Advanced Financial Instruments for Sustainable Business and Decentralized Markets

Prof. Abhinava Tripathi

Department of Management Sciences

Indian Institute of Technology, Kanpur

Week 9

Lesson 28

In this lesson, we will perform various operations related to portfolio construction and optimization using our return series from Carbon Market, Bitcoin, SG Fund and S&P 500 data. In this video, we will start with our portfolio optimization objective. To begin with, we will initiate a portfolio object. First, as I did earlier, I will create a copy of my asset return object. So, I will create a copy by the name R. This is my return object R.

Now, first, I will create a vector with the asset's name. So this fund object will carry the name of the asset. So call names R. So if I run this, let me print this for you in the console.

Just have a look at my console window. If I print this funds object, it has all the four assets that I need. In the next step, I will initiate a portfolio object called initiate.portf and I will use this portfolio.spec function from the portfolio analytics package and write assets equal to funds, and this will help me initiate my portfolio object.

Let's just analyze this portfolio object with this print command. Inside this object, we can see there are four assets. If you want to have more details about this initiated object, you can also use summary command which will give us a slightly more detailed summary of this object. So init. portf.

If I run this summary command, the entire object is printed here, we can see all the assets. The initiating object has equal weight. So you can see equal weighted object, 25% weight in all the assets, Bitcoin, S&P, ESG and so on. Then the object carries other parameters such as constraint, objectives and so on which we will discuss in the next set of videos. So in this video, we saw how to initiate a portfolio object.

In next set of videos, we will learn how to put portfolio constraints in order to construct a portfolio object. In this video and next set of videos, we will understand how to put constraints in a portfolio object that we just initiated. To begin with, we start with a simple weight sum constraint. This constraint will determine how much of the initial wealth is put in the portfolio and how much we can borrow. The syntax is pretty simple.

We have already initiated portfolio object. We will use add.constraint function. Then, we will assign our already initiated portfolio object, which contains the information about assets. Now we will put the constraint type, the type we are putting as weight sum.

This is a very generic kind of constraint. There are some other more specific constraints like for example dollar neutral where no investment is made or long only and various other constraints. A broad generic term is weight sum where you can define the minimum sum of your investment. I am defining it as 0.99 which means 99% of my initial original wealth add maximum as 1.

01. Essentially it means that I can leverage up to 1% of my original wealth. How do I leverage? By borrowing at a risk-free rate. Similarly, when I say 0.99, that means out of my original wealth, 99% is invested in this portfolio, and 1% is at a risk-free rate. So that way leverage means that I can borrow more and invest further but at max I can go 1%.

So this is called leverage. So this is a more generic term. I can use the type as leverage or type as dollar neutral and so on. You can go and add put this question mark add dot constraint and help me know will open where you can examine in more detail what kind of functionalities are available. So with this I can initiate the object.

Let me do it. And now, once you have done this command, all you need to do is if you want to see in more detail, you can just have the summary of this initiating object initiate dot port if. So once you summarize you will have some information for example notice that this constraint command has been done if you want to see in a simple term you can just run this initiate.portf you can see that one weight sum constraint has been added enabled. So this is one constraint which is enabled. Let me introduce one more constraint in this video. So you can also add box constraint which essentially determines what are the limits for each of the asset.

For example again similar structure will be required where I use now this init dot now this init dot portfolio object that I'm using it has updated and it already carries one weight sum constraint. Now, this time, I'm adding a box constraint, which will put restrictions on individual assets. So I'm putting a minimum of zero point zero five and maximum of zero point nine that means each of these four assets carbon future bitcoin ESG fund and S&P 500 so I'm saying that minimum investment in each of the assets should not go below five percent of my wealth and maximum should not be more than 90 percent. So this is my box constraint so now if I print this initiate port of object I can see that a new box constraint has been also enabled. Lastly I would also like to add one more constraint called group constraint.

Now group constraint in a way that you can if you have large number of assets unlike our case where there are only four asset if you have large number of assets you can classify them in different groups and then group wise you can put constraints as we will see. So again it is very similar to the one previously I'll again augment my original initiate.portf object by add dot constraint similar exactly similar set of steps needed. So I'll use initiate dot portf object but this time I will type the constraint type as group. Now I need to specify first what is this group. So let's say I have four assets let me put them in two groups so I'll use two groups.

So in the form of list object here I am saying that my group A I'm defining my group A as asset number one and two which are the first two assets and then I'll define my group B as asset number three and four. We have only four assets so this would suffice. Now once you have defined your assets now all you need to do is you need to specify the minimum and maximum group weight. For example minimum weight I'm specifying now I'm strategically and intentionally I'm defining the weight same as my individual weight so that my group constraint and individual box constraints are exactly identical. So in a way this would not this addition of group constraint would not have any effect on my optimization because my group constraint is exactly identical to my box constraint. So I have done it intentionally to avoid complexity in optimization but you can change your group constraint which is not exactly similar to your box constraint.

If you notice my group constraint and box constraints are same that minimum weight is 0.05 percent and maximum is 90 percent. So now if I run this and let me print my so if we run this let me print this object. Now we can see it has box weight sum and group constraints being added. So now it has three constraints.

So the three constraints are pinted here. In this video we created initiated and initiate dot portf object which is a portfolio object and we added three constraint one weight sum constraint which defined individual overall investment we defined it as 99 percent minimum and 101 percent maximum. Then we added a box constraint which put constraint in individual assets we put as 5 percent minimum and 90 percent maximum as box and group constraint which is again similar we defined two groups of our assets asset number 1, 2 and 3, 4 in same groups and then for both the groups we define minimum investment as 5 and max percent and maximum as 90 percent. So these constraints are exactly identical to box constraint that we added earlier but for more practical purposes we can change those constraints as well. In next set of videos we will understand how to assign objective functions to this portfolio object.

In a series of next few videos we will create portfolios with certain pre assigned objectives. Optimize them will optimize these portfolios and then visualize and find some of the summary measures. To begin with we start with a portfolio with maximize return objective. So this is our first portfolio. In this video we will try to construct this portfolio with the objective to maximize returns and then try to optimize with three solvers or three optimizers which is ROID, optimum and random portfolio.

Let's see how to do it. So first let us create this maxret.portf portfolio and we will use this add.objective function. Again we have already created a portfolio object called as initiate.portf. We will use this objective already constraints are defined but now the type of objective is return so we are trying to maximize our return and the name of the return is mean. So mean is to be maximized which is in a way of saying that return average return needs to be maximized. Now this is our object. When I print this object notice those earlier predefined constraints that is weight, sum, walk, group they are there and additionally an objective is added. Now in addition to that to this objective I will add one more objective which is addition of standard deviation.

However this is only required so that our portfolio object carries the computation of standard deviation also but we do not exactly want to do anything with standard deviation in terms of objective per se. So the trick is that even though we are using this add objective function and in that we have already defined maxret object. Since we want to compute standard deviation which is a type of risk so the type is risk and the name is standard deviation but we do not want the standard deviation to be used in optimization in any manner. It is just that we want the computation of standard deviation. So we will use smartly use this parameter multiplier as zero which will ensure that even though standard deviation is computed but it is not utilized in optimization function.

So now we will perform optimization with three optimizers. What are these optimizers? So first we will use this maxret first we will use the roi optimizer so maxret dot object max return object with roi and this roi we will use optimize dot portfolio and we will use our portfolio. Notice we need to supply our asset details which is r so we have saved a copy of our assets in our returns data then we need to specify our portfolio object which is maxret dot portfolio and we need to provide the optimize method which is roi. So with this we are ready to optimize let me just make it more visually simple so this is our overall object which you can run and then you can print also then you can print our you can first I will show you how to extract weight so you can extract weights notice 8% in bitcoin 5% here eag fund 5% other 82.5 in eua future so you can print weight or if you want the summary of complete object you can directly either print this object here so you can directly print the full object when you print this object it gives you the weight which we have already seen and it also tells us when we when the optimization takes place what is the mean return which was maximized so this is the maximum return 0.001678

which is the maximum daily return and at this return this is standard deviation so standard deviation has not been utilized in optimization only that it is computed for our maximized return observation so this was first we did the roi optimizer we used it for our optimizer next we will use de optim so I will not rewrite the whole code a small tweak we will just change roi to de here I need to provide de optim so I will create a de optim optimizer so de optim but when you are using this de optim you need to also tell how many iterations or the kind of portfolios that will be produced for the optimization purpose so you need to search size parameters so how many portfolio objects to be created so approximately 2000 is a good number based on my experience and also trace as true so that all the computations that are done as a part of optimization are available for computation of different measures. So first let us run this optimization objective it may take some time we have defined 2000 portfolios depending upon the size of such size of number of portfolios that are to be created it will be there so now it has optimized so let us print the weights we seem to be pretty similar to what we have got from roi because the objective is pretty simple maximization of returns average returns so we are getting similar weights as we got from roi but they may differ also we can print the whole object and we can see the mean returns are also very similar because weights are similar so mean return or average returns and standard deviation is also very similar lastly let us do it with the random portfolio also random portfolios optimization so for that again I will copy paste this I will just copy paste and here I will use RP for random portfolios and all I need to do is I need to just smartly modify the code a little bit I need to just here write random so that it knows that random of portfolio generation is to be used for optimization module so it will optimize let us run this RP while it may take some time I can modify D to RP so first let us wait for the schedule to run so this red symbol shows here that it is still running it may take a few seconds extra and let me show you the weights again see weights are very similar what we got earlier around 7% for Bitcoin little higher simply 5% the ESG 5% and this is minimum weight so recall we have already defined the minimum limits as 5% so I guess it has hit the minima and UFHS around 83% so if I run the whole objective also you can see a whole portfolio object you can see 1.67% and standard deviation of 2.6 so very similar for all the three optimization schedules we get very similar kind of portfolio objects so in this particular video we saw how to optimize through three optimizers random the optim and ROI how to solve this optimization problem we created these three objects we saw the weights for all the three optimization schedules weights were pretty similar around 5% for ESG and S&P Bitcoin around 7% and UF around more than 80 sometimes 83 and so on overall the expected returns from this portfolio object are around 0.17% and standard deviation of 2.61% in next set of videos we will try to visualize these three portfolio objectives and make more sense out of it.

In this video we will visualize the portfolio objects created earlier so first we will visualize portfolio weights and I will use this powermflow command to plot all the three portfolio objects in one window so this will create three plotting windows for us in one same region now first and foremost I will use this chart.weights command weight function which will help me plot it appropriately the max return object so first I will use max ROI object and central heading is maximize returns with ROI so that is one object and next I will not retype it I will use the same and this time around I will plot DE and maximize with DE opt-in and the last is random portfolio. So these are the three portfolio objects that we want to maximize so I will run these commands and let's visualize them I need to enlarge my plot window a little so that plots are proper. So notice the three plots are there ROI DE opt-in let me zoom them for more visibility so you can see almost similar results are there a very small way to s and p and esg fund close to very five percent in some cases bitcoin has given given a higher weight in case of random portfolio this yellow or kind of light yellow line shows you the equal weights which is 0.25 or 25 percent to each asset and highest weight to ua futures this is there along close to 0.8 and more so this is one way to visualize.

Another way is in the form of bar plot so all these three I can again slightly change the nature of the plot by adding the plot type changing the plot type I can change the plot dot type and instead I can plot bar plot with but there will be duplicate legends so one set of legend dot loc allocate is null so this now I'll add this argument to all the other three and then we'll see how the plot looks. It although it will give you the same result but it’s only a different way of presentation that is it nothing else changes so let us just run this so now you can see the same result here in the form of bars and it looks nice I find this one is slightly better I guess but it's up to individual taste and preferences. In the last step we'll visualize the complete portfolio object let's do that so in this particular step we'll visualize the complete but this we have to done do one by one so I am again taking back param pro to one by one so so that only one plot is plotted on one window and now let us write that portfolio object so I am using plot now one is max dot max rate roi object and again now we are plotting the entire risk return framework here so risk measure would be required which is standard deviation I'll also put the asset names so chart dot assets as true but in this case of roi only one so there is no not 2000 portfolios were not created so we'll get only a point we'll get portfolios in the case of d the object I'll also put main central heading main in a separate line maybe so main heading is portfolio portfolio optimization with arwing because here we use no such simulation of 2000 portfolios here we'll you'll get only one portfolio in other cases for example in de and random portfolios we'll see a set of portfolios that were utilized in the optimization process so this is with d and I am using chart dot assets as true so that we can see the original assets random portfolio method random portfolio object and here if you recall we had the object name rp so here the object name is rp and now let's visualize them one by one.

So first I'll use the roi let's see what how it appears so it seems that this first object will not be able to create because there are no such 2000 portfolios so we'll stick to the two objects that is de so let me first plot de for you so you can see on risk returns on x axis we have risk on y axis we have returns and we have all the series of portfolios that were simulated let me zoom this so on the very right there is bitcoin snp is there ag is there your futures are there this is for de optimization we can see the optimum portfolio in blue we can also see the weights as we can see your features has the highest rate and very small ways to bitcoin s and p and esg probably there because maybe they have high risk as we can see bitcoin is all very far right on the x axis so it's just here your futures are somewhere in between ag and snp on the very left and this is our optimum portfolio and this is entire feasible region so essentially we have plotted the entire feasible region and this is our optimal portfolio and this is our optimal region so we have plotted the entire feasible region and this is our optimal portfolio so this is one and then we can also visualize the random put through random portfolio.

Let's see how it appears there so i run the random portfolio method let us zoom it so with random portfolio the orange one is equal weight line so this orange yellowish line is the equal weight line 25 weight it appears in mid across the sea of portfolios again the position of individual portfolios remains same on the risk return because they are just individual assets and the optimum portfolio is also there so which is very close to optimization so we can visualize very nicely in this fashion with this d and random portfolio solver we can visualize the entire feasible region between expected return and risk and we also saw the portfolio beats in the next video we'll try to optimize for another objective which is the risk standard deviation measure in the previous video we saw the optimization of maximum return objective and optimization of return objective.

In this video we'll minimize the risk objective and optimize the portfolio the rest measure we'll use a standard deviation so we'll try to optimize around this minimization of risk objective and standard deviation being our risk measure so minimization of standard deviation we'll create this portfolio objective object and name it standard deviation port f again the same set of steps we need to add an objective function where our portfolio initially created object object any port initiate port f object will be utilized but now the type of our objective is risk and name of the risk measure is standard deviation this is our risk measure we'll run this and if i print this objective now if you notice on my console if i print this the objective is changed to standard deviation now we'll add one more objective here which is the return objective the idea is that we also want to compute returns while we do not want this return objective to sort of we should our optimization process so return which is average return but at the same time we'll use this parameter multiplier which is we recognize this parameter we'll set it to zero so that while a new objective is added but it will not affect the optimization process so if i run this you will notice oh my bad so i need to add this here we need to augment our original objective not the mod not modified by mistake i modified it so i need to sort of add here.

Now when i'll run it rather so let me rerun these so first i'll assign this and now i'll run it assign this and now i'll run it so notice when i run it you would find that mean objective return objective has been added but it will not be part of optimization because it has a multiplier of zero so now let us optimize and again for optimization i will not rewrite the commands i'll just simply use the same set of commands that i used earlier which is same set of optimizations so let's start with optimization part so first instead of maxlet i'll call it minimum standard deviation objective and roi. Now here instead of maxlet we need to use our new object which is minimum standard deviation objective so we'll use this objective and we are using our roi method so we will use this method and we are using our roi method so we'll run this optimization let us see what portfolio weights we get.

So this observation has taken quickly again five percent for smpsg and bitcoin eight percent eighty two point five which is very similar okay so let me run this okay very similar to similar to the one earlier we are getting very similar results. Let us run the minimum standard deviation objective here but this time around we'll apply d and minimum standard deviation portfolio object we'll use here and optimization is the optim so we'll keep that as it is let us run this and while the optimization takes place let us change the name of the objective function so let's see what weights we get again 0.5 percent to this is a simple 10 percent eag fund so okay so if i i need to correct it for the previous object let let us see first the earlier ones.

Let us first optimize for the roi let's see what we'd be good so for ro for roi the weights are pretty different but when i run it for deoptim you notice the weights are pretty different so pretty different weights we get so let us also try for deoptim we are getting very different weights for both the optimizations deoptim as well as roi let us run the same for random portfolio objective rp again we'll use our minimum standard deviation port f objective and let us run the optimization and while the optimization runs let us modify the codes so may take some time so previously you can see around five percent for bitcoin 6.8 for s and p for 5.80 percent for eag and five percent for eua future this was for deoptim for ua future this was for deoptim let us see for random portfolio optimization okay five percent for bitcoin five percent s and p and eighty percent eag fund eu features five percent so very similar kind of weights and the return in fact here the objective standard division which is around 1.2 and expected turn of very small around 0.03 percent if i print the de objective again very similar 0.033 return and 1.2 standard deviation while if i run the roi object it gives me five five percent for ehd and snp and eight percent for bitcoin eighty percent for eu features so slightly different result.

In the next set of video we'll try to visualize so in this video we optimized with an objective of minimizing the standard deviation which is a risk measure and we found a very heavy weight for both random portfolio and deoptim very heavy weights for this eua future so we can see here for roi it was 82 percent but we when we ran it with the deoptim we got 81 for ehg fund so different set of weights and in next set of video we'll try to see the weights and overall feasible region in the previous video we constructed and optimized our portfolio with objective that is to minimize risk and risk measure was standard deviation in this video we'll try to visualize various parameters of the portfolio particularly the portfolio weight and we also see its performance on feasible region but we'll not rewrite the codes i simply copy paste the previous codes on visualization and just modify them a little bit so i just copy paste the same code on the visualization here recall our objective was minimize standard deviation.

So minimize standard deviation with first with ROI minimize standard deviation a minimize standard deviation with ROI first then minimize minimize standard deviation with the optim objective and lastly with random portfolios random portfolios so these are three objectives that we have so let us first visualize with them and what kind of results we get so let me enlarge the plot window so that we have sufficient space so notice there is a very stark difference here with ROI as compared to with the optimum random portfolios it is very different the solution we are getting is very different for example your future weight is very small for the and the optimum random while ROI it is very high so that was the difference I was talking about earlier let us also look at the results in the bar plot form and for that all I need to do is I need to copy the same I will copy the same thing here all I need to do is here write a small comment the plot dot type equal to bar plot and legend dot loc is equal to null so this is the only change that I need to make and let me just copy paste it in all the others and I will get this is done and let us visualize on the bar plot which is again a good way of visualizing the result you can see.

So there is a slight difference the green bar which represents ESG fund ESG fund is very different in the optimum and warpy portfolios almost 80 percent and very small around 5 percent in ROI so the results are slightly different here which we can clearly see so the construction is different this is driven by the fact that the mechanism through which de-optimizer and random portfolio optimization works they are pretty different lastly let us visualize their performance on feasible region and for that we need to modify tweak our codes a little bit so I need to modify here our user objective minimize standard division and here minimize through RP so here we plot feasible region so let's let's see how it works so first let's look at the feasible region for de-optimization here you can see you have the sets here again bitcoin individual assets will remain same in their position on this risk return framework on the x axis we have standard division as risk measure on the y axis we have written but here objective is to minimize the standard deviation and again we can see the optimum portfolio as a very different location in de-optimization as compared to maximization of written objective.

Here on the second diagram we can see the weights so we have bitcoin s&p is highest weight is given to ESG fund and de-optimization and optimal portfolio is on the blue here on the top similarly we can also plot as per the random portfolio let me zoom it so we can see the orange one represents on the top diagram is the equal weight portfolio again the optimal portfolio position is same as the opt-in we can see that entire feasible region on the bottom we have weights again the ESG fund is given a very heavy weight in this optimization as well so to summarize we saw the optimization with the objective to minimize risk which is standard deviation and we saw that ESG fund particularly in random portfolio and de-optimization the ESG fund is getting a very heavy weight flows to 80 percent while others are getting a very small weight close to five percent in the next set of video we'll minimize another risk objective which is expected shortfall on this in the previous video we have optimized a portfolio with an objective to minimize the risk measure which was standard deviation.

In this video we'll create and optimize a portfolio object with risk objective that is expected shortfall so we'll minimize the risk which is expected shortfall or es measure the theoretical underpinnings regarding the topic expected shortfall have been discussed in the previous sessions so let us start with the portfolio objective min es dot portf these are portfolio objective to construct this portfolio objective we make use of our original portfolio object which is initiate dot port f which was our initial portfolio object now if you recall we have to use the type as risk so we'll use the risk type and the name of this risk measure would be es expected shortfall.

So this is our portfolio object yes if we print this object you can see the relevant summaries for example notice here these are some of the constraints weight sum box group as earlier and additionally risk measure has been added as expected shortfall or es. Next we'll add another objective because we want to also visualize the object on optimized object on feasible frontier we need the expected return or return measure so we are adding this objective just to compute or facilitate the computation of return measure however we do not want the return measure to be part of the optimization process and if you recall in order to conduct this kind of routine what we do is we though specify the return objective with type name as mean average return but we also add a parameter called multiplier as zero this ensures that even though return measure is computed but it is not part of optimization process so now if i print this object many years dot port f you'll find that the return object as added as mean or average return however it will not be part of the optimization process in our routines.

Now i'll not rewrite the whole code all i i would do is copy paste the previous routines that we have already done for standard deviation so i'll just borrow the codes for optimization let us do that so i'll just copy paste the same codes optimization with three optimizers all i need to do is just replace my objective portfolio object which is min es dot port f i'll just replace simply replace this min es dot port f and here in this object i'll put it as min es so first is min es with roi we can run the optimization schedule and while the optimization takes place let us just replace minis minis so if i print the weights around 14 percent with bitcoin six percent with s and p 500 and five percent with ehg fund 75 percent with ua futures we can also print the complete object you can see there is computation of return which is around 0.16 percent and expected short fall measure which is 5.64 percent but please always remember this particular yes value is corresponding to a 95 percent confidence level so whenever you are computing the yes measure we should ideally by default this number is taken as 95 but you can specify this number in this case we did not mention so by default the number is taken as 95 percent though we can mention a different number also so as a practice we should optimize with 95 percent which is the generic case you can change the number also see you can see we are getting the same figures because by default it was taken as 95 percent and then you can print the full object also with its weights and mean and ds.

Next we'll also compute this for d optim with the d optim optimizer we'll perform these computations with d optim so i'll compute the d optim measure let me do that and we'll print the weights along with the portfolio object so suddenly there is a drastic change now ehg fund is getting around 60 76 percent while others like bitcoin is 10 percent s and p 5.6 eua future 6.4 of the way we can again print the whole object es measure is around 6.5 percent and mean is around 0.039. We can also work out with the random portfolio method so minimum es objective we can set up our optimization scheme i'll run it meanwhile i'll just modify the course to get the output for minimum es objective so we'll just supply our objective and we'll run it let's see while the optimization schedule is running once it is completed we'll print our object.

It may take a few seconds to complete the optimization process so now that we have done with the optimization schedule let us print the weights again you can see further another different kind of object so in contrast now we are getting s and p 500 as 83 percent bit coin as five percent ehe fund is five percent which are minimum values and ea futures also close to minimum around five percent so for all the three optimizations we are getting different value this is slightly surprising but different optima it is always feasible that to get or possible to get different optimization values so in this video we created our portfolio object with an objective to minimize the expected shortfall measure we also saw how to optimize it and obtain the weights from the optimization schedule.

In the next video we'll visualize the portfolio objects that we have created that is random portfolios de-optim portfolios and roi based optimized portfolios in the previous video we computed our minimum expected shortfall objective optimized portfolio object in this video we'll conduct the visualization as we have been doing for other portfolio object so i'll not rewrite the whole course of again i'll just copy paste the previously executed code for standard deviation so i'll just copy these visualization objects and paste them here. All i need all i'll do is just change our optimized portfolio object for example in this case our first this thing is roi so minimized es with roi. Similarly we have minimized es with d minimized es with random portfolios so minimize es with de-optim minimize es with random portfolios so this is our first set of portfolios. Let us visualize that so i'll create with this param flow 3 we have created 3 plotting windows i'll run it and now i'll run our plotting objects so you can see all the 3 objects that we have plotted you can see that when optimization goes with roi very different set of weights are there with de-optim and random portfolios for example the highest weight almost close to 80 weight is given to eua futures with roi and with de-optim esg fund is getting close to 80 percent and while with random portfolios s and p 500 is getting 80 percent the yellow line in the third graph is for equal weighted portfolios with 25 weights but see with different optimization should use different portfolio objects the different composition of portfolio objects is being obtained there which is interesting.

Next let us visualize the same weights in the form of bar plot so for that all we need to do is we need to i can make use of the same set of code only that i'll specify the plot type as bar plot and also legend dot loc as null so this would do the job so i'll just the same thing i need to do with all the plots and no now that we have all the 3 codes we are good to go we'll run these codes again the visualization will be of weights only just a different measure or way of representing the plots in the form of bar plot you can see again same result with roi you have ag ua futures has the highest weight almost 80 percent with de-optim you have esg fund as 80 percent close to 80 percent with random portfolio.

So this is another way to represent the same result that we obtained earlier lastly we'll also see how these figures work on the feasible region so i'll recall that this feasible region will not work out with roi object so we'll have to do only with the de-optim so we'll do it with the de-optim we have to specify that risk is here es and with random portfolio objects again we'll specify that yes so let me print the objects with one by one again will you make use of one full plotting window so first i'll use with de-optim and you can see the feasible region feasible region is plotted along with the optimum portfolio in the blue form of blue point so that is our optimum portfolio. You can also see again the position of bitcoin s and p eua futures and ag fund on the risk so on y axis we have average return or mean on x axis we have expected shortfall measure on which the feasible region is plotted in the form of different different portfolios feasible port these are feasible portfolios for example eua futures s and p and esg fund are also there each of these points would indicate a hundred percent investment in let's say eua futures or hundred percent investment.

In bitcoin then this kind of portfolio will appear you can see here bitcoin is the most riskiest you can see in our optimum portfolio the weights are visualized in the bottom where you can see highest weight is two ehg fund as per the de-optimization if i run the same thing with the random portfolio a slightly different sort of plot will appear you can see that let me zoom it for you so you can see that the yellow portfolio on the feasible region is equal weighted portfolio optimal portfolio is also shown you have individual portfolios like ua futures their location will obviously remain same because these are individual portfolios but the optimum portfolio will differ because now the weights have changed for example now we have highest rate allocated to s and p 500 almost 80 so the location of optimum portfolio will shift slightly.

But you can visualize how on the feasible region the optimum portfolio appears and also you can visualize the weights in this optimum portfolio of all the different different assets so to summarize in this video we visualized our portfolio objects all the three objects with roi we visualize the weights we plotted their weights and for all the three objects that is roi de-optim and random portfolio optimization and in the last step we visualized our two portfolio objects that is b of tim based optimization and random portfolio based optimization on the feasible region and we also saw the location of optimum portfolio in the next video we'll start with the optimization for shapir ratio which is a combination of return and risk measure where risk is standardization.

In a series of next few videos we'll optimize a portfolio objective within objective of maximizing shapir ratio now the theoretical underpinnings of sharpe ratio already well discussed. Here we have a combination of return for a per unit of risk or what we call as price of risk that is per unit of risk how much risk return risk premia is there so we maximize the shapir ratio object often a very important measure of fund managers so we'll try to see how to optimize against around this objective function so first we'll set the objective function as sharpe ratio. So we'll create a objective portfolio object with this shapir ratio how to do that we'll again use of add dot objective now first recall that there are two objectives combined so first is we'll again start with our portfolio in initiation objective initiate put for port f but first we'll specify the objective type as return with name as mean so that is first now in the next step i'll add another constraint to this object portfolio object and we have been doing this already but in this case in this particular case previously also we saw how to add two portfolios so this is not new to us but in this case we'll keep that objective as a part of optimization process.

So see i'm adding type as risk now i have added another objective name in this case because we are using sharpe ratio the risk appropriate risk measure is standard deviation but i'm not using that parameter or feature as multiplier equal to zero so now the standard deviation will remain part of optimization process and therefore if i print this sr.portf you would notice when i print this this contains all the constraints but now we have two objectives my bad i should have used this sr.portf here so that both the objectives are added so now you have two objects here mean as well as standard division so now you have two objectives and now when it is optimized the return will be on numerator this will be on denominator so you will get something similar to sharpe issue or exactly the shapir issue now we'll start with the optimization process.

So i'll not rewrite the full code again i'll just borrow from the previous optimizations so let us go back to the optimization with three optimizers and we'll copy these codes with as very little adjustment the same codes can be reused rather than rewriting the entire thing so for example here we have as minimum es as objective so we'll use minimum sr now there's a small tweak that is needed so now that we have put it as the objective as maximize sr maximize our sr we will add one more argument to this entire code which is to enable this kind of numerator denominator optimization maxsr equal to true let us put this trace also equal to true so generally when you put trace also true all the computations are saved all the computations that are happening are saved so let me run it so let us run this kind of optimization again here max instead of min es we make use of our sr dot portif objective we have already created this objective and while the optimization schedule runs let us put our so we can see the weights 9.3 or 9.4 percent to bitcoin 19.7 to s and p 500 esg fund as the minimum five percent and 66.93 to eu futures we can also print the whole object we can see here the expected return as close to 0.14 and standard deviation as 2.2 so this is our complete object.

Now the same thing we will do with our maxsr d optim objective again so d optim also maxsr here again sr dot portif we'll replace it with sr dot portif now recall that we have added these two this additional so trace is already set as true all we need to do is this maxsr equal to true other parameters such as such size and other things are already there so we'll just keep them as it is and while the optimization takes place we'll just tweak our code so let's see what weights we get so five percent for bitcoin 6.6 for s and p esg fund as 79 and 8.44 ef features you can print your full objective again the expected return is 0.04 percent close to and risk is 0.1.25 percent.

So now the last is random portfolio again we as we have been doing will you tweak the name and reuse the existing code we need to add this maxsr argument as true so we'll add this maxsr argument as true also do not forget to change or replace generally this is the mistake we tend to miss this part we need to replace this sr dot portif as portfolio object and while the optimization takes place we let us tweak the object so it may take a few seconds to optimize. You can see the red box here running which means the code is still running so let it run depending upon the speed of your computer it'll take some time and now once it is done you can see the output five percent for bitcoin s and p 500 again the minimum weight we have already set the constraint so constraint is minimum five percent esg fund is 82 percent and your future so across the three optimizations you can see the weight changing and also the risk measures changing though there's not much change in terms of overall expected return at close to 0.035 percent and risk at 1.2 but still there's there are minor changes minor changes across different optimization schedules so in this particular video we saw different three different optimizations and the different weights that we are getting there were some minor differences but at the overall level we can see the return and risk is quite similar for all the three optimizations.

In the next video we'll see the visualization of these three optimized portfolio objects that we have created in this video we'll visualize the portfolio objects first we'll visualize the portfolio weight so let us start with that so path and flow now we have since we have three portfolio objects and again we'll make use of our chart dot weights and we have already created this maxsr objective maxsr first we'll use maxsr and the central heading is minimize sharpe ratio minimize sorry maximize sharpe ratio with our oi object now all i need to do is just copy paste it and the second object is d with d optim and the third objective of ours was to use random portfolios random portfolio based optimization so now we'll we have written the code so let us visualize so let us zoom in on our three objects with roi optimization we have eua futures has almost 65 percent weight close to 70 percent in fact and smaller weights to bitcoin in fact very close to five percent to ag fund which is our minimum threshold and then some close to around 20 to s and p 500 but if you contrast it with the d optimum random portfolio optimization so here you can see the highest weight close to 80 percent is given to esg fund while very small very close to five to seven percent base to other securities so there is certain difference let us again use our bar chart beats method.

So we'll visualize with with bar plots the same set of course only i'll tweak them in a minor fashion so i'll just add plot dot type as bar plot there are some other types which you can check with question mark that i will uh argument that i have already shown here you can add legend dot loc as null now you can just simply copy paste it in the other three quotes also to see in the interest of time just and now i'll help you visualize so i'll just run this so you can see again the same result but in a different way of representation it looks very nice aesthetically you can see here that ua futures has a very high weight in the roi optimization but with the ag fund with de-optimization and random portfolio optimization the eag fund is getting a very high weight so it probably is due to difference due to optimization scheme. Now let us plot a very important plot of overall picture of this optimize so we have created an overall portfolio objective let us visualize that so we'll create plot of feasible portfolios for that we'll make use of good old plot command and max sr so we have already our objective object portfolio object ready with us only that in the risk call we have standard deviation because this was sharpe ratio so this measure is standard deviation we are if you want to see all the assets in the plot then you can you need to put chart dot assets as true so all the assets will also be shown and the central heading is optimized portfolio plot with roi.

So let us and before printing i'll also create the other three which is d d based with d and with random portfolio rp with random portfolios random so i've created these three plot objectives plot commands let me let me just show you how these plots appear so i'll start with the roi let's see so just have a look at this graph now with one caveat that in this optimization the portfolio the 2000 portfolios were not simulated so only you can see the optimized portfolio on the risk written diagram so on y axis you have mean which is average return and on x axis you have standard deviation so you can see your optimal portfolio along with other assets and on the bottom chart you have the average on the bottom chart you have weights you can see the highest weight given to your futures as per roi schedule.

In this case you do not see the entire feasible set of portfolios because they were not part of the optimization in the other d optim schedule you will find them so as you can see in d optim you can see all those points right those portfolios that were simulated you can also see the change slight bit change in the optimal portfolio location which is different from the previous one and you can see all the other plots you have features bitcoin and their positions also in this case eig fund gets almost 80 percent of the weight and the location of optimal portfolio vis-a-vis other four assets is provided next i'll show you the random portfolio again this with random portfolio you can see the optimal portfolio is almost at the same equation which is different from roi much different from roi again eig funds get almost 80 percent of the weight and the location of other assets will obviously remain same in their position on the mean and standard deviation mean variance graph you can also see equal weighted portfolio in yellow somewhere in at the center of this feasible portfolio region so this region where all the simulated portfolios in the form of circles are there is called feasible region.

These are all feasible portfolios based given under our constraint and objective functions the constraints and we can see the optimal portfolio here and esg fund and so on let us also add to this plot another couple of interesting plots so we'll also add chart the risk reward diagram let's see how it looks so we'll try to plot the risk reward diagram so let's draw this risk reward diagram with our maxsr objective so roi and again our risk dot call equal to standard deviation and return dot call is mean also because there will be three plots so i'll just add this power m flow as three now all i need to do is i can reuse the same and just add de and the third one for us is random portfolio let us see if we are able to plot them without any error so the three commands i have written for the three different plots because of this power m pro command three plots will be plotted on the same plot window.

So you can see the three plots you have on y-axis you have mean on x-axis your standard division only that in the first roi optimization schedule you will not have those simulated portfolios which are there in other three let me add the name also to make them better so i'll add the central heading as maybe roi rof based optimization now for others i'll reuse this de optim based optimization so now my plot will be slightly better otherwise it was not making much sense whether which kind of optimization is used in different different plots random portfolio based optimization so now the graph will make more sense i hope so let's instead let's pull all three of them.

So you can see roi based not other feasible portfolios are there but in de optim and random portfolio based optimization you have the optimal you can notice the optimal portfolio location is very identical in de based and random portfolio gates as compared to roi and the reason being the composition of individual assets were very different while similar in de optim and random portfolio it was very different in roi so that's why the location of optimal portfolio is also very different optimal portfolio in a sense means that portfolio which maximizes your Sharpe ratio under different optimization schemes to summarize in this video we visualize the portfolio optimized portfolio objects and saw the weights and composition of the optimal portfolio through visualization.

In the next video we'll conclude this Sharpe ratio maximization with charting of efficient frontier and visualization of the same in the previous video we have computed the optimized portfolio and visualize their weights and some other attributes in this video we'll see how to compute the mean variance efficient frontier for Sharpe ratio maximization so in the previous video the measure was Sharpe ratio which is price of risk per unit of risk so in this video we'll try to compute efficient frontier for that so this was on mean variance so we'll use the name of the object for simplicity mean bar dot here because the efficient frontier is created for mean various object the function that we are using is create efficient frontier first you need to supply the return object which is r which contains the return of assets then if you recall for Sharpe ratio the portfolio object that we created was sr.portf type this is kind of mean standard deviation which is our risk measure.

This is the optimization now you also you can also provide number of portfolios that you want to use for this optimization take place 25 in my experience is a good number so let's run it simultaneously you can also print the object that you have created for example if i print this object you can see here mean standard deviation are the objectives and it has these constraints we can also summarize this so let's just summarize the object that we have created summary mean bar and digits to limit restrict the digits to two so you can see maybe i would you can see some of the measures being computed here the weights for efficient frontier for the 25 portfolios and risk return matrix probably if i put digits as four maybe i'll get something yes so we get the risk in here we get the mean standard deviation for different portfolios now that we have computed this object which contains the 25 efficient portfolios on the efficient frontier.

Let us chart it so we'll use this chart dot efficient frontier function now here you have to supply the object that you have created and you have to also supply the risk measure which is standard deviation in mac.col so this will use the name standard deviation now i can have a type as well we can change this type as well later and if you want to change the heading you have to use this rar dot rar is for risk adjusted return so if you do not provide it the default is modified Sharpe ratio if you want to provide as in this case the risk measure is Sharpe ratio only also for plotting the these efficient portfolios for me pch4 is works well it's you will see the shape of those so you can see how the pch4 gives you these dots so you can see now the efficient frontier is there and the tangent line assuming rf equal to zero which is the risk free rate is given your Sharpe ratio comes out to around 6.49 which is the price of risk that is per unit of risk. How much return or risk mean you're getting in addition to that you have also you can see here ua futures the location of bid coin eag fund snp 500 all the assets their location is given and on this feasible frontier you have the efficient frontier here the beam or expected return or average return is on y-axis standard deviation on x-axis and this is your efficient frontier the tangency portfolio is also shown here you can also chart the asset weights for example let me show you so you can write this.

You can chart the asset weights along the efficient frontier you can increase the size of label with sex.lab we'll see that so you can chart the efficient frontier weights by writing this mean bar here and you can provide again the mash.call argument we'll use this argument standard deviation now if you want to decrease or increase the size of your labels you can use main so for central heading this main i'm using empty and then you can use this six.lab for size for now let's keep this as when and see if it is it suits our taste and preferences otherwise we'll change it yeah so it looks better so you can see so you can see the weights of all those efficient frontier portfolios you can see starting from this and we can see as we move ahead as we increase the risk the weight of your future increases as we go further up here different composition so on the portfolios that are on efficient frontier those 25 portfolios their weights are shown and we can see how the weight the black color is for bitcoin so its weight remains mostly steady at a very low level.

While s and p 500 weights fluctuates a lot it increases and then it decreases then esg fund is in green and go one is eua futures you can see and there are three axes presented for example on bottom axis you have return on top you have risk and on vertical axis you have weights and how these weights are changing with risk written portfolios each portfolio is there are 25 such portfolios and each portfolio you can see the combination of return risk added and the composition of individual assets so to summarize in this video we saw how to compute the efficient frontier for our mean variance framework in this case sharper ratio based mean variance framework and we also visualize the efficient frontier we computed

25 portfolios that are part of efficient frontier and what are their compositions in terms of weights that also we visualized in the previous video we maximize sharpe ratio where risk measure was standard deviation.

In this video we'll maximize star ratio which is stable tail adjusted return ratio which is very similar to sharp ratio only that here the risk measure is expected shortfall or what we call as conditional war or c bar so we'll maximize the star ratio here let us start with the objective which is max star we'll use this max star dot port f and again we'll have to specify our objective add objective and as we did earlier we'll use this initiate dot port f type as return and name equal to mean so this is our return objective first objective again we'll just copy paste it and please do not forget to replace the portfolio object because we are augmenting not replacing but augmenting our max start portf object and here now the rest measure is our es expected shortfall or what we call as conditional war but this is this measure runs on certain confidence level so you have to specify by default 95 confidence is used. But you can specify that with this argument a different value can also be used now let me print this so if you print this from object you can see here there are two objectives mean and es and they will be simultaneously optimized when we'll go ahead with the optimization scheme shortly.

So let us shortly so let us start with the optimization scheme i'll copy paste the same i'll not rewrite the entire thing i'll just copy paste the optimization schedule so very few changes will perform so in the optimization schedule first we'll use max star we'll replace this and we'll make use of our max star portfolio here so let's remove this and this is our first objective let me run this optimization schedule max star object and when i run it i'll also show you the weights and the portfolio objects so you can see the weights here 14 percent to bitcoin 6.242 snp 500 ag fund is getting the minimum five percent and es futures are getting close to 75 you can print the full object where the return which is 0.16 expected shortfall measure which is 5.64 percent is being calculated along with the weight you can see the full object here all the parameters similarly i'll use the deopt so i'll again copy paste this max star because we are using the deopt so portfolio object max star need to be pasted at this sr port if you recall so we'll just other parameters will keep as same only this max star will be removed and we'll run this while this optimization schedule runs we'll just slightly tweak our codes to print the object the optimization schedule has run quite quickly so we'll see the object again five percent to bitcoin 8.462 snp five percent to agent 5.82 years futures let us print the full objective so we have okay so this in this case you can see the return measure which is 0.05 percent and expected shortfall as 6.4 percent they are slightly changed we can see the optimal portfolio weights in this particular scheme.

Let us go ahead with the random portfolio optimization schedule so again as we do we'll just copy paste it and we make use of max object we paste it here small tweak of course so that we don't have to rewrite the entire thing again max this needs to be removed and we'll run the optimization schedule it will take a few seconds maybe so meanwhile we'll adjust our codes to print the object so let the code has run so let's see the weights or again 5.2 percent 84 percent to snp 500 and close to five percent to all the assets we can print our fully random portfolio objective again very similar to the optimal optimization so again we are seeing it again again that the optimal optimization and random portfolio optimizations works in a very similar way so the weights assigned to assets and our optimal portfolio objective is very sort of similar to the optimum with random portfolio while different from roi optimization so in this video we constructed our max star or stable tail adjusted return ratio which is a combination of return and expected shortfall or conditional bar measure so both of them together optimized the risk and return and we computed our optimization objects based on random portfolio deoptim and roi methods in the next video we will visualize these objects that we have created.

In this video we'll visualize our star put optimized objects so in the previous video we optimized portfolio for maximizing star ratio and in this video we'll perform the visualization exercise we'll not rewrite the full course we'll make use of the previously written codes so let's just start by copy pasting the previous course we'll just copy paste them and let us start one by one so first let us start with the weight visualization plot so here instead of maxsr i need to conduct max star for roi so this is max star objective and here we are max star with roi the next is max star d so i'll change the name accordingly so it's very identical set of course we are using the same code with the minor tweak so with a minor tweak we have adjusted our portfolio objects so let's start with the visualization exercise we will so we have the three plots here in front of us notice when we focus on our portfolio object you can see here that with the optimization schedule has written a different portfolio with roi as compared to d optima and random portfolio so in roi plot you can see the maximum way to ua future close to 80 while with d optim and random portfolio the star object has highest weight to sdp 500 which is close to 80 let us also modify our object with the bar plot so let us visualize with the bar plot as well so all i need to do is i need to just make use of the same code i'll just modify them a little bit so first i need to add plot.type as bar plot and legend if you recall this used to be null so now i need to just copy paste this okay and now we are good to go so we'll just plot them and this the same plot will result.

But it's just a different way of visualization you can see all the three plots but in a bar plot form the same inference is that 80 percent weight for ua features for max star with roi while d optima results in 80 percent to sdp 500 so very nice aesthetic plot has resulted next we'll plot our feasible portfolio the trick is to again use our good old portfolio max star object here so max star object and in this max star object the rest measure is es and optimize portfolio plot with roi rest measure is es so we'll see one by one so all the three plots so first max star and notice here in the optimum portfolio you can see the there is no feasible portfolios because this is roi optimization that will come in the d optimum random portfolios but you can see on the mean variance framework the risk measure is the same on the mean variance framework the risk measure is es on x axis on y axis we have the mean optimal portfolio is this blue one and we can see its position you can also see the ua features in the bottom you have the weights and ua features have almost 80 percent now if i run this with the e optim you have feasible portfolios and the position of optimal portfolios change and the 80 weight is now with s and p 500 which we saw earlier also the position of other assets like your future on this mean and es diagram will remain same because they are individual assets so their position will remain same but optimal portfolio has changed because the weights are different for random portfolio if i run now i have run with the random portfolio here with the random portfolio you can see the portfolio with d optim is quite similar it is quite similar to d optim the yellow one is on the top diagram you can see the yellow one is equal weighted portfolio in the bottom also you can see with yellow one the weights are identical 25 to all the four assets the position of optimal portfolio is very similar to that with d optim here and you also have set of feasible portfolios plotted for you.

Lastly let us also risk reward on the risk reward diagram so a minor tweak again we'll use our max star objective here max star objective and i'll slightly change the standard deviation to here i will not get those feasible portfolios so we have to make use of our empty kind of diagram so it doesn't look good aesthetically but it's still in the interest of comparison we'll just plot it so we'll have this max star objective with this caveat we move ahead and let me show you the diagram so let us print our objectives and now we have three diagrams you can see the position of optimal portfolio is very similar in d optim based optimization and random portfolio optimization however with the the roi based optimization there are no feasible portfolios so it's not very meaningful but still you can compare the location of optimal portfolio the optimal portfolio with roi is very different because of obviously the costumed weights are very different in d optimum and random as compared to roi we can see their relative positions on the mean es diagram so on the y axis you have average returns or mean returns on x axis if you have risk you can see the optimal portfolio is much lower risk in the optimum and random portfolio while higher risk but a higher return on optimization in addition a very interesting diagram is the concentration diagram that i would like to show so concentration of acid now the trick here is to make use of this very interesting function called chart dot concentration and in this i'll provide our max star objective so it is only because there are no feasible portfolios for roi so this is only available for d in constant type we'll put weights.

You can have percentage contribution also but we'll use weights for now weights you can check other parameters with the help and though we'll also we'd like to plot assets as true and let us run this so before running i'll also write the same code for the other one which is random portfolio so i'll show you both of them first we'll run the deoptium based so you can see as the degree of concentration increases on the top you have all the feasible portfolios with y-axis being average return and x-axis being the es risk measure you have individual assets also being plotted as you can see and on the bottom diagram we have increasing concentration and as you would have expected as the concentration increases the risk increases so we can see the concentration increasing along with the risk for example the ones on the far right will have very high concentration and also those extremely risky portfolios the same way if we if i run this for random portfolio there's minor changes and you can see the concentration moving with the portfolio so you can compare how with concentration as you keep increasing the formula for this concentration you can check it is something like summation of squares summation of weight squares because weights are in percentages their squares will be summed up and added to give you.

This concentration you can check for on the help window for the exact computation of this concentration level to summarize this video here we visualized the portfolio object created for our star which is stable tail adjusted return ratio so for that star optimized portfolio we computed at the optimization of objects and then visualize them particularly we visualize the chart weights for portfolio weights we also visualized on the feasible frontier the feasible portfolios and lastly we also visualize the concentration plot in the next video we'll visualize the efficient frontier in the previous video we visualize various attributes of our star portfolio object which is the coefficient of the star which is optimization or maximization of star object with return to expected shortfall risk ratio in this video we'll compute the mean variance or rather mean es i would call it mean es efficient frontier we'll compute it and visualize the object so first let us start with the computation of mean es mean es dot efficient frontier so for that we'll create we'll make use of the efficient frontier objective.

Again we'll provide our asset object r and recall that for the portfolio we have already specified our max star portfolio object in this case the type as i noted will be equal to mean yes let me just put it like that the objective is of clean yes type this is the type of optimization we've done again for a efficient frontier you need to specify how many portfolios if you recall 20 portfolio works well so we'll look on this now first and foremost now that we have created our mean yes efficient frontier objective let us see what is there inside it so we'll print it you can see two objectives mean along with this measure of es and then there were constraints wait some constraint box constraint and group constraint so you can also print summary of it and in the summary mean es objective will provide digits we know that it would be good if you provide four digit so when we print it for all the 25 portfolios we have the weights you can see their weights and these are 25 points you can also see their risk return risk is mean and expected shortfall so while plotting these attributes will be employed let's start plot with our efficient frontier plot so first and foremost let us write the code so the code that we use was chart.fe efficient frontier and if you recall in the previous code we provided this mean yes object along with match.col in the previous case it was standard deviation in this case this is expected shortfall the risk measure the type we are using line type you can also choose box type or other types you can check on the help for RAR text which is risk adjusted return.

We are in this particular case we would like to use star ratio previously we use Sharpe ratio in this case we would like to use star stable tail adjusted return ratio and PCHS4 you can change this PCH also but PCH4 works well for me so let me plot this so let's see so this is your efficient frontier you can see the tangent line you can see the star ratio of 0.0284 risk free given risk free rate of 0 on x axis you have the expected shortfall or cvar measure on y axis you have expected average returns individual assets are also plotted you can see the tangency or optimal portfolio and the efficient frontier has been now if you recall the next step was to efficient frontier weights and for we'll plot the weights of EF portfolios how to do that so we'll make use of this chart EF weights command where we need to provide our mean yes object again in mash.call parameter we have expected shortfall and central heading will use as empty again sex.lab parameter can be taken as one it in it gives you the size of axis label so we'll so let us run this code let's see what do we get so here you can see the weight composition of all the those 25 portfolios on the bottom you have their return on the top you have their risk and their weight compositions you can see the changing weights the green one is ESG fund the red or maroon one is the s&p 500 the black one is bitcoin and blue one is your features as you can see as the risk written profile changes how the weight composition changes across all the 25 portfolios very nicely.

So you can analyze that so to conclude in this video we computed the efficient frontier we plotted the efficient frontier in the previous diagram it appeared like this we had the tangency line the star ratio so in this efficient frontier the risk measure is expected shortfall so we plotted on mean yes diagram we plotted the tangency portfolio and efficient frontier using those 25 portfolios and then we also saw their complete composition using chartier weight function in the next video we'll conclude our portfolio analytics exercise by visualizing and computing the combined optimizations recall that we have previously created two objects one with maximizing star ratio and one with maximizing sharp ratio and each of these optimizations are performed using the opt-in method as well as random portfolio method so in this particular video we'll perform combined optimizations we'll try to compare all these four optimizations two for sharp ratio two for star ratio by combining our optimization objects let's see how to do that so let's start so first is optimization with the schedule so here we'll make use of this combine optimizations function and we have we'll put it in the form of list object first we have mean sd where our objective was to minimize the standard deviation the d then we had mean yes where we had minimized the yes objective with d. Next we had mean keep this so we have mean sr which is maximize sharp ratio objective and then we have mean star which has maximized star so this was for d and similarly we had another one for random portfolios wherein for standard deviation objectives we had random portfolio for all the es also we had random portfolios so we have two rp also so these are random portfolio optimizations.

So now we have created two combined optimization objects one is for the schedule one is for random portfolio in the next we'll extract the object parameter so we'll extract object parameters from each of these parameters from each combined each optimization object each optimization object let's see how it is done so we'll make use of optimize b and let's call it object d which require extraction of object extract objective measures function and in this case our this is object and we use opt underscore d so this is first and if you recall the second one is for random portfolio random portfolio we'll run this as well so this is random portfolio now we'll extract weight so weights underscore d which is extra so we'll write heading extract weights weights function where we have opt will also extract for random portfolios we'll make use of these shortly.

So let us first print them one by one so first let us print object d so when I print it you can see object dot b carries standard deviation mean and expected shortfall for all these four measures object b similarly I can print for object rp you can print for object rp also and all these parameters will be given to you standard deviation mean and es for rp for all the four configurations mean sd mean es mean sr you can see the standard deviation measure you can see the mean which is average return and es measure similarly I can extract the weights for d let's see the weights you can see the weights for individual assets for each configuration bitcoin snp 500 esg fund ua futures you can see for mean sd mean es mean sr individually you can compare the weights and the same you can do for random portfolio optimization you can print the weights.

Let us carry out the visualization exercise also so to visualize first we'll visualize chart weights so chart dot weights for that I'll use first for d and let us so to ensure that because maximum access can go up till one maximum weight can go up till slightly higher than one in fact but let's see so this is for of d let's visualize the weights we'll write the heading as visualize the weights so this is the full command as you can see here this is our full command but we need to enlarge the plot window to visualize you can see the movement here so you can see for all the configurations mean sd mean es mean sr mean star you can see how the weights are moving across different assets the same you can do with rp object you can see with the rp object also in another fashion you can plot it with what you can do is you can change the plot type currently the plot type is line so you can change the plot type to bar and let me first show you if for the d so this is for d you can see and you can see for each of the bitcoin you can see for bitcoin for all the four configuration what is made for s and p 500 for all the four configuration what is made and so on similarly for random portfolio you can see the weights and so on.

Lastly you can chart the optimal portfolios in the risk reward space that is also not too difficult what we need to do is we need you can use this chart dot risk reward we have already plotted this so i can add opt d and central heading as optimal portfolios so now you can also specify whether you want to have say for example risk dot call as standard deviation you can have standard deviation or also you can have es as well similarly the same plots you can plot for random portfolios i'll show one by one so random portfolios also you can plot these so i'll show you one by one how they appear. So first we'll do it for d with standard deviation so you can see on y axis we have a average return and x axis you have standard deviation and all the four portfolios are plotted now if you want to have instead of standard deviation you have expected shortfall you can change it similarly for random portfolios also you can change it so this way you can plot it and the commands are shown here.

For example the first one optimal portfolios with d opt and std dev so this is for that then optimal portfolios with de optimization and es measure now the graph will look more proper with random portfolios and standard deviation with random portfolios and es so now i'll i'll again run it and you will see the difference now the central heading is changed you can see optimal portfolio with d optimum standard deviation the optimum with es measure random portfolios standard deviation and random portfolio these measures so with this we have compared and compared our optimized portfolio objectives in a combined method also to summarize the lesson first we initiated the portfolio object then we explored how to add various constraints such as weight sum constraint box constraints and group constraints next we optimize the portfolio with maximum returns and found the weights with the help of three optimizers namely random portfolio d optic and roe optimizers next we visualize this portfolio with maximum returns next we optimize the portfolio with minimum standard deviation and found the weights using the three optimizers namely roi d optim and random portfolio subsequently we visualize this portfolio with minimum standard deviation then we optimize and construct a portfolio with minimum expected shortfall as risk measure computed weight and visualize the portfolio next we optimize and construct a portfolio with maximum sharp ratio measure we also plot the efficient frontier identify the most optimum market portfolio next we optimize and construct the portfolio with maximum star ratio is stable tail adjusted return ratio measure we also found the portfolio weights and also visualize the portfolio object lastly we conducted the combined portfolio optimizations with all the four objects namely standard deviation expected shortfall sharp ratio and star measure we compared and visualize all these portfolio objects .