit from industry speaker events. During the fall 2022 semester, the MFM program hosted over 29 industry professionals representing 12 organizations for guest lectures on topics that included company information sessions, alumni panels, and technical trainings. Organizations hosted include Bank of America, Aspida, McKinsey & Co., SAS, Fifth Third Bank, Wells Fargo, Truist, EY, Credit Suisse, Millennium Advisors, Arch Mortgage, and Bitwyre.

A highlight this fall was when Bank of America hosted coffee chats and a networking luncheon followed by a panel discussion with 3 current quantitative analysts and a talent acquisition manager. Bank of America was recruiting for several quantitative summer internships and full-time positions. This event saw over 60 MFM students attend and take advantage of the opportunity to learn about career paths at one of largest banks in the United States. In addition to industry speakers, the MFM program provides individualized career counseling services. Students can request an appointment with me to discuss topics that include resume and cover letter writing, job searching, interview practice and preparation, salary negotiation, networking and social media, and general career advice and planning.

I look forward to working with each student to help them achieve their career goals together!

Perspectives with a Program Specialist

Susan Uy
Program Specialist

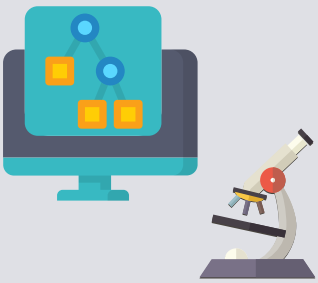
It is my pleasure to work alongside Dr. Pang and Patrick Roberts in supporting our hardworking and dedicated graduate students. I am here to provide program support both with our student onboarding and orientation as well as to prepare students for graduating. Have a question about your enrollment status, how to register for a special class, or when to expect your fellowship to clear? I can help address these and many more questions and issues that may arise during a student's graduate career in our program. Our students come from all over to challenge themselves in learning all aspects of the financial industry and while here, I can navigate them through the university system's processes and requirements.

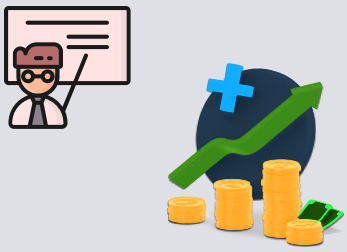
I would like to think I also offer an interesting perspective in my support role. I have had three different career "tracks" in my life to date, and although each was unique in its trajectory, all three added to the framework from which I have cultivated my work ethic. My first career track was immediately after college and began with a great opportunity at a nonprofit that - despite the work experience it provided - meant I still had to live with my folks. I learned quickly that I was of a more independent nature and struck out on my own in another city to prove I could find better opportunities (thank goodness for old college roommates with sleeper sofas).

I managed to go from non-profit to profit when I landed at ABB here in Raleigh. ABB was one of NC State's first business partners, located on Centennial Campus - which was mostly woods then. Although I first landed in the secretarial pool, ABB offered an opportunity in their oil analytics lab if I earned a Chemistry degree. Through NC State and evening classes, I did just that and soon found myself working at the lab. I think of my time after college and at ABB as my first career track, although I held several job titles during those first 12-15 years. It was this time - before marriage and kids - that I saw my biggest learning curve and growth potential. Through my time at ABB in particular, I went from lab technician to technical writer to database designer and Lotus Notes manager. In a for-profit, global organiziation such as ABB, I was able to discover my strengths and weaknesses, and challenge myself. I even took time to backpack around the globe for six months and push my physical limits whether hiking in Nepal, learning to scuba dive in Australia and just driving on the "wrong" side of the road in New Zealand.

But "life" happens, and when it does we often find our focus redirected inward as we face new and more unique challenges. Having children would definitely qualify as a great challenge and became my second "career" track in a way. I was able to enjoy just being "mom" for a number of years, leaving IT behind as I learned to care and guide my wonderful children. As soon as the kids were of a more self-sufficient age was when I knew I needed to take on additional challenges. What could I do that would allow me to be home for the kids but give me a somewhat flexible schedule? I picked up the book "Rich Dad, Poor Dad" by Robert Kiyosaki and found myself eager to learn more about futures trading! I studied trading techniques using Fibonacci levels and Bollinger bands and how to read the market (as best as I could with the tools I had at hand). I discovered that I preferred the Bear to the Bull for my trades, which meant I missed out on the other half of market opportunities when I didn't leave my "comfort zone". I also found that without real training and expertise, like what our program provides to our graduate students, the market can be as trying as a toddler! And when it turns volatile, you had better have a coping strategy and a sense of humor. My almost two years in trading naturally meant both gains and losses but also taught me that there is an exceptional skillset to not only understanding the market but how to position yourself to be flexible and recognize opportunities when they come. There's a good life lesson in that - one that I think our students are learning well!

Today you will find me in my third career track, which began over four years ago when I started working for NC State University. The kids are grown and I found that I was ready to do the same...again. Going forward, as I help our students navigate through their graduate career, they are helping me understand the best way to provide that guidance and support. We are learning from each other, challenging expectations as well as adapting to circumstances - pandemic and market alike! We just need to remember our coping and hedging strategies, and never forget to laugh once in a while!





An Intereview with the FM Ambassadors

Jianheng Chen; Zhaodong Zhu; Tingyu Lei; Kyle (Zhikai) Yan
Bandhuli Ray and Shuhan Yang
Not Shown: Raiden Han

Tingyu Lei; Kyle (Zhikai) Yan; and YiSiou Feng

Why were you interested in being a FM Ambassador?

Raiden Han – There were three main reasons...From my own perspective, firstly, I wanted to enhance my leadership and teamwork skills. Secondly, I hoped this position would inspire me to spontaneously explore interesting topics and areas that are difficult to access in typical courses and to share this knowledge with others in the form of a project. And finally, from an overall program perspective, I also hoped to contribute to program operations and future development.

What was your undergraduate background or previous work experience? Did it help you with your role as FM Ambassador?

Kyle Yan – My undergraduate background is applied mathematics with a concentration in financial mathematics…I wish I had some working experience before I became an ambassador, so I had more to share with my classmates. (But some of them later told me that they actually preferred someone like me because we were both fresh to the job market and thus could discuss the same types of problems and solutions).

Describe an event that you participated in as a FM Ambassador. Tell us what you were expected to do and the challenges you may have faced.

Raiden Han – On the one hand, because some of the students had never heard of factor investing, I had to spend some time going over the fundamental ideas. However, the associated interviews frequently required more in-depth information, making it difficult to strike a balance between the two. In order to overcome this challenge, I would spend the initial few minutes of the workshop learning participants' background knowledge and then included more interaction to better meet the needs of the students.

Are there any unique challenges to the duties of being a FM Ambassador?

Tingyu Lei – Definitely leading a semester project. I found it is very challenging not only because you have to devote time to gain expertise in some area, but also you have to manage your team well. So, communication and leadership skills are vital in this role.

What is the best thing (in your personal experience) about being an FM Ambassador?

Jianheng Chen – I gained a lot of helpful leadership experience and learned from other students.

Kyle Yan - I did not need to do any assignment for FIM 500 and FIM 601, which was really nice!

Raiden Han – On the one hand, I am proud of all the projects I've led. I have learned a lot in preparing these projects, and I am confident that the content of the projects can substantially help the students in their job search. On the other hand, I am very grateful to all the other FM Ambassadors, I am excited to work with them and I have learned a lot from them.

Any final thoughts to share to students who are interested in applying for future FM Ambassador opportunities?

Tingyu Lei – Being a project leader, you will learn more than your group members, utilizing that as great experience to learn more technical knowledge. Also, you can then convey this experience in future interview settings.

Raiden Han – This is not an easy job. As an FM Ambassador, you need to be highly self-motivated and enjoy teamwork. But if you're ready for challenges and want to learn about and lead more fascinating and worthwhile projects, join us!

Kyle Yan – … No one is 100% prepared for something they have never done before, and you could be underestimating your capability, just like me, before I applied for this position. A great man does not seek to lead: he's called to it. If you feel the calling inside you, then I will encourage you to apply, because this position is not only about calling those who are qualified, but also about qualifying those who are willing to answer the call; ironically, the latter ones sometimes do better than the previous ones.

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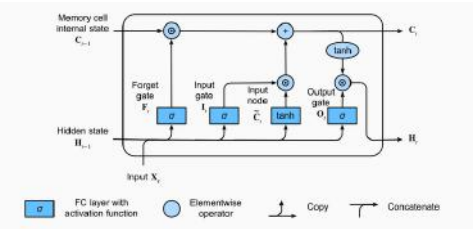
Financial Mathematics Series

Rushikesh Amode

Stock Price Prediction Using LSTM

Famous investor Warren Buffet once said, '*History doesn't tell you of future happenings.'* which was my motivation when I started this project. I have to say it's a conclusion in the financial world put forth by laymen and an erudite alike. In the era of machine learning and data it is hard not to predict anything and everything. Hence, during my first year working in finance, I set out on this journey of stock price prediction with the hope of creating an automated portfolio manager. To achieve this ambitious task, I chose the infamous *'Long-Short Term memory model'(LSTM)* and, no, the Long-short is related to the positions on stocks was not the selection criteria for the algorithm (although it's uncanny to overlook the similarity). In this article we'll discuss what, why and how of LSTM for this specific task of stock price prediction.

Firstly, LSTM is a type of Recurrent Neural Network (RNN) - which is one of the most used tools in the natural language processing (NLP) world. NLP is the study of written information, RNN, if trained efficiently can perform a range of tasks from creating summaries, predicting dropped words/sentences, searching documents etc. The similarity between text/written data and stock prices is the sequential nature of them. This paved the way to use RNN for our task. However, traditional RNN lacks one of the aspects crucial to stock-prices, that is - higher importance for recent information than older information. Stock prices are dependent largely on the present state rather than the historical states. LSTM does exactly this, now we'll dive deep into the working of the model.



Being an electronics and communications engineer, LSTM was interesting to me as it's similar to the signal processing using filters. But here, rather than actual signals it's the flow of information. An LSTM model has three types of gates - Forget gate, Input gate and Output gate as shown in the figure. The Forget gate, as the name suggests is responsible for deciding if the new information provided is important or not, while the Input gate passes on the information collected till now and merges it to the previous information stream and the output gate outputs the information gathered till now. Hence, it can be seen from here that an LSTM model is selective in storing information and has an internal memory responsible for storing past information a long time ago.

Hence, in the case of stock price prediction, the general trends in stock prices that happened a long time ago for a particular stock can be captured using the memory state. And the recent information is added directly to the output of the LSTM model. Stock prices abide by the weak market efficiency principle which dictates that the price would only be dependent on the current price. Although it's a weak statement, it's true more often than not. Our model efficiently captures information selectively and ensures that current prices have higher weightage while still influencing the predicted price using historical data. Due to this working mechanism, it's recommended to use LSTM models for stock price prediction. Concluding, LSTM could be essential in predicting stock prices but shouldn't be used as a sole source of information for investing.

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Xudong Chen

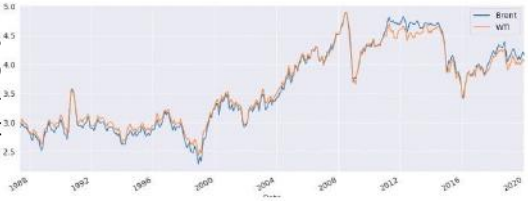
Statistical Arbitrage: An Example With Backtest In Quantconnect

Theory behind the project:

The basic idea of statistical arbitrage, also known as pair trading algorithm, is to construct two asset price time series and check the residual after we do a linear combination. If the residual is stationary, we can consider these two time series as cointegrate. The residual is mean reverting, so we can build the strategy based on this series. This process is also known as the Engle-Grangle two step method.

Plot checking:

I used two assets as my example to show the co-integrate. The first asset is Brent and the other is WTI. In order to have a good pattern, we transfer the two prices into a logarithm, to have a smoother pattern. As you can see, afterwards these two trends become similar to each other, whether increasing or decreasing. This gives us a good motivation to do the cointegrate on the logarithm of these two prices.



ADF checking:

Augmented Dickey-Fuller Results	
Test Statistic	-1.780
P-value	0.391
Lags	1

Trend: Constant
Critical Values: -3.45 (1%), -2.87 (5%), -2.57 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.

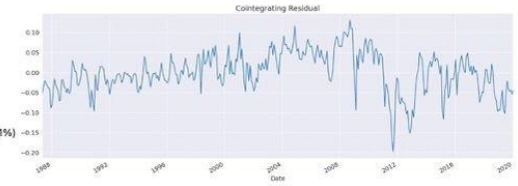
Augmented Dickey-Fuller Results	
Test Statistic	-1.655
P-value	0.454
Lags	1

Trend: Constant
Critical Values: -3.45 (1%), -2.87 (5%), -2.57 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.

As the test shows, the logarithm of Brent and WTI is a non-stationary process. So, we can do a linear combine for these two time series, and use the Engle-Grangle test to see if their residual after the linear combining is stationary or otherwise mean reverting. In the EG test, null hypothesis is rejected and (graph) you can see the residual is clearly mean reverting, so we can build a strategy based on this.

Engle-Granger Cointegration Test	
Test Statistic	-5.837
P-value	0.000
ADF Lag length	0
Estimated Root ρ (γ+1)	0.840

Trend: Constant
Critical Values: -3.52 (10%), -3.81 (5%), -4.37 (1%)
Null Hypothesis: No Cointegration
Alternative Hypothesis: Cointegration
Distribution Order: 1



Back Testing

Compared to the Brent and WTI example, we can try to backtest with other assets to show the performance of our algorithm. Using stock pairs, I backtest a pair trading strategy performance based on statistical arbitrage, starting with $10,000 and backtesting from 2010 to 2017. Overall, the performance strategy is good. When Chevron is paired with a technology company, the performance is better -

Figure 1 Chevron-ExxonMobile Pair

Net Profit: 1,116

Figure 2 IBM-Chevron Pair

Net Profit: 1,301

Figure 3 Amazon-Chevron Pair

Net Profit: 5,725

Manisha Chhetri

Data Science to Combat Money Laundering

> *Let me deposit this cash from my cousin in my bank account to buy cryptocurrencies for him. I don't care where he got the cash from.*

A common scheme of money laundering faced by the financial institutions! Money Laundering was established as a federal crime in 1986. The Financial Crimes Enforcement Network (FINCEN) defines money laundering as the process of making illegally gained proceeds (i.e., "dirty money") appear legal (i.e., "clean"). In the U.S., roughly $300 billion is laundered each year. With the gigantic measures of information streaming all through financial frameworks, it is unimaginable for banks to follow the traditional way to manage risk. The Anti-money laundering system (AML) has been in place for the last two decades. It is a well-known system to detect money laundering but majorly involves manual effort from the compliance department often leading to high cost.

With the increase in technology, risk, and creativity of the criminals, banks these days rely on a stronger weapon like machine learning and artificial intelligence to combat money laundering. Use of data science in financial crime compliance has been vastly developed over the last decade. Institutions utilize machine learning to include intelligent systems to detect patterns and irregularities in the transactions. The utilization of AI models has been displayed to recognize "true positive" results with more prominent precision than rule-based traditional methods and, and even anticipate events before they happen. These models are continuously retrained, further developing accuracy of AML alerts.

These models are not meant to replace the existing system but rather add a shield to protect the institutions. Various supervised and unsupervised machine learning models can be used depending upon the use cases. Data scientists combine mathematics and statistics, business understanding and technology. The analysis is capable of detecting different anomalies that the traditional rules-based engines. Machine learning-based systems can be self-learning. They adapt to evolving money laundering and terrorist financing in near real time and reduce the human input once trained accurately.

However, money laundering is a complex problem to quantify. As much as money laundering may be detected by the use of machine learning, the front-line workers or the employees who interact with members need to have a stronger skillset to know their customers and feed the right information. Machines can only learn what we train them at. According to the AML Fines 2021 Report, fines faced by banks totaled $2.7 billion in 2021 for violations of anti-money laundering policies. While institutions are taking the leap from traditional to advanced technology, it takes a blend of machine and human intelligence to fight against issues like this.

Dimitrios Ligas

Linear Algebra Setup for Triangular Arbitrage

Triangular arbitrage is the result of discrepancies between the tick sizes of three or more foreign currencies and can be implemented when the currency's exchange rates do not perfectly align with each other. A trader can deploy a triangular arbitrage strategy, for example, by exchanging an amount at one rate $\frac{€}{\$}$, convert it again $\frac{£}{¥}$, and finally convert it back to the initial $\frac{\$}{¥}$ amount, and assuming very low transaction costs, capitalize a risk-neutral profit. Given n currencies, let m_{ij} denote the exchange rate of currency i with respect to currency j. Then, the $n \times n$ matrix of the foreign exchange rate is given by:

$$M = (m_{ij})_{1 \le i,j \le n} = \begin{bmatrix} 1 & m_{12} & m_{13} & \cdots & m_{1n} \\ m_{21} & 1 & m_{23} & \ddots & m_{2n} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \vdots & \vdots & \cdots & \ddots & \square \\ m_{n1} & m_{n2} & \cdots & \cdots & 1 \end{bmatrix}$$

The cross-currency exchange rate matrix M has some very interesting properties:

1. $m_{ij} > 0 \; \forall \; i,j = 1{:}n$
2. $m_{ij} = 1/m_{ji} \; \forall \; i,j = 1{:}n$, which implies that there exists no direct arbitrage opportunity between the currencies i, j.
3. $m_{ik} * m_{kj} = m_{ij} \; \forall \; i,k,j = 1{:}n$, which implies that there exists no triangular arbitrage opportunity between any of the given currencies.

A $n \times n$ cross-currency exchange rate matrix M with the above properties constitutes an arbitrage-free matrix, in the sense that it denotes the equilibrium price between each currency pair. Any given cross-currency matrix that deviates from the above properties, gives rise to triangular or in general circular arbitrage setups.

Conditions for Triangular Arbitrage

Since all the entries of the $n \times n$ matrix M are real positive values, it can be proved using Perron-Frobenius Theorem that triangular arbitrage opportunities do not exist, if and only if $\lambda_{max} = n$, where λ_{max} denotes the maximum real eigenvalue of matrix M. In any other case, triangular arbitrage opportunities for a triplet (i, j, k) of the currencies within the matrix emerge. If $\lambda_{max} \neq n$ then, the greater the maximum eigenvalue, the greater the profit from the arbitrage setup. Furthermore, again from Perron-Frobenius Theorem, we have that the eigenvector v corresponding to λ_{max} is unique and positive-valued. This eigenvector v can be exploited to construct a corresponding arbitrage-free cross-currency matrix and from thereon identify the most efficient arbitrage path using the timeless principle "Buy Low - Sell High".

Vaishnavi Choppalli
GARCH Modelling

Generalized Autoregressive conditional Heteroscedasticity (GARCH) is a statistical tool to approach the estimated volatility in markets. This model has various uses in financial modelling because it provides values closer to reality when we try to predict the prices and rates of financial instruments. Firstly, heteroscedasticity tells us the asymmetrical arrangement of variation of error term where they are no more linear rather form clusters. So with many limitations that exist in modelling, this tool analyses the data in today's world and estimates the volatility of returns for stocks, bonds, or market indices. So we first fit the autoregressive model, then compute the sigma terms as well as residual terms and then check for their significance. While doing this we check the stationarity of the residual series too. This report consists of the steps performed to perform the GARCH Analysis followed by forecasting.

The data was extracted from the NSE website with the help of the Python. Now the log returns are calculated for the closing prices for the further analysis. The company for which this analysis is done is Apollo Hospital. The time period chosen for the analysis is the financial year of 2018-2019. We can extend this to several industries so as to compare volatilities.

Heteroscedasticity is the change in variance with time the conditional variability in the latest volatility, and the autoregressive means the positive correlation today's and yesterday's volatility. In GARCH the variance tend to show mean reversion and gets pulled to a long term volatility rate over time.

$$\sigma_{t+1}^2 = \gamma V_L + \alpha \mu_t^2 + \beta \sigma_t^2$$

Long-term average Volatility

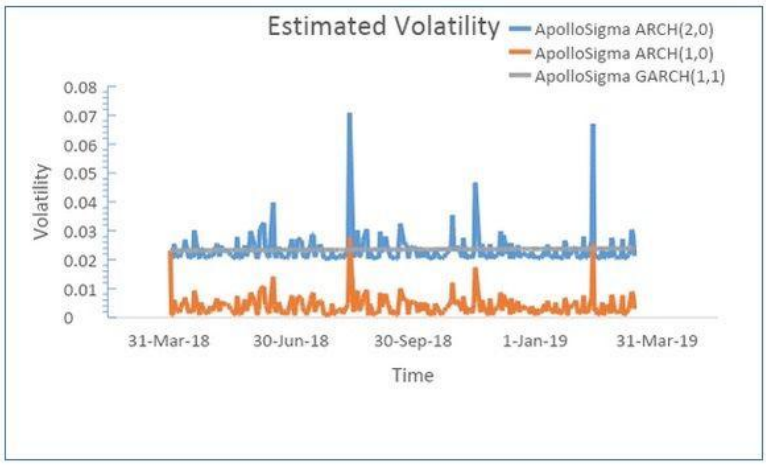
GARCH model gets rid of the least squares and also a prediction is computed for the variance of each error term. Three Models are attempted with the log returns. They are GARCH (1, 1), ARCH (1, 0), ARCH (2, 0). The Log Returns seemed stationary by ACF and PACF test.

We find the residuals and the sigma of the GARCH (1, 1), ARCH (1, 0) and ARCH (2, 0) then check for their stationarity by ACF and PACF plots. The data needs to be stationary for time series to be applied with shocks that should be absorbed by the data and get reverted back to the mean. After analysis the results show that the residuals for all the models are stationary.

The volatility is estimated for all the three models GARCH (1, 1), ARCH (1, 0) and ARCH (2, 0) and plotted. Clearly the GARCH (1, 1) seems the most sorted series because it's always reverting back to mean and also for the above reasons being Information criteria.

CONCLUSION:

This analysis helped to analyze the data using advanced statistics methods. The goal is to provide a volatility measure standard deviation that can be used in financial decisions concerning risk analysis, portfolio selection and derivative pricing. The best model for most of the cases was GARCH (1, 1) because it takes into account the lagged terms and also error terms, technically it is incorporating moving average and auto regression in one model. Proffering GARCH (1, 1) over the other models will bring us closer to reality, especially when we are measuring the volatility.



GV Gundepudi

Using Python to Create Interactive Plots for Finance

In this article we will look into using Python to read and plot financial data as candlestick charts using python. For backtesting strategies there exist a lot of proprietary software however using Python allows the researcher to explore more and play around with the data. When backtesting it is pivotal to have the ability to look at the data in a visual format. Though matplotlib is considered one of the "original" ways to plot data, new packages like Plotly, Pyfolio Quantlib etc are used widely in recent times.

Importing the necessary libraries for prototyping

- matplotlib for plotting inline jupyter
- pandas for data wrangling
- pandas_datareader for Up-to-date remote data access for pandas. Works for multiple versions of pandas.
- datetime for ts manipulation

In case you do not have any package installed in your computer or it gives you a ModuleNotFoundError then open your anaconda command prompt from the windows search and then type the following code (image, right).

```
import matplotlib.pyplot as plt
import pandas as pd
import pandas_datareader.data as web
from datetime import datetime as dt
start = dt(2016, 11, 1)
end = dt(2021, 11, 1)
aapl = web.DataReader("AAPL", "yahoo", start, end)
# The head function gives us the first five rows of a dataframe
aapl.head()
```

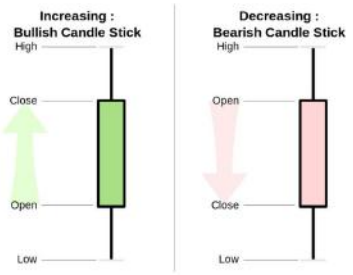
Now we will view the data of the Adjusted Close of AAPL stock from 2016 November to 2021 November. Before we go into plotting candlestick charts we will first understand what they are:

Plotting a Candlestick Chart

Candlestick charts are thought to be used in Japan from the late 1800s and they are composed of the real body, the area between close and open and the wicks or shadows, the little lines above and below the candlestick's real body

- if the asset closes above the open price it is green in color and is called a bullish candlestick chart
- If the asset closes below the open price it is red in color and is called a bearish candlestick chart

There are several different ways of creating a candlestick plot in Python. You can create your own script in MatPlotLib using boxplot but there are also a number of different open source libraries such as mlp finance, bokeh and plotly. In this article we will be using the Plotly package mainly because it allows for interactive visualization with the candlesticks and you can pan across the data.



Adding a Trendline to the Chart

A trendline can be any indicator that you use. For now just think that indicators are some math functions that are plotted along with your data for you to make decisions. One example is the **Simple Moving Average** which is used to try and tell the direction of a market. (Look at the code (image, right) and let me know why it might show the trend line).

```
import plotly
import plotly.graph_objects as go
# Taking google data for the month of October
start = dt(2021, 10,2)
end = dt(2021, 11, 1)
goog = web.DataReader("GOOG", "yahoo", start, end)
# Define the data
candlestick = go.Candlestick(
      x=goog.index,
      open=goog['Open'],
      high=goog['High'],
      low=goog['Low'],
      close=goog['Close'],
      name="OHLC")
# Create the figure
fig = go.Figure(data = [candlestick])
# This makes sure the range slider below the graph is not there, comment
this and then try again
fig.update_layout(xaxis_rangeslider_visible=False)
# Using the show() function to show the graph
fig.show()
```

```
# Using rolling to calculate simple moving average
goog["SMA"] = goog.Close.rolling(5).mean()
# Looking at the first 5 days
goog.head()
scatter = go.Scatter(
        x=goog.index,
        y=goog.SMA,
        line=dict(color='blue', width=1),
        name="5 day MA"
    )
fig = go.Figure(data = [candlestick, scatter])
fig.update_layout(xaxis_rangeslider_visible=False)
fig.show()
```

What is a simple Moving Average?

Simple Moving Average takes the average of previous n periods. So on the date 2022 Jan 01, if I wanted the simple moving average for the past 5 periods, with each period being equal to a day, it would take the average of the previous 5 working days. For the date 2022 Jan 02 it would just shift one day and take a simple average. For now, let us use some basic pandas functionality for rolling averages. The function rolling() allows you to mention the period or the number of rows it needs to take and the function you apply after it can either be mean, median, sum or anything. (Image, left)

Adding Volume to the Chart

Generally, traders would like to add volume for their charts. *Learn more about volume* HERE. In the following code (image, right) you will see two snippets. One where we add volume as an overlay of the chart or as another subplot under the main chart. For each trader it is their own preference.

```
# Create subplots
fig = make_subplots(
    rows=2, cols=1,
    shared_xaxes=True,
    vertical_spacing=0.1,
    subplot_titles=('OHLC', 'Volume'),
    row_heights=[0.7, 0.3]
)
# Plot candlestick on 1st row
fig.add_trace(
    candlestick,
    row=1, col=1
)
# Plot scatter on 1st row
fig.add_trace(
    scatter,
    row=1, col=1
)
# Plot Bar trace for volumes on 2nd row without legend
fig.add_trace(
    go.Bar(
        x=goog.index,
        y=goog['Volume'],
        opacity=0.1,
        marker_color='blue',
        showlegend=False
    ),
    row=2, col=1
)
# Do not show OHLC's rangeslider plot
fig.update(layout_xaxis_rangeslider_visible=False)
fig.show()
```

The final result must look something like this (image, below):

Nakul Haridas

Extreme Value Theory

Extreme Value Theory (EVT) is concerned with the study of events which are extreme deviations from the median of the distribution under consideration. So primarily, this deals with situations which have theoretically extremely minute probability of occurring, but in most cases, the impact of such an event can be adversely significant.

EVT finds applications in the field of structural engineering, earth sciences, traffic prediction and of course in finance. For example, on Black Monday, Oct 19,1987, the Dow Jones Industrial Average (DJIA) dropped close to 22% in a single day, which was the biggest drop in the stock market since the Great Depression. Millions of dollars were lost by investors due to this atomic crash. Thus, we cannot discount the impact of extreme events and a theoretical study of such events is crucial for risk management.

For univariates, where there is just one variable under consideration, suppose we have a sequence of random variables X_1, X_2, which are independently and identically distributed with cumulative distribution function F, then we are interested in knowing the distribution of the maximum of these random variables,

$$M = max\{X_1, X_2, X_3..\}$$

$$Pr(M \leq z) = F(z)^n$$

In practice, the distribution of the random variables will be unknown, but we have *Fisher–Tippett–Gnedenko* theorem, which states that as the number of these random variables approaches a very high value, the distribution will be Gumbel, Fréchet or Weibull. This is a strong result, as we can approximate the extreme event using the above distributions and try to get some insight about these events. For example, we can model the stock prices as the random variables, X_1 = stock price at time 1, X_2 = stock price at time 2 and so on. Also, Historically, this stock price has never gone beyond $50. But if we are shorting this stock, we are concerned if the stock price goes well beyond $50, since margin will have to be posted. We can use the extreme value theory, to model the behavior of the maximum value of this stock and hedge our position by using derivatives.

In the multivariate case, when there is more than one variable, we encounter some problems. One of them is that there is no consensus on defining what constitutes an extreme event. For example, if we are interested in the stock price (S) and the interest rate (R) in the economy. Now the observations we have are of the form (S, R). In certain cases, (100, 5%) might not be classified as an extreme event, but (99.5, 5.3%). Hence, there is a fundamental problem in ordering the vectors. Generally, effort is made to simplify the multivariate case into a univariate case in a logical way and then proceed with the analysis.

The widely used normal distribution gives minute probability to extreme events, and thus breaks down when applied to real world problems. EVT also finds applications in the calculation of Value-at-Risk (Var) and Expected Shortfall, which are important metrics for a financial institution. Given that extreme financial events are very unexpected and have a huge impact on the economy, the study of this branch of statistics is paramount.

Rohit Jain

Crop Yield Density Modelling

Crop yield density modelling is something that is a hot topic in agricultural economics. Every agronomist wants to get their hands on the inferences obtained from this area to have a significant contribution. My professor and his PhD supervisor wanted to achieve similar heights and I was working as a Research Assistant under them. I was tasked with data extraction, manipulation, pre-processing and modelling with help of beta regression in the project.

Data extraction proved to be very laborious as I had to identify the weather station which had the desired data then request for the data from the weather station. After extraction of the data, I had to code in R to model and create the variables like Killing Degree Days to make data compatible with the modelling. This process took me around 2 months to complete. After the data was ready for modelling, I read a few papers around beta distribution, beta modelling and bootstrapping to get a better idea of how to execute the model properly.

I was then tasked with the modelling of crop yield density through beta regression. My professor and I had to sit down for hours, and it took weeks to produce an acceptable model. This process was very arduous as we had to decide on what variables to include, which variables would be better off with interaction while finding justification of the results generated. We used log likelihood and HQIC as our information criteria while working on the mean and dispersion part of the beta regression. When we had few possible models, we went on to construct a confidence interval through bootstrapping. As we had no idea of how to bootstrap, we read around 15 papers and a few class presentation slides to get an idea of how to perform bootstrap.

After a few attempts, we managed to construct a confidence interval through bootstrap! It was a wonderful experience working as a research assistant, as I learned a lot about how a research work is done and the work that is put in to create models and get the data. Weekly presentations and updates kept me on track and achieved my goals.

Abhilash Kalapatapu

Auctioning Or Assigning Of An Object: Different Mechanisms

One of the major applications of game-theoretic ideas is understanding the behaviours of buyers and sellers in an auction. An auction is a place of economic activity where people can buy and sell a variety of goods. Understanding simple types of auctions in which one seller auctions a single item to a set of buyers and the rules such auctions set for the buyers and sellers, plays a key role in building more complex economic interactions between them.

When simulating auctions, our fundamental premise is that every bidder has an intrinsic value for the item in auction. The bidder would not want to pay any higher than the intrinsic value (estimated true value) to purchase the item. There are four main types of auctions when a single item is being sold:

1. **Ascending-bid auctions:** These auctions are carried out either electronically or physically (real-time interactive). As the seller gradually increases the price, bidders withdraw, and eventually there is just one bidder. This last-standing bidder wins the item.
2. **Descending-bid auctions:** In such auctions, the seller gradually reduces the price from an initial high value until the first point at which a bidder accepts and pays the current price.
3. **First price sealed-bid auctions:** Bidders submit "sealed bids" to the seller in this sort of auction. On opening them all together, the seller determines the highest bid. The highest bidder wins the item and pays the value of the highest bid.
4. **Second price sealed-bid auctions:** Bidders submit "sealed bids" to the seller in this sort of auction. On opening them all together, the seller determines the highest bid. The highest bidder wins the item and pays the value of the second highest bid.

Finally, employing auctions is most appropriate when the sellers do not have a good estimate of the buyers' intrinsic values for an item, and the buyers do not know each other's intrinsic estimates.

Shivani Kohade

Ways You Can Financially Prepare For A Recession

Markets all across the world are flashing warning signs that the world economy is perilously close to collapse. Inflation is at a 40-year high. Interest rates are at an all-time high. Investors are being taken on a terrible roller coaster ride by the stock market. Unsurprisingly, the crypto market is collapsing. Making decisions based on recessionary worries can put you in a worse financial situation, so you should avoid doing that.

Tips to protect yourself whether a recession is coming or not.

Don't be concerned about a bear market.

If you're a longer-term investor, just adjust your perspective a little and see this as an opportunity.

Pay attention to businesses with solid cash flows, healthy balance sheets, and goods that customers want and need. Companies in the healthcare and consumer goods sectors have frequently prospered during economic downturns because people still need to purchase their products.

Avoid attempting to time the market.

Many people might wish to stop investing in the stock market or cut back until conditions improve. Stock returns for the S&P 500 have a tendency to be above average once the bear market's bottom point has been reached.

If you have a balanced portfolio, you can weather the storm. Trying to predict the market's bottom at this time would be the worst thing an investor could do.

Build up your funds.

Because a recession can drastically alter your situation, you should start saving while you still have excess cash.

If you don't have a sizable emergency reserve, you might want to postpone an unnecessary pricey renovation project or cancel a trip. "You don't want to have to turn to debt if you lose your job or because your wages aren't keeping up with historically high inflation. For many people right now, this inflation situation is similar to an emergency. Furthermore, it may not be necessary to have three to six months' worth of living expenses saved up.

Bonds can be a powerful component of your retirement plan.

Bonds typically offset your stock holdings when stocks are down. However, bond prices have also been impacted. Bonds have nevertheless fared better than almost any other market area in previous recessions. In other words, keep them aboard even if they aren't performing well at the moment. They are a crucial component of any portfolio, particularly for those approaching or in retirement.

Take on a side job.

Many businesses are asking for employees. The unemployment rate is at 3.6 percent, and there are a record amount of job vacancies. According to the Labor Department, the economy added jobs in the areas of government, education, health services, leisure and hospitality, transportation, and warehousing. However, there is undoubtedly a chance that unemployment may increase. Even if you aren't in immediate need of cash, now may be a good time to start looking for a second job or work in the gig economy to increase your earnings and savings. The moment has come to plan for the worst while hoping for the best.

Reference: https://www.washingtonpost.com/business/2022/06/15/7-tips-on-how-to- survive-a-recession/

Sachin Margam

Macroeconomic Forecasting

A time-series based forecasting is essential in determining how past events affect future events. This study focuses on the main tools for decision-making; namely, models based on time. Here, I present an analysis of the accuracy of the three types of univariate models which are exponential smoothing (ES), Holt-Winters (HW), and Autoregressive moving average models (ARIMA). To determine the best model, different strategies have been done to quantify the predictive accuracy of these models.

Methodology

Spot prices for West Texas Intermediate (WTI) crude oil from January 2013 to January 2018 are used as time series data in this project. The accuracy of the oil price forecasts of the three models was determined and related to each other. The first step is to read the WTI spot oil prices data and eliminate the non-stationary part of ARIMA. Next, to remove the seasonality from the data, the seasonal component is deducted from the time series and then subtract to make it stationary.

Fit the model

Once the data is ready and satisfied with all the modeling assumptions, three variables which are non-negative integers that are referred to the order of the average autoregressive parties, integrated and mobile models, respectively. To examine which values p and q will be appropriate, the acf and pacf tests are performed. In the time k, pacf is an autocorrelation function that describes the correlation between all data points that are exactly at k, considering its correlation with the data between these k steps. It helps to identify the number of autoregressive coefficients (AR) (p-value) in an ARIMA model.

Choosing the best model

R uses the maximum likelihood estimate (MLE) to estimate the ARIMA model. It attempts to maximize the logarithmic probability for given values of p, d, and q when searching for parameter estimates to maximize the probability of obtaining the data that has been observed. First, tried Akaike AIC for a range of models and explored models with the lowest AICs. Then, tried out the Black Bayesian Information Criterion (BIC) and examined the models with the lowest BIC values. When estimating model parameters using the MLE, it is possible to increase the probability by adding additional parameters, which may lead to over-fitting. The BIC solves this problem by introducing a penalty for the number of model parameters. With AIC and BIC, values of these coefficients are closely monitored, and to decide whether to include by significance level.

Conclusion

The properties of the predictions have been determined by comparing the results of the given models with the actual data. The ARIMA model (0,1,1) provided more accurate predictions than the ES or HW models. The Auto-Arima function is used to quantify the qualities of the predictions that provide the lowest values for the ARIMA prediction. In the end, the best decision-making process will be the most effective. Predicting future events based on an appropriate model of the time series will help decision-makers and marketing strategists to make decisions and appropriate strategic plans in the oil industry.

Hemanth Pinnamaraju

Interest Rates: The Numbers You Know, The Mystery You Don't

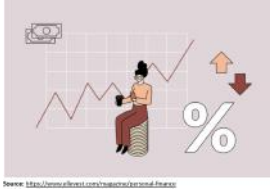
Interest rates are one of the hottest topics in the financial world. While a layman may not appreciate the nuance involved, setting a number to the most influential tool, that keeps the most powerful economy running and perhaps the world, is no less than a miracle that the FED does daily.

I'm tempted to say that the floating rate on my student debt is what got me interested about "Interest Rates," but it was actually because of a project I am currently working on where I'm trying to predict the Expected Loss of Single-Family Loans. I was particularly intrigued by the extent to which interest rates influence prepayment percentages and the effect these changes have on the underlying Mortgage-Backed Securities (MBS). Although there may be other factors affecting the prices of MBS such as Loan-to-Value (LTV), Private Mortgage Insurance (PMI), Personal Income etc., interest rates have a huge role to play.

The Fed employs three basic types of economic indicators: coincident, lagging, and leading. In contrast to lagging indicators, which represent historical events that are still crucial to study like Unemployment rate and CPI, leading indicators are used to forecast impending economic events, a few examples would be new housing and money supply. Coincidence-based indicators keep track on changing economic conditions, GDP and Personal Income are noteworthy examples.

It's remarkable the variety of data the FED looks at before deciding the upper and lower bounds. While Gross Domestic Product, Consumer Price Index and Unemployment are of course the first obvious guesses, the FED also looks at a multitude of lesser spoken about figures like retail sales, consumer confidence, the stock market, new building permits, in some cases even aggregate Google searches, although this may be an exaggeration. In 2022, the FED has already raised the rates by 375 bps, and more rate hikes are expected to come later this year and into the next one. The most recent inflation measurements suggest that prices are still very close to 40-year highs, prompting the latest rate increase. The chairman noted that the "terminal rate," or the point when the Fed stops raising rates, to be higher than it was at the September meeting. This also implies that the "Soft Landing" that the FOMC (Federal Open Market Committee) was emphasizing has also narrowed.

The United States economy is now walking a tight rope. On one end of the pole is curbing inflation and cost of living increases which are currently taking the front seat. On the other end, is to only increase rates so much, as to not push it to a recession. While this is a situation every other country is grappling with, all eyes look towards the United States. Would there be a recession? Well, only time can tell.



Jack McManus

Equity Factor Models, Vix Beta, And Oil And Gas Companies

In my senior year of undergrad, I studied the Fama-French Three and Five Factor models as well as the momentum (MOM), short- and long-term reversal (STR and LTR), illiquidity (ILLIQ), betting-against-beta (BAB), idiosyncratic volatility (IVOL), and preference for lottery stock (MAX) factors. For the final project of this course, I investigated the relationship between the returns of oil and gas companies and their sensitivity to changes in market volatility. It is commonly argued that stocks with high sensitivity to changes in market volatility provide a hedge against the downward market movements that are commonly associated with increases in volatility. The demand for such stocks with large, positive VIX betas increases their price and lowers their average return.

My project investigated if this relationship holds true for oil and gas stocks. In other words, my goal was to determine if the excess returns of oil and gas stocks can be explained, in part, by their sensitivity to changes in market volatility. I measured change in market volatility using daily percent change in VIX, and used this data along with daily excess returns for stocks with SICCD's 1311, 1321, 1381, 1382, and 1389 to calculate a VIX Beta for each security. I then read this data into SAS, sorted the stocks into VIX Beta decile portfolios, created a low VIX Beta – high VIX Beta long-short portfolio, and tested to see if the alpha generated by this portfolio was statically significant. Ultimately, I found no such evidence in either the equal-weighted or value-weighted cases.

I ran separate tests controlling for CAPM, the Fama-French Three Factor model, and the Fama-French Five Factor model and each time the alpha of the long-short portfolio became smaller in magnitude. This suggests that the sensitivity of oil and gas stocks to changes in market volatility is captured to some extent in the Fama-French factors. It is interesting to note that in the five-factor case, RWA and CMA were not found to be statistically significant for any of the decile portfolios and for the three- and five-factor cases SMB and HML were only statistically significant for some portfolios; the return of oil and gas stocks were best predicted by their market beta. My project was inspired by research performed by Ang, Hodrick, Xing, and Zhang who found that high sensitivity to changes in market risk generated lower alphas even after controlling for CAPM and the Fama-French Three- and Five-Factor models. I believe the main reason I got a different result from Ang, et al. is that they tested their model using all stocks listed on the NYSE, AMEX, and NASDAQ with a sufficient number of observations and I only used oil and gas companies. Additionally, the returns of oil and gas companies are likely dependent on the actions of large international participants in the oil market such as OPEC+ to a much greater degree than other equities.

Here is a summary of the more important results from my report which I have made reference to:

CAPM

VW Portfolio	AvgExRet	STDEV	BETA
LVIXBETA	-0.0027	0.0099	0.1473
2	-0.0022	0.0092	0.1216
3	-0.0026	0.0084	0.1379
4	-0.0024	0.0076	0.1076
5	-0.0030	0.0079	0.1032
6	-0.0021	0.0069	0.0829
7	-0.0017	0.0062	0.0927
8	-0.0008	0.0063	0.0829
9	-0.0020	0.0078	0.1090
HVIXBETA	-0.0023	0.0079	0.1029
LVIXBETA - HVIXBETA	-0.0004		
t-stat	-0.55		

VW Portfolio	CAPM Alpha	t-stat
LVIXBETA	-0.48	-5.00
HVIXBETA	-0.39	-5.03
LVIXBETA_HVIXBETA	-0.09	-0.94

FF3

VW Portfolio	AvgExRet	STDEV	BETA(MKT)	BETA(SMB)	BETA(HML)
LVIXBETA	-0.0027	0.0099	0.1242	0.0380	0.0958
2	-0.0022	0.0092	0.0219	0.0791	0.0507
3	-0.0026	0.0084	0.1121	0.0687	0.0540
4	-0.0024	0.0076	0.0806	0.0680	0.0651
5	-0.0030	0.0079	0.0883	0.0166	0.0774
6	-0.0021	0.0069	0.0651	0.0393	0.0530
7	-0.0017	0.0062	0.0751	0.0483	0.0338
8	-0.0008	0.0063	0.0641	0.0517	0.0355
9	-0.0020	0.0078	0.0908	0.0445	0.0462
HVIXBETA	-0.0023	0.0079	0.0774	0.0754	0.0387
LVIXBETA - HVIXBETA	-0.0004				
t-stat	-0.55				

VW Portfolio	FF3 Alpha	t-stat
LVIXBETA	-0.41	-4.90
HVIXBETA	-0.34	-4.41
LVIXBETA_HVIXBETA	-0.07	-0.86

FF5

VW Portfolio	AvgExRet	STDEV	BETA(MKT)	BETA(SMB)	BETA(HML)	BETA(RWA)	BETA(CMA)
LVIXBETA	-0.0027	0.0099	0.1203	0.0424	0.1091	0.0275	-0.0463
2	-0.0022	0.0092	0.0996	0.0924	0.0220	0.0304	0.0819
3	-0.0026	0.0084	0.1104	0.0764	0.0578	0.0327	-0.0180
4	-0.0024	0.0076	0.0776	0.0651	0.0780	-0.0015	-0.0391
5	-0.0030	0.0079	0.0912	0.0368	0.0584	0.0643	0.0457
6	-0.0021	0.0069	0.0724	0.0423	0.0233	-0.0107	0.0929
7	-0.0017	0.0062	0.0783	0.0507	0.0205	-0.0009	0.0408
8	-0.0008	0.0063	0.0655	0.0567	0.0282	0.0139	0.0198
9	-0.0020	0.0078	0.0963	0.0435	0.0249	-0.0200	0.0690
HVIXBETA	-0.0023	0.0079	0.0817	0.0807	0.0199	0.0064	0.0563
LVIXBETA - HVIXBETA	-0.0004						
t-stat	-0.55						

VW Portfolio	FF5 Alpha	t-stat
LVIXBETA	-0.41	-4.87
HVIXBETA	-0.34	-4.34
LVIXBETA_HVIXBETA	-0.06	-0.76

FF5

VW Portfolio	Alpha	BETA(MKT)	BETA(SMB)	BETA(HML)	BETA(RWA)	BETA(CMA)
LVIXBETA	0.11	0.12	0.04	0.11	0.03	-0.05
(t-stat)	**-4.87**	**-5.18**	**-1.47**	**-3.12**	**-0.45**	**-0.79**
2	0.08	0.07	0.08	0.00	-0.04	0.00
	-4.30	**4.32**	**2.71**	**0.40**	**0.65**	**1.09**
3	-0.41	0.11	0.08	0.06	0.03	-0.02
	-5.69	**5.51**	**3.10**	**2.18**	**0.62**	**-0.41**
4	-0.34	0.08	0.07	0.08	0.00	-0.04
	-4.26	**5.34**	**2.34**	**2.93**	**-0.04**	**-0.90**
5	-0.34	0.08	0.07	0.08	0.00	-0.04
	-4.26	**5.34**	**2.34**	**2.93**	**-0.04**	**-0.90**
6	-0.31	0.07	0.04	0.02	-0.01	0.09
	-4.03	**3.86**	**1.24**	**0.88**	**-0.30**	**2.16**
7	-0.29	0.08	0.05	0.02	0.00	0.04
	-4.70	**4.93**	**2.40**	**0.94**	**-0.03**	**1.05**
8	-0.18	0.07	0.06	0.03	0.01	0.02
	-2.93	**4.70**	**2.57**	**1.25**	**0.34**	**0.52**
9	-0.33	0.10	0.04	0.02	-0.02	0.07
	-4.17	**4.90**	**1.39**	**0.91**	**-0.40**	**1.25**
HVIXBETA	-0.34	0.08	0.08	0.02	0.01	0.06
	-4.34	**3.91**	**2.67**	**0.46**	**0.14**	**0.96**

Works Cited

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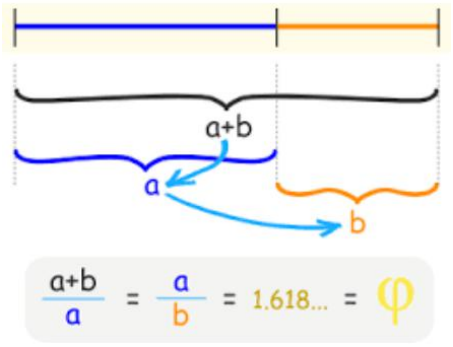
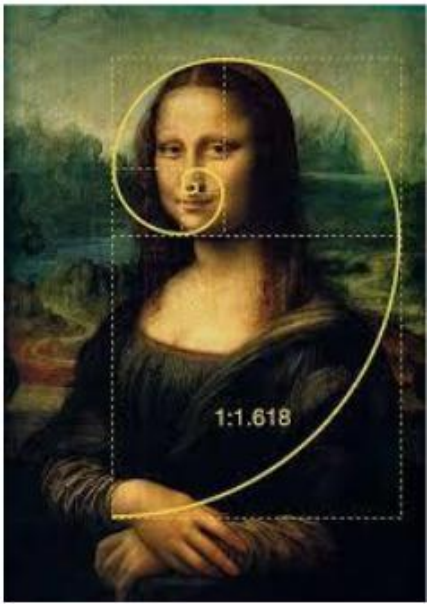
Ritu Sharma

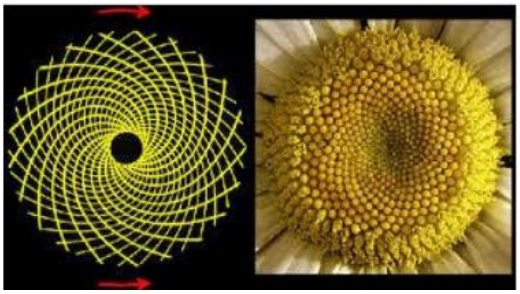
Mystery Of The Golden Ratio

1.6180339 Just a number for most of us, whereas a mystery number for the mathematics enthusiasts. Without furthering into much of it's technicalities, let me tell you the specialty of this golden ratio. On unequally dividing a line into 2 parts, the ratio of longer to shorter segments is equal to the ratio of the whole line segment to the longer part. You might be wondering what's so special about this number? Maybe it's just a matter of coincidence. But there has been surprising evidence embossed by nature in support of this not so regular irrational decimal number. Even before the discovery of 1.618... legendary painters like Leonardo da Vinci have used this ratio in their paintings. Remember the mesmerizing beauty - Mona Lisa? Yes, the pretty lady's eyes are bordered by the golden rectangle (ratio of length to breadth is 1.618). Also, many architectural monuments have dimensions in accordance with the golden ratio (for example: the Great Pyramid of Giza). Ancient mathematicians believe 1.618 has a deeper aesthetic aspect to it. Research has proven that people with the most beautiful smile have their front two teeth as golden rectangles.





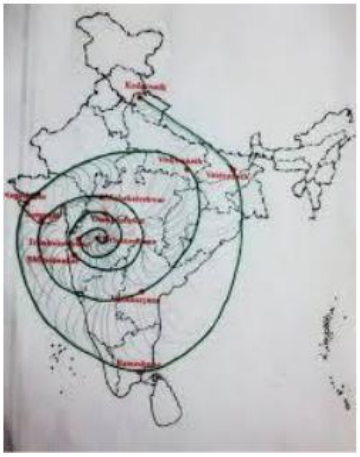
Here comes another revelation of the Fibonacci series. As the numbers of Fibonacci series become bigger, the value of the ratio of any 2 consecutive numbers of the series becomes closer to the golden ratio. Don't trust me? Try it yourself!



Time for some mathematical awe striking wonders of nature. The number of petals of most of the flowers (lily, sunflower, buttercup to name a few) are a member of the Fibonacci series.

Observe carefully the pattern of the sunflower seeds. Yes, they rightly hint at the golden spirals. The shells of the snails and the curled horns of goats are golden spirals, too. The 12 *jyotirlingas* in India when connected together form the golden spiral structure.

Smitten by the mystery of Golden Ratio, aren't you? So keep up the keen observation and curiosity and you might discover some hidden mystery behind many more regular, everyday numbers.



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Zitao Song

Volatility With Time Series Models

Volatility in the financial market is a statistical measurement of the dispersion of returns for a given asset in a given time interval. It indicates the expected range of return movement. Volatility is a part of risk which, by definition, is the degree of uncertainty inherent in the investment decision. In most cases, high volatility will increase risk in finance. In a volatile market, an asset's price tends to rise or fall significantly in a short period. Dramatic fluctuation brings risk to investors. Forecasting volatility can reduce the impact of this uncertainty in price change by analyzing it in investment decisions, that is, risk management. If the model gives a good prediction of volatility, the investors can adjust or rebalance their portfolios to reduce risk using these metrics.

Volatility is more important in the short term due to its clustering effect which is a tendency of large changes in returns to follow large changes, and small changes in returns to follow small changes. In statistics, volatility clustering can refer to heteroskedasticity. This statistical property enables the forecasting of volatility. Knowing expected volatility beforehand can also contribute to trading opportunities. For example, if the model gives a continuous volatility trend in the next few days, then investors can construct option strategies to gain profits.

Volatility is also a key factor to option pricing. In the Geometric Brownian motion, the volatility of the stock price is the variance rate. The Brownian motion follows Ito's Lemma; thus, the value of an option can be expressed as a differential equation. The Black-Sholes model is a solution to this equation. Theoretically, the volatility parameter in the Black-Sholes formula refers to historical volatility which is the standard deviation of the percentage change in the stock price in a time interval.

Common types of volatilities are market volatility, stock volatility, historical volatility, and implied volatility. Market volatility measures the overall dispersion of value changes including commodities, forex, and the stock market. Stock volatility often referred to the systematic risk or beta, is a measure of the correlation between a stock's volatility and that of the whole market. Implied volatility is the future volatility of a stock assessed by the market. Historical volatility or realized volatility describes how much volatility a stock has had in a period. It can be obtained by calculating the standard deviation of returns for a stock in a given time period. Forecasting future realized volatility is the main objective of this thesis.

Time series is a collection of observations of data items obtained through repeated measurement over time. Similar to other analyses, time series can also be modeled. Normally, a time series model contains two parts: deterministic trend and stochastic trend. The deterministic part, also called signal, can be modeled using standard modeling techniques like linear regression. The main purpose is to remove the deterministic trend and seasonal trend contained in the time series data. After removing these trends, the stochastic part or noise is left. This part can be modeled by fitting the times series model, such as ARMA or ARIMA, with the assumption of stationarity. Moving average and autoregression are two main processes of the stochastic part. However, if the stochastic trend is still not stationary which implies that the variance over time is not constant, then the data has heteroskedasticity and it can be explained by conditional heteroskedasticity using the ARCH or GARCH model. ARCH model is a class of models used to model changing variance of a time series.

Niyati Srivastava

Geometric Brownian Motion: An Evolution

Back in the 1900s when Louis Bachelier introduced Bachelier's model, it was one of the first models under Brownian motion for asset prices to be modeled. The equation involves the change in asset price, dependent on the market variance times a random effect called the Wiener Process. (dSt= σ * dWt) This model was fairly used for option pricing formulas and laid the niche for asset price movements. Then what went wrong that introduced new models such as the famous Geometric Brownian motion into play?

Firstly, there existed no limitation on the value of prices. These prices could go negative which at that time seemed an impossible scenario. The second drawback was the non-dependency of the price change on the initial value. However, while looking at a practical scenario of return on any investment that one makes, it surely depends on the initial amount invested. That is, there is a relative profit or loss based on how much one initially paid up. The equation fails to incorporate this relation which sends a major drawback when pricing asset prices.

Thus, we moved to Geometric Brownian Motion (GBM) which not only solves these issues but provides an ideal way of modeling, primarily attributed to the normal distribution it approximates which makes life all the simpler.

$$dS_t = \mu S_t dt + \sigma S_t dW_t$$

(dS_t =Asset Price Change, μ=Mean (or drift), σ=Volatility, dW_t=Wiener Process)

Though still strong, there are some deviations from this classic behavior that has been evidenced by the market from time to time. For a long time, we all have been part of this ecosystem of finance, if not personally, one cannot ignore the monetary policy decisions, stock market screams or a financial economic debate on television. There are enough circumstances to believe that the market exhibits a mean reverting reaction. This is simply to say either 'good' time or 'bad' time is not a permanent situation and a 'normalcy' will eventually be reached. But in a world where GBM is used to model investment returns, the independent increment property of the Wiener process makes this tendency hard to achieve. This property implies that between any two time intervals, the movement of asset prices does not depend on one another, which clearly dismisses the idea of mean reversion.

The log-normal GBM conforms to a normal distribution. But in reality, because of extreme situations arising like the recent Covid crisis or the financial crisis of 2007, the market tends to exhibit times when prices approach extreme values. One example is the crash of the stock market during Covid, it's a rare event but one that on occurrence leads to massive turbulence. Thus, approximating such scenarios with a normal distribution, when in reality it can have taller peaks and fatter tails might seem to one as presumptuous.

There are other empirical deficiencies one can find in the approximation of GBM, though none of them necessarily imply a market inefficiency. Despite these shortcomings, we can't simply ignore that the normal distribution which comes with GBM is a powerful distribution in the field of finance. Even with these deviations, searching for a substitution of this model will lead to the retesting of various hypotheses and the issues associated will seem greatly weakened.

Ameya Tembhekar

Structured Products: An Introduction

During my time at a Wealth Management firm in India where I was working in the Product team, I was introduced to Structured Products. As a part of the firm's wealth management strategy, they advised the clients to construct a portfolio which included Mutual Funds and Structured Products. Where an Equity Mutual Fund provided the client a participation in the Equity markets, the Structured Product ensured that even if there were minimal returns in the Equity markets the client would still be able to beat inflation and preserve the purchasing power of their savings.
So how exactly is a Structured Product created? A Structured Product has two return components, one from a Fixed Income and the other from an Options Strategy. To explain the simplest format of the Structured Product, let us assume that the client has $100,000 to invest. Also let us assume that the company offers an interest rate of 7% per annum. This is the Fixed Income return component of the product. The company produces this return by lending in the home loan, personal loan and investing some in the treasury papers. This return also could be an indication of the credit rating of the firm (in this case the firm was not rated by a rating agency).

Now, coming to the Options Strategy, the client sells Put options on the broad equity index, at a strike slightly higher than the current level, for instance 5% higher than the current level. To make calculations easy, let us assume that the option premium which the client receives is $4,000. So, this inflow of the option premium is yet again invested in the Fixed Income component discussed before, which grows at 7% per annum. The investment horizon of the product is 3 years, so the option will also have a 3-year maturity. After 3 years if the broad markets are above the option strike 5%, the option expires worthless for the buyer and the client would not owe them anything.

So, as we sum up the payoffs from the Fixed Income component, we have a payoff equation as follows:

$$(\$100,000 + \$4,000) * (1.07)^3 = 127,404.5$$

The total payoff from the product is as follows:

Index Performance (Absolute)	Fixed Income Proceeds 1	Fixed Income Proceeds 2	Liability from Option	Final Product Payoff (Absolute)
10%	22.5%	5%	0%	27%
5%	22.5%	5%	0%	27%
-10%	22.5%	5%	-15%	12%
-13%	22.5%	5%	-18%	9%

From the table, we can see that during a muted index performance, this product still delivers a good return.
This all looks so good! So, what should we as an investor be aware of while investing? There is a certain credit risk we are assuming which comes with the Fixed Income component. As the firm is also not rated, this raises further questions about the certainty of the returns. Another reason to consider this is if the market tanks significantly in a very short period, even though it might rebound back during the investment horizon, there is a certain margin management cost involved which increases sharply with high volatility.

To conclude, though it looks like a good product to keep in our portfolio, it comes with a certain risk which one has to assume and it also demands a good understanding of the options market mechanism.

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Nidhay Acharekar

Career Prospects and Professional Plan

I am currently a student at North Carolina State University pursuing a master's degree in Financial Mathematics. After completing my bachelor's degree and having worked as a CVA trader at a leading global investment bank, I decided to go for higher education in order to fulfill my future career goals. So, I would like to discuss my career goals as well as my academic plans while enrolled in this master's program which will help me achieve my goals and my professional development.

I have been charmed by mathematics and its applications in finance which led me to choose this career path. After starting my role in credit risk trading, I became aware that even though my theoretical foundations were solid, I lacked the experience in practical applications which included research and programming. At the same time, I observed that the field was being revolutionized by advancement in technology like big data and machine learning and their growing influence in the industry made me realize that I needed to step out of my comfort zone and learn these tools in order to achieve my goals.

In the future, I plan on working in active portfolio management roles in the long term. In realizing this, it is necessary to get adequate work experience in quantitative research, data analysis and modeling in my opinion. I believe that to become a successful portfolio manager I should be proficient at analyzing data, doing research on that data to create investment strategies and develop models to test those strategies.

As a student at North Carolina State University, I have been enrolled in many courses in statistics and finance. In the near future, I have also planned on taking electives in portfolio management, data analysis and machine learning while also demonstrating my technical skills by establishing a Github presence.

Thank You!

Chieh-hsi Cheng

Life in NC Financial Mathematics

I think there will be a lot of topics contained in this article, like why I chose NC State FM, what I have gone through since I entered into this program, or even what I expect myself to be in the next few semesters. Although it has just passed a few months in this semester, I have lots of different feelings of studying in this program as being an international student.

At first, I thought there are lots of reasons why I chose NC state FM as my master's degree, like it's ranking on Quantnet, it's 100% employment rate, it's mathematics-oriented courses, and its small size class. Those are really appealing for an international student who really wants to stay in America and those are exactly the same as what I expected before. However, I could say that I still haven't prepared myself yet for getting these resources. Take most of the students in the class for example, they almost all have work experience before entering the program, they know what to learn, how to do networking, and how to present their strengths. But as for me, I am not confident enough to express those and I am still learning and accustoming myself to life here. It's not an excuse, but as a one and a half year program, I think its pace is too fast, and I sometimes just feel that I cannot follow the progress or do deeper research in my interests related to the coursework. This is quite different as what I thought before, and maybe it is time for me to adjust myself and pay more attention on my career.

Then, I will give a short description about what I felt in some activities I passed through this semester. The most impressive thing for me in this program might be the professional photo session. This is the first time I dressed in a suit, and taking this formal picture really gave me the feeling that I am entering into a business industry. Besides, the FIM500 course also give me a lot of resources before entering into my career. I would say that this course really helps me progress a lot. I discuss a project with my teammate every week and we just finish our practical presentation recently. This is also my first time speaking English in a presentation. I felt really nervous and could barely remember what to say when standing on the stage. I thought this is an unforgettable experience because I learned a lot from this, like I know I need to practice more in my English communication skills, skills in presenting what I want to express to others, and how to work in a team.

Finally, just like what I said in my first part, I feel I have not prepared enough for this program. However, I think this is also an opportunity for me to think about what I truly want to learn in the future and how I can set my goals. So, as my first short-term goal, I would like to take progress in my English speaking skills, and that's why I am attending the UUG mentor activity, which help me to pair up with another American undergraduate student and we can learn from each other. For the second goal, I hope I can focus more on the courses I'm interested in and do more research, and be more proficient in time management skills. Lastly, I expect myself to be more active in networking and be more confident, which is my biggest weakness. I would put the professional photo I take first in this program because it impresses me the most.

Colson Chen

Projects Oriented Programme

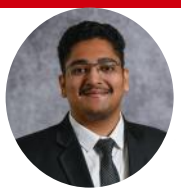
One distinct feature of our financial mathematics program is the emphasis on the application of theory into real-life practice and getting students' hands dirty. Academic projects that were offered throughout the first semester served this purpose perfectly and provided us with a great opportunity to practice techniques taught in the classroom. It could also be considered a precious opportunity to enhance our interpersonal skills via daily interaction within the team.

This year I had the opportunity to contribute as part of three projects with different classmates to achieve various targets. The biggest project was called 'LGD Model-Residential Mortgage' and we focused on building up a Loss-Given-Default prediction model utilizing existing data from Fannie Mae. Our team leader utilized his network and found an external team who guided us through the whole model-building process and provided many insights about real industrial practices adopted by the modeling team at a mortgage insurance company. During the semester, we followed the general instructions and successfully preprocessed and shrank the dataset, fitted some linear models, and tried different methods for performance comparison. Ultimately, we managed to extract useful information from over 500GB of raw data files and built a concrete OLS model on our clean data with sound justification for each variable, and explored the nonlinear effect embedded in some variables to have a taste of feature engineering. This experience reminds of me the famous quote in computer science "Garbage in, Garbage out" which I will keep in mind when completing data-related work in the future.

Another two projects I participated in were called the "State Transition Model for PD model" and "Supercointegration Phenomenon in Pair Trading" respectively. The former one was focusing on the risk measurement and management side while the second one emphasized the trading side more. However, we went through a similar procedure for both, starting from data collection and all the way to model testing and validation. The exposure to various models and business knowledge in different finance sectors obtained in these projects enriched my toolkit as well as helped me to determine the career path I want to pursue in the long term.

The most relaxing project, or so-called challenge, I have been working on is the Bloomberg Trading Challenge, in which we could invest using some virtual money and try our best to capture any alpha in the equity market. We have freedom and total control over what securities we want to long and the timing of trades. It turned out that all our team members had a joyful time picking stock without responsibility and thus it also reflected how hard actual trading could be once we need to take the loss.

Nowadays everyone is learning OOP (Object-Oriented Programming) but learning it in a POP way may be one of the best things our faculty provides. I am thankful for these experiences provided through the program at NC State and I am very much enjoying these projects!



Shashank Jaipuria

Journey to make a DREAM come TRUE

The journey to the "Finance" industry started years back working as a child helping his father with data entry and accounting. Gradually this sparked an interest in accounting and working with numbers. Further in academics in the later grades of schooling and high school he started playing with numbers and making his way through his analytical skills and gained impressive knowledge in probability and statistics, and accounting. With his excellence in high school mathematics, he cracked the 'Joint Entrance Examination' which is taken by around 2 million students in India, making his way into the Indian Institute of Technology Kharagpur.

In the graduation years, he worked further on his problem solving and analytical skills, achieved several awards and medals in academia as well as extra-curricular activities. His internships helped him gain practice in his programming skills, and undergraduate projects allowed him to put his analytical skills and his passion for numbers to use. Though his undergraduate major was in Aerospace Engineering, he did not lose his way to the Finance Industry, working part-time for Insurance companies like HDFC Life Insurance Co. Ltd. as a Financial Consultant & Insurance Agent, and Star Health & Allied Insurance Co. as a Sales Manager, as well as an internship as an accountant at Agrawal Sharma Associates. While working in the insurance industry he found himself veering towards flow of money in the companies and furthermore as an accountant when he had the opportunity to work with financial statements and reports of firms, his curious nature demanded of him to explore the working of the markets and global finance.

Realizing his passion and interests, he took up online courses through platforms like Coursera and Youtube to gain more knowledge and wanted to make his way to one of the best Universities in Financial Engineering. He worked hard and made his way into the North Carolina State University Master of Financial Mathematics Program. From the beginning of this program, he has been giving his best at all he can, working on projects like, "Exchange Traded Funds (ETF) Portfolio", and "Black-Litterman Portfolio Model" where he used programming and statistical skills. In the ETF Portfolio project, he came up with a portfolio and managed to secure an annualized holding period of return of around 149.80% for a holding period of 2 months.

He aspires to be a Portfolio Manager and associate himself with the best firms in Asset Management and Investment Banking to obtain a lifetime of exposure to portfolio analysis, management as well as investment-based research and development. He aims to become one of the finest, most appreciated, and well-known Portfolio Managers around the world. To achieve this, he has been giving his best and is ready to try even better to strive for the best. He has tried to and still does expand his network so that he can explore the field he has stepped into and open new and bigger opportunities ahead for himself.

Forrest Jin

Snake Wrangling

Coming into the Financial Mathematics program at NC State, I knew that I had to learn Python at some point. My coding experience was with Java and was purely academic. The most impressive experience I had was a small application that simulated wait times of people queueing to use elevators in a building of a given height; funnily enough, my first foray into modeling. Now, I had to learn to use a new language for real-world data analysis, and quickly because there were projects that needed to be completed and internships that needed to be applied to.

At first, the going was not easy. Doing away with all the semicolons and curly brackets that I was used to was a shock, and I found myself struggling to even do the basics; not to mention all the methods I was unaware of in base Python and packages as pandas or seaborn. On top of that, the unexpected errors and subsequent hair-pulling to figure out why was a feeling that was infuriating, yet somehow nostalgic. Even just importing pandas turned into an afternoon of figuring out how to use the terminal to install packages in a virtual environment. But after the dust settled, I came out to the other end with my finished product: a dataset that was filtered, cleaned, and ready for model building, and some effective histograms and boxplots.

While I saw this as a victory akin to the moon landing, in the back of my mind I knew that the Cold War had just begun. In the grand scheme of things, I was still a toddler just taking their first steps. Having taken those first steps, however, I felt encouraged now that the annoying boilerplate had been dealt with. I was ready to continue my quest to be proficient in Python.

Eby Kannamkara

Why I chose Financial Mathematics at North Carolina State University

From an early childhood, puzzles and patterns have always drawn great interest from me. I took great pleasure in understanding the inner workings of such conundrums. Hence, I naturally gravitated to mathematics as my favourite subject to spend hours over, beginning in high school. From books and accounts, I learned how engineering combined problem solving and the tangible world around in beautiful harmony. I was presented the opportunity to take up a bachelors in the National Institute of Technology at Warangal. Being a highly sought after degree, in a prestigious institution, this stint offered an opportunity to take classes with the best minds of the country, and to be taught by the forerunners of research and development.

In light of internships and academic projects undertaken, I found myself moving further away from the EEE Electrical Engineering core jobs and gravitating more towards software. During my third year of undergrad, I got to choose Engineering Economics and Accountancy, and this course really helped solidify in a sense, where I saw myself settling into career wise.

After undergrad, I got a Pre Placement Offer from Wipro, where I had previously worked as an intern. Taking the offer, I was drafted into Wipro's Vulnerability Assessment Project. Working as a Security Data Analyst in the Wipro SOC(Security and Operations Centre), we were in charge of analysing the data concerning the major security flaws and the point of contact for the clients to present their security concerns. The team worked closely with the Remediation team and the Security department, to offer quick and optimal solutions to the concerned clients.

Being presented with an opportunity to work as an analyst in the Banking and Financial Services Department, was just the kind of horizontal movement I was pursuing in WIPRO. The responsibilities consisted of helping the team analyse the departments, clients and regions with increasing revenue, profits and margins. Machine Learning Algorithms, primarily decision tree models were implemented using python for the same. The team helps senior management in negotiating costs and services for upcoming and new client projects.

I had begun learning Machine learning and Blockchain simultaneously with my work in Wipro. As the studies progressed, I started considering options for a Masters that would help me take that next big step in my career . It was during this time, I came across the Chartered Financial Analyst(CFA) certifications and the curriculum it entailed. Working as an analyst in WIPRO, CFA felt like the next step to establishing a firm credibility in the field.

With my passion for problem solving, it felt unquestionable that a masters in Financial Mathematics would be an incredible opportunity to lay down a solid foundation for a career in finance. Going through different course syllabus I found to be resonating with the Master of Science in Financial Mathematics offered by North Carolina State University. I got in touch with a couple of alumni through LinkedIn and found the program to be best serving for career growth and advancing my knowledge in the field

Amritesh Kumar
An Aspiring Quant

"In trading, as in life, minimizing loss on bad days and maximizing profits on the good ones will make you successful, even if your good days are rare."

I am passionate about Finance and Numbers and believe in making data-based decisions. The dynamic nature of the ever-changing financial markets and techniques excite and challenge me.

I completed my undergraduate in Electrical & Electronics Engineering from BITS Pilani and jumped into a career as Data Analyst at Capital One. I was fortunate to have the name and experience of a renowned institution and an established organization on my resume. After a 3-year stint at Data Analytics, a role that I immensely loved, at a company that I admire to date, I had to move forward to explore the career I had begun to develop a passion for, Quant Trading. As Quant is a highly competitive field, I realized that a master's degree would be essential in bridging any gaps that need to be filled.

As the great musician John Lennon said, "Life is what happens when you're busy making other plans." My father was diagnosed to be terminally ill, and that altered the course I had planned for myself. I delayed my master's to be with him at a crucial time for our family. However, I never lost my passion for being a Trader. I started to do certifications in Finance and Data Science while also driving business growth and success at Axis Bank, to whom I will always be grateful for allowing me to work remotely and lead a business segment for them as a Business Analyst. It was gratifying to be able to provide business growth of 20% during my 18 months at the firm and deliver on the task I was recruited while still being able to be there for my family.

After losing my father to the inevitable, I took over the responsibility of my family business and completed a six-month certification program in Algorithmic Trading. The period was challenging, but my father continued to be my biggest motivation, even in his absence, pushing me to grow and evolve through each challenge. Using the learning from the course, I started to trade in the Equity and Cryptocurrency market in my free time. With the experience of live trading and after stabilizing the family business, I was finally ready to start my master's at North Carolina State University.

The long wait has only increased my desire, skill & passion for chasing my aspiration. My present courses in Finance, Statistics, and the interview experiences I have had with some of the best firms within my first semester in the program have been and continue to be the most exciting period of my journey as an aspiring quant trader.

Olivia Li
Pursuing My Career in Data Science

No matter how complex the data a business needs, my passion for data science never wanes. This enthusiasm for machine learning and the uses to which they can be put into the modern world began long ago.

During my working time after I finished my bachelor's degree, I got to utilize data every day. It gives me a feeling of being a detective, seeking abnormal data variables. It was fun. The changeable data behind finance fascinates me. Since then, I decided to pursue a master's degree in financial mathematics.

I chose elective courses that include: statistical programming and have enrolled in online courses on data science, such as Datacamp. I delved into this arena and with each lesson, became more and more fascinated with neural networks and machine learning. Soon data science was no longer an interest, but an addiction, which led me to a journey culminating in a desire to earn a master's in financial mathematics.

I relish in how they perform complex computations with ease, and long to make them even more efficient. Through my studies, I have found that neural networks are particularly useful in classification tasks, especially supervised learning, which is a technique wherein we provide the system with objects (images) and the groups they are classified into. For example, we would give the system ten images of person X and train the system that this is person X. Although training a system to perform given pattern classification tasks may seem simplistic to some, it involved complex feed-forward and feed-back nonlinear structures, along with implementation of non-linear systems theory and various types of training algorithms. In addition, we needed to develop a sufficiently diverse and comprehensive set of training samples for classes to ensure that the network could perform facial recognition on samples not present in the training set.
I have found that the more I am exposed to data science, the more I am fascinated by data science.

Parth Mahajan

Career Goals

- *Become president*
- *Start a civilization on Mars*
- *Own the Mona Lisa*
- *End world hunger*

Unlike the above, my career goals have not always been so well defined. I have constantly been driven by my fascinations and interests. What started out as a small hobby of checking the prices on CNBC strips with my dad, ended up creating a huge curiosity in my mind for the financial markets. As I enrolled in my undergrad college, I took up a minor in finance along with my engineering courses. This is where I got an understanding of the inner workings of the derivatives industry, how companies are valued and why the Financial Crisis of 2008 happened. Several projects involving big data and machine learning helped me build a good start for my future career.

Allured by the glamor of a trading job, I took up my first job at Future's First as a commodity trader. This is where I was exposed to the intricacies of Wall Street and simultaneously appalled at the idea of exploitation to get filthy rich.

Wanting a deeper purpose for a career, I built on my critical thinking and data analysis skills and worked as a data analyst. However, I missed being close to the financial industry. I decided that I wanted to help people. I searched for opportunities in the financial field where I could make a difference. Finally, I found out how.

Helping people and finance don't really go well together. However, with the modern advancements in risk modeling and buy now pay later companies, small business owners and financially marginalized people who historically did not have access to debt now found themselves with access to tools previously only available to the rich. Especially, in developing countries, this idea will change lives as small businesses struggle to access debt in order to grow.

This is how I decided to upskill myself by getting a master's in financial mathematics with a focus in Risk Management. I intend to use the knowledge gained in this program as well as from my previous work experiences to make a career working as a credit risk modeler at a lending company that focuses on the above.

Eventually, however, I want to grow into the leadership side where I can influence decisions and lead my fellow employees with a deep understanding of the technicalities of the underlying work. I am also interested in how decentralized finance grows and how I can mix it with P2P lending at small scale with crypto. If and when it does become the mainstream, a credit score is not what will determine the rate at which money is lent. Instead, a more robust credit score calculated at every transaction will allow a great deal of flexibility currently not offered by FICO. The culmination of credit risk and P2P lending with crypto is where I want to steer my career to make a difference in society and utilize my skills and knowledge.

Sauvik Mittra

Career Goals

> *Most Important quality in an investor is temperament, not intellect*

Mathematics fascinated me from a very young age and as I learned the application of the subject in the field of finance, I was further intrigued by the vast opportunities available. Having completed my MBA in Finance from India, I was looking at various opportunities in the industry that would keep me involved and bring about the motivation to go the extra mile daily. Fortunately, post-graduation I was campus selected by one of the leading domestic brokerage firms in India as an Institutional Sales Trader. We handled trades of various institutional clients across the globe who traded in the Indian equity markets. Executing large trades worth millions of dollars brought out the adrenaline rush on the trading floor, but we always had to be careful while executing these sensitive million-dollar trades. Analyzing various sectors and stocks within the Indian markets, and continuously learning new technology further piqued my curiosity. These experiences helped me provide valuable inputs to various portfolio managers and traders across the globe.

As my interest and understanding of emerging market equities grew, I became more inclined to understand the skills required to manage portfolios or funds. This led me to pursue the much-accredited CFA degree and having cleared two levels, I started to become more familiar with stock picking. The sell side of the industry has taught me a lot and I look to develop my skills further towards the Buy side and manage a fund one day. Portfolio and Fund Managers always require the assistance of quantitative analysts and I aim to bridge this gap. With an interest to further improve my quantitative skills, I enrolled in the Financial Mathematics program of North Carolina State University. The journey so far has been an exponential learning curve and with a focus on becoming a portfolio manager, I continue to work hard on my strengths and improve my weaknesses. In the long run, I wish to open an Investment Management firm and compete with the best in the industry to generate alpha for my clients.

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Ankit Saw

Playing the Game of Alpha

I chose North Carolina State University for admission to M.S. with Financial Mathematics. After careful consideration of my areas of interest and my ambition of starting a Hedge Fund, I see this as an essential step towards achieving my career objective.

From the very beginning, I have been a self-reliant, hard-working, and driven person. I was fascinated by math, physics, finance and stock trading. After graduation, I joined Innoplexus where my projects involved webpage classification, creating a crawling engine, building chatbots and setting up deep learning architecture. Before coming to the university, I was engaged with Infoedge, where I have worked on many projects such as Trends recommendation system, Photo Recommendation, Renewal Model, DPP Suggestion, and Monetization. I have contacted Rakesh Jhunjhunwala (often referred to as India's Warren Buffett) for guidance on Investment. His exact words are “Each boat has to find its Own Shore”. His words inspired me more to work on my own way of Investment and trading.

I am very delighted to be part of NC State University. It is in the top 1% of the universities worldwide. It’s famous for its statistics and mathematics school, with which my course is affiliated. The program director, Professor Tao Pang is very approachable and helpful and has been guiding me and I find that very comforting. It is one of the top universities and also very widely known for the same. NC State focuses on modern ways of teaching with research and innovation. The faculty at NC State help the students to spot the real-life problems and teach how to solve them. NC State’s world-class researchers get straight to work solving society’s most pressing problems and their innovative outcomes are felt locally, nationally, and globally.

NC State’s Financial Mathematics Program is ranked in the top 10. It provides meticulous training in the main areas of statistics, probability, mathematical modeling, investment theory and economics. It allows me to acquire a working knowledge of models and procedures and modern financial mathematics as it is applied in banks, broker companies and insurance companies as well as in the financial departments of national and international companies. The program organizes great opportunities for networking through workshops such as the two-day CECL summit, attended by regulators, consultants and banking officials. It also provides a platform to present our projects and get feedback from the attendees.

The Financial Mathematics Program has been helping me. My journey so far has been pretty good and I have gained enormous knowledge as well as experience. The career development program goes a long way to get people prepared for interviews and helps many graduate with multiple offers. The program also offers flexibility in selecting subjects from Statistics, Finance, Operations Research or Business School. In order to provide accelerated learning, on a regular basis workshops are being organized on subjects that include Python, R and SAS. This program is greatly enhancing my knowledge in Statistics and Finance which will be a big opportunity for me.

Palak Sinha

Planning My Career Path

Beyond my graduate studies in Financial Mathematics from North Carolina State University, I foresee working as a Data Scientist with a leading financial corporation. I am particularly interested in the risk sector and contributing to data-driven financial decision making for investment efficacy. There are several reasons I have chosen this career path, as I have used my time exploring the world of finance and expanding my understanding of the economy. By developing a greater understanding of banking and finance, my interest in the field and resolve to pursue it has continued to grow. Furthermore, I have taken courses on risk as part of my graduate study. In one of the projects based on Machine Learning protocols, I used Python to predict the probability of defaulting on credit card payments and the risks associated with credit cards.

I envisage working on country and sectoral analysis to develop tools for investment modeling. I plan to quantify the potential negative effects of risk-related activities and identify practices within the organization that contribute to increased financial risk. Over the longer term, I envision working with multilateral financial institutions and finding data-driven solutions to enhance financial inclusion of the unserved masses. Despite the phenomenal growth that Fintech has seen over the last two decades, a large part of humanity is still beyond the reach of the safety net that is banking and insurance. The ongoing pandemic has emphasized the vulnerability and miseries of people outside the financial systems and underscored the need for their systemic inclusion in the banking system. I intend to devote my efforts to lessen the hardships of this vulnerable set of people.

Zhong Tian

My First Project in the Financial Mathematics Program

During my first semester in the NC State Financial Mathematics program, led by a senior student, I partnered with 3 other students to build a two stage LGD model with Fannie Mae's Single-Family Loan Data. It was my first encounter with credit risk modeling. At the very beginning, our team leader arranged some training for us in order to prepare us well for the coming tasks. We spent several weeks on data preprocessing and exploratory data analysis (EDA), which makes sense since it is common for any modeler to spend the most time on data.

In the meantime, the team leader also taught us how to use Git and GitHub, which proved to be a very efficient tool as we are collaborating to finish a project together. The size of Fannie Mae's Single-Family data was large which was very different from the data set I have handled before. I cannot even load the whole data set into my computer memory all at once, therefore our job included cleaning the data piece by piece.

A great aspect of the project was working as a team. All of us worked really hard and everyone was responsible for some pieces of data. After preparing the data for modeling, 4 of us separated into 2 smaller teams and each sub-team was responsible for one stage of the modeling. Basically, we needed to use two classifiers to separate the sample points with LGD equal to 1 or 0 and then use one regressor to model those sample points with LGD between 1 and 0. I chose to build the classifiers with another teammate. Two of us decided to try logistic regression and the decision tree and then compare the results to find out which one will be the best model for the job. Firstly, we fitted a logistic regression model aiming to separate sample points with LGD 1 from those with LGD less than one, and then fitted another logistic regression model aiming to separate sample points with LGD 0 from those with LGD larger than 0.

Secondly, we repeated the above steps using a decision tree. At last, 2 logistic regression models achieved above 90 percent accuracy, and 2 decision tree models achieved above 80 percent accuracy, so logistic regression is our final model. Later our team combined our work together, and we successfully presented the model to rest of the program.

Ruikang Zhang

Quant Quarterly

As a current graduate student in Financial Mathematics at North Carolina State University, and having obtained a bachelor's degree at Virginia Tech study in Investment management & Financial analytics, I have a strong Financial, statistics, accounting, and mathematics background.

In addition, I have had the opportunity to finish several academic projects about the stock market and financial modeling. One of the project's topics is "How to use sharp ratio analysis of the investment on stock market during the Covid-19", the other one is "How to use **Black-Scholes Model** to calculate the risk-free interest rate and other parameters influencing the value of options". After finishing the project, these experiences increased my data mining, data cleaning and data allocation skills.

Throughout my working experience and graduate study, I have had three internships at different companies. The most recent experience was working for Rally Cry Venture Capital to conduct the data analytics and financial analysis. During the internship, I finished a real project on the valuation of the pet supplier's industry focusing on Petco and PetSmart. I focused on collecting these two company's financial data from their 10-k report from 2008-2020. Then calculated and compared this information with their market share and reported to my team manager to perform the valuation model. This working experience helped me to improve my communication skills during a team project, and how to collect the useful data from several of the annual reports.

Recently, I am currently working on a LGD Mortgage Model in Financial Mathematics program and continue to increase my Python skills. I have also applied to a consulting club at NC State University, called CYC consulting club. CYC is a student based nonprofit organization, working for local companies, around the Raleigh area. I already passed the first-round interview and am waiting for the second round. I hope I can use my education and technical skills to help the local companies develop in the future.

Why I chose NCSU for my masters is because before I enrolled, I talked with professor Pang, and he told me about this program's goals and how the program helps students be ready for jobs in the future. So, I was attracted to this program and I made the decision to be here. As a result, I am able to submit several job applications on company websites and LinkedIn, including EY-Parthenon and BCG. My goal is to get an internship offer in the near future.

Reflections
















Masters of Financial Mathematics Group Photo Fall 2022

SAS Hall at NCSU's Main Campus

NC STATE UNIVERSITY

Financial Mathematics Graduate Program

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Editor-in-Chief
Tao Pang

Associate Editors
Patrick Roberts
Susan Uy

Cover Design
Joshua Johnstone
Susan Uy

Financial-mathematics@ncsu.edu
http://financial.math.ncsu.edu