First of all we would like to thank the ITC staff,

For helping us throughout the course for the time invested so that we can all reach this status of presenting our final project,

So we wanted to say thank you very much.

Morris Head of Department - for the mathematical study we would not have understood without him and still not fully understand everything.

Daniel and Jennifer - for the management and investing so much time throughout the course.

For the placement team - Yonatan, Kobi, Amit - about the time you invest in finding us a future job.

And of course to Olivier Yoni Krishevsky Yoni Meisel Benni David Adam - you deserve a huge thank you for teaching us and investing so many hours so that we can reach this present day as prepared as possible.

And now let's make a sharp transition to our project,

Our project deals with the prediction of returns from the capital market – and in other words, Can identify the ups and downs in the capital market effectively?

We asked ourselves a number of questions, is it even possible to predict whether the market will rise or fall?

Can we identify ups and downs and if so will we know to go out and pull our investment in time to maximize our profit?

If we think about it from a different perspective if the market is going down for two days in a row now what is the probability that it will continue with that trend?

Or if the market has been in decline for 10 days in a row and now it is on the rise for two consecutive days what is the probability that it will rise more tomorrow?

The fact is nowadays, everyone is invested in the Market! Via our Study funds (Keren Hishtalmout), Pension Funds, and Manager’s Funds (Bituah Menahalim). And this turns out to be very profitable for all of us since on the long run, the market is (almost…) always up, so we generally make tens of percent gain… But during these periods we often get caught inside “bear markets” (defined as at least 20% drop in the market) … During these times, we generally get anxious when we think about our savings, hoping for a quick turnaround…

Our ultimate question is: Can we invest in the Market for a long term, but with a strategy that will be proven to be better than “Long-Only” investment? A strategy that will indicate us when to get our of the market and when to get back in?

In order to try to solve this question we used HMM in a very intuitive way and we needed 2 things:

For each day - Is it a good day to invest, The return for each day.

We need to understand that if we would know when to exit the market on time, the profit potential is huge, but on the other hand, the question arises as to whether the stock market can be predicted at all.

In fact what we used the VOLATILITY that predicts in other words is the market safe and calm at the present day

When this volatility is low the market is calm and you can invest with less worries, and when its high than it’s a bit risky and the market is pretty unpredictable and less trendy.

And the returns is precisely the profit we will earn if we leave the money invested.

As we presented earlier - we used the HMM model and what we introduced as variables to the model are the returns and the volatility for day after day.

We chose the model to predict 3 investment or exit options -

High volatility and positive return

Low volatility and positive return

High volatility and negative return

This way we can see what the markings of the colored dots on the graph show us and what is happening there, we can see that the classification is very good.

We can see it's a really good indicator and we can conclude from the colors that the model can predict the TREND really well on the ups and downs!

And so we set it all up and tried to predict the future of the SPY ETF.

And here are the results before us we can see in train that the model is very precise and predicts very well!

We can see in the blue markings on the graph that the results speak for themselves we could not have asked for better results for what we were trying to predict.

Our model knew how to get in and out of most declines and showed us a very high return than if we had let our money lie in the index. Which is also a way to invest.

We then moved on to test set where we saw a similar result.

The return is really high and stands at about 27 percent higher than the SPY ETF itself!

And even beyond that we have a Z SCORE that can give us an indication that what we see here is not by accident the for both TRAIN and the TEST the Z score is higher than 2 which shows that the results do speak for themselves and every minute we do not invest according to our model predictions is a wasted time.

Our model knew how to avoid the corona. He knew how to get in and out on time - just as if he knew the future.

We decided to examine the matter in depth after Morris's advice and see if the results are correct and we do not have a data leak so we let the model predict day after day instead of the whole test set using a simple loop.

We can see the results on the above graph not so promising indeed the model knew how to get in and out while corona but he still did not know how to do it effectively as before.

Why did this happen ?

In order to answer this question we need to check according to which model HMM knows how to predict and what is algorithm it uses to choose the path of our investment.

After testing we were able to answer this question, our model tests according to a Viterbi algorithm that tries to find the best way to get the result we want it to reach.

The algorithm works in a certain way that he knows all the options that exist and what happens at each point along the way, it knows how to calculate and find the optimal way to get from point A to point B at the most optimal way so he found the best way to invest.

What actually happened is that we gave the algorithm all the information it needs in order to select the most optimal path so he had no choice but selecting it after we gave him only one data point at a time didn’t made the best choices.

After seeing that this way we are not getting the optimal result we checked more additional parameters like for example the MOVING AVAREGE for every few days and tried to compare it to each other and investment without spending our money from the investment.

We have come to the conclusion that for 120 days we get the best results.

We tested this on two different index funds and the results were as we see here. Sometimes the model predicted really well and sometimes less well but in Total Run he overcame the investment in Long.

In other words, theoretically if we had invested in a large portfolio that contains a lot of indices, there is a good chance that we would have been able to earn a few shekels more.

As we saw not everything went smoothly but we learned a lot from the project from working on it together.