Investment Management
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Lecture - 33
Forming Portfolio with ETFs (Contd.)

Hi there. Welcome back and we are discussing about Forming Portfolio using ETF data for 5 years monthly return. And in previous session we discussed about how we can implement this example in solver add-in. And using this approach we try to find a portfolio that has optimal weight assigned to each of the individual ETFs 10 assets or 10 securities that we have as part of the portfolio. In this particular session we are going to talk about the implementation and the result part.

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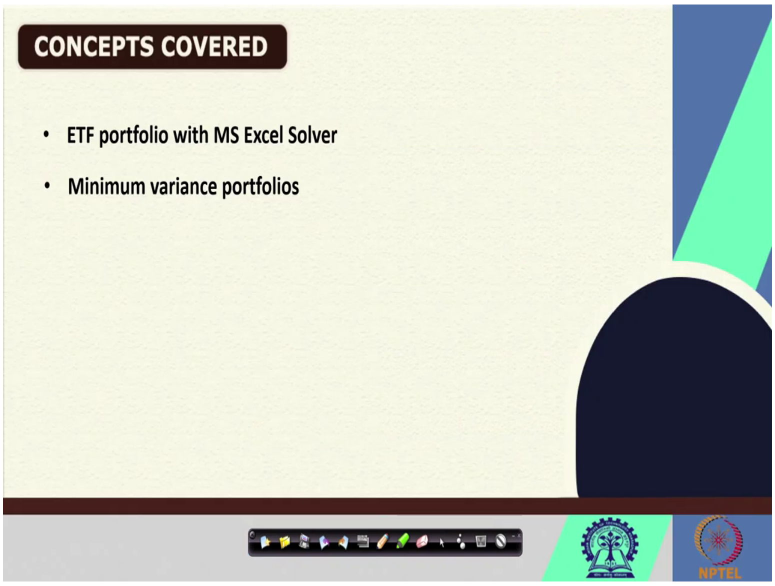

Where we will see how our ETF portfolio is constructed, where we will try to find the weight assigned to individual ETFs. Now, we know that the weight assigned to individual ETF will determine the total rate of return as well as the risk. So, we will try to find a portfolio of ETFs where each ETF will have 0 or more than 0, but less than 1 weight assigned to them.

And we will try to achieve the minimum variance or minimum portfolio risk where our return is given or for an expected rate of return that is desired by the investor. So, we will try to find weights and such that the return will be desired return, but risk will be minimum. So, in this session we will focus on finding the weight for individual securities as part of the portfolio such that the portfolio is of minimum variance portfolio.

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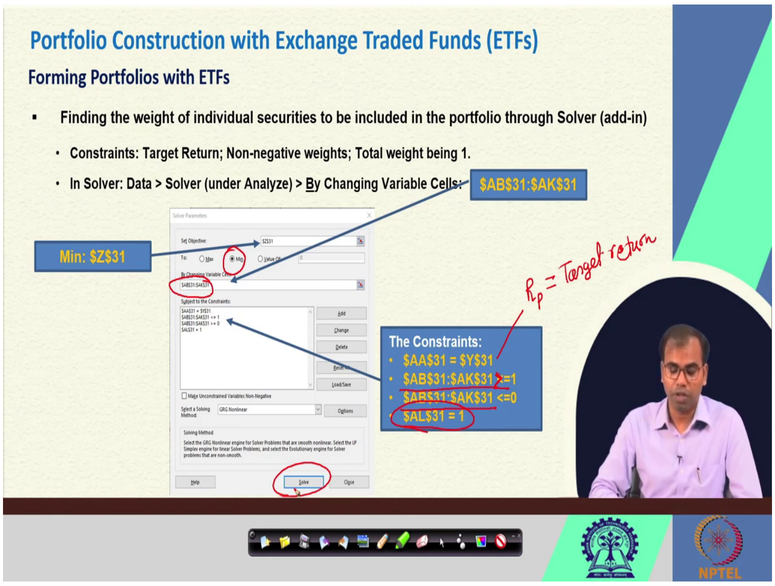

Now, if we remember earlier, we have shown that once we have the objective function of minimization of portfolio risk, we need to have certain constraint and those constraints are indicated as target return which is like desired rate of return for an investor. Then we have non-negative weights which means weights assigned to individual ETFs cannot be less than 0 or for that matter more than 1 which means total investment should not be more than total funds available for investment.

So, the weight or some total of individual weights of ETF or the money to be invested in ETFs cannot be more than 100 percent of the funds available. When we implement this constraint in the date in solver add-in we know that we have to first set the objective where we identified the cell Z31 which is the cell where we have inserted the standard deviation.

So, we will try to minimize the standard deviation by choosing this particular function. So, minimization of objective function and then we have weights indicated in these cells. So, the this particular set of cells indicate the weights of individual ETF from ETF1 through ETF10. So, we are trying to optimize the weights assigned to each of the individual securities.

So, we will be changing the value in these cells subject to the constraints and these are the constraints. So, first constraint is about portfolio return should be equal to target return the return that investor is desiring. Second constraint is about the weight of individual ETFs weight assigned to individual ETF cannot be less than more than 1. Here we have another constraint related constraint that is weight assigned to individual security cannot be less than 1.

And finally, the sum total of individual weights assigned to individual securities cannot be more anything, but less than or anything, but 100 percent of the funds available for investment. Once we put this then remaining part remaining part is related to the implementation or going for the solve function.

So, once we solve for this objective function of minimization of standard deviation by changing this values of individual weights for ETF under the constraint as defined, we will get an optimal value of weights allocated for individual ETFs. And that will get us the minimum risk that we need to bear for a given level of return for a desired level of return.

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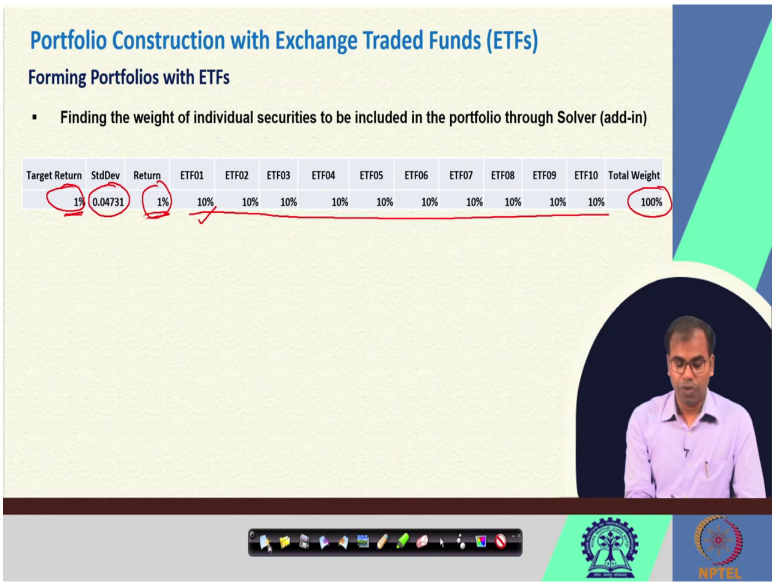

So, once we have this data set. So, once we have the data set with us, we can find this weight in assigned to individual securities or individual ETFs to start with we will assign equal weight to all the 10 ETFs that we have as part of the portfolio. And here we have given 10 percent weight to each of the individual ETF and sum total of the weight is 100 percent.

We identify a cell where we have the target return or desired level of return. And this return is a function of weight assigned to individual securities and average rate of return that we have calculated earlier by using annualized return from the 5 years data. And this particular function, this particular cell indicates about the standard deviation for the portfolio of these 10 ETFs where this is the minimum return minimum risk for given level of return.

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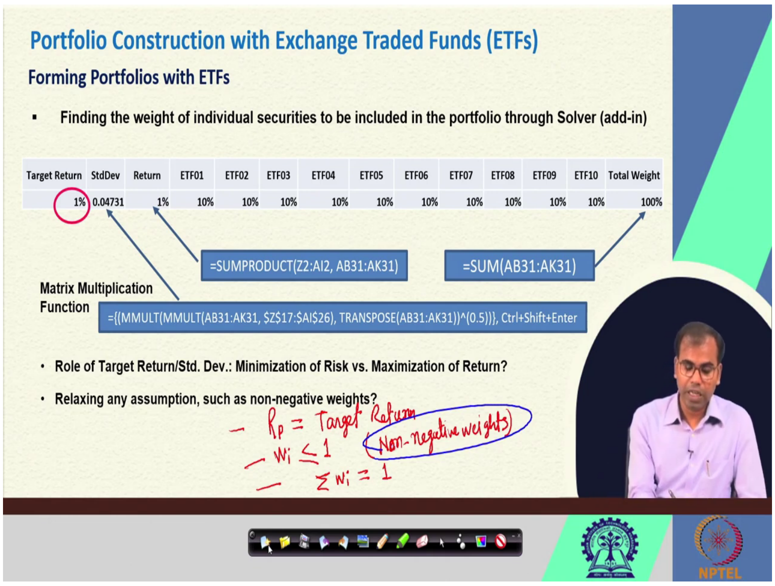

Now, with this implementation we can use these function to indicate in the Excel sheet where we have the function for finding the weighted average rate of return for individual securities, combined together to find the portfolio return. We have the sum total of all individual weights starting from ETF1 through ETF10.

And then we use this matrix multiplication function for all the returns that we have including the weights. So, we have the weights from 10, then we have the return for individual securities and we transpose the covariance matrix to find out the minimum value of standard deviation that will help us achieve this level of return.

With this function what we get as, we get the minimum standard deviation that will be required for attaining the rate of return that is desired that is indicated here. So, if we know that this is the maximum return for a given level of risk then I know that that is the optimal portfolio.

Now, we know that we can modify the objectives if earlier we see that here that the objective function is defined as the minimization of risk, we can also include the maximization of return where we will try to find for a given level of risk what will be the maximum return that an investor can earn. Or what will be the minimum risk that can be earned by changing the value of weight assigned to each individual securities and the return should be highest and risk should be minimal.

So, here we need to indicate what is our target return. So, that we can find whether the portfolio achieves that return or not. And also, if we relax any assumptions such as non-negative weights then what will be the implications that we can see? So, if we go back and see the assumptions. So, assumptions indicate that the target return, the portfolio return should be equal to target return, that is first constraint.

Second is weight of individual securities cannot need to be anything, but 0 or equal to less than or equal to 1 and it cannot be non-negative constraint which is it cannot be negative in terms of. So, non-negative weights and the sum total of all individual weights should be 1.

So, if we relax one of these assumptions such as for example, if we relax the assumption of non-negative weights which says that the individual weights assigned to the security is that we are considering as part of the portfolio can be negative which means it can be short selling, it can be a leveraged portfolio where weights of assigned to one or the more securities is negative to help achieve higher rate of return.

We will not consider that as part of this example we are trying to keep it simple. And with this let us try to see what we get out of this exercise.

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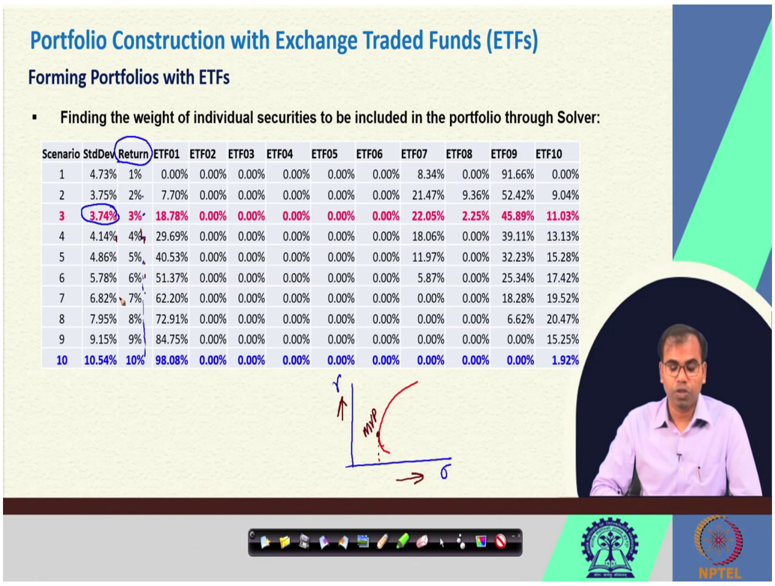

So, once we implement this in add in this is the different this is the set of scenarios that we are considering. So, assume that we are considering 10 scenarios where our desired return or target return is given here. So, in scenario 1 we have a target return of 1 percent, scenario 2 we have target return of 2 percent, scenario 3 we have target return of 3 percent, scenario 4 we have target return of 4 percent and so on.

So, we simulated 10 scenarios where we have target returns given as 1 percent through 10 percent. And for every target return we wanted to find the weight assigned to individual securities that will help us minimize the risk. And if you look at this data set you will be able to see that third scenario which is a target return of 3 percent has the minimum variance or minimum risk, which means this is the point where the portfolio is based at a location on the frontier where there is minimum risk for the investor.

So, if we visualize this on this particular graph and this is the scenario. So, we know that this is the point which is the minimum variance point. So, this particular portfolio essentially is located here after that the return might be increasing and so will be the risk. So, we can see here that risk is increasing as well and return is increasing as well. So, we know that if return is increasing 4 percent, 5 percent, 6 percent risk is also increasing correspondingly.

So, this is the point where we have the minimum risk for a given level of return. If an investor wants to earn higher return, she has to assume higher risk and that is shown by this table. What is of more interest is the weight that is calculated for each of the individual securities.

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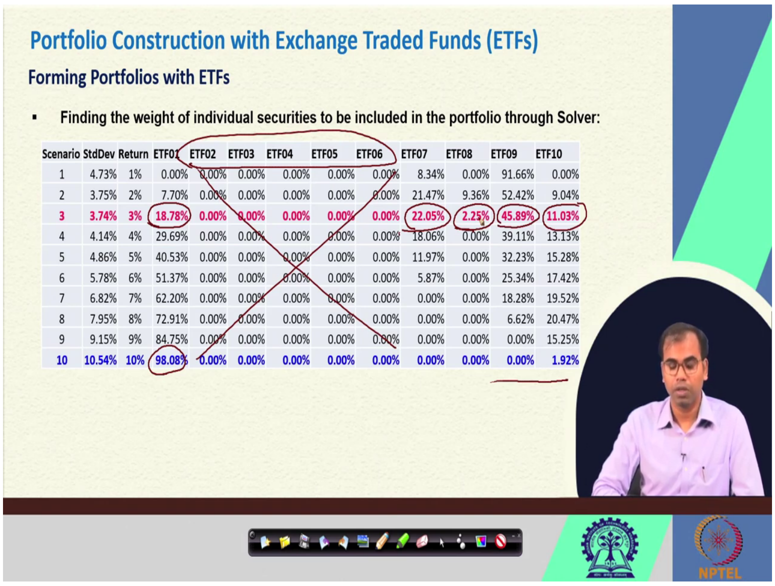

In most cases we observe that many ETFs have not got any allocation particularly from ETF2 to ETF6 we do not see any money allocated to these securities which means they are not worth considering for the portfolio. If we are ready to assume more risk, we can consider allocating more money to as ETF1 and less money to other ETFs.

If we are considering to have more return with least risk then we need to allocate the highest amount of money to ETF9, 2nd highest will be for ETF7, 3rd highest will be ETF1, 4th highest will be ETF10 and 5th highest will be ETF8. These are the allocation; these are the weights for individual securities as part of the portfolio.

So, eventually the portfolio will have only 5 assets. And these 5 assets will have this much of weight assigned to them. And this will help us achieve 3 percent of return for the minimum level of risk.

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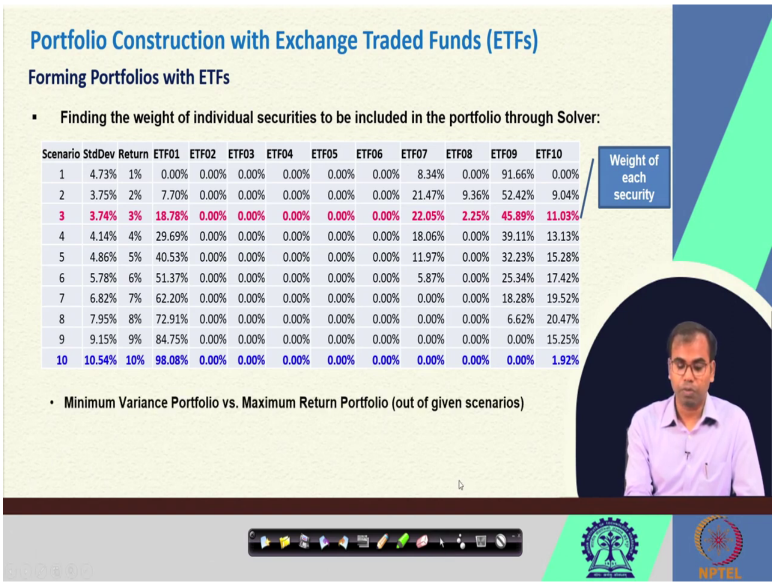

So, we this way we can find the weight of each securities to be considered for individual for the portfolio.

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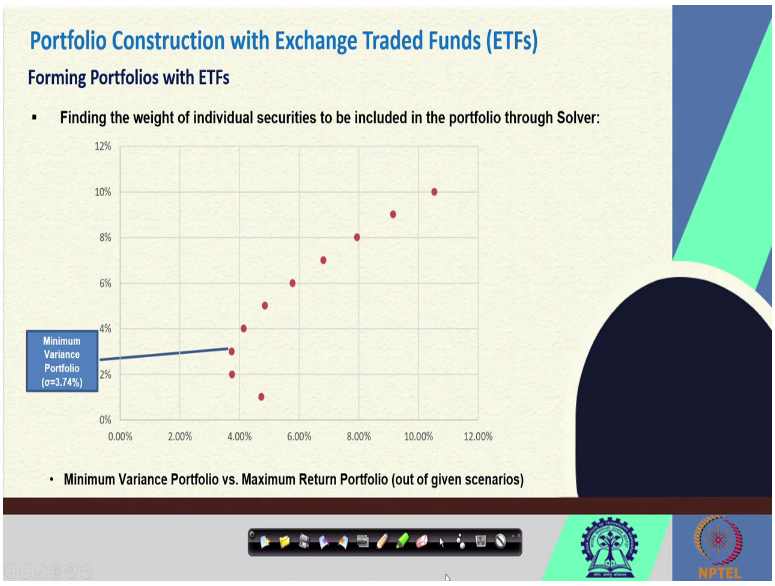

And we know that once we plot this, we can find a graph like this where this particular point is the minimum variance portfolio where standard deviation is 3.74. And as we progress further, we want to have higher return, it will also come with higher level of risk.

So, if we want to see how this works let me just quickly go through the Excels example where we have the Excel sheet with the data and this way, we can understand how we can implement the case of portfolio construction with certain number of assets with solver add-in in spreadsheet. So, I will quickly shift to Excel sheet and show how we can calculate the return. Subsequently we will we will be able to get the risk and various covariance.

So, we will simply use this data set, that same data set that we have been seeing in this example from previous session.

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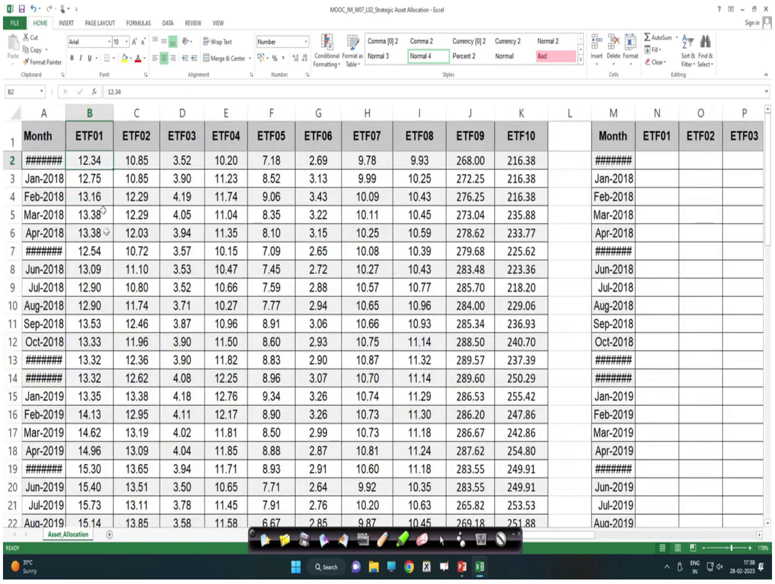

Month	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10		Month	ETF01	ETF02	ETF03
#######	12.34	10.85	3.52	10.20	7.18	2.69	9.78	9.93	268.00	216.38		#######			
Jan-2018	12.75	10.85	3.90	11.23	8.52	3.13	9.99	10.25	272.25	216.38		Jan-2018			
Feb-2018	13.16	12.29	4.19	11.74	9.06	3.43	10.09	10.43	276.25	216.38		Feb-2018			
Mar-2018	13.38	12.29	4.05	11.04	8.35	3.22	10.11	10.45	273.04	235.88		Mar-2018			
Apr-2018	13.38	12.03	3.94	11.35	8.10	3.15	10.25	10.59	278.62	233.77		Apr-2018			
#######	12.54	10.72	3.57	10.15	7.09	2.65	10.08	10.39	279.68	225.62		#######			
Jun-2018	13.09	11.10	3.53	10.47	7.45	2.72	10.27	10.43	283.48	223.36		Jun-2018			
Jul-2018	12.90	10.80	3.52	10.66	7.59	2.88	10.57	10.77	285.70	218.20		Jul-2018			
Aug-2018	12.90	11.74	3.71	10.27	7.77	2.94	10.65	10.96	284.00	229.06		Aug-2018			
Sep-2018	13.53	12.46	3.87	10.96	8.91	3.06	10.66	10.93	285.34	236.93		Sep-2018			
Oct-2018	13.33	11.96	3.90	11.50	8.60	2.93	10.75	11.14	288.50	240.70		Oct-2018			
#######	13.32	12.36	3.90	11.82	8.83	2.90	10.87	11.32	289.57	237.39		#######			
#######	13.32	12.62	4.08	12.25	8.96	3.07	10.70	11.14	289.60	250.29		#######			
Jan-2019	13.35	13.38	4.18	12.76	9.34	3.26	10.74	11.29	286.53	255.42		Jan-2019			
Feb-2019	14.13	12.95	4.11	12.17	8.90	3.26	10.73	11.30	286.20	247.86		Feb-2019			
Mar-2019	14.62	13.19	4.02	11.81	8.50	2.99	10.73	11.18	286.67	242.86		Mar-2019			
Apr-2019	14.96	13.09	4.04	11.85	8.88	2.87	10.81	11.24	287.62	254.80		Apr-2019			
#######	15.30	13.65	3.94	11.71	8.93	2.91	10.60	11.18	283.55	249.91		#######			
Jun-2019	15.40	13.51	3.50	10.65	7.71	2.64	9.92	10.35	283.55	249.91		Jun-2019			
Jul-2019	15.73	13.11	3.78	11.45	7.91	2.76	10.20	10.63	265.82	253.53		Jul-2019			
Aug-2019	15.14	13.85	3.58	11.58	6.67	2.85	9.87	10.45	269.18	251.88		Aug-2019			

So, we have the data set on 10 ETFs ETF1 through ETF10 from January 2017 to December 2022.

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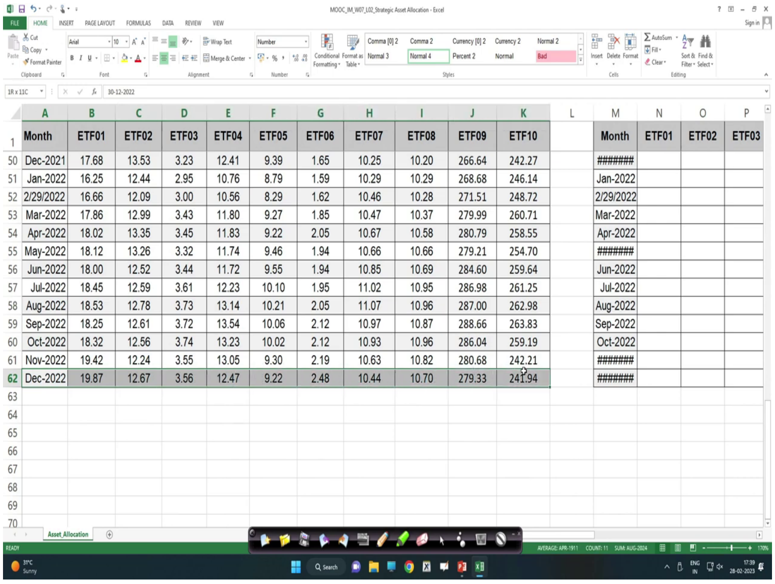

Month	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10		Month	ETF01	ETF02	ETF03
Dec-2021	17.68	13.53	3.23	12.41	9.39	1.65	10.25	10.20	266.64	242.27		#######			
Jan-2022	16.25	12.44	2.95	10.76	8.79	1.59	10.29	10.29	268.68	246.14		Jan-2022			
2/29/2022	16.66	12.09	3.00	10.56	8.29	1.62	10.46	10.28	271.51	248.72		2/29/2022			
Mar-2022	17.86	12.99	3.43	11.80	9.27	1.85	10.47	10.37	279.99	260.71		Mar-2022			
Apr-2022	18.02	13.35	3.45	11.83	9.22	2.05	10.67	10.58	280.79	258.55		Apr-2022			
May-2022	18.12	13.26	3.32	11.74	9.46	1.94	10.66	10.66	279.21	254.70		#######			
Jun-2022	18.00	12.52	3.44	11.72	9.55	1.94	10.85	10.69	284.60	259.64		Jun-2022			
Jul-2022	18.45	12.59	3.61	12.23	10.10	1.95	11.02	10.95	286.98	261.25		Jul-2022			
Aug-2022	18.53	12.78	3.73	13.14	10.21	2.05	11.07	10.96	287.00	262.98		Aug-2022			
Sep-2022	18.25	12.61	3.72	13.54	10.06	2.12	10.97	10.87	288.66	263.83		Sep-2022			
Oct-2022	18.32	12.56	3.74	13.23	10.02	2.12	10.93	10.96	286.04	259.19		Oct-2022			
Nov-2022	19.42	12.24	3.55	13.05	9.30	2.19	10.63	10.82	280.68	242.21		#######			
Dec-2022	19.87	12.67	3.56	12.47	9.22	2.48	10.44	10.70	279.33	241.94		#######			

First step is to calculate the return. So, here this particular table is. So, going to calculate the return as I was indicating that first return will be calculated in the month of January 2018 where we use the price data of January 2018 minus price data of December 2017 divided by price data of December 2017 will get us the return for January month for first ETF. Similarly, we can calculate for second ETF, third ETF.

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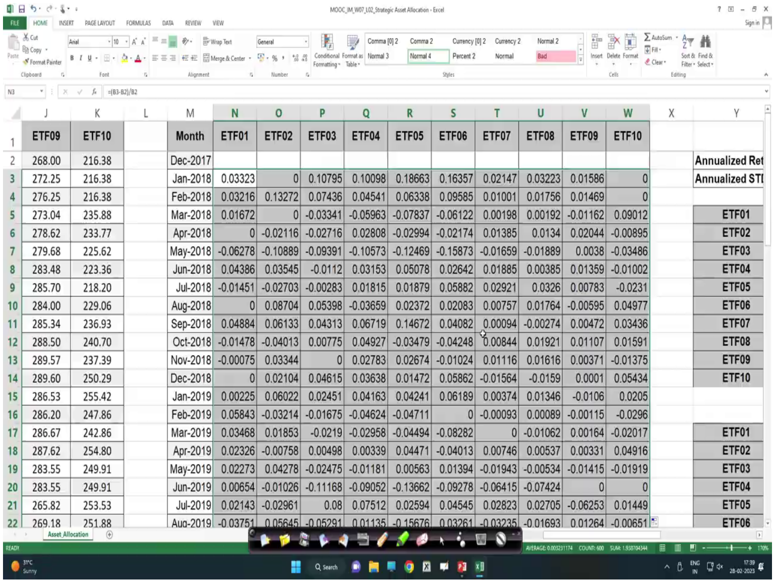

	ETF09	ETF10	Month	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10	
2	268.00	216.38	Dec-2017											Annualized Ret
3	272.25	216.38	Jan-2018	0.03323	0	0.10795	0.10098	0.18663	0.16357	0.02147	0.03223	0.01586	0	Annualized STI
4	276.25	216.38	Feb-2018	0.03216	0.13272	0.07436	0.04541	0.06338	0.09585	0.01001	0.01756	0.01469	0	
5	273.04	235.88	Mar-2018	0.01672	0	-0.03341	-0.05963	-0.07837	-0.06122	0.00198	0.00192	-0.01162	0.09012	ETF01
6	278.62	233.77	Apr-2018	0	-0.02116	-0.02716	0.02808	-0.02994	-0.02174	0.01385	0.0134	0.02044	-0.00895	ETF02
7	279.68	225.62	May-2018	-0.06278	-0.10889	-0.09391	-0.10573	-0.12469	-0.15873	-0.01659	-0.01889	0.0038	-0.03486	ETF03
8	283.48	223.36	Jun-2018	0.04386	0.03545	-0.0112	0.03153	0.05078	0.02642	0.01885	0.00385	0.01359	-0.01002	ETF04
9	285.70	218.20	Jul-2018	-0.01451	-0.02703	-0.00283	0.01815	0.01879	0.05882	0.02921	0.0326	0.00783	-0.0231	ETF05
10	284.00	229.06	Aug-2018	0	0.08704	0.05398	-0.03659	0.02372	0.02083	0.00757	0.01764	-0.00595	0.04977	ETF06
11	285.34	236.93	Sep-2018	0.04884	0.06133	0.04313	0.06719	0.14672	0.04082	0.00094	-0.00274	0.00472	0.03436	ETF07
12	288.50	240.70	Oct-2018	-0.01478	-0.04013	0.00775	0.04927	-0.03479	-0.04248	0.00844	0.01921	0.01107	0.01591	ETF08
13	289.57	237.39	Nov-2018	-0.00075	0.03344	0	0.02783	0.02674	-0.01024	0.01116	0.01616	0.00371	-0.01375	ETF09
14	289.60	250.29	Dec-2018	0	0.02104	0.04615	0.03638	0.01472	0.05862	-0.01564	-0.0159	0.0001	0.05434	ETF10
15	286.53	255.42	Jan-2019	0.00225	0.06022	0.02451	0.04163	0.04241	0.06189	0.00374	0.01346	-0.0106	0.0205	
16	286.20	247.86	Feb-2019	0.05843	-0.03214	-0.01675	-0.04624	-0.04711	0	-0.00093	0.00089	-0.00115	-0.0296	
17	286.67	242.86	Mar-2019	0.03468	0.01853	-0.0219	-0.02958	-0.04494	-0.08282	0	-0.01062	0.00164	-0.02017	ETF01
18	287.62	254.80	Apr-2019	0.02326	-0.00758	0.00498	0.00339	0.04471	-0.04013	0.00746	0.00537	0.00331	0.04916	ETF02
19	283.55	249.91	May-2019	0.02273	0.04278	-0.02475	-0.01181	0.00563	0.01394	-0.01943	-0.00534	-0.01415	-0.01919	ETF03
20	283.55	249.91	Jun-2019	0.00654	-0.01026	-0.11168	-0.09052	-0.13662	-0.09278	-0.06415	-0.07424	0	0	ETF04
21	265.82	253.53	Jul-2019	0.02143	-0.02961	0.08	0.07512	0.02594	0.04545	0.02823	0.02705	-0.06253	0.01449	ETF05
22	269.18	251.88	Aug-2019	-0.03751	0.05645	-0.05291	0.01135	-0.15676	0.03261	-0.03235	-0.01693	0.01264	-0.00651	ETF06

We can calculate this return for all 10 ETFs and we can drag it down to find the return for individual securities for individual month.

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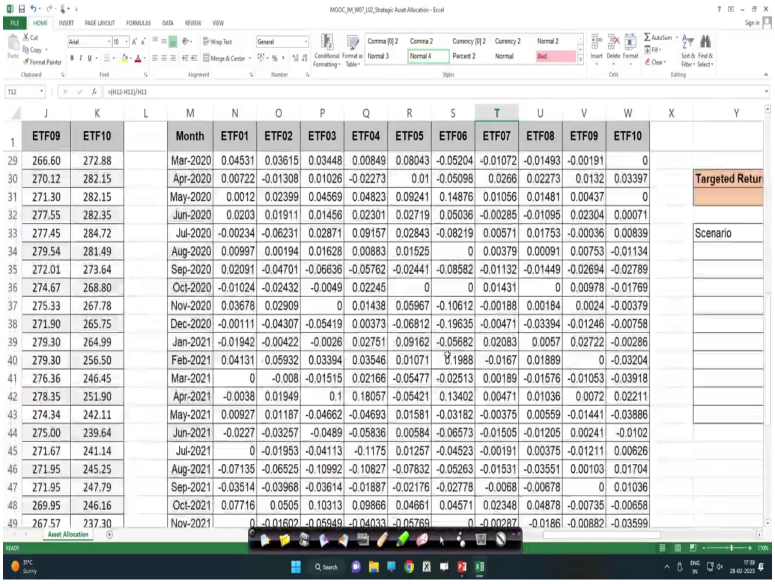

	ETF09	ETF10	Month	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10
29	266.60	272.88	Mar-2020	0.04531	0.03615	0.03448	0.00849	0.08043	-0.05204	-0.01072	-0.01493	-0.00191	0
30	270.12	282.15	Apr-2020	0.00722	-0.01308	0.01026	-0.02273	0.01	-0.05098	0.0266	0.02273	0.0132	0.03397
31	271.30	282.15	May-2020	0.0012	0.02399	0.04569	0.04823	0.09241	0.14876	0.01056	0.01481	0.00437	0
32	277.55	282.35	Jun-2020	0.0203	0.01911	0.01456	0.02301	0.02719	0.05036	-0.00285	-0.01095	0.02304	0.00071
33	277.45	284.72	Jul-2020	-0.00234	-0.06231	0.02871	0.09157	0.02843	-0.08219	0.00571	0.01753	-0.00036	0.00839
34	279.54	281.49	Aug-2020	0.00997	0.00194	0.01628	0.00883	0.01525	0	0.00379	0.00091	0.00753	-0.01134
35	272.01	273.64	Sep-2020	0.02091	-0.04701	-0.06636	-0.05762	-0.02441	-0.08582	-0.01132	-0.01449	-0.02694	-0.02789
36	274.67	268.80	Oct-2020	-0.01024	-0.02432	-0.0049	0.02245	0	0	0.01431	0	0.00978	-0.01769
37	275.33	267.78	Nov-2020	0.03678	0.02909	0	0.01438	0.05967	-0.10612	-0.00188	0.00184	0.0024	-0.00379
38	271.90	265.75	Dec-2020	-0.00111	-0.04307	-0.05419	0.00373	-0.06812	-0.19635	-0.00471	-0.03394	-0.01246	-0.00758
39	279.30	264.99	Jan-2021	-0.01942	-0.00422	-0.0026	0.02751	0.09162	-0.05682	0.02083	0.0057	0.02722	-0.00286
40	279.30	256.50	Feb-2021	0.04131	0.05932	0.03394	0.03546	0.01071	0.1988	-0.0167	0.01889	0	-0.03204
41	276.36	246.45	Mar-2021	0	-0.008	-0.01515	0.02166	-0.05477	-0.02513	0.00189	-0.01576	-0.01053	-0.03918
42	278.35	251.90	Apr-2021	-0.0038	0.01949	0.1	0.18057	-0.05421	0.13402	0.00471	0.01036	0.0072	0.02211
43	274.34	242.11	May-2021	0.00927	0.01187	-0.04662	-0.04693	0.01581	-0.03182	-0.00375	0.00559	-0.01441	-0.03886
44	275.00	239.64	Jun-2021	-0.0227	-0.03257	-0.0489	-0.05836	0.00584	-0.06573	-0.01505	-0.01205	0.00241	-0.0102
45	271.67	241.14	Jul-2021	0	-0.01953	-0.04113	-0.1175	0.01257	-0.04523	-0.00191	0.00375	-0.01211	0.00626
46	271.95	245.25	Aug-2021	-0.07135	-0.06525	-0.10992	-0.10827	-0.07832	-0.05263	-0.01531	-0.03551	0.00103	0.01704
47	271.95	247.79	Sep-2021	-0.03514	-0.03968	-0.03614	-0.01887	-0.02176	-0.02778	-0.0068	-0.00678	0	0.01036
48	269.95	246.16	Oct-2021	0.07716	0.0505	0.10313	0.09866	0.04661	0.04571	0.02348	0.04878	-0.00735	-0.00658
49	267.57	237.30	Nov-2021	0	-0.01602	-0.05949	-0.04033	-0.05769	0	-0.00287	-0.0186	-0.00882	-0.03599

So, this is the way we calculate the return.

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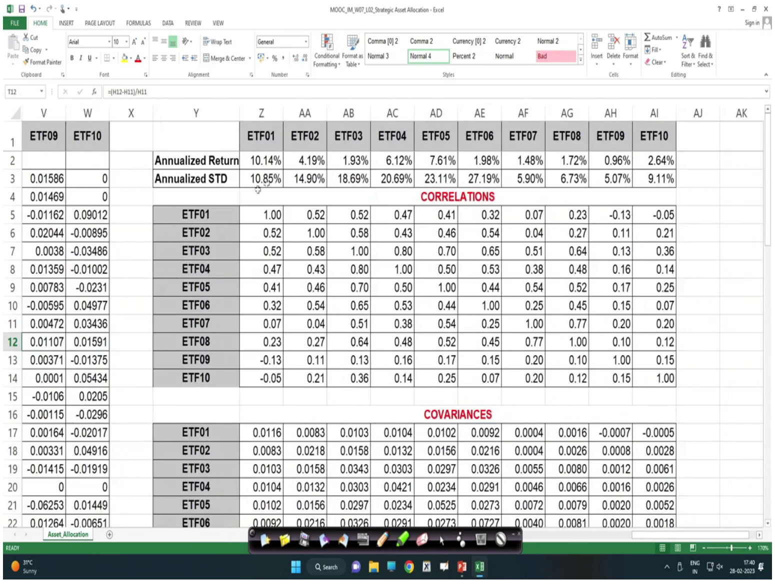

	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI
1	ETF09	ETF10			ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10
2				Annualized Return	10.14%	4.19%	1.93%	6.12%	7.61%	1.98%	1.48%	1.72%	0.96%	2.64%
3	0.01586	0		Annualized STD	10.85%	14.90%	18.69%	20.69%	23.11%	27.19%	5.90%	6.73%	5.07%	9.11%
4	0.01469	0							CORRELATIONS					
5	-0.01162	0.09012		ETF01	1.00	0.52	0.52	0.47	0.41	0.32	0.07	0.23	-0.13	-0.05
6	0.02044	-0.00895		ETF02	0.52	1.00	0.58	0.43	0.46	0.54	0.04	0.27	0.11	0.21
7	0.0038	-0.03486		ETF03	0.52	0.58	1.00	0.80	0.70	0.65	0.51	0.64	0.13	0.36
8	0.01359	-0.01002		ETF04	0.47	0.43	0.80	1.00	0.50	0.53	0.38	0.48	0.16	0.14
9	0.00783	-0.0231		ETF05	0.41	0.46	0.70	0.50	1.00	0.44	0.54	0.52	0.17	0.25
10	-0.00595	0.04977		ETF06	0.32	0.54	0.65	0.53	0.44	1.00	0.25	0.45	0.15	0.07
11	0.00472	0.03436		ETF07	0.07	0.04	0.51	0.38	0.54	0.25	1.00	0.77	0.20	0.20
12	0.01107	0.01591		ETF08	0.23	0.27	0.64	0.48	0.52	0.45	0.77	1.00	0.10	0.12
13	0.00371	-0.01375		ETF09	-0.13	0.11	0.13	0.16	0.17	0.15	0.20	0.10	1.00	0.15
14	0.0001	0.05434		ETF10	-0.05	0.21	0.36	0.14	0.25	0.07	0.20	0.12	0.15	1.00
15	-0.0106	0.0205												
16	-0.00115	-0.0296							COVARIANCES					
17	0.00164	-0.02017		ETF01	0.0116	0.0083	0.0103	0.0104	0.0102	0.0092	0.0004	0.0016	-0.0007	-0.0005
18	0.00331	0.04916		ETF02	0.0083	0.0218	0.0158	0.0132	0.0156	0.0216	0.0004	0.0026	0.0008	0.0028
19	-0.01415	-0.01919		ETF03	0.0103	0.0158	0.0343	0.0303	0.0297	0.0326	0.0055	0.0080	0.0012	0.0061
20	0	0		ETF04	0.0104	0.0132	0.0303	0.0421	0.0234	0.0291	0.0046	0.0066	0.0016	0.0026
21	-0.06253	0.01449		ETF05	0.0102	0.0156	0.0297	0.0234	0.0525	0.0273	0.0072	0.0079	0.0020	0.0052
22	0.01264	-0.00651		ETF06	0.0092	0.0216	0.0326	0.0291	0.0273	0.0727	0.0040	0.0081	0.0020	0.0018

Now, second step is to calculate the annualized return and standard deviation. Here we have used the function of annualized return for individual ETFs. So, we can use the function for calculating the annualized return for the entire sample period that is 5 years which is 60 months, 12 years 12 months into 5 years.

So, 60 months, we calculated the annualized return and annualized standard deviation for individual securities. Subsequently, we calculated the correlation pairwise correlation for individual securities with itself and others and subsequently we calculated the covariance. Next task was based on solver.

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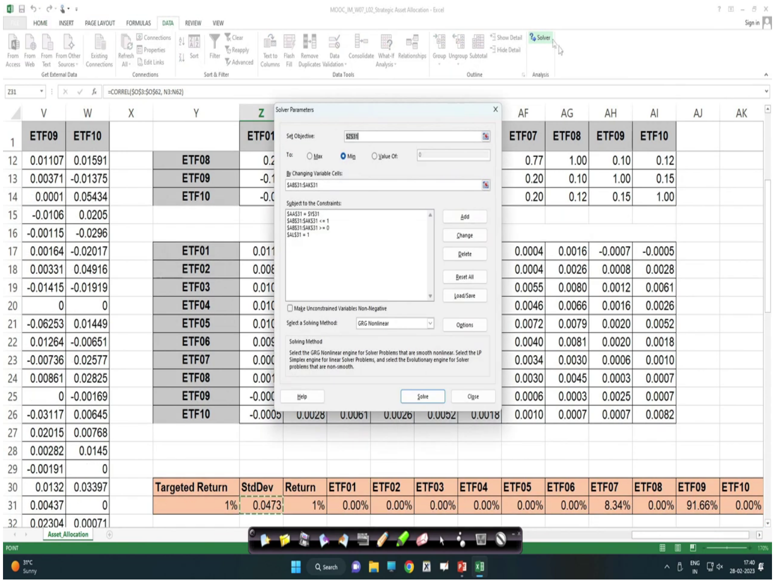

So, if we look at the solver, we have the solver here. And we can see that in solver we have this objective function which is basically minimization of Z31 which is basically Z31 this particular cell. Then we have by changing the variable cell that is weight assigned to each of these securities here in from 1 ETF1 through ETF10 under constraint of as following.

So, if you look at the constraint, we have this AA31 is equal to Y31 which is basically this return should be the portfolio return should be equal to target return. Second constraint is about the weight cannot be less than equal to more than equal to 1 and weight cannot be less than 0. And finally, the sum total of all the weight should be equal to 1. So, with this constraint we can go ahead and see here.

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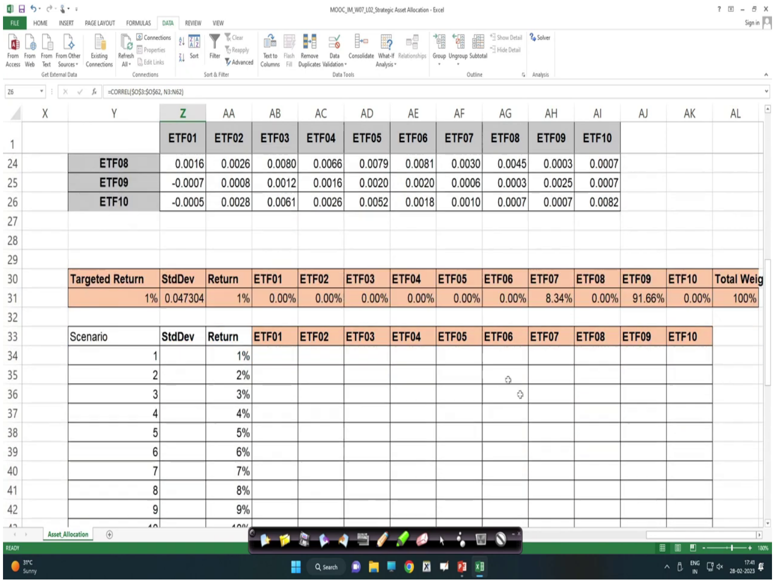

So, here if we look at this particular table this tells us about the 10 ETFs and if we use this 10 ETF for equally weighted portfolio to start with let us assign 10 percent weight to each of the ETFs. And then we can find the portfolio return which is basically some product of return of individual securities that is the annualized rate of return here and weight assigned to each of the securities.

And if we target for 4 percent return then this will be the standard deviation, but let us look at the target return. If first scenario is 1 percent target return and this is the standard deviation for the portfolio.

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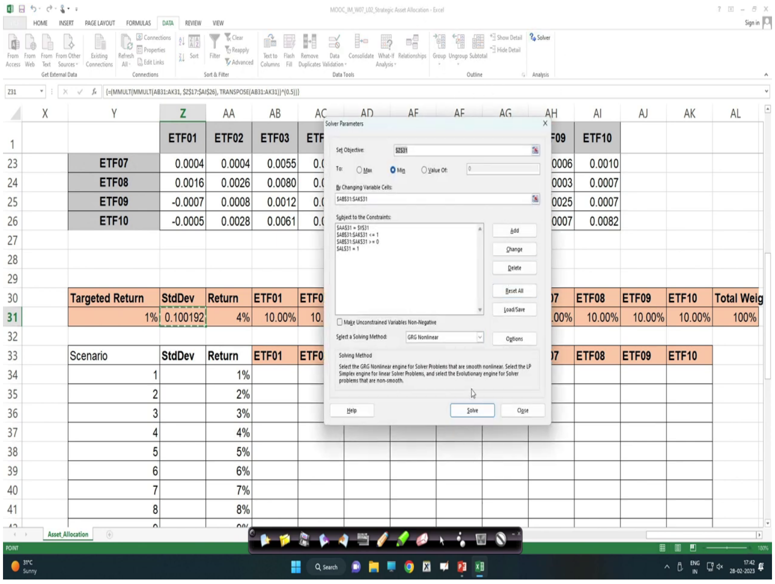

Using solver function, we can simply solve this objective function of minimization of standard deviation and we get this 1 percent of portfolio return for this much of risk.

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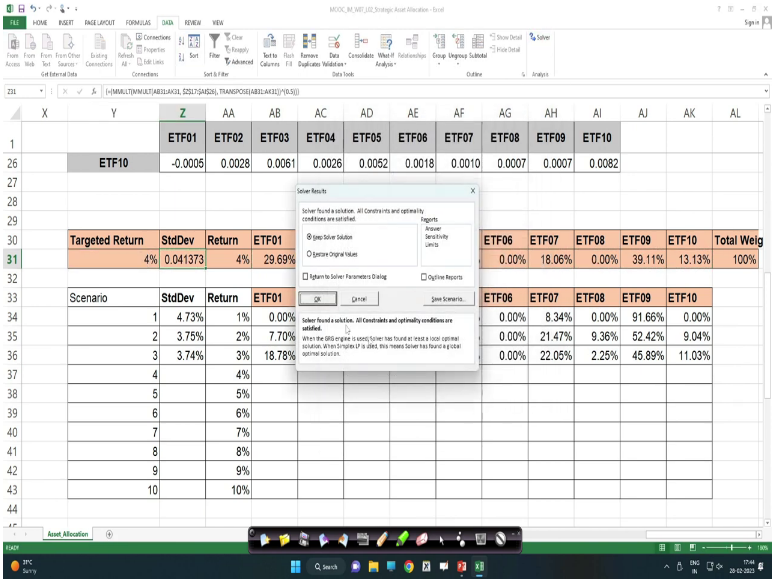

And this is the weight that is assigned to individual securities. So, we get for the first scenario where we have the 1 percent return, 4 percent, 4.73 percent of standard deviation and risk weight assigned to individual securities in this way. Similarly, we change the target return to 2 percent, solve this again for the same approach.

We get 3.75 percent of risk and weight allocation to the 10 ETFs is given here. We will repeat this exercise for every scenario. Here we are considering only 10 scenarios of 1 percent each. So, 1 percent, 2 percent, 3 percent, 4 percent till 10 percent. It can be any other percentage of target return that individual investor can desire. Similarly, we can continue for more scenarios, but due to time and other constraint we are considering only 10 scenarios of return where we have percentage of portfolio return given.

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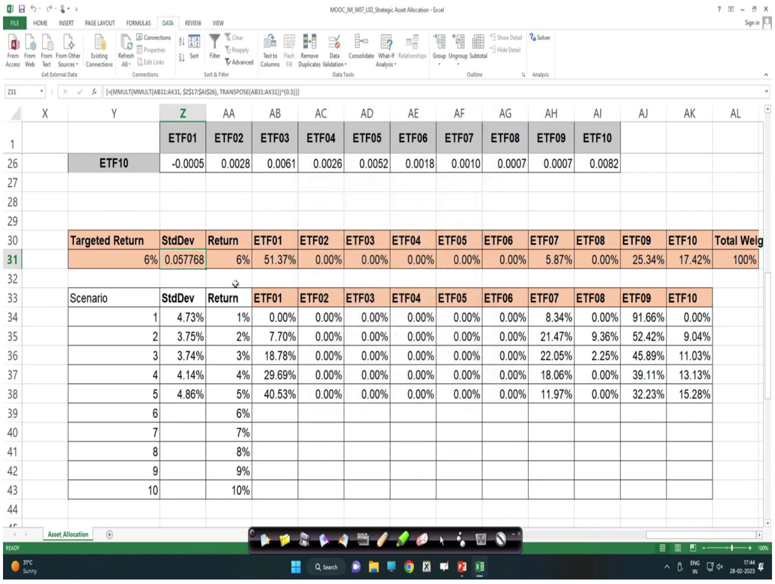

	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10
ETF10	-0.0005	0.0028	0.0061	0.0026	0.0052	0.0018	0.0010	0.0007	0.0007	0.0082

Targeted Return	StdDev	Return	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10	Total Weig
6%	0.057768	6%	51.37%	0.00%	0.00%	0.00%	0.00%	0.00%	5.87%	0.00%	25.34%	17.42%	100%

Scenario	StdDev	Return	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10
1	4.73%	1%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.34%	0.00%	91.66%	0.00%
2	3.75%	2%	7.70%	0.00%	0.00%	0.00%	0.00%	0.00%	21.47%	9.36%	52.42%	9.04%
3	3.74%	3%	18.78%	0.00%	0.00%	0.00%	0.00%	0.00%	22.05%	2.25%	45.89%	11.03%
4	4.14%	4%	29.69%	0.00%	0.00%	0.00%	0.00%	0.00%	18.06%	0.00%	39.11%	13.13%
5	4.86%	5%	40.53%	0.00%	0.00%	0.00%	0.00%	0.00%	11.97%	0.00%	32.23%	15.28%
6		6%										
7		7%										
8		8%										
9		9%										
10		10%										

And we optimize the weight to find the asset allocation for individual securities that are part of it this portfolio. Here there are 10 assets ETF1 through ETF10 and we are trying to find the weight to be assigned under different scenarios. As you can see solver helps us achieve the optimal weight to be assigned to individual 10 ETFs. And as I was telling earlier that in not in all scenarios every ETF will get allocation which means some ETFs are simply not feasible, not optimal for inclusion in the portfolio.

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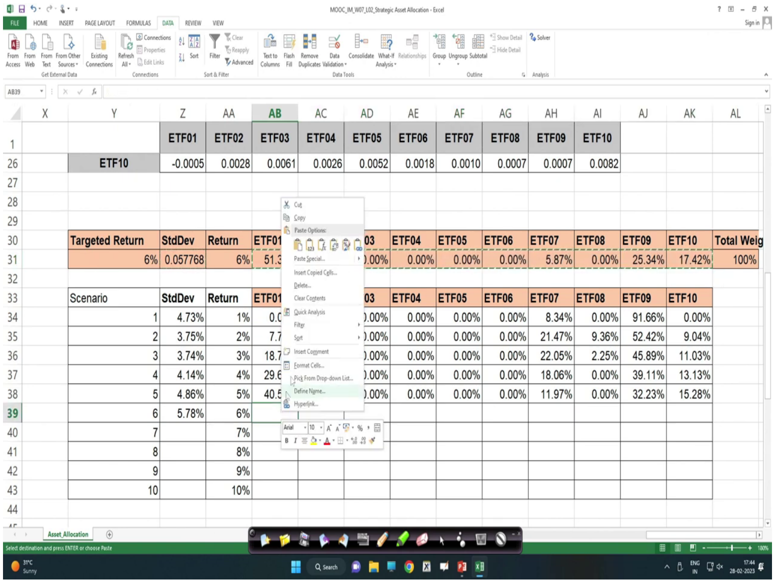

And that is why they are not getting allocated or they are not getting any weight as such. So, once we have this repeat exercise done, we know that we have the scenarios created here for 10 different target returns.

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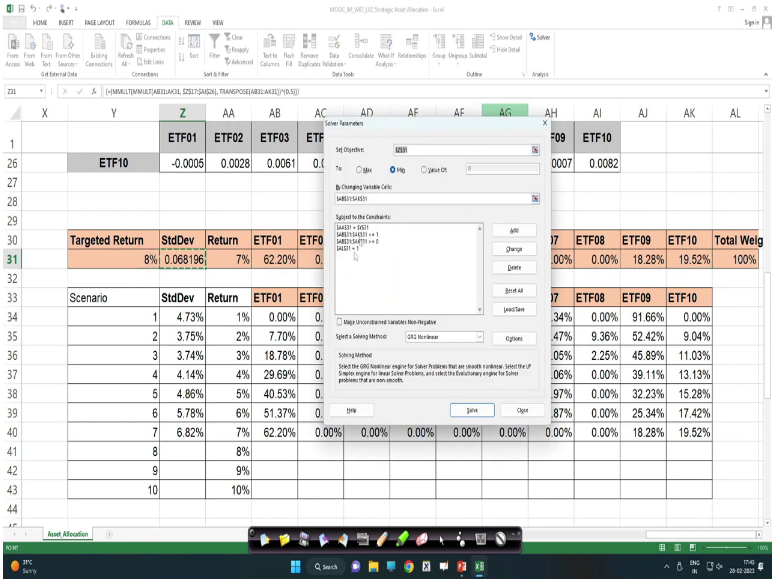

We get individual weights for each of the 10 ETFs.

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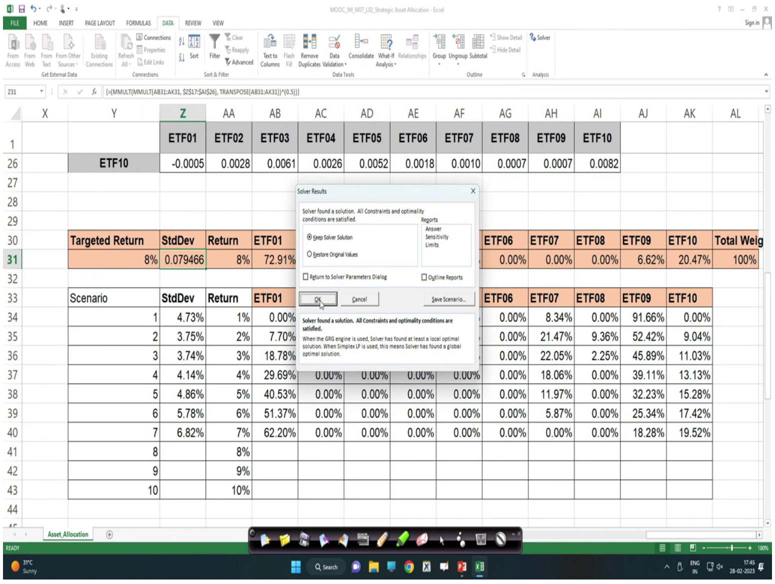

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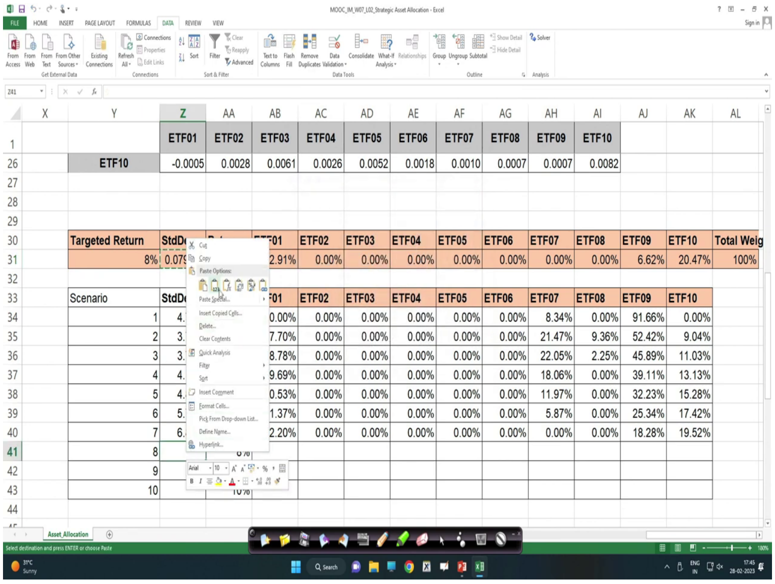

And this way we can compare what is the allocation for each of the ETFs that we have as part of our portfolio and what should be the minimum return that what should be the minimum risk that we should be ready to accept for a given level of target return.

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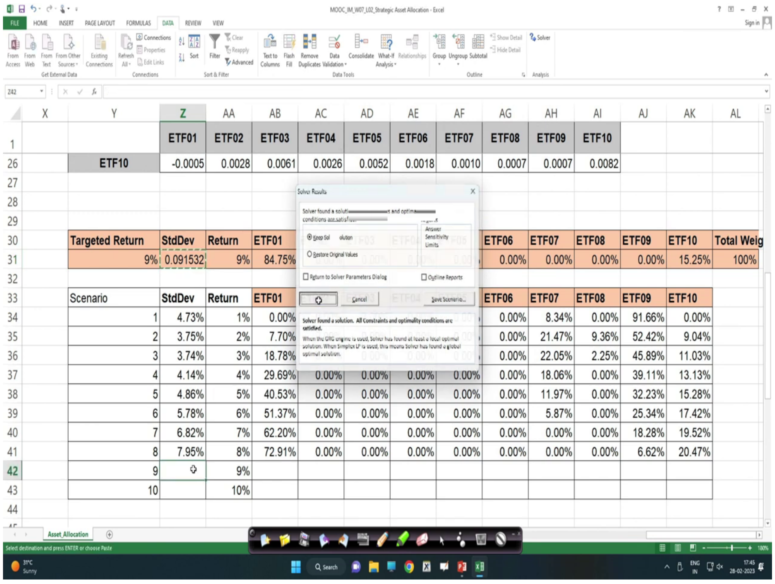

So, if we decide about the target return and we know that solver will give us minimum risk that we have to accept and it will also help us identify which assets are to be included as part of the portfolio in what proportion. So, these 10 scenarios will tell us about the minimum risk that we have to accept and the weight of individual securities.

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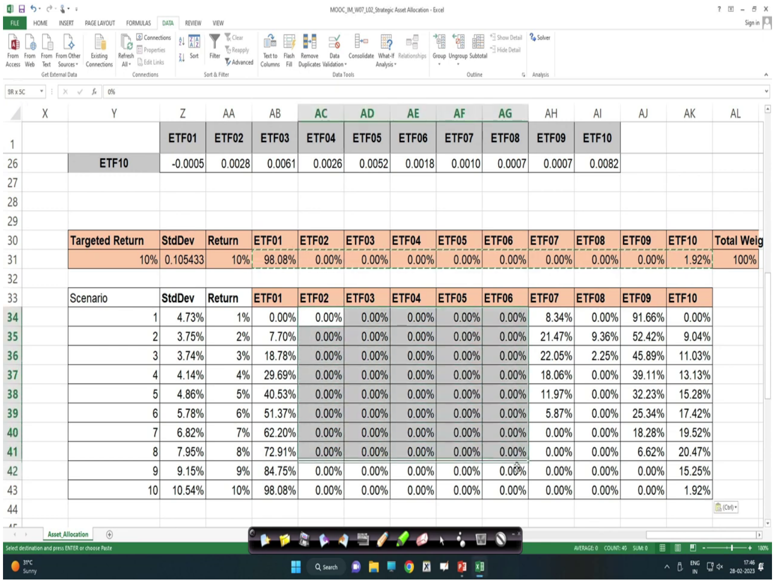

	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10
ETF10	-0.0005	0.0028	0.0061	0.0026	0.0052	0.0018	0.0010	0.0007	0.0007	0.0082

Targeted Return	StdDev	Return	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10	Total Weig
10%	0.105433	10%	98.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.92%	100%

Scenario	StdDev	Return	ETF01	ETF02	ETF03	ETF04	ETF05	ETF06	ETF07	ETF08	ETF09	ETF10
1	4.73%	1%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.34%	0.00%	91.66%	0.00%
2	3.75%	2%	7.70%	0.00%	0.00%	0.00%	0.00%	0.00%	21.47%	9.36%	52.42%	9.04%
3	3.74%	3%	18.78%	0.00%	0.00%	0.00%	0.00%	0.00%	22.05%	2.25%	45.89%	11.03%
4	4.14%	4%	29.69%	0.00%	0.00%	0.00%	0.00%	0.00%	18.06%	0.00%	39.11%	13.13%
5	4.86%	5%	40.53%	0.00%	0.00%	0.00%	0.00%	0.00%	11.97%	0.00%	32.23%	15.28%
6	5.78%	6%	51.37%	0.00%	0.00%	0.00%	0.00%	0.00%	5.87%	0.00%	25.34%	17.42%
7	6.82%	7%	62.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	18.28%	19.52%
8	7.95%	8%	72.91%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.62%	20.47%
9	9.15%	9%	84.75%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	15.25%
10	10.54%	10%	98.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.92%

And as I was showing earlier it would not have allocation to certain assets and these assets are basically not feasible, not competitive and that is why they are not getting any allocation. Whereas, the some assets are getting higher allocation under certain circumstances.

Some other assets are getting higher allocation under certain different circumstances. If someone is looking for a lower risk with reasonable ok is return then more allocation is done towards ETF9, but if someone is looking for higher risk and higher return then more allocation is happening to ETF1.

This way we can create scenario and find the weight. These weights essentially implies that if we have 100 rupees, we will invest in scenario 10. It tells us that if we have 100 rupees 98.08

will be invested in ETF1 and 1.92 will be invested in ETF10 and that will give us a return of 10 percent and a risk of 10.4 percent. If we just simply want to change the assumption.

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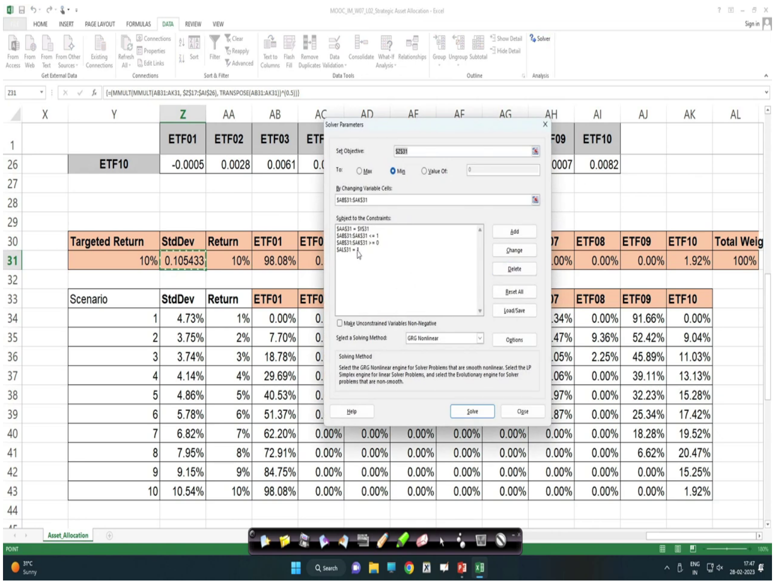

Suppose if we relax the assumption that the weight need not to be non-negative. If sorry, weight cannot be just 0 or higher than 0 it can be non it can be negative as well. So, if we remove this assumption, if we remove this constraint which means that weight can be negative as well. And once, we change this constraint and we solve this for the same objective function, we realize that for 10 percent of target return the risk now is 7.23 percent how does that happen?

Because this risk has been changed and we see that we asset allocation has changed drastically. Here certain assets have got negative weights and other assets have got positive weights which means short selling constraint is relaxed. So, with this we can implement a portfolio construction using ETF.

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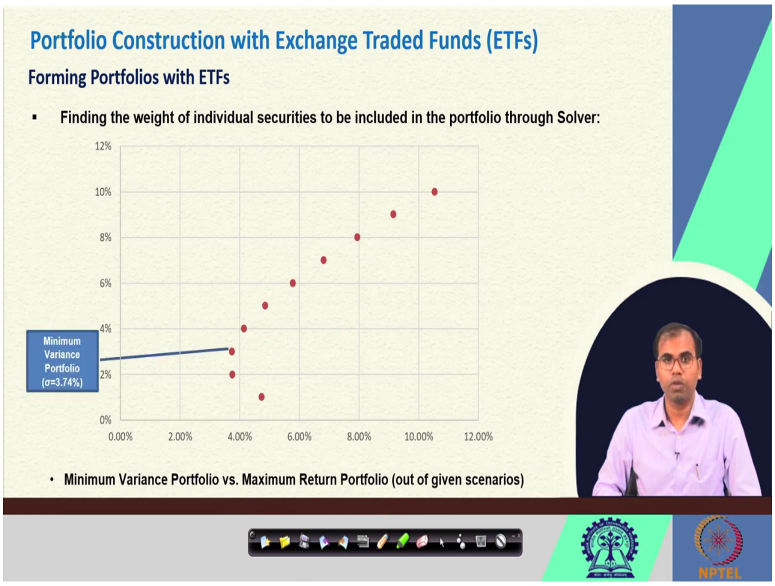

We can also see if we have other portfolios other assets that we can consider as part of portfolio and with the data set on those assets to be included in the portfolio we can replicate this exercise to find the optimal weight where we can find the minimum variance portfolio as well as maximum return portfolio.

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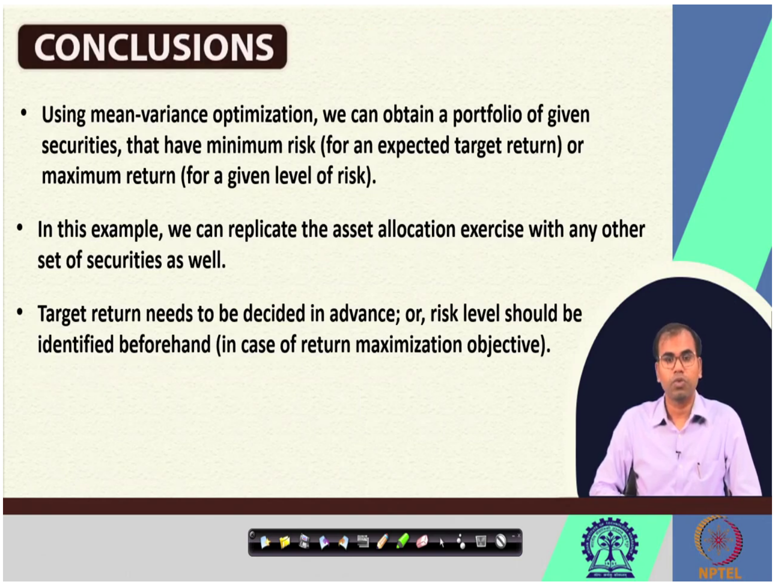

So, to conclude this session we have seen that using mean variance optimization coming from the Markovich Portfolio Theory, we can obtain a portfolio of given securities. In this case it was 10 ETFs, but we can have any other securities for that matter to form a portfolio that have minimum risk for a expected rate of return or expected target return or maximum return for a given level of risk.

In this example we replicated the asset allocation exercise with any other set of securities as well 10 ETFs can be replaced with 10 stocks or 10 funds. Target return needs to be decided in advance because that is what desired level of return of an investor. Similarly, risk level should be identified beforehand in case of return maximization objective. With this I end up this session.

Thank you very much.