Artificial Intelligence (AI) for Investments
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Lecture- 36

In this video, we will learn how to initiate a simple portfolio object. So we will initiate and interpret a simple portfolio object. For example, I can simply create a simple portfolio object with default specifications, let us call it default spec by just writing this portfolio spec function. I can nicely print the contents of this default spec object by just typing default spec and printed it in the console, I can print the output. The function portfolio spec here allows us to define the specification settings from scratch. The default setting as we can see here MB mean variance, the default settings are for a mean variance portfolio.

We can easily see the arguments for this function by printing the summary as we can, as we have already done here. It's a very easy to read summary with all the formal. First and foremost, we have the model slot that covers all the settings to specify a model portfolio. This includes the type of portfolio that is mean variance portfolio, the objective function to be optimized, which is risk minimization, min risk.

The estimators for mean and covariance here we are by default using covariance co estimator and then some other optional parameters are there. One can easily modify the type of model portfolio that is to be constructed. For example, you can use this get type function, you can use this get type function and apply it to your default portfolio, default spec and you can extract mean variance portfolio spec MB. You can change it for example, let's say you want to change it to C bar type. So you can use this set type argument, put your default spec and assign it a specification of C bar and now your specification are changed.

Notice along with that your solver is also changed, we will discuss more about the solver, but the idea here is that solver is changed to the relevant optimization portfolio. Now if you want to print this default spec, you can simply print it, you can print it and you can notice that now your type is C bar. So we just change the specification from a mean variance portfolio to a mean C bar or conditional value at risk portfolio. For more discussion at C bar, refer to the video topic on C bar. Also notice that this model list entry provides the objective to be optimized, which is minimize risk, min risk.

This list entry optimize in the model slot describes which objective function should be optimized. For example, one choice which is default is min risk which minimizes the risk for a given target return, then you have max return which maximizes the risk return for a given target risk and then you have objective risk function which you can define a particular objective function. To put simply, the first two options that is minimize risk or maximize return are the most common choices. These are either minimizing the portfolio's risk for a given target return or maximizing the portfolio's return for a given target risk. In the default case of the mean variance portfolio, the target risk is calculated from the sample covariance.

The target return is computed by the sample mean of the assets if not otherwise specified. The third option leaves the user or somebody using the programming with the possibility to define any other portfolio objective function. For example, one can maximize the Sharpey ratio. So for example, if you want to change the setting to optimize, you can type get optimize function. You can use this get optimize function and provide the argument of default spec.

Let us see. This currently it is set to min risk. Now you can change it by putting it set optimize set optimize and you can provide the default spec object and you can change it to max return. You can run this and now if I print my default spec object, notice now it is maximize return. Also please notice the estimator slot in the model list.

In Harry Markowitz mean variance portfolio model the type MV, the default estimator is COV covariance estimator is employed, which computes the sample column means and the sample covariance matrix of the multivariate data series such as we have been dealing in this lesson. There are number of alternative estimators that will be discussed and also provided for by F portfolio functions such as candles and Spearman's rank based covariance estimators, various robust estimators, a shrinkage and a bagged estimator as well. We will apply them wherever as may be required. Notice the portfolio slot. In the portfolio list slot, we have all the settings to specify the parameters for a portfolio.

For example, you have target weights, target return and risk, risk free rate, number of frontier points and the status of the solver. So number of for example, here you can see the solver is Solve RGLPK. So you can use the extractor functions to retrieve the current settings in the portfolio slot and change those settings as we did earlier for the model slot. Three important arguments here are weights, which is a numeric vector of weight, target return, which is a numeric value of target return and target risk, which is a numeric value of target risk. Now, for example, if the weights of a portfolio are given, then the target return and target risk are determined.

They are no longer free. As a consequence, if you set the weights to a new value, then the target return and target risk are also changed to a new value. Similarly, if you change the values of target return and risk, the other two values are set to NA or they are determined. If all the three values are set to null, then it is assumed as an equal weight portfolio. In summary, if one only one of the three values is different from null, then the following procedure will be started.

For example, if the weights are specified, then it is assumed that a feasible portfolio should be considered. If the target return is specified, then it is assumed that the efficient portfolio with minimal risk should be considered. And if it is risk is fixed, then the return should be maximized. Let's see this with one example. Currently, as we can see in the portfolio list, all the three arguments target, weight, return, risk are set to null.

Now, let's set one of the one of them, let's set weights, set weights of this default spec, default spec object. Since we have seven objects, we can set it C from 1 to, so we have sequence of 1 to 1 and we will specify the length of 7. Let's have this sequence of 1 to 1 and we will divide it by 7, we will divide the sequence by 7. So we will set the weights, we have the sequence, let's print this inside this object we have 1 and we will divide it by 7 to have equal weighted object 7. So now it has assigned equal weighted object, I can print this default spec.

So it has equal weights. Notice that the target return, target risk are set to NA because we have specified the weights. So the target return and risk objects are now fixed to NA. So basically, we are telling portfolio to optimization to create a feasible portfolio with these equal weights. So the target return risk objects are fixed and they are set to NA, they will be determined in the optimization process.

Similarly, if I set my target return, if I set my target return and let me set the target return of this default spec object to let's say 0.025 and let me print this default spec. Now that I have given the default returns, notice the other two objects weights and target risk are set to NA. So it will given this return, it will minimize the risk and automatically the weights are automatically computed in the optimization process. Similarly, we can set the risk and then other two parameters return and weights are also determined in the process, they are no longer variable, they are fixed by the optimization process.

Next, you have risk-free rate, you can determine the risk-free rate using the extractor function, you can see the current risk-free rate and change the settings. You can also check the number of default frontier points. Currently, the risk-free rate is set to 0 and number of frontier points to 50. These are often employed. Risk-free rate will be employed if you are constructing the tangency portfolio and computing Sharpe ratio.

Number of frontier points will be required when you are constructing the efficient frontier. Lastly, you have Optim slot or Optim list where you have the solver settings. The name of the solver to be used currently is set to Solve RGL-PK. Again, you have the extractor functions to see the current solver information or change it to some other solver. The name of the default solver used for the optimization of the mean variance Markowitz portfolio which is the default portfolio is the quadratic programming solver which is named to Solve R-Quad programming.

Since we changed it to C-bar setting, we are seeing this as Solve RGL-PK. Let me again show it to you. If I change the set type of default spec to mean variance portfolio, it will be changed back. Notice the solver is changed back to Solve quad programming again. A number of solvers are available with different parameters and different attributes depending upon the objective function, risk and return.

To summarize in this video, we initiated a simple portfolio object. We discussed in great detail the parameters including model list which contain type of the portfolio function, the objective to be optimized, the estimator. We also discussed the portfolio list slot where we discussed the weight, target return, target risk, rest rate and number of frontier points. And lastly, we discussed the optimum slot where we discussed the solver properties. In this video, we will discuss how to set the portfolio constraints.

Let's start with the simple portfolio specification object. Let's call it spec-s-p-e-c. We can use the portfolio spec function to initiate this object. Once this object is initiated, let's start with the simple constraints which is long constraints. Let's call them constraints, long only.

Now many times we use only long constraints that means we have all the long positions, no short positions. So let's define our default constraints as portfolio. Now we will use portfolio constraints function to specify our constraints. This is our return object that we are using and we have initialized a portfolio spec, simple portfolio object with spec default configuration. And then we will use our constraints which are long only.

Let's assign this object and let's print the constraints. Notice in the constraints, notice when I run this default constraint object, notice the output, there is a lower value of 0 and upper value of 1. This is because the long only constraints assign lower and upper bounds for each asset between 0 and 1, 1 indicates 100 percent. So all the weights are allowed to vary between 0 and 1. One can also define short constraints.

So instead of using long only constraints, I can use very similar setting and define my constraints as short only. Let's put it as short. And if I do that, so now I will assign the short constraint and I will run my default constraint object. Let me run this. So now if I run my default constraint object, notice now instead of 0 to 1, we have minus infinite to plus infinite that is there are no bounds because we have allowed unlimited short sale.

So one can take any position on the negative or positive side in each of the assets individually. Next we will discuss the box constraints. However, to make our portfolio object more appropriate, let me assign a target return to this and we will most of the time we will use long only conditions. So I am running this long only condition and in addition to that, I am setting the target return set target return as equal to set target return for this spec object equal to mean of final return. So the final rate object, mean of this object will be my final return and this is my, these are my default constraints.

So if I print my default constraint object, it will appear like this. Now we will set a very interesting box constraint. Let's say I want my first box constraint to be that the minimum amount in each of the assets, the minimum weight in each of the assets from 1 to 3, asset number 1, 2 and 3 should be equal to minus 0.1. So this is the minimum weight that I want each of the set to have.

Then the second box constraint I want from asset 4 to 7, asset number 4 to 7, the minimum amount I want is minus 0.2. Next, the maximum amount, let me specify the remaining two conditions. So I will use the box dot 3 third constraint which is the maximum weight in asset 1 to 3 should be equal to 0.

So it should not exceed by 0.5. Similarly, I am assigning the last and final box constraint that my maximum weight, max weight should not exceed 0.8 from asset 4 to 7. So this is my box constraint that I have specified. Now let's set up my box constraint object, aggregate all these constraint conditions, that's my box constraint object which is a combination of box dot 1, box dot 2, box dot 3 and box dot 4.

So this is my combined box object. You can print it also, I can just print it separately. If I run it, I get all the box conditions. Now let me have my consolidated constraint object printed. So I will use this portfolio constraint and I will specify that I want my return object to be final rate. This is my return object that we have already discussed in previous set of videos on introduction and initiation of portfolio object, then specification spec object which is already there and box constraint.

Now if I print this object, notice the following interesting things. First and foremost, the lower limit which is specified as for a set 1 to 3 minus 0.1, for a set 4 to 7, here notice for a set 4 to 7 minus 0.

2 and the upper limit as 0.5 for a set 1 to 3 and 0.8 for a set 4 to 7. So these are our box constraints that we have specified. Next we will move to group constraint where we can assign a condition which applies to a group of assets. How do we do that? So let us start with our first group constraint group dot 1 equal to equi sum W and I specify that asset number 1 and 3 should have a weight which is equal to 0.

So 1 plus 3 should be equal to 0.6, this is my first constraint. Let us decide the second constraint group dot 2 which is equal to min sum W equal to, now I am specifying that a set let us say 2 to 4 should have a minimum sum of 0.2, so 2 to 4 should have a minimum sum of 0.2 and group 3 that maximum sum for a set let us say 5 to 7 should be equal to 0.

So this is my last constraint. Let me combine all these constraints. So I can use this group constraints object and I can assign all the group constraint group 1, group 2, group 3. So all these group constraints are assigned in this group constraint object. I can print this as well.

So all three constraints are there. Now again I can use the same portfolio constraint object, portfolio constraint object where I need to specify my returns, asset having returns, then my portfolio object which I have already initialized which is spec. Similarly I will provide my group constraint and let us print this. So let us run all these commands and let me print this object. Notice what happens, so first since this was a long object, so we have minimum and maximum limits 0 to 1, but now we have put group constraints.

So let us interpret them. So first we specified the equal sum weight which is 0.6 for security 1 and 3. So notice this equal sum 0.6 which is for security 1 NFTY and security 3 CAC. Similarly we have minimum sum constraint as 0.2 which we can see lower matrix constraints here 0.2 for security number 2 to 4. So 2, 3, 4, SNP, CAC and DAX. Lastly we have maximum sum constraint which is 0.
8 which is applicable to security 5, 6 and 7. So these are our group constraints. Next we will also talk about risk budget constraints. So to assign budget constraints let us have a look at simple example I can have budget dot 1 which is my first budget constraint and when I say budget constraint this means risk budget constraint. So what is the contribution of each security to the risk of portfolio. So let us put first the minimum budget constraint and I will put 1 to N assets which is my number of assets in this case it is 7.

So this N assets and I specify the minimum as minus maybe minus 2 and the maximum this obviously pertains to on the lower side budget 2 which I specify as max the maximum risk contribution to the risk of the portfolio max B and I specify this as C1. So first asset and then 2 to N assets that means I want some combination for asset 1 and some combination for assets 2 and I specify this as C0.5 this will be assigned to asset number 1 so 0.5 for asset number 1 and then I will repeat from 0.6 instead of repeat I will just use a sequence I will use a sequence from 0.

4 to 1 by 0.1 so it will assign interesting sequence and here instead of 1 I will use just 1 to N assets. So all the assets will be assigned a sequence of 0.05 but since there are 7 assets I will use it as 0.4 and then I will close the entire thing so this is my risk budget constraint. Let me print this also so let us decide or define rather complete object as budget constraints which is equal to C budget dot 1 comma budget dot 2 so these are my risk budgets for individual assets.

Now if you want to print the complete thing you again will follow the same procedure budget constraints I need to specify the return object then the portfolio specification object that I have initialized already and then budget constraints that we have already defined. So one small issue although it is just a warning but we need to have only 0.4 here and I can remove this so now this will work out fine. Now once I run this command notice the budget constraints so for example the minimum constraint is minus 2 as we can see here for all the assets as I specified here and the maximum budget constraints start from 0.

4 up to 1 for all the assets with an increment by 0.1 so this is my budget constraint. Now as a final thing you would like to set up a very complex object which contains all these budget group and individual box constraints, asset constraints so let us see how it is done. So first I will specify my constraints as a combination of box constraints then group constraints and lastly my budget constraints. This is my complete object. Finally I will again use the same set of portfolio constraint function to create this object with very complex constraints which are constraints and if I print this the complex object is produced for example these are the set of individual box constraints that are applied for each assets maximum and minimum.

Then you have group constraints for example equal sum constraint that we discussed already here you have lower group constraint and upper group constraint that we have already discussed and then you have risk budget bounds that we have discussed individually minus 2 and then 0.421 so this is a very complex kind of object with very complex budget constraints for box group and risk budget. To summarize this video we introduced budget constraints and how to implement them in portfolio. We started with long and short portfolios where individual securities can be in the long or short which is minus infinity to plus infinite unlimited short sale.

Then we introduced the individual asset constraints with box constraints. Next we introduced group constraints for a group of assets and lastly we introduced budget constraints for risk budgets and finally we created a very complex portfolio object with complex constraints which are a combination of box group and budget constraints. Recall our discussion about feasible portfolios in the video topic portfolio optimization. We noted that there is a range of portfolios that are called feasible portfolios that represent all the possible combinations of risk and return. In this video we will compute one such feasible portfolio which is also an equal weighted portfolio. A feasible portfolio is an existing portfolio described by the setting of portfolio specification that is expected return and risk.

Existing here means that the portfolio was specified as parameters in a manner that risk versus return plot of the portfolio has a solution and it is part of that feasible set including the efficient frontier. The generic way to define a feasible portfolio is to define the portfolio weights. For example the equal weights portfolio is also one such a portfolio. So here we will compute one such equal weight feasible portfolio.

So here we will compute one such equal weight feasible portfolio. For ease of plotting and computations let us use our return object as we computed earlier and we will multiply it with 100 to make it easy for plotting another aesthetic purposes. Now as a first step I need to define equal weighted spec EW spec object and initiate with our portfolio specification with portfolio spec function. So with this portfolio spec function we have initiated the object but we need to do a number of things starting with let us design this n assets object which will contain the number of assets that is n call finalRib. So basically it will contain the number of assets that is 7 in our case.

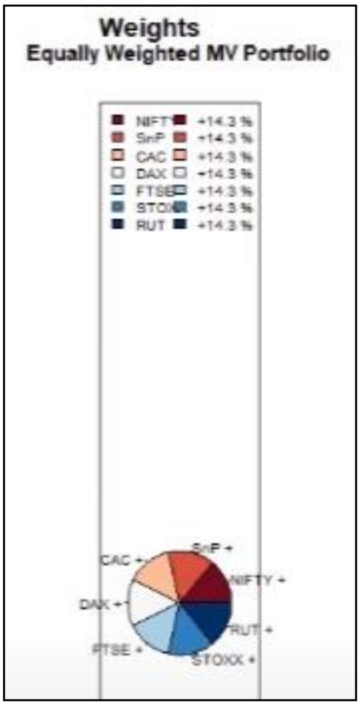
You can check that by printing this so there are 7 assets. Now we need to specify the weight of each asset in the portfolio which is equal so we will use this set weights command and we will use our EW spec object and we will assign equal weight. How to do that? Very easy. We can use this rep command. We can use this repeat or rep command where 1 upon n assets that means 1 by 7 in this case and we will repeat it 7 times.

So in a way we are assigning equal weights to all the 7 assets. Let us print this object and see if it is done actually. So let us print this EW spec and notice 7 equal weights are created in this portfolio weight slot. Now we have created this EW spec object. We have initiated the portfolio specification object. We have also assigned equal weights to all the 7 assets and now we will define our feasible portfolio.

Let us name this object as equal weight portfolio and using this feasible portfolio, feasible portfolio command, we will use our final return data here and we will specify the specification object which is EW spec. We also need to specify the constraints as we have done earlier. We will use long only constraints. Most of the times you rely on long portfolios. Generally short positions are not very desirable so in order to define this equal weighted feasible portfolio, we will use long only constraints.

Now let us print this object. Let us see what we have created here. So let us print this. We can simply run this and print and see the value that we have. So it is the estimator, the solver, minimum risk, long only object.

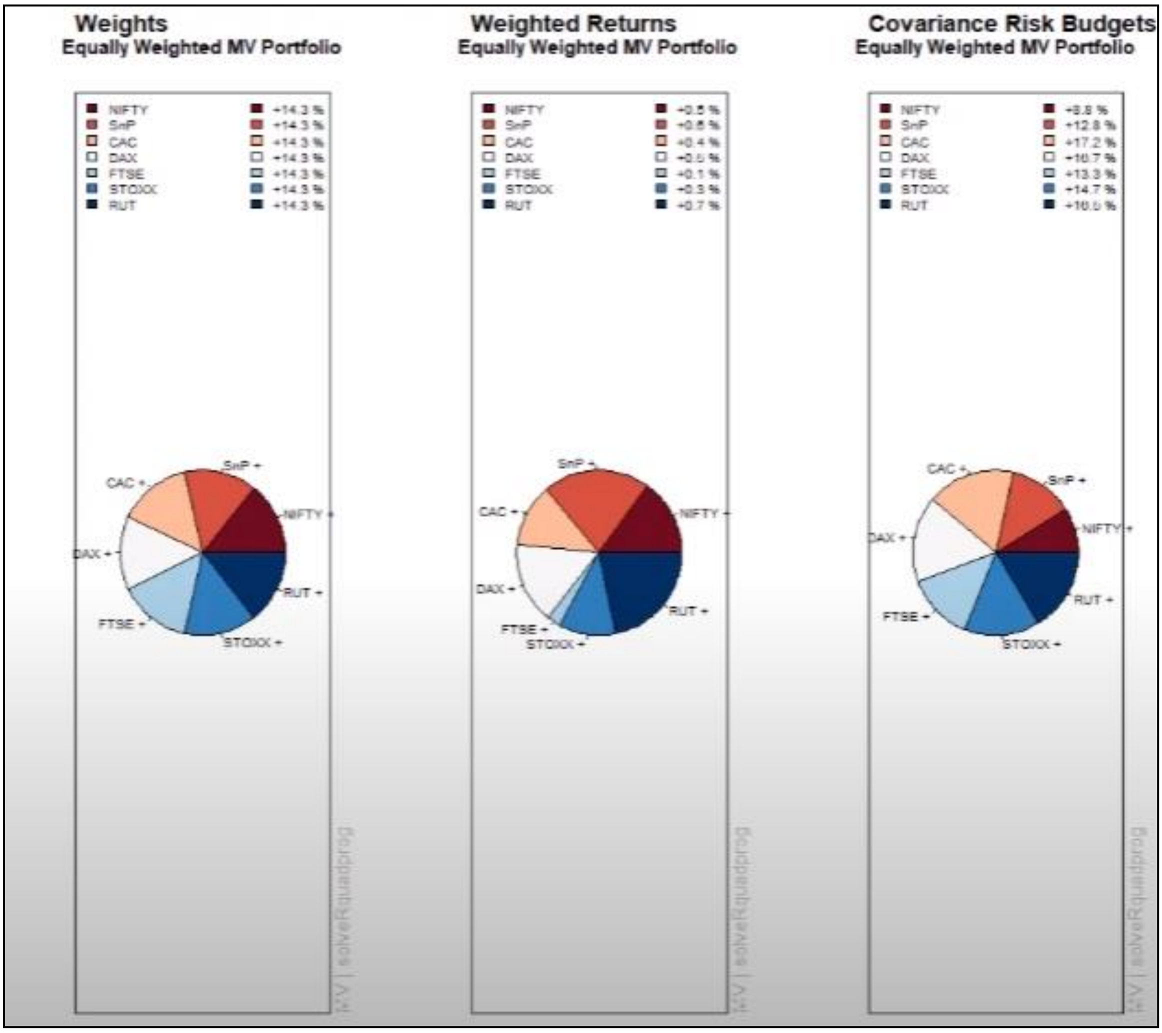
You can see the weights. All the weights are equal here. Also the covariance risk budgets are computed. The target returns and risk covariance are often called here standard deviation also and C bar and bar are represented. Notice here covariance risk for the portfolio in this particular functional terminology is same as the standard deviation of the portfolio. So the standard deviation or variance of the portfolio is measured or represented by this COV covariance object.



C bar risks, bar risks are computed along with the mean return of the portfolio. Now let us print this equal weighted object and first we will define an interesting color palette. In R, there are lot of interesting commands to create colors. So we will use this tip palette command in app portfolio and here we need to specify the number of colors to be generated which we will generate using ncol final return which is 7 assets. So we will generate 7 colors. With this command, we will specify that 7 colors are needed and we will specify that the palette has to be in the red-blue format.

So this is the symbol red-blue which tells R that red-blue palette color combination is to be created. Now we have the colors. Also we will specify 3 windows. So using this par, mfro equal to C 1,3.

We will specify that 3 objects will be printed now and these 3 objects. First we will specify the weights pi object, the proportion of individual asset weights in the portfolio. This is pi. In the weight pi object, we will specify our portfolio object which is ew portfolio.



Also we will specify the radius. Let's take a radius of 0.7. Based on my past experience of coding these kind of figures, I find this 0.7 to be useful. I specify the color as col.

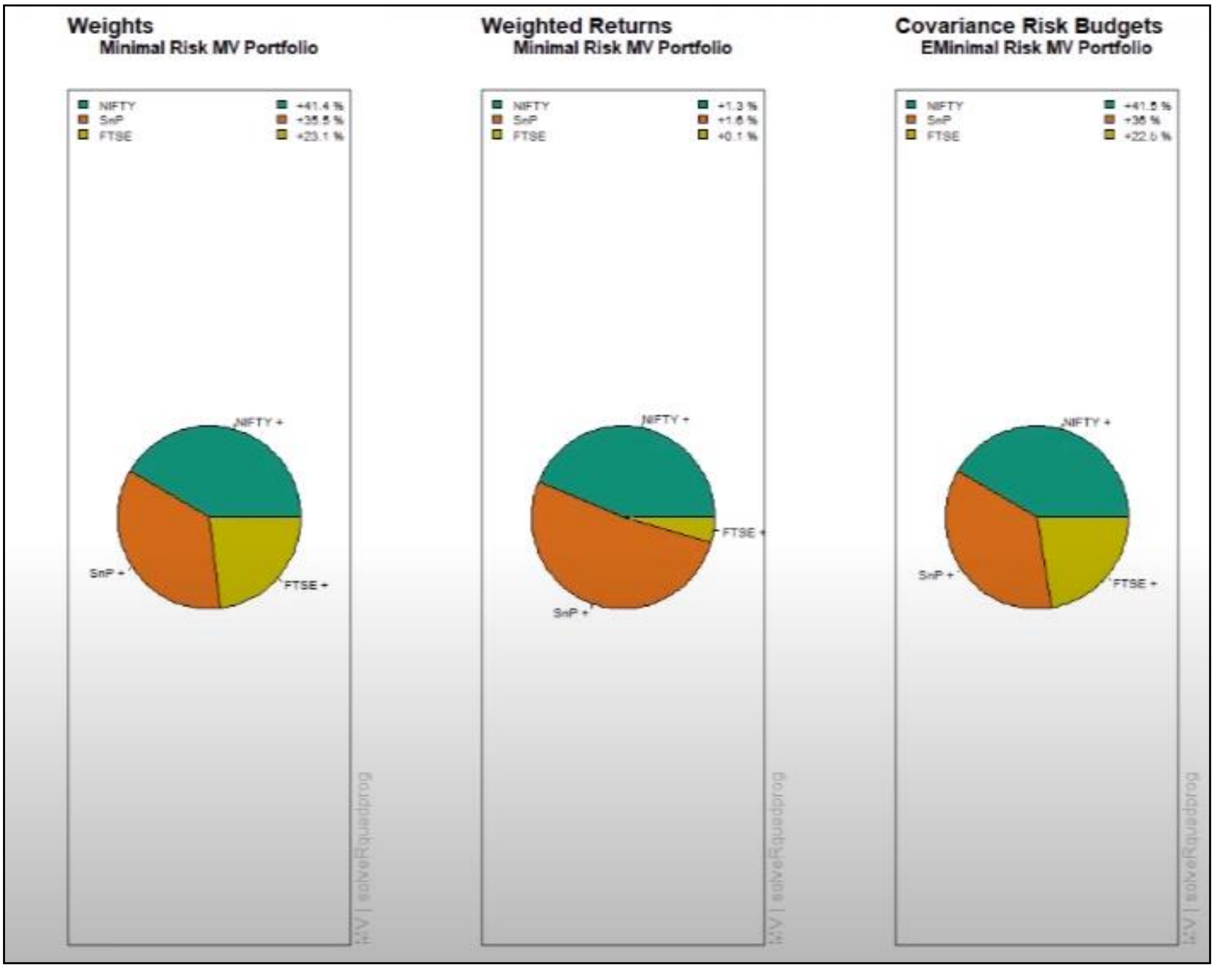
I specify the color as col which we have created. Also some headings are needed here. So mtext command text. The text is equally weighted minimum variance portfolio.

Side equal to 3, line equal to 0.5. These are some of the parameters font equal to 2, 6 equal to 0.7, adjustment equal to 0. So this is first object. So let's see if we have correctly created. Yes, so this is correctly created.

At the end of it, I will format it properly but before that we will create these objects. Next object is weighted returns pi. So weighted returns pi. So we will use this weighted returns pi function. I will specify the portfolio spec which is ew portfolio.

Again the same set of objects radius equal to 0.7, col is col. Again I will use the same mtext heading as earlier. I will just copy paste. Lastly I will also specify the covariance risk budgets. We will explain these things in detail shortly. Here also I will specify the same parameters that is the portfolio, equilibrated portfolio, radius and color remains the same.

And now I will again give the heading mtext. Now let me plot them in one go. First I will specify the color object which col and then par telling are that three plots are to be created. First weight pack, name it. Then returns, weighted returns, named covariance risk object and name it. Let me zoom the plot and explain it in detail.



So as you notice the first plot is equally weighted and minimum variance portfolio. Since it is equally weighted portfolio, notice all the weights are 14.3% for all the securities. The next weight is weighted returns which indicates the contribution to overall returns by individual assets. As we can see here, the color coding represents the contribution to return by individual objects clearly. The last one is covariance risk budget which indicates the contribution of individual securities to overall risk of the portfolio.

As we can see here for example, if we have 8.8% contributions, S&P 500, S 12.8% and this will sum up to 100%. So these are contribution to the risk of the portfolio by individual securities. To summarize, in this video, we created a feasible portfolio with equal weight specification. Subsequently, we visualize the portfolio with the respective weights of the individual assets, their contribution to returns in the form of weighted returns and their contribution to the overall risk of the portfolio through covariance risk budget plot. In the previous video, we computed a feasible equal weighted asset portfolio. In this video, we will try to compute minimum variance portfolio and we will try to visualize various aspects of this portfolio.

Now for a minimum variance portfolio, for every return, there is one portfolio which has the minimum variance or minimum risk and therefore in this particular portfolio, we will try to initiate this mini risk, let us call it mini or min risk spec and we will initiate this with portfolio spec object through a portfolio spec function. Like we noted earlier, we need to specify a particular return for which we will compute the minimum variance portfolio. So let us set the target return equal to, let us set the target return of this min risk spec as mean of final return. So the mean of all the securities will be considered as the target return for which we will compute the minimum risk portfolio.

Now that we have assigned target return, let us specify this minimum risk portfolio object. Let us call it min risk portfolio and for this min risk portfolio, a very simple command is to use is efficient portfolio because this will be part of our efficient frontier and we need to specify the data. Like we noted earlier, once the target return is specified, other parameters that is weight and risk are automatically computed as part of the efficient portfolio. That means we have identified a particular portfolio on the efficient frontier once we specify either the risk or return.

So this is our data final return object. We need to specify that specifications are min risk. So min risk spec and lastly, since we are working with long only constraints, we will specify the constraints as long only. So with this, we will start with our min risk portfolio object. In fact, we can very well print this min risk object like this. We can see the printed object, it has portfolio weights are given, the resulting portfolio weights.

We can see the only three assets have been used NIFTY, FTSE and S&P. The covariance risk budgets are also provided along with target returns and the risk covariance or variance risk C bar var. Now let us do a little bit of visualization as we did earlier. So I will not write the command again, I will simply just copy paste the commands. Although this time around we will use a different color palette, let us call this color palette while visualizing instead of div palette, we will use QALY palette and here the color specified is let us use dark 2 theme.

So with this theme and also this is not the feasible portfolio but min risk portfolio. So we need to specify that this is not equal weight portfolio, this is min risk portfolio that we are using and this we need to highlight in the heading also, so minimum risk MB portfolio. So this is minimal risk MB portfolio. This is minimum risk MB portfolio, so we will specify likewise.

This is the minimal risk portfolio. Instead of equal weight specification, this is the minimum risk. So now let us run the visualization. So again we will specify the color, 3 windows to be plotted, first, second and third. Now because in this case as a part of efficient frontier only 3 assets were utilized. So let us have a look at this diagram.

As we can see here, you have Nifty, S&P and FTSE and their corresponding weights are provided 41%, 35.5 and 23%. We can also notice the minimal risk portfolio weighted returns, the contribution of 2 returns from all these 3 assets Nifty, S&P and FTSE and we can also see their covariance risk budgets as a part of visualization exercise. So in this video, we created a efficient portfolio. The target return was mean return of all the 7 assets, the mean returns as target and corresponding portfolio with minimum risk which is corresponding to this given return. Obviously, that portfolio will lie on the efficient frontier that portfolio has been identified with long wholly constraints.

So no short constraints, only long positions are considered and then we subsequently visualize the portfolio its 3 properties. First the weights of individual assets, we found that only 3 assets have been utilized to create this portfolio. We also visualize the weighted returns and the covariance risk budgets. In the previous video, we computed minimum risk portfolio while for every portfolio with a given expected return or a target expected return, one efficient portfolio with the minimum risk can be identified on efficient frontier. However, there is one particular portfolio for which the risk is minimum across the entire efficient frontier and this is called global minimum variance portfolio.

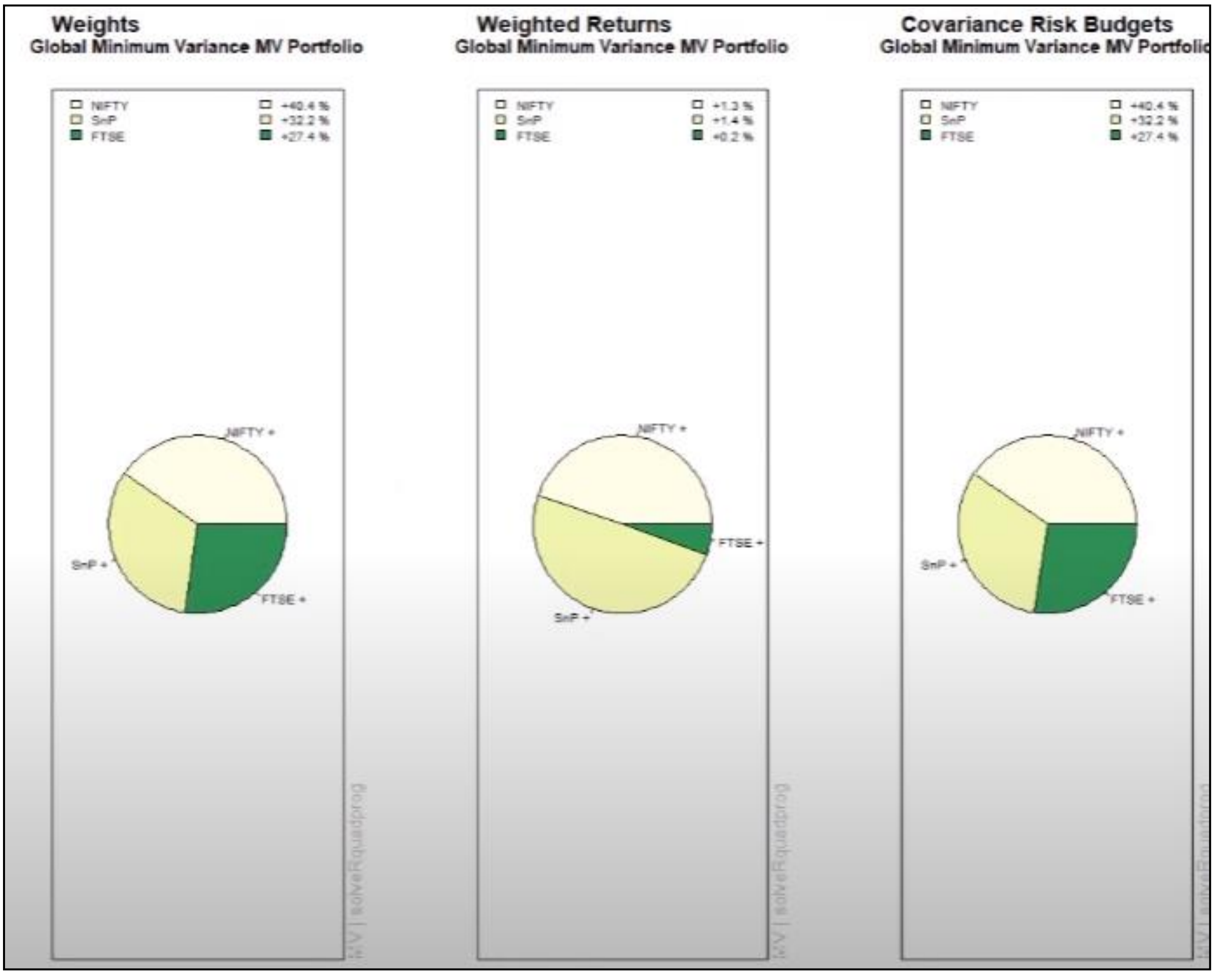
In this video, we will try to identify this global minimum variance portfolio. Let us name it global min spec, global min spec and this is portfolio spec. Let us name it global min spec specification. Let us initialize this as we have been doing in the previous videos. Now for this portfolio, let us start with global, let us call it global min portfolio and let us initialize it with the command

The command that is used is called minimum variance portfolio. Now here we specify the data which is final return. We also need to provide the spec which is global min spec. Next we need to provide the constraints and as we did earlier, we will use the long only constraints, long only. So we will initiate our portfolio object which is global minimum variance portfolio.

Let us print this. So for this portfolio, as we can see in the printed object, this portfolio employs NFTY, S&P and FTSE. We can see the respective contribution of these assets to the portfolio risk in the covariance risk budgets, 40 percent contribution to risk by NFTY, 27.9 by FTSE and 32.2 percent risk contribution by S&P. We can also see the mean value of the return, risk measure that is covariance risk of the portfolio essentially which is the variance of this portfolio C bar and bar.

So three risk measures. In this terminology, this covariance is same as the variance of the portfolio along with the C bar and bar. Now let us visualize this and again, we will use the same set of commands for visualization. So I am just copy pasting them from previous video and here we need to just change a few parameters. So this is global min portfolio. So instead of this min risk portfolio object, we will replace it with the global min portfolio.

Also in the nomenclature, the headache, we will call it global min. Instead of minimum risk, we will call it global minimum variance MB portfolio. So we will call it global minimum variance MB portfolio. And we will define a slightly interesting another color palette.



This is called Siqui palette. And here again, we will define a new color scheme, yellow green. So we use this YLGN, YLGN for yellow green. And let us run it. I will enlarge my plotting window a little bit so that graphs are clean, global minimum variance and all the three plots are here. Let us visualize them a little bit.

So we have global minimum variance MB portfolio, we can see Nifty 40%, S&P 30, those we already saw and this is in the form of pie chart.

We also have weighted returns. So that is contribution to overall returns from each asset which is Nifty 1.3, S&P 1.4 and 4C 0.2. Lastly, we have contribution to the portfolio risk around 40% from Nifty, 32% from S&P, and 27% from FTSE. So this is the risk contribution. To summarize this video, we created a global minimum variance portfolio object with long constraints. Then we visualize the portfolio, we visualize in pie chart format, we visualize the weights of different assets, we found that only three assets are employed out of the given seven assets in the minimum risk variance, global minimum risk or global minimum variance portfolio.

We also computed the weighted returns plot indicating the contribution to overall returns from different assets. Again, the three assets were employed. And then we also saw the covariance risk budget pie plots where we saw the contribution of individual assets to overall portfolio risk. Recall our discussion on video topic portfolio optimization. We noted that in the presence of risk-free lending and borrowing, there is one particular portfolio that is best among all and that portfolio was identified through a tangent line from the free rate to the efficient frontier.

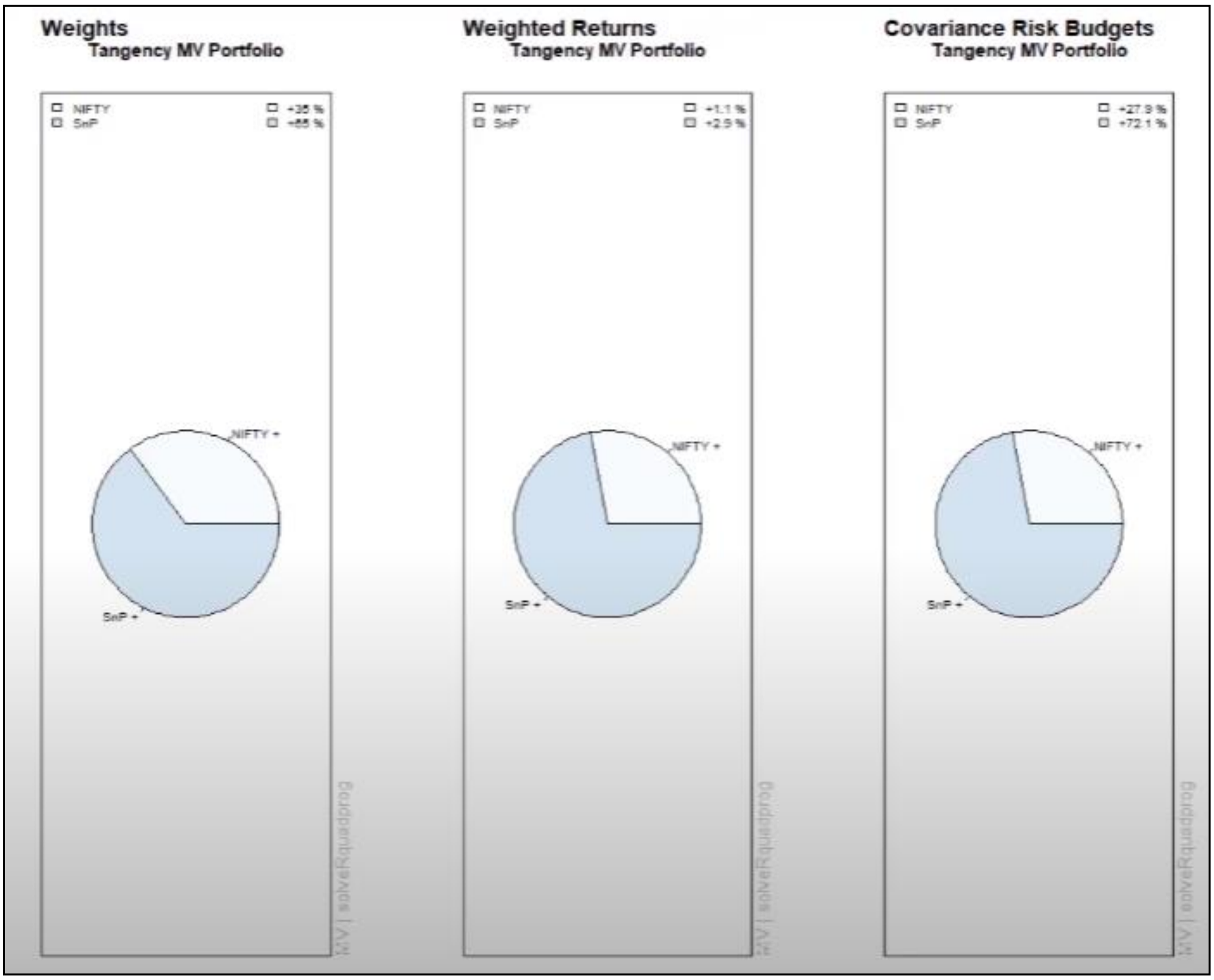
So in this video, we will try to plot visualize and construct that tangency portfolio or the best portfolio across all the portfolios. Let's call it and initialize this portfolio with TG spec. As we have done in the previous videos, we will initially initiate the object with portfolio spec, portfolio spec function, the object is initiated.

However, this object will need risk-free rate. So we will set the risk-free rate for this TG spec object. Let's have a 0% rate. So we will assign it a 0 value. One can assign depending upon the market and security, one can assign a suitable and appropriate value. Now let's call this portfolio a TG portfolio, tangency portfolio and we need the function tangency portfolio to create this object. The data employed is again final rate, which contains the seven security returns that we have selected earlier.

We need to provide the specifications which we have initiated the object TG spec object that we have initiated earlier. And we are using long only constraints later on we will also employ short constraints, but for now we are using long only constraints. So long only and this is our portfolio.

Now let's print this portfolio object. Let's see what are the contents. So for this portfolio, we have the portfolio weights. Notice only two assets are employed here. It seems these two assets, the combination of these two assets provide the best among all, Nifty, S&P, their risk budgets 27% and 72% for Nifty and S&P respectively. Their mean, the risk of the portfolio, covariance, C-bar and bar risks are provided.

Let's try to visualize this portfolio as we have been doing. And again, we will copy paste the same visualization command. Now we will use another palette, let's blue purple kind of palette with sequential. We will use this blue purple, BU, BU, blue purple. And again, this is TG portfolio object. So we will change the name from global minimum portfolio to TG portfolio, which is our tangency portfolio.



The best efficient portfolio identified through tangent line from risk free rate to this. So I need to copy paste it properly, TG portfolio instead of global minimum portfolio. Also the name has to be changed. So I have written global minimum variance MB, so I will call it tangency, tangency MB portfolio.

So this is the best efficient portfolio. We will visualize it. So I have created a color scheme. Let me plot this and let us zoom and visualize the object properly. So in this object, only two assets are employed, SNP and NFTY and as we saw 35 percent contribution, 35 percent wait for NFTY and 65 percent for recent weighted returns, the contribution to return 1.

1 percent from NFTY and 2.9 percent from SNP. Also let us look at the contribution to risk, the covariance risk budgets which indicate the contribution to risk. So NFTY has 27.9 percent while SNP has 72 percent contribution to risk, which also reflects the higher weight assigned to SNP. To summarize in this video, we computed the tangency portfolio with the risk free rate of 0 percent and long only constraints.

We also tried to visualize the portfolio. We visualize the respective weights. We found that only two assets NFTY and SNP 500 were utilized in construction of this portfolio with weights of 35 percent and 65 percent. We also found the weighted returns, the contribution to returns from these two assets in this portfolio, tangency portfolio and we also computed the contribution to the overall risk from NFTY and SNP to this tangency portfolio which works around 27.9 percent contribution from NFTY and 72.1 percent contribution from SNP as we can see in the charts. Thank you.