Portfolio Management

Yield Curve as Leading Indicator for Regime Prediction and Portfolio selection

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Yield curve is a powerful tool used by traders and investors across. The changes in the curve tell a story on how the overall economy is and will drive in near, medium and long term. Many practitioners have used this tool in making their financial investment decisions. In this study, we will understand the predictive power of Yield curve for our (Equities) portfolio management decisions within Indian Markets.

We will break down this paper in the following manner. We start with defining the problem statement and then talking about our data needs. The problem statement is broken into smaller problems. Each individual problem is then discussed independently. While doing so, we will gradually discuss the linkage between all problems before concluding the findings from it.

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Problem Description

Equities markets' performance can be categorized into different regimes, such as Risk On/ Off etc. With the help of Yield curve and its predictive power, we will predict whether the market will be in either Regime in forward looking months. We will use that prediction to drive our investment decisions.

In simple terms, if our investment horizon is 3 months, we would like to understand which regime the market is going to be in more likely for next 3 months, so that our today's investment decision lasts for 3 months.

The problem is further broken down into multiple sub-problems:

1. **P1.** Define various market regimes and identify the current regime in which the market is. Also Assess how various sectors performed in difference regimes
2. **P2.** Analysis of Yield Curve, and features selection
3. **P3.** Use Yield curve and various features for regime classification in next 1,2,3,4,5,6 months
4. **P4.** Based on regime classification, select the appropriate sector to invest in for desired duration.
5. **P5.** Perform Backtesting based on above strategy and analyse its performance

Data Requirements

Following data sets are used for entire problem:

Asset Type	Category	Comments
Equities	Major	Nifty 50
Equities	Sectors	Realty,Services,OMC,Metal,IT,Infrastructure,Manufacturing,Housing, FMCG,Energy,Consumer Durables,Bank,Auto
Yield Curve		Curve points for all maturities

Note:

- All data is collected at daily frequency
- Source for Equities: https://www.niftyindices.com/reports/historical-data
- Source for Yield Curve: https://www.investing.com/
- Start date for data collection: Jan 2005

P1. Current Regime Identification

P1.1. Different Market Regimes

Financial market moves in various regimes. There is no hard rule on defining these regimes. Research by Two Sigma segregates the market into 4 different regimes. There are other studies which define regimes in different fashion. For our study, we take 2 different approaches, and will study them separately:

1. Market with 4 regimes (M4)
2. Market with 2 regimes (M2)

P1.1.1. Market with 4 regimes (M4)

Somewhat inspired from this article, we segregate the market into 4 regimes as below:

Regime	Key Insights
Risk On	- Happens during early stages of business cycle, or immediately following recession. - Includes Accommodative monetary policy, i.e. cheaper money.
Expansionary Risk On (ERon)	- It still is expansionary phase, but relatively more volatile. - Central banks start raising short term rates to keep inflation in check
Risk Off	- Appears quite early and before recession - Usually short term rates start falling faster than long term rates
Recessionary Risk Off (RROff)	- Highly volatile - Falling long term inflation expectations as recession is looming - Growth outlook is deteriorating

P1.1.2. Market with 2 regimes (M2)

This is a subset of the above. Instead of granulating the Risk on and Risk off regimes, we simply that either the market is in Risk on or Risk off.

Regime	Key Insights
Risk On	- Happens during early stages of business cycle, - or immediately following recession. - Includes Accommodative monetary policy, i.e. cheaper money.
Risk Off	- Appears quite early and before recession - Usually short term rates start falling faster than long term rates

P1.2. Identify Market regimes

The challenge for us is to identify which regime the Indian financial market has been. Since, our objective is to have Equities Portfolio selection at the end, we will only consider the Equities market while deciding the regimes.

Regime Identification problem can be understood as an unsupervised Machine Learning Problem. Our aim is to divide different periods in financial history into 4 (or 2) regimes. Such type of problem can be solved using different models. Some of them are listed as below:

Model	Key Insights
K-means clustering	- Finds similar 'k' clusters and divide the dataset in these clusters - An example here.
Hidden Markov model	- A stochastic state space model with an underlying process (regime) which is unobservable, i.e. hidden - A detailed example can be explored from here
Gaussian Mixture model	- Uses gaussian distributions to model different parts of the data. - This Two Sigma research explains this in more detail. - We use GMM Model for our regime identification.

We will make use of Gaussian Mixture models for our regime identification. The study will be performed across both 4 regime system (M4) and 2 regime system (M2)

P1.2.1. 4 Regime System

P1.2.1.1. Regime Identification using GMMs

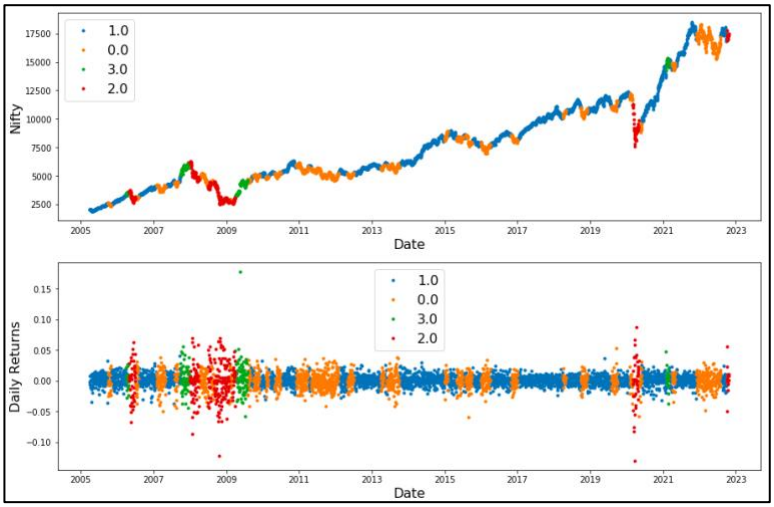
We considered the monthly returns, volatility as well as Quarterly returns of Nifty 50 for regime identification purposes.

Mean of Generated Gaussian distributions

REGIME\ FEATURE	MONTHLY RETURN	VOLATILITY	QUARTERLY RETURN
0 – RISK OFF	-0.00548404	0.19235487	-0.02571809
1 – RISK ON	0.02296662	0.12366235	0.07605876
2 – RROFF	-0.02583437	0.42935016	-0.12064638
3 – ERON	0.07659727	0.31267042	0.27394766

Inference: Returns follow this order: EROn > Risk On > Risk Off > RROff. (as expected)

The next figure plots the Nifty and its daily returns and segregates it across different market regimes

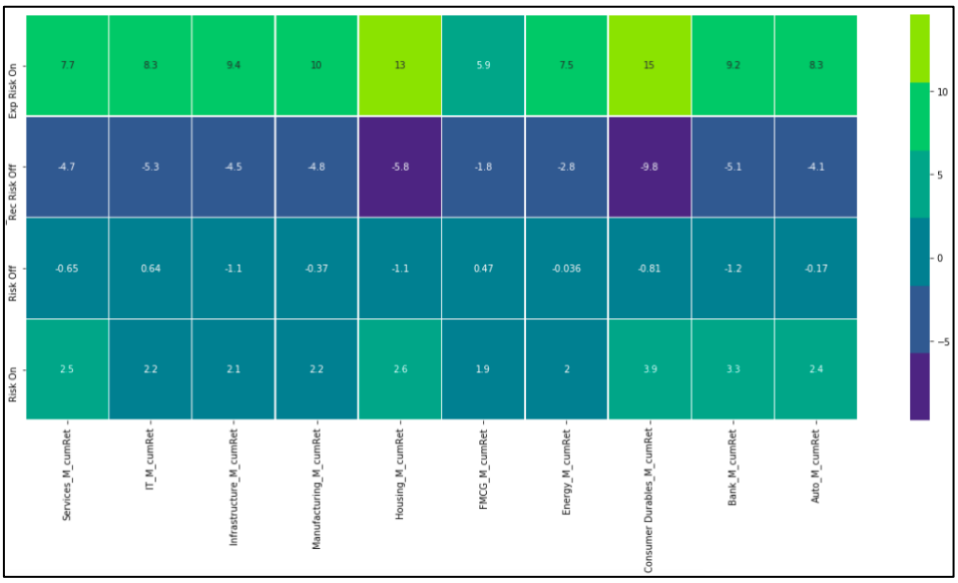


Inference:

- RROff phase is evident during Global Financial crisis (2009), and onset of Covid 19 (Mar 2020)
- Start of 2017 – End of 2018, Nifty had a great bull run. Our model also suggested it to be a Risk On phase.

P1.2.1.2. Sector Analysis across regimes

Let's now look at how different sectors have fared across regimes
In the below plot, we show average monthly returns for various sectors.



Sector Analysis

Key Insights:

1. During Risk On, all sectors are doing good.
2. Expansionary Risk On -> relatively higher returns than Risk On. **Housing & Consumer Durables stand out**
3. Risk Off, as expected, tend to have close to 0 returns. **FMCG is relatively better.**
4. Recessionary Risk Off -> A significant downturn across board. The **impact is lowest for FMCG sector.**

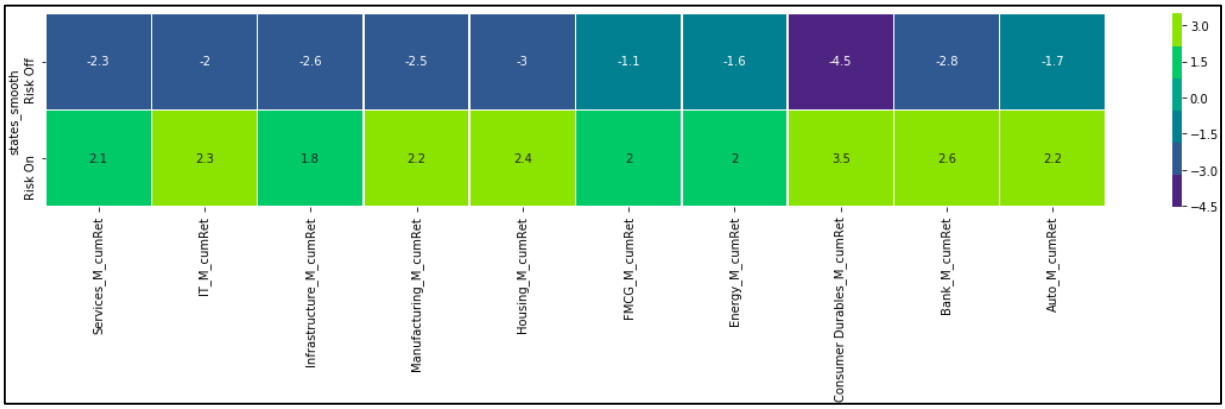
P1.2.2. 2 Regime System

A similar GMM based modeling is performed for 2 regime system. Below are the results for 2 regimes

REGIME\ FEATURE	MONTHLY RETURN	VOLATILITY	QUARTERLY RETURN
0 – RISK OFF	-0.01195389	0.27736715	-0.0625836
1 – RISK ON	0.02025122	0.14849098	0.06892558

Inference:

- Risk Off phase represents the significant market down periods.
- Overall returns during each regime also signify the drastic difference in the periods.



Key Insights:

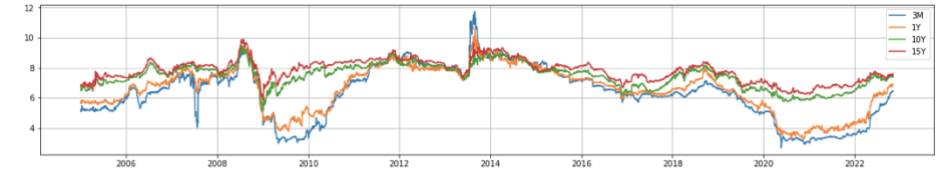
1. During Risk On, all sectors are doing good.
2. Risk Off -> Housing and Consumer durables are worst hit. FMCG is again a good bet during this time.

P2. India Yield Curve Analysis

P2.1. Yield Curve Analysis

For our analysis, we will consider only 4 curve points. These points are well used in the practitioners' world

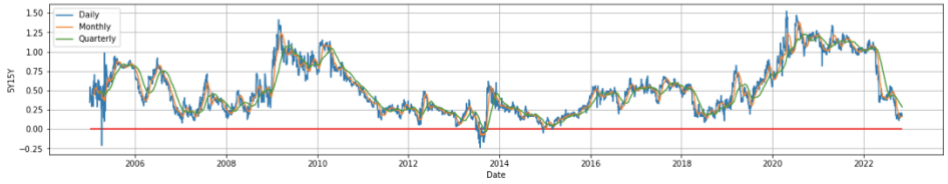
- 3 Months Yield
- 1 Year Yield
- 10 Years Yield
- 15 Years Yield



Post GFC and Covid, market enjoyed quite lower short term rates for quicker recovery

1.Curve inversion happened just before 2009 crisis.
2.During recovery, long term rates rose faster than short term sighting growth
3.Recently, short term rates are on rise

1.In recent times, gap between 5Y and 1Y is on decline, as RBI has been hiking up short term rates to control inflationary mode

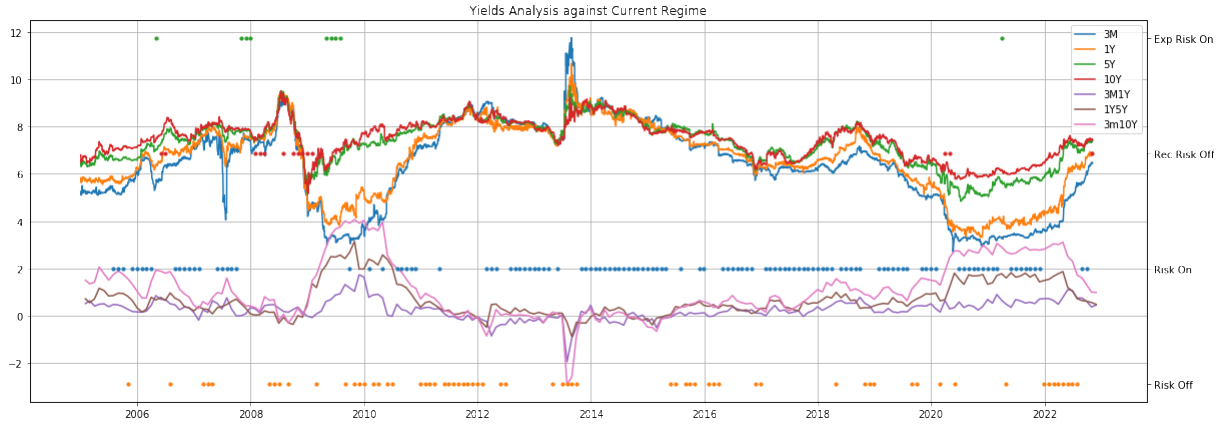


P2.2. Yield Curve across regimes

Here we look at how yield curve shifts have happened across market regimes

P2.2.1. Market with 4 regimes (M4)

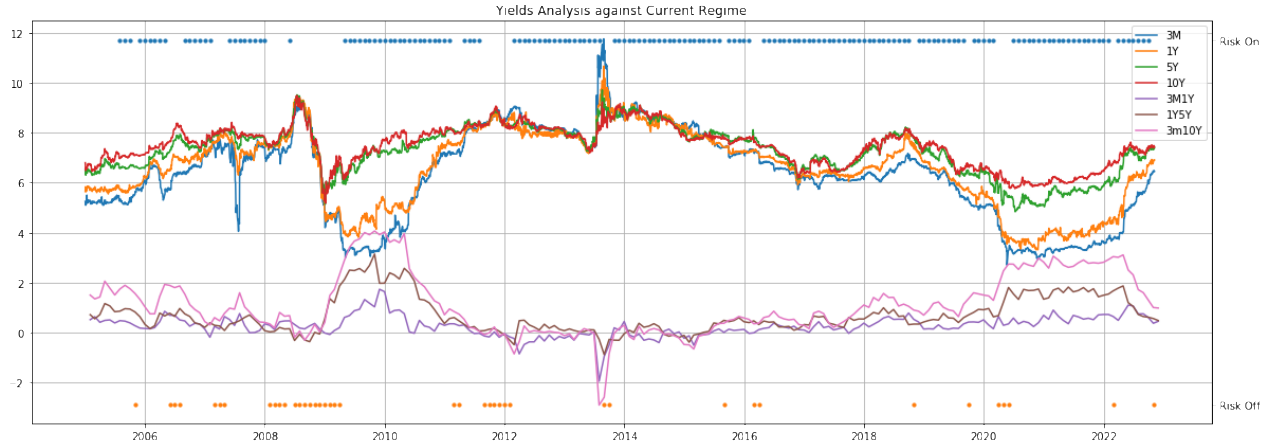
What does the yield curve tell us about current regime



Key Insights:

1. During RROff phase, all rates are going down. Short term rates falling faster than long term, indicating a need to boost economy in the short run
2. EROn, all rates rising. Long term rates rising faster than short term rates suggesting a long term growth potential, but controlling an overheated economy by making money expensive.

P2.2.1. Market with 2 regimes (M2)



Key Insights:

1. During Risk Off phase, the yield curve seems either flattish or inverted (end of 2013)

P3. Forward looking Regime Classification using Yield Curve

This problem is now a classic ML Classification problem. Our feature set will include Yield curve and various spreads.
Example feature set for 1 such spread:

3M1Y spread (Current)	Monthly Rolling Avg.	Quarterly Rolling Avg.	Spread (T-10 days)	Spread (T-1M)	Spread (T-3M)	Spread (T-6M)

Using this feature set, we would like to classify the forward looking regime, i.e. what would the regime be in 1 month from now, or 2 months from now…. 6 months from now.

In simple terms, this problem statement is as below:
For forward looking month: 1, i.e. Using the current yield statistics (feature data), predict which regime the market is going to be in next 1 month

We will not go in the detail of different classification algorithms, as there are several open sources available in detail. Here, we will focus on the performance of different models. These models are best performing models across all forward looking months.

4 Regime Market Classification model

Forward Looking Month	1	2	3	4	5	6
Name	LightGBM	RandomForest	LightGBM	XGBoost	LightGBM	XGBoost
params	max_depth: 4_n_estimators: 5_					
recall_4states_ROn	0.80556	0.8	0.5	0.61765	0.69697	0.28125
recall_4states_EROn	0	0	0	0	0	0
recall_4states_ROff	0.17647	0.29412	0.47059	0.125	0.125	0.8125
recall_4states_RROff	0	0	0	0	0	0
recall_2states_ROn	0.86486	0.80556	0.51429	0.71429	0.79412	0.27273
recall_2states_ROff	0.2	0.15	0.5	0.15789	0.21053	0.84211
weighted_f1_4states	0.52107	0.54991	0.46531	0.42276	0.4559	0.41145
weighted_f1_2states	0.58554	0.52613	0.51838	0.49239	0.55141	0.45202

(Training Period: 2005 – 2017)

We use recall as our performance metrics for comparison. Recall signifies the True positive rate of the classifier.

Key insights from the model performances:

- Recall rate for ERon and RROff phase is 0 (across all forward looking months).
    - This means that no model has been able to predict these regimes.
    - This can be attributed to historical availability of these regimes.
    - ERon and RROff have been quite scarce in the context of Indian markets.
- To adjust for scarcity of ERON and RROff, we computed adjusted regime, i.e.
    - Risk Off: combination of Risk Off and RROff
    - Risk On: combination of Risk On and ERON
- The recall numbers achieved with these “best” models hover around 60-70%.
    - Even though, a higher recall is always better; For Risk On, we can tolerate a lower if the Risk Off’s recall is better.
    - Reason: If model’s prediction is Risk On, and market is actually Risk Off -> that implies we are betting market to go up, but it will lead us to more losses.

2 Regime Market Classification model

Forward Looking Mont	1	2	4	5	6
Model	NNClassifier_[16, 8, 2]_1e-05	NNClassifier_[32, 2]_0.001	NNClassifier_[32, 2]_1e-05	NNClassifier_[32, 2]_1e-05	NNClassifier_[32, 2]_1e-05
Name	NN Model	NN Model	NN Model	NN Model	NN Model
	network: [16, 8, 2]_learning_rate:	network: [32, 2]_learning_rate:	network: [32, 2]_learning_rate:	network: [32, 2]_learning_rate:	network: [32, 2]_learning_rate:
params	1e-05_	0.001_	1e-05_	1e-05_	1e-05_
recall_2states_ROn	0.52	0.40816	0.38298	0.52174	0.2
recall_2states_ROff	0.71429	0.85714	0.71429	0.85714	0.71429
weighted_f1_2states	0.61891	0.53571	0.49928	0.63205	0.3062

(Training Period: 2005 – 2017)

Key insights from the 2 regime model performances:

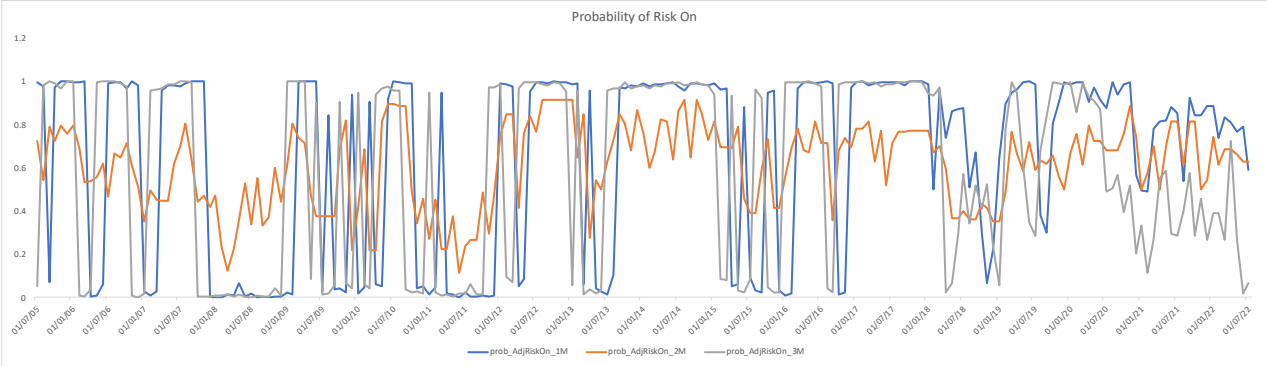
- Recall for Risk off is relatively higher than Risk On.
    - Our models' ability to classify a Risk Off phase in future months is now better.
- There is no model for 3 month forward looking. All tried models for 3 month forward looking regime had a very poor performance.

Models Conclusion:

- Our 4 regime model classification didn't have a good classification for EROn and RROff phases, we will utilize only *2 regime Market*
- We will use the adjusted regimes as suggested by 4 regime market classification model, and utilize respective models
- Instead of using the models as classification directly, we will make use of the probability of each classification

Probabilities based on the best models

Below time series demonstrates how the models have predicted the probabilities for market to be in Risk On mode after 1, 2 and 3 months respectively.



Key Insights:

- 2008: market fell badly in Risk Off mode. That's what our 1M, 2M and 3Months models have also predicted

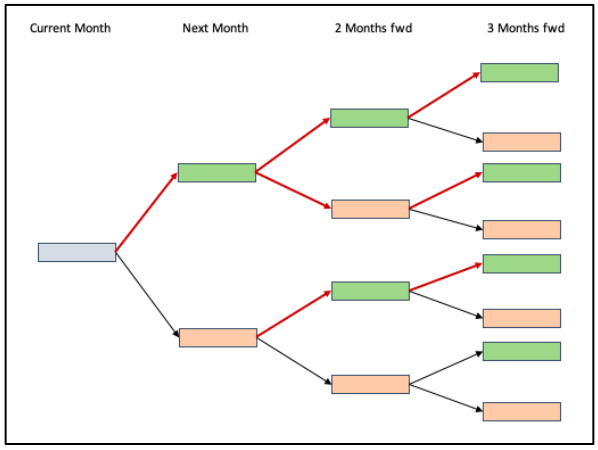
P4. Portfolio Selection using our prediction and analysis

Our last sub problem is about the Investment decision that we need to make today. Reiterating this problem in simple terms:

"Lets say our Investment Horizon is 3 months. We would like to understand which regime the market is going to be in more likely for next 3 months, and drive our investment decision today so that it lasts good for next 3 months."

P.4.1. Investment Horizon: 3 months

What is the Probability for market being in Risk On regime in next 3 months?

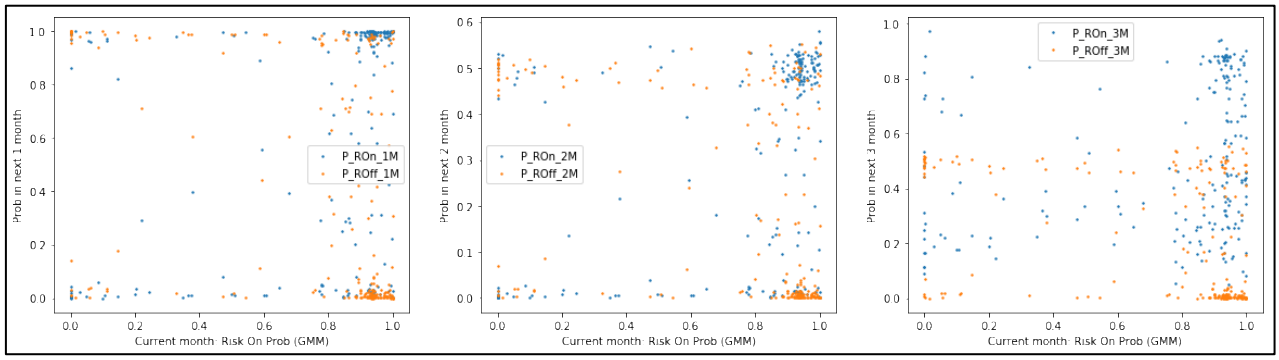


We are looking for market to be in Risk on in next 3 months. For this to be happen, we will consider only the below cases:

- Any -> Ron -> Ron -> Ron
- Any -> Ron -> Roff -> Ron
- Any -> Roff -> Ron -> Ron

And Similarly, we will find the probability for the market to be in Risk Off regime in next 3 months.

From the models generated in P3, we now find the probability of being in either Risk On phase or Risk Off phase for next 1 month, next 2 months or next 3 months.



One thing which is evident is that if the current market is in Risk On regime, there are relatively high chances, it is going to be in Risk on regime for next few months.

Date	CurrentState	Proposed_Next_1M	Proposed_Next_2M	Proposed_Next_3M
31/08/07	Risk Off	Risk On	Risk On	Risk On
30/09/07	Risk On	Risk On	Risk On	Risk On
31/10/07	Risk On	Risk On	Risk On	Risk On
30/11/07	Risk On	Risk On	Risk On	Risk On
31/12/07	Risk On	Risk Off	Maybe Risk Off	Risk Off
31/01/08	Risk Off	Risk Off	Maybe Risk Off	Risk Off
29/02/08	Risk Off	Risk Off	Risk Off	Risk Off
31/03/08	Risk Off	Risk Off	Risk Off	Risk Off
30/04/08	Risk Off	Risk Off	Risk Off	Risk Off
31/05/08	Risk On	Risk Off	Maybe Risk Off	Risk Off
30/06/08	Risk Off	Risk Off	Maybe Risk Off	Risk Off
31/07/08	Risk Off	Risk Off	Maybe Risk Off	Risk Off
31/08/08	Risk Off	Risk Off	Risk Off	Risk Off
30/09/08	Risk Off	Risk Off	Risk Off	Risk Off
31/10/08	Risk Off	Risk Off	Risk Off	Risk Off
30/11/08	Risk Off	Risk Off	Risk Off	Maybe Risk Off
31/12/08	Risk Off	Risk Off	Maybe Risk Off	Risk Off
31/01/09	Risk Off	Risk Off	Maybe Risk Off	Risk On
28/02/09	Risk On	Risk Off	Maybe Risk Off	Risk On
31/03/09	Risk Off	Risk On	Risk On	Risk On
30/04/09	Risk On	Risk On	Risk On	Risk On
31/05/09	Risk On	Risk On	Risk On	Risk On

Based on the computed Probability for next 1, 2 and 3 months; we marked it is either Risk On/ Risk Off or Maybe regimes for us to make the investment decisions today.

Now, based on these predicted markets for upcoming next few months, our next aim is to purchase securities accordingly and hold on to it for next few months.

Let's recap our journey so far.

- Hypothesized that Yield curve can act as a good indicator to define which regime market is going to be in.
- We utilized a data-driven approach to identify the market regimes.
- Analysed the Indian market Yield curve and its dynamics through time.
- Designed a classification model utilizing Yield curve to predict future regimes.

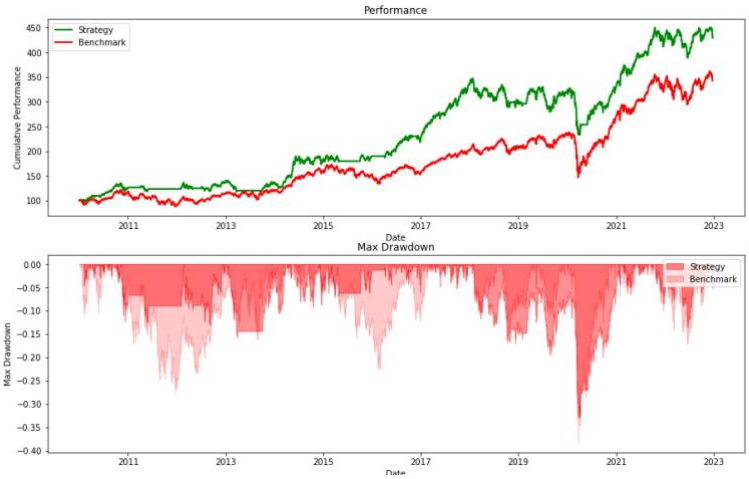
Now, only thing left for us is to design an investment strategy using the signals & indicators from the above classification model. Let's review it.

P5. Backtest the Investment Strategy

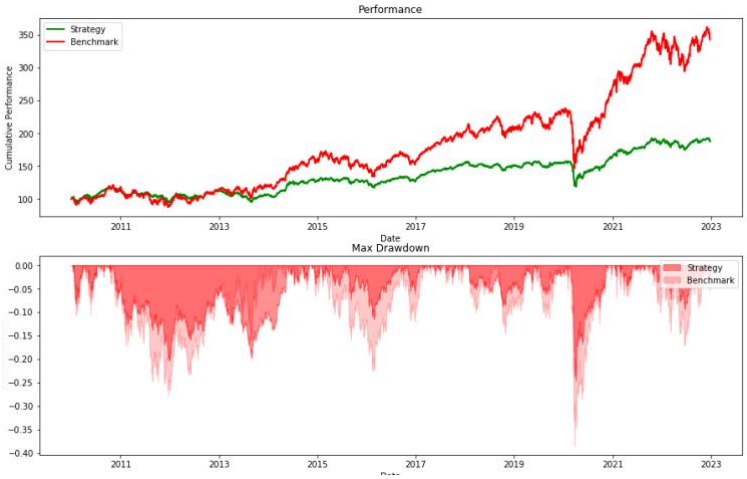
For comparison purposes, we will have 2 independent strategies. One utilizing the benefits of the above model and other not. Both of the strategies will have key Entry and Exit signals. Some of them are highlighted below
Our Benchmark for comparison has been Nifty50 Index performance.

ENTRY SIGNAL\ STGY * **	**MODEL DRIVEN**	**NO MODEL DRIVEN (VANILLA)**
INITIAL ENTRY STATIC	YES	YES
CRITERIA: DEFINED BY MODEL	YES	NO
EXIT SIGNAL\ STGY * **		
STOP LOSS	YES	YES
MAX PROFIT	YES	YES
TIME BOUND EXIT	YES	YES
SIGNAL DRIVEN BY MODEL	YES	NO

(More specific details about the strategy can be shared upon request)*
*(** Transaction costs are also undertaken. However, no impact cost assumed)*



Model driven Trading Strategy



Vanilla Trading Strategy

Key Insights:

A backtest of nearly 12 years show stark differences with and without the yield curve driven model.

Model driven Trading Strategy

	Stgy	Benchmark
Returns	0.1187	0.0995
Volatility	0.1123	0.1686
Max Drawdown	-0.3289	-0.3844
Sharpe Ratio	1.0573	0.5898
Sortino Ratio	1.6070	0.9273
Beta	0.5657	1.0000
Tracking Error	0.1176	0.0000
Information Ratio	0.1636	NaN

Vanilla Trading Strategy

	Stgy	Benchmark
Returns	0.0497	0.0995
Volatility	0.0774	0.1686
Max Drawdown	-0.2460	-0.3844
Sharpe Ratio	0.6417	0.5898
Sortino Ratio	0.9504	0.9273
Beta	0.4839	1.0000
Tracking Error	0.0963	0.0000
Information Ratio	-0.5167	NaN

1. Both in terms of risk and return, our Strategy has delivered a significantly better performance over the benchmark.
2. The Vanilla strategy has shown even lower risk, but the returns are also compromised significantly; as the strategy didn't take any positions driven by forward looking market data.

Conclusion

The yield curve based regime identification model has proven to provide alpha over traditional market, and can be used in overall portfolio management decisions.

There are definitely certain areas where there is scope for improvement and future work will be done to address those.

1. More robust classification models for regime classification using yield curve
2. Undertake alternative data, besides price information, to design the classification models
3. In this version, we created the investment strategy undertaking representative indices for relevant available sectors. In next version, would like to extend it further to representative stocks.