

# **Portfolio Construction and Performance Evaluation:**

## A Mean-Variance and Socially Responsible Investment Analysis.

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## **Task One: Mean–Variance Portfolio Construction and Evaluation**

### **1. Investment Objective and Policy**

As of 1st December 2024, the investment objective was to build a group of diversified equity portfolios based on the modern theory of portfolios, with the goal of providing maximum risk-adjusted returns to a client with a medium to high risk tolerance level. From a total capital base of £1,350,000, £900,000 was invested in quantitatively optimised equity portfolios based on the mean-variance approach.

The strategic objective of Task One was to achieve the following: First, to obtain the minimum variance frontier based on a diversified group of equities from different industries. Second, to measure the effect of short-selling constraints on the efficiency, composition, and risk-return profile of the portfolios. Third, to measure the performance of the optimal risky portfolios developed out-of-sample versus a benchmark over the period from January 2025 to November 2025.

To construct the portfolios, the closing prices were used from November 2019 to November 2024. This gave 61 observations to estimate the expected returns, variances, and covariances. A market benchmark and a risk-free asset were also included to estimate the CAPM. It was assumed that all the portfolios were fully invested, and the weights added up to one.

		data until 11/30/2024 is used for efficient frontiers, data from 2025 only used for task 6																							
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W		
1	Date	S&P 500	AAPL.US	MSFT.US	GOOGL.US	NVDA.US	METALS	JNLS.US	PFE.US	UNH.US	MRK.US	ABBV.US	XOM.US	CVX.US	COP.US	SLL.US	OXY.US	AMZN.US	TSLA.US	NKE.US	HD.US	MCD.US			
2	11/30/2019	3140.98	64.7028	144.81	64.9689	5.39616	201.64	127.221	34.9495	256.13	74.2955	76.3487	57.1664	101.663	53.7057	33.4143	36.247	21.998	99.6452	204.532	181.422				
3	12/31/2019	3230.78	71.0911	150.829	66.7276	5.85806	205.25	134.967	35.0859	270.074	78.0395	77.0538	58.5536	104.598	58.2669	37.6249	39.5284	92.392	27.8887	98.5707	203.855	184.364			
4	1/31/2020	3225.52	74.9374	162.823	71.3803	5.8861	201.91	137.745	33.6984	250.299	73.3116	71.4607	52.1264	93.003	53.2486	31.3623	38.1009	100.436	43.37	95.6761	212.922	199.608			
5	2/29/2020	2954.22	66.3379	155.378	66.7206	5.72787	192.47	125.24	30.3237	234.219	65.6924	75.5994	43.7842	81.9648	43.6911	25.7289	31.4039	94.1875	44.5533	87.1829	203.353	182.279			
6	3/31/2020	2610.75	61.9756	158.528	57.8701	5.861	162.45	122.55	25.3235	208.456	67.8099	72.5528	52.5288	77.1242	51.1683	30.5225	37.1245	100.483	54.347	95.3071	177.452	165.572			
7	4/30/2020	2912.43	71.299	158.528	59.0918	7.20084	204.71	139.713	34.7024	269.853	60.6399	73.584	52.057	39.4527	81.7094	38.4408	17.5423	12.2987	122.118	55.6687	98.3971	235.501	176.072		
8	5/31/2020	3044.31	77.3669	176.243	71.4371	8.84379	235.09	139.478	34.9204	281.248	69.8339	71.2254	58.2984	87.8892	38.802	79.5045	38.2987	17.5848	18.0961	137.941	71.9887	95.8785	238.827	174.331	
9	6/30/2020	3100.29	88.7671	195.719	70.8463	9.46818	227.07	131.866	29.755	273.312	67.4338	87.8892	38.802	79.5045	38.2987	17.5848	18.0961	137.941	71.9887	95.8785	238.827	174.331			
10	7/31/2020	3271.12	103.436	197.173	74.1287	10.5813	253.67	136.674	35.4997	280.575	69.9799	85.5993	36.5118	74.791	34.4234	17.3446	15.6663	158.234	95.3833	95.4481	250.986	183.606			
11	8/31/2020	3500.31	125.828	217.421	81.1823	13.3331	293.2	144.803	34.8634	289.608	74.3555	86.778	35.337	75.861	34.8845	18.1779	12.5988	172.548	166.107	109.664	269.448	202.963			
12	9/30/2020	3363	112.918	202.781	73.0153	13.4929	261.9	140.528	33.5852	290.084	72.8609	79.3655	30.3753	65.0773	30.2952	14.9784	9.90898	157.436	143.009	123.04	263.913	208.638			
13	10/30/2020	3298.01	106.321	195.211	80.8396	12.4913	263.1	128.417	30.4001	280.941	70.6103	79.312	28.0345	72.3675	28.0345	14.1808	10.0361	129.347	177.301	253.652	202.911				
14	11/30/2020	3621.63	116.29	206.937	101.4031	13.3651	267.067	137.517	30.4001	312.832	70.6103	79.312	28.0345	72.3675	28.0345	14.1808	10.0361	129.347	177.301	253.652	202.911				
15	12/31/2020	3756.07	128.613	215	87.3154	13.0216	273.16	148.57	34.431	327.453	72.4174	98.4186	37.3501	77.4547	37.2705	21.1382	17.1419	162.846	235.223	138.928	253.796	205.185			
16	1/31/2021	3714.24	128.894	224.23	91.0381	12.9567	258.33	155.05	31.515	311.5	68.229	95.2214	40.6303	78.1413	37.3081	21.5088	19.8647	160.31	264.51	131.182	258.77	198.743			
17	2/28/2021	3811.15	118.616	225.136	100.731	13.6807	257.62	151.55	31.5542	310.217	64.2898	100.115	50.102	93.0127	49.9163	27.1547	26.352	154.846	225.167	132.52	246.838	198.33			
18	3/31/2021	3972.89	119.491	228.43	102.753	13.3191	294.53	157.179	34.1364	348.661	68.8464	100.557	51.4446	97.4584	49.8209	26.454	26.3708	154.704	222.641	130.756	293.5	215.641			
19	4/30/2021	4181.17	121.856	244.322	117.25	14.9767	325.08	155.62	36.514	373.717	66.5344	104.862	52.7478	95.8686	48.0978	26.3186	25.1232	173.371	234.8	130.488	311.204	227.128			
20	5/31/2021	4204.17	122.256	245.488	117.410	16.2404	328.19	162.874	36.8514	380.775	67.7755	104.464	54.0446	97.7212	52.834	161.806	164.407	130.554	303.091	204.407	402.795	262.201			
21	6/30/2021	4297.5	134.214	245.949	120.863	14.3653	328.71	165.553	36.8514	376.65	70.5105	105.941	56.9757	98.31	57.2064	162.408	226.407	152.893	308.921	225.493					
22	7/31/2021	4098.26	142.939	276.668	134.241	19.462	365.3	165.72	41.023	387.703	69.2406	110.8	53.8243	95.8589	53.4244	28.1628	25.5688	166.38	229.057	165.158	317.21	234.8			
23	8/31/2021	4522.68	149.007	293.714	144.175	22.3449	379.38	167.594	44.2321	391.513	68.7177	114.846	54.7741	92.3377	53.039	27.5125	25.5938	173.54	245.24	162.697	315.258	230.974			
24	9/30/2021	4037.54	138.857	274.296	133.193	20.6781	339.39	156.344	41.9496	368.795	68.2614	96.803	64.7273	29.082	29.0252	164.252	258.498	143.43	318.889	314.524					
25	10/31/2021	4065.38	147.006	322.644	147.511	25.522	323.57	157.679	41.9953	434.611	80.022	110.244	109.241	71.5732	31.6529	33.2408	168.622	371.333	165.215	361.125	238.852				
26	11/30/2021	4567	162.459	322.235	141.386	32.6173	324.46	151.943	52.6040	419.747	68.0801	101.593	57.5569	108.948	67.3838	28.2597	29.3938	176.354	381.587	167.148	389.172	239.245			
27	12/31/2021	4746.12	174.512	327.822	144.338	29.3938	338.19	156.692	57.1922	476.467	70.3126	130.323	58.0615	113.269	69.8464	29.511	28.7794	166.77	352.29	160.493	402.795	262.201			
28	1/31/2022	4615.85	177.125	303.226	145.448	24.2485	342.71	162.874	36.8514	380.775	67.7755	104.464	54.0446	97.7212	52.834	30.956	25.574	166.77	352.29	160.493	402.795	262.201			
29	2/28/2022	4737.94	162.489	291.84	134.569	24.5448	311.03	161.366	45.8992	450.514	70.28	146.7	76.264	140.453	91.3074	39.7653	43.3675	153.563	200.143	135.099	308.084	240.74			
30	3/31/2022	4530.41	171.822	301.198	138.566	27.2454	222.36	175.801	50.5228	484.33	75.9459	157.648	80.3193	158.818	96.6381	40.8313	56.4039	162.998	359.2	133.433	285.746	243.208			
31	4/30/2022	4131.93	155.138	271.065	138.519	20.7486	207.49	176.969	47.879	482.979	82.0917	144.053	82.9082	152.811	92.3098	38.5579	54.7637	124.282	209.253	123.656	294.977	245.058			
32	5/31/2022	4132.15	146.682	266.163	133.351	18.6443	193.64	177.188	52.1843	471.804	85.1833	144.533	84.3106	171.758	109.07	45.5929	48.8994	120.21	252.75	117.854	297.103	248.058			
33	6/30/2022	3785.38	134.738	251.444	108.57	15.397	175.18	151.272	50.6080	516.91	83.3702	142.064	95.2307	161.059	95.3112	36.7343	65.4538	134.95	297.15	114.24	297.15	260.469			
34	7/31/2022	4130.29	160.150	274.848	115.9	18.1397	159.1	172.243	50.6080	516.91	83.3702	142.064	95.2307	161.059	95.3112	36.7343	65.4538	134.95	297.15	114.24	297.15	260.469			
35	8/31/2022	3985	155.138	258.527	107.854	15.009	182.668	44.8456	494.978	79.9378	130.106	94.0123	94.0123	94.0123	94.0123	94.0123	94.0123	126.51	201.45	102.89	284.931	250.446			
36	9/30/2022	3855.69	165.895	259.226	142.127	15.669	182.315	44.8456	494.978	79.9378	130.106	94.0123	94.0123	94.0123	94.0123	94.0123	94.0123	126.51	201.45	102.89	284.931	250.446			
37	10/31/2022	3871.98	151.336	227.74	94.1687	13.4837	93.16	172.854	46.1544	530.778	95.1984	146.4	108.925	179.511	125.61	51.8528	72.4519	102.44	227.54	92.3964	284.349	271.133			
38	11/30/2022	4080.11	146.328	251.022	100.625	16.916	118.1	178	50.13	523.713	103.589	161.18	111.34	183.311	123.51	51.3744	69.3492	96.54	194.7	109.354	323.99	272.79			
39	12/31/2022	3838.5	128.437	235.949	87.9113	1																			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	Date	S&P 500	APPL.US	MSFT.US	GOOGL.US	NVDA.US	META.US	JN.JUS	PFE.US	UNH.US	MRK.US	ABBV.US	XOM.US	CVX.US	COP.US	SLB.U
2	11/30/2019															
3	12/31/2019	0.0273065	0.0974496	0.0402815	0.0257865	0.0843146	0.0166199	0.0596028	0.0158614	0.0531578	0.04911	0.0079519	0.0229737	0.0275866	0.0836462	0.12
4	1/31/2020	-0.002895	0.0528372	0.0782538	0.0684601	0.0035199	-0.01754	0.0193013	-0.041069	-0.074487	-0.06185	-0.073854	-0.111033	-0.11212	-0.087393	-0.1
5	2/29/2020	-0.085377	-0.116022	-0.046991	-0.066547	0.1417431	-0.04802	-0.092182	-0.103872	-0.06551	-0.10519	0.0566491	0.161305	-0.119953	0.180755	-0.1
6	3/31/2020	-0.125361	-0.070019	-0.026758	-0.132626	-0.024242	-0.133613	-0.02507	-0.023614	-0.017909	0.0130201	-0.111317	-0.262135	-0.223946	-0.364137	-0.5
7	4/30/2020	0.1267274	0.1552902	0.1362067	0.1588826	0.1086857	0.2271615	0.1440309	0.175196	0.1727442	0.0310699	0.0948475	0.2237689	0.2695517	0.366761	0.24
8	5/31/2020	0.0451734	0.0849966	0.0252818	0.0643601	0.2145578	0.0994471	-0.001783	0.0053726	0.0421184	0.0172868	0.1272699	-0.002639	0.0112647	0.0118006	0.09
9	6/30/2020	0.0182551	0.1472191	0.1103795	-0.010926	0.0704688	0.0086631	-0.054701	-0.14392	-0.02835	-0.034502	0.0593216	-0.016627	-0.027077	-0.003882	0.00
10	7/31/2020	0.054993	0.1651432	0.0073207	0.0491851	0.117456	0.1170362	0.0363372	0.1881463	0.0264657	0.0375152	-0.021612	-0.059131	-0.059399	-0.101248	-0.0
11	8/31/2020	0.0699814	0.216408	0.1026882	0.0950701	0.2599792	0.155749	0.059394	-0.018007	0.0321113	0.0625799	0.089714	-0.032259	0.0142232	0.0133116	0.04
12	9/30/2020	-0.03932	-0.102699	-0.067426	-0.100692	0.011886	-0.106845	-0.029615	-0.028924	0.0015519	-0.020194	-0.085511	-0.140503	-0.142242	-0.133369	-0.1
13	10/31/2020	-0.0277449	-0.060029	-0.037414	0.1026116	-0.073782	0.0045368	-0.079149	-0.033316	-0.021367	-0.093391	-0.015257	-0.0499	-0.03481	-0.117896	-0.0
14	11/30/2020	0.1074707	0.0954605	0.0599114	0.0854944	0.0691899	0.0526026	0.0625134	0.0907997	0.1021475	0.0687752	0.2287713	0.197007	0.2727809	0.3821603	0.39
15	12/31/2020	0.0370464	0.114492	0.0389689	-0.001078	-0.025703	-0.013833	0.0875723	-0.039215	0.0463281	0.0255118	0.0246053	0.0809605	-0.031377	0.0108286	0.05
16	1/31/2021	-0.011203	-0.005614	0.0428636	0.0425684	-0.005051	-0.054357	0.0365717	-0.014202	-0.048785	-0.057904	-0.032552	0.0877564	0.0087979	0.0009422	0.01
17	2/28/2021	0.0260581	-0.079773	0.0040072	0.1064375	0.0585451	-0.002782	-0.022607	-0.067167	-0.004152	-0.057771	0.0513585	0.2331006	0.1902809	0.3111109	0.26
18	3/31/2021	0.0424136	0.0073517	0.0146062	0.0200483	-0.026456	0.143248	0.0371179	0.0818088	0.1239012	0.0708543	0.0043899	0.0268379	0.0477717	0.0184678	-
19	4/30/2021	0.0524086	0.0762066	0.0695539	0.1410692	0.1244362	0.1037079	-0.009929	0.0667654	0.0718468	-0.033599	0.0427949	0.0252377	-0.016329	-0.034603	-0.0
20	5/31/2021	0.0054698	-0.050523	-0.007658	0.0013991	0.082191	0.0112113	0.0466159	0.0119368	0.0328906	0.0186353	0.0152319	0.0345706	0.019314	0.0984535	0.15
21	6/30/2021	0.0221806	0.0991444	0.084968	0.036018	0.2316685	0.057704	-0.02671	0.011087	-0.024346	0.0335496	-0.004918	0.0806579	0.0091489	0.0925188	0.02
22	7/31/2021	0.0227064	0.0648919	0.051672	0.1034693	-0.025153	0.0246628	0.0452927	0.1030441	0.0293585	-0.011617	0.0439356	-0.08739	-0.02803	-0.072481	-0.0
23	8/31/2021	0.0289487	0.0424829	0.0615701	0.0739596	0.148088	0.0647352	0.012666	0.0761049	0.0097854	-0.007594	0.0383489	-0.03869	-0.036775	-0.0095	-0.0
24	9/30/2021	-0.047602	-0.068151	-0.066145	-0.076205	-0.074628	-0.105442	-0.067148	-0.066444	-0.05806	-0.006674	-0.106776	0.0788491	0.048325	0.2204075	0.05

Figure 2: Calculation of monthly excess returns used for expected return and covariance estimation.

Though the mean-variance approach offers a rigorous quantitative approach, the results obtained in this project also reveal several practical limitations with the approach, which can be clearly seen with the constructed portfolios. In particular, the results obtained from the optimisation approach were found to be sensitive to the input parameters used for the optimisation process, especially the expected excess returns. Though the estimation period used was long with 61 monthly observations, it was seen that small changes in the expected returns resulted in significant changes in the weights obtained, especially in the unconstrained optimisation approach. This also reiterates the widely known criticism that the portfolios constructed using the mean-variance approach can be unstable due to estimation errors in the expected returns.

In the unconstrained optimisation, this sensitivity was evidenced by more concentrated portfolio weights, whereby a smaller set of equities received disproportionately large weight allocations. This is because the unconstrained optimisation algorithm exploited the marginal differences in expected return, even where such differences may not be economically

meaningful, as a result of the ability to implement short sales. In contrast, the constrained optimisation exhibited more even weight distributions, which suggests that the short sales constraints acted as a form of implicit regularisation.

The results also indicate that the optimisation was influenced more by the covariance structure of the returns than the expected returns. Assets with lower correlation to the rest of the assets in the portfolio always received higher weightings, even if their expected returns were not the highest. This is consistent with the general observation that the benefits of diversification dominate the expected returns in the mean-variance optimisation approach to portfolio construction.

Moreover, the comparison of the high-beta and low-beta sub-portfolios also reveals another limitation of the framework. In this regard, it should be noted that even though the high-beta portfolios offered greater upside potential, their out-of-sample performance showed greater volatility and lower downside protection compared with the low-beta portfolios. This again reveals that, although beta is an important measure of systematic risk, it does not capture downside risk very well.

A	B	C	D	E	F	G	H	I
30								
31								
32								
33								
34		Tangency Portfolio (High Beta, No Short Selling)						
35		Tangency Excess Return	0.054866712					
36		Tangency Volatility	0.116231885					
37		Tangency Sharpe	0.472045273					
38		Investment Amount	200000					
39								
40								
41		Asset	Weight	Allocation				
42		TSLA.US	0.141061979	28212.39584				
43		NVDA.US	0.66335738	132671.4759				
44		OXY.US	0	0				
45		SLB.US	0	0				
46		AAPL.US	0	0				
47		COP.US	0.195580641	39116.12826				
48		META.US	0	0				
49		AMZN.US	0	0				
50		CVX.US	0	0				
51		HD.US	0	0				
52		SUM	1	200000				
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								

Prices    Returns    Excess Returns    RiskFree    Stats    MV\_HighBeta    MV\_LowBeta    MV\_NoShortSelling    MV\_RestrictedSelling    Performance\_2025    +

D43	A	B	C	D	E	F	G	H	I	J	K	L
28												
29												
30												
31												
32												
33			Tangency Portfolio (Low Beta, No Short Selling)									
34			Tangency Excess Return	0.016126937								
35			Tangency Volatility	0.047634211								
36			Tangency Sharpe	0.338557668								
37			Investment Amount	200000								
38												
39			Asset	Weight	Allocation							
40			NKE.US	0	0							
41			GOOGL.US	0.039325714	7865.142885							
42			MSFT.US	0.437480768	87496.15355							
43			XOM.US	0.079955823	15991.16466							
44			PFE.US	0	0							
45			UNH.US	0.236375113	47275.02251							
46			ABV.US	0.206862582	41372.5164							
47			JNJ.US	0	0							
48			MCD.US	0	0							
49			MRK.US	0	0							
50			SUM	1	200000							
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Figures 3 and 4: CAPM beta estimates and classification into high- and low-beta portfolios.

In spite of its limitations, mean-variance optimisation is an important technique when it is used as a decision-support tool rather than an absolute allocation tool. In this project, the incorporation of short-selling constraints, diversification across industries, and out-of-sample performance testing ensured that the optimised portfolios remained economically meaningful.

### 3. Portfolio Characteristics and Composition

A universe of 20 equities was chosen, representing at least three different industries to ensure diversification of the portfolio, thereby reducing idiosyncratic risk. The minimum variance frontier was obtained by solving a series of constrained quadratic optimization problems, each for different levels of target return.

From the frontiers, the tangency portfolios were identified, which correspond to the portfolios with the highest Sharpe ratio, representing the optimal risky portfolio for a mean-variance investor (Sharpe, 1966). In accordance with the client's allocation requirements, £250,000 was invested in each of the two tangency portfolios obtained from the unconstrained and restricted short-selling frontiers.

To further investigate the relationship between systematic risk and portfolio performance, the equity universe was divided between high and low beta equities, based on estimates of the beta coefficients using the capital asset pricing model. The betas were estimated using 61

months of data, employing a regression analysis on the equities with respect to the market benchmark. Two additional tangency portfolios were constructed using the sub-universes without short-selling, with £200,000 invested in each.

SUM	G	H	I	J	K	L	M	N	O	P	Q	R
1	Covariance Matrix (20 stocks)	AAPL.US	MSFT.US	GOOGL.US	NVDA.US	META.US	JN.J.US	PFE.US	UNH.US	MRK.US	ABV.US	
2	AAPL.US	0.00706043	0.00376736	0.003422691	0.006381246	0.00397429	0.001724772	0.00223864	0.00189944	0.00070276	0.00109151	
3	MSFT.US	0.00376736	0.00418317	0.003268843	0.005965302	0.00424083	0.000994654	0.00112053	0.001319804	0.00104809	0.00097914	
4	GOOGL.US	0.00342269	0.00326884	0.005916369	0.00627238	0.00416813	0.000638696	0.00158137	0.001183275	-5.5357E-05	0.00140853	
5	NVDA.US	0.00638125	0.0059653	0.00627238	0.020586352	0.00905872	-4.09196E-05	0.00239927	-5.2146E-06	0.00041469	0.00182265	
6	META.US	0.00397429	0.00424083	0.004168127	0.009058725	0.01408528	0.001176647	0.00178677	0.000338961	0.00054277	0.00135479	
7	JN.J.US	0.00172477	0.00099465	0.000638696	-4.09196E-05	0.00117665	0.002510021	0.00214463	0.001724622	0.00153179	0.00163472	
8	PFE.US	0.00223864	0.00112053	0.001831972	0.002399265	0.00178677	0.002144628	=COVARIANCE.S(				
9	UNH.US	0.00189944	0.0013198	0.00183275	-5.2146E-06	0.00033896	0.001724622	INDEX(Returns!\$C\$3:\$V\$62,0,MATCH(\$H\$,Returns!				
10	MRK.US	0.00070276	0.00104809	-5.53567E-05	0.00041469	0.00054277	0.001531791	=\$C\$1:\$V\$1,0))				
11	ABV.US	0.00109151	0.00097914	0.001408534	0.001822647	0.00135479	0.001634723	INDEX(Returns!\$C\$3:\$V\$62,0,MATCH(O\$2,Returns!				
12	XOM.US	0.00158287	0.00077552	0.001832313	7.61072E-05	-0.00032019	0.00169351	=\$C\$1:\$V\$1,0))				
13	CVX.US	0.00228152	0.00133485	0.00261576	0.00172584	0.00013625	0.0019045 )					
14	COP.US	0.00195237	0.0010869	0.003015839	0.000740464	0.00032206	0.001988276					
15	SLB.US	0.00310216	0.00106331	0.002895607	0.001518666	0.00047946	0.002706119	0.00177958	0.002926417	0.00320773	0.00459911	
16	OXY.US	0.00355491	0.00282897	0.004204038	0.000683616	0.00050448	0.002138185	0.00061901	0.002471886	0.00230786	0.00526216	
17	AMZN.US	0.00545897	0.00413741	0.004470163	0.008407281	0.00529042	0.000425113	0.00091888	0.00093168	-0.00046069	-0.00028014	
18	TSLA.US	0.01304267	0.00749754	0.007510471	0.012816371	0.0080722	0.00244754	0.00148678	0.003184351	-6.6798E-05	0.00060614	
19	NKE.US	0.00354866	0.00286345	0.001812799	0.004685116	0.00346072	0.001497292	0.00159358	0.001963827	0.00186574	0.00139719	
20	HD.US	0.00310277	0.00235995	0.002090082	0.003896008	0.00408194	0.0016803	0.00262118	0.001881684	0.00123672	0.00138893	
21	MCD.US	0.00273041	0.00147908	0.001439273	0.001231015	0.00167925	0.0016309	0.00161957	0.001580743	0.00132008	0.00091024	
22												
23												
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Figure 5: Covariance matrix of excess returns used in mean-variance optimisation.

### 3.1 Portfolio Structure, Diversification and Weight Concentration

A notable characteristic that was evident with the constructed portfolios was related to weight concentration and diversification, especially between the constrained and unconstrained optimisation portfolios. In the unconstrained mean-variance optimisation portfolio, it was evident that the weights were more concentrated within a smaller number of equities. This was due to the tendency of the optimiser to exploit marginal differences between the expected excess return and covariance when short selling was allowed, thus increasing the long positions within the portfolio with more positive diversification benefits.

Conversely, the portfolios constructed with the short selling constraint had a more diversified allocation among the equities. This was due to the constraints placed on the optimiser, thus forcing it to diversify and avoid extreme positions. Although this resulted in a less

theoretically efficient portfolio with respect to achieving the highest Sharpe ratio possible, it resulted in a more realistic approach to investment and risk management within the portfolio.

Further structural differences were revealed when comparing the high beta and low beta portfolios. The high beta portfolio showed more sensitivity to market movements, thereby generating higher expected returns but with more volatility. This meant that the high beta tangency portfolio was more exposed to systematic risks and drawdowns in the market during bad times. On the other hand, the low beta portfolio showed more stable return dynamics, with lower volatility and better downside protection, albeit with lower upside potential. This structural difference between the two portfolios re-emphasises the importance of beta as a systematic risk indicator, rather than a marker of better or worse investment performance.

From the perspective of diversification, assets from different industries with lower cross-correlations were given higher weights across all optimised portfolios. This is consistent with the idea that the optimisation process was dominated by correlation effects, rather than expected returns, thereby re-emphasising the importance of diversification in modern portfolio theory.

The tangency portfolio (no short selling) achieved an expected monthly excess return of 2.10% with volatility of 4.77%, producing a Sharpe ratio of 0.440.

The tangency portfolio (restricted short selling) achieved an expected monthly excess return of 2.10% with lower volatility of 4.05%, producing a higher Sharpe ratio of 0.518.

Within the beta-split portfolios, the high-beta tangency portfolio delivered an expected monthly excess return of 5.49% with volatility of 11.62% (Sharpe = 0.472), whereas the low-beta tangency portfolio delivered 1.61% excess return with 4.76% volatility (Sharpe = 0.339).

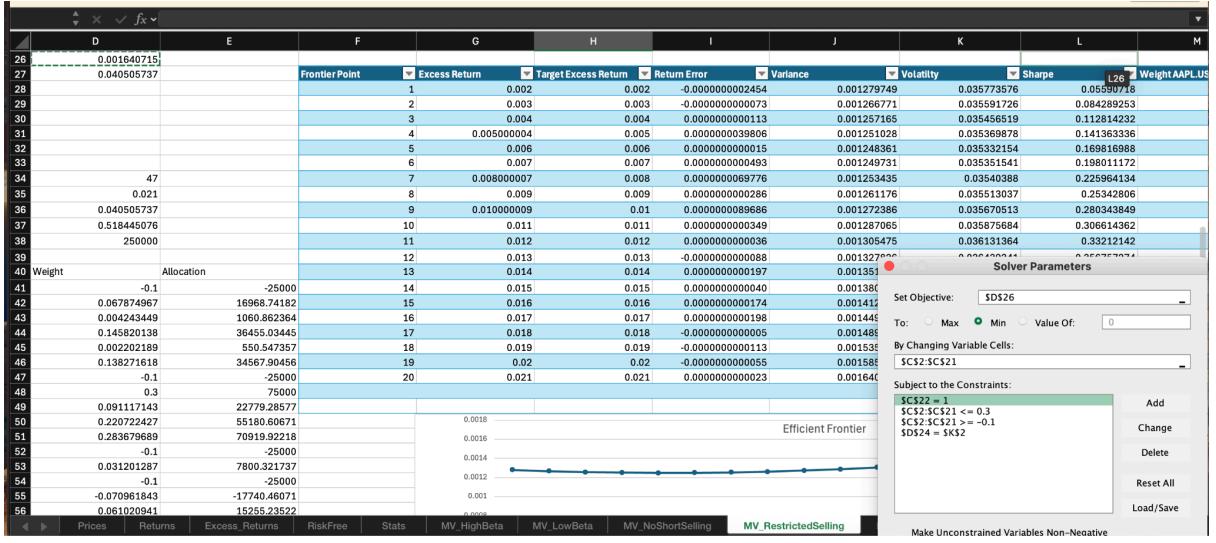


Figure 6: Solver setup for constrained mean–variance optimisation.

#### 4. Performance Evaluation (January 2025 – November 2025)

From Jan 2025 to Nov 2025, the benchmark index rose from 100.00 to 113.39 (+13.39%).

Over the same period, the no-short tangency portfolio rose to 102.65 (+2.65%), the restricted portfolio rose to 115.01 (+15.01%), the high-beta portfolio rose to 131.85 (+31.85%), and the low-beta portfolio rose to 107.65 (+7.65%).

The four portfolios were evaluated using the aforementioned risk-adjusted performance measures, i.e., Sharpe ratio, Treynor ratio, Sortino ratio, and Jensen’s alpha. The use of multiple risk-adjusted performance measures is a more comprehensive approach to evaluate the portfolios, as it does not depend on a single definition of risk. This is in accordance with the suggestion of Elton et al. (2014).

The Sharpe ratio measured the total risk, while the Treynor ratio and Jensen’s alpha measured the systematic risk in comparison to the market. The Sortino ratio measured the downside risk, which is of particular concern to investors who focus on negative deviations in expected rates of return.

The comparison of Sharpe, Treynor, Sortino ratios, and Jensen's alpha for the four tangency portfolios shows the differences in the way each portfolio compensated investors for different types of risk.

Over Jan–Nov 2025, Sharpe ratios were 0.334 (benchmark), 0.024 (no-short), 0.271 (restricted), 0.209 (high-beta), and 0.157 (low-beta). Treynor ratios were 0.0083 (no-short), −0.0337 (restricted), 0.0089 (high-beta), and 0.0120 (low-beta). Sortino ratios were 0.0224 (no-short), 0.2530 (restricted), 0.2695 (high-beta), and 0.2203 (low-beta). Jensen's alpha was −0.00045 (no-short), +0.01567 (restricted), −0.00453 (high-beta), and +0.00047 (low-beta).

The unconstrained tangency portfolio has the highest Sharpe ratio for the January to November 2025 period. This is a result of the unconstrained portfolio's ability to take advantage of the diversification effects and the limited short positions to minimize the total variance of the portfolio. However, when the performance of the portfolios is measured using the Sortino ratio, the unconstrained portfolio does not maintain a substantial lead. This shows that the unconstrained portfolio, although performing well in terms of total risk, does not dominate the constrained portfolios in the management of downside risk. For an investor who is more interested in avoiding negative deviations in the rate of return, the constrained portfolios seem to be more stable in terms of performance.

The Treynor ratio and Jensen's alpha also gave further insight into the role of systematic risk. The high-beta tangency portfolio showed higher sensitivity to market risk, resulting in higher volatility. Although the portfolio benefited from the rise of the market, the Treynor ratio also showed lower results compared to the other portfolios with lower beta risk. This shows that the portfolio obtained higher returns through higher risk. On the other hand, the low-beta tangency portfolio showed better Treynor ratio and Jensen's alpha results, indicating that the portfolio obtained better returns relative to the level of risk.

Jensen's alpha also gave further support to the above findings. The portfolios with higher systematic risk did not give consistent positive alpha, indicating that the portfolio did not perform better due to the skills of the portfolio manager. On the contrary, the portfolios with better risk balance showed more consistent alpha results, indicating the importance of risk control and diversification.

The multi-metric evaluation also confirms the above findings that the performance of the portfolio must be evaluated as a whole, considering the type of risk involved.

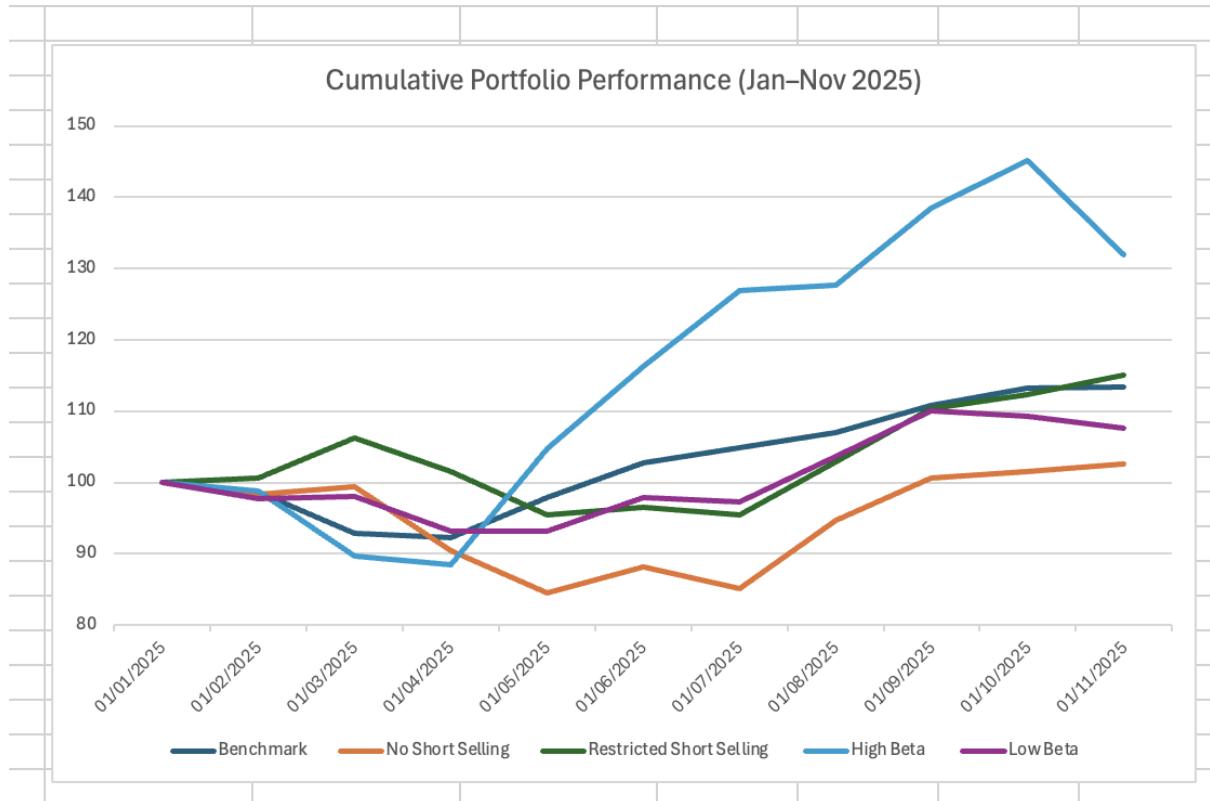


Figure 8: Efficient frontiers with and without short-selling constraints and corresponding tangency portfolios.

## 5. Critical Discussion: Short-Selling Constraints

Although short selling helps in improving the efficiency of the portfolio through hedging and exploiting negative views, it also creates a number of operational challenges. Short selling involves a margin, recall risk, and regulatory or risk management restrictions on short sales, as noted in Fabozzi, Huang, and Zhou (2010). The comparison between the unconstrained and restricted short-selling portfolios offers useful insight into the real-world implications of the ability to short sell.

The unconstrained portfolios offered improved efficiency, as evidenced by the higher Sharpe ratios, this came at the cost of increased weight concentration and volatility sensitivity. The ability to short sell was seen as an opportunity for the optimiser to be more aggressive in the portfolio, thus increasing the estimation error and market volatility.

In terms of the overall risk management of the portfolio, the ability to short sell also introduces a number of further complexities. The need for margin on short positions, as well as recall risk, means that positions are subject to early closure in the event of a deteriorating market position. This is not reflected in the optimisation process but is an important consideration for portfolio implementation. The results of this project have shown that although the ability to short sell improves the efficient frontier, the marginal benefits are reduced once realistic constraints are applied.

The behavioural and market dynamics make the application of short selling an even more complex process. During unstable market periods, short selling can result in asymmetric losses. The restricted short selling portfolios in the above portfolios have shown more stable downside risk, which is also reflected in the Sortino ratios. This is particularly relevant in the case of institutional investors where the preservation of capital is a primary objective in addition to generating returns.

In conclusion, the results of this analysis are in agreement with the fact that short selling is a risk management tool and not an optimisation tool. Although it can improve portfolio diversification and efficiency, the costs of short selling may outweigh the benefits in most cases. The constrained portfolios designed in this project have found a more realistic balance between portfolio efficiency and implementability, which is in closer alignment with professional fund management.

## **Task Two: Investment Fund Construction and Performance Attribution**

### **1. Investment Objective and Policy**

Task Two required the creation of a £450,000 investment fund with a focus on non-traditional and socially responsible investments. The client's goal was to seek competitive risk-adjusted

returns while also considering environmental and social factors in the allocation of the investments.

The fund had a multi-industry approach, with investments made in the stocks of two different industries known for their socially responsible practices. The closing prices from at least two years up to November 2024 were used to construct the fund. The performance was also measured from January 2025 to November 2025.

Benchmarks were chosen based on the industry to ensure the performance was properly measurable. Strategic industry weights were also assigned to the fund based on various factors such as risks and expected returns.

	A	B	C	D	E	F	G	H	I	J	K
	Date	S&P	AAPLUS	GOOGL.US	MSFT.US	JNJ.US	PFE.US	UNH.US	TECH_BENCH	XLK.US	HEALTH_BENCH
1	30/11/2022	4080.11	146.328	100.625	251.022	178	50.13	523.713	66.3315	139.02	
2	31/12/2022	3839.5	128.437	87.9113	235.949	176.65	51.24	508.466	60.8857	135.85	
3	31/01/2023	4076.6	142.632	98.483	243.81	163.42	44.16	478.744	66.5227	133.36	
4	28/02/2023	3970.15	145.938	89.7348	246.009	153.26	40.57	456.447	66.7963	127.17	
5	31/03/2023	4109.31	163.255	103.356	284.355	155	40.8	454.849	74.0493	129.46	
6	30/04/2023	4169.48	167.985	106.952	303.055	163.7	38.89	473.619	73.9609	133.53	
7	31/05/2023	4179.83	175.723	122.426	324.604	155.06	38.02	468.95	80.5569	127.83	
8	30/06/2023	4450.38	192.298	119.268	336.616	165.52	36.68	464.496	85.4315	132.73	
9	31/07/2023	4588.96	194.757	132.24	332.048	167.53	36.06	489.362	87.6387	134.15	
10	31/08/2023	4507.66	186.504	135.679	324.668	161.68	35.38	460.572	86.3162	133.21	
11	30/09/2023	4288.05	169.965	130.388	312.771	155.75	33.17	489.153	80.7247	128.74	
12	31/10/2023	4193.8	169.527	123.632	334.921	148.34	30.56	519.586	80.7646	124.54	
13	30/11/2023	4567.8	188.816	132.052	376.098	154.66	30.47	536.478	91.1783	131.31	
14	31/12/2023	4769.83	191.382	139.185	373.249	156.74	28.79	512.511	94.993	136.38	
15	31/01/2024	4845.65	183.299	139.594	394.628	158.9	27.08	498.171	97.5591	140.38	
16	29/02/2024	5096.27	179.9	137.96	411.329	161.38	26.56	480.512	102.149	144.82	
17	31/03/2024	5254.35	170.674	150.385	418.37	158.19	27.75	483.48	102.956	147.73	
18	30/04/2024	5035.69	169.529	162.192	387.155	144.59	25.62	472.73	97.0234	140.33	
19	31/05/2024	5277.51	191.606	171.877	413.555	148.58	28.16	484.135	103.891	141.4	
20	30/06/2024	5460.48	209.914	181.701	445.255	146.16	27.98	499.823	112.03	145.75	
21	31/07/2024	5522.3	221.336	171.117	416.763	157.85	30.54	565.482	108.351	149.63	
22	31/08/2024	5648.4	228.497	162.976	416.307	165.86	29.01	579.263	109.109	157.2	
23	30/09/2024	5762.48	232.488	165.66	429.44	162.06	28.94	575.879	111.998	154.02	
24	31/10/2024	5705.45	225.414	170.914	405.538	159.86	28.3	556.003	110.251	146.87	
25	30/11/2024	6032.38	237.069	168.757	423.46	155.01	26.21	601.016	115.952	147.41	
26	31/12/2024	5881.63	249.292	189.3	421.5	144.62	26.53	500.156	115.541	137.57	
27	31/01/2025	6040.53	234.937	204.02	415.06	152.15	26.52	536.373	114.691	146.87	
28	28/02/2025	5954.5	241.015	170.28	396.99	165.02	26.43	469.605	112.068	148.93	
29	31/03/2025	5611.85	221.373	154.64	375.39	165.84	25.34	520.058	102.782	146.01	
30	30/04/2025	5569.06	211.776	158.8	395.26	156.31	24.41	408.54	104.519	140.47	
31	31/05/2025	5911.69	200.428	171.74	460.36	155.21	23.49	299.782	114.942	132.64	
32	30/06/2025	6204.95	204.739	176.23	497.41	152.75	24.24	311.97	126.261	134.79	
33	31/07/2025	6339.39	207.134	191.9	533.5	164.74	23.29	249.56	131.003	130.43	
34	31/08/2025	6460.26	231.915	212.91	506.69	177.17	24.76	309.87	130.858	137.43	
35	30/09/2025	6688.46	254.383	243.1	517.95	185.42	25.48	345.3	140.717	139.17	
36	31/10/2025	6840.2	270.108	281.19	517.81	188.87	24.65	341.56	150.112	144.25	
37	30/11/2025	6849.09	278.85	320.18	492.01	206.92	25.74	329.77	142.893	157.65	
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Figure 9: Monthly closing prices for socially responsible investment fund assets and industry benchmarks.

## 2. Rationale for Fund Construction

Socially responsible investing has emerged as a prominent concept, as studies suggest that portfolios aligned to ESG factors do not require any compromises on financial performance, as argued in the study by Friede, Busch, and Bassen (2015). The fund has therefore been created to ensure a balance between ethical considerations and quantitative disciplines.

The industry weights were set to ensure lower volatility, with a focus on ESG integration. However, the process differed in the sense that the weights were not purely mean-variance-based, unlike the Task One optimization process.

## 3. Fund Characteristics and Benchmark Selection

The investment fund used equities of two industries. Each industry was benchmarked to an appropriate industry index. This two-benchmark approach enabled the performance attribution to distinguish between the allocation effects and the selection effects.

The benchmark portfolio was formed with the same industry weights but with the benchmark returns. This ensured that the relative performance could be interpreted as the result of active management decisions.

	A	B	C	D	E	F	G	H	I	J
1	Date	Tech Return	Tech Weight	Tech Contribution	Health Return	Health Weight	Health Contribution	Fund Return	S&P Return	Risk Free Rate
2	30/11/2022	-0.109136485	0.6	-0.065481891	-0.005085935	0.4	-0.002034374	-0.067516265	-0.060781799	0.00346
3	31/12/2022	0.083719507	0.6	0.050231704	-0.095593406	0.4	-0.038237362	0.011994342	0.059921158	0.00369
4	28/02/2023	-0.020377472	0.6	-0.012226483	-0.065557229	0.4	-0.026222892	-0.038449375	-0.02645943	0.00378
5	31/03/2023	0.132769181	0.6	0.079661509	0.004478466	0.4	0.001791387	0.081452895	0.034451254	0.00381
6	30/04/2023	0.04215098	0.6	0.025290588	0.015701046	0.4	0.006280419	0.031571007	0.014536197	0.00400
7	31/05/2023	0.082950834	0.6	0.049770501	-0.028918402	0.4	-0.011567361	0.03820314	0.002479248	0.00417
8	30/06/2023	0.033446831	0.6	0.020068099	0.006618666	0.4	0.002647467	0.022715565	0.06271891	0.00419
9	31/07/2023	0.034096163	0.6	0.020457698	0.015724177	0.4	0.006289671	0.026747369	0.030663933	0.00426
10	31/08/2023	-0.013367669	0.6	-0.008020602	-0.038404734	0.4	-0.015361894	-0.023382495	-0.017875247	0.00430
11	30/09/2023	-0.0566656387	0.6	-0.033993832	-0.013887207	0.4	-0.005554883	-0.039548715	-0.049946088	0.00431
12	31/10/2023	0.004212618	0.6	0.002527571	-0.023447364	0.4	-0.009378946	-0.006851375	-0.02222484	0.00433
13	30/11/2023	0.096534076	0.6	0.057920446	0.023588689	0.4	0.009435475	0.067355921	0.085424444	0.00427
14	31/12/2023	0.019500881	0.6	0.011700529	-0.029686215	0.4	-0.011874486	-0.000173958	0.043278976	0.00425
15	31/01/2024	0.005159762	0.6	0.003095857	-0.025308249	0.4	-0.0101233	-0.007027442	0.01577073	0.00424
16	29/02/2024	0.003652617	0.6	0.00219157	-0.013331185	0.4	-0.005332474	-0.003140903	0.050427504	0.00425
17	31/03/2024	0.016853958	0.6	0.010112375	0.010007424	0.4	0.00400297	0.014115345	0.030547405	0.00425
18	30/04/2024	-0.002896744	0.6	-0.001738047	-0.064080928	0.4	-0.025632371	-0.027370418	-0.042505747	0.00425
19	31/05/2024	0.08212695	0.6	0.04927617	0.048530003	0.4	0.019412001	0.068688171	0.046903838	0.00426
20	30/06/2024	0.073565584	0.6	0.04413935	0.003018686	0.4	0.001207474	0.045346825	0.034082302	0.00425
21	31/07/2024	-0.024368799	0.6	-0.014632079	0.095971688	0.4	0.03838675	0.023756596	0.011257742	0.00422
22	31/08/2024	-0.005999385	0.6	-0.003599631	0.007393428	0.4	0.002957371	-0.00064226	0.022577879	0.0041
23	30/09/2024	0.021569713	0.6	0.012941828	-0.010484112	0.4	-0.004193645	0.008748183	0.019995618	0.00384
24	31/10/2024	-0.018981447	0.6	-0.011388868	-0.023718334	0.4	-0.009487333	-0.020876202	-0.009946079	0.00367
25	30/11/2024	0.026985436	0.6	0.016191262	-0.009893907	0.4	-0.003957563	0.012233699	0.055719768	0.00360
26	31/12/2024	0.053502543	0.6	0.032101526	-0.080315458	0.4	-0.032126183	-2.46575E-05	-0.025307692	0.00348

Figure 10: Strategic industry and asset allocation of the investment fund.

## 4. Performance Evaluation

Fund performance was evaluated using Sharpe ratio, Treynor ratio, and Sortino ratio, and Jensen's alpha for the period from January to November 2025. The fund's performance was quite competitive compared to its benchmark index, with a positive Jensen's alpha showing that value was added to the fund.

From the Sortino ratio, it was evident that the fund had managed its downside risk very well, given its focus on sustainability and long-term risk management.

	B4	▲ × ✓ f <sub>x</sub> ~STDEV.S(INDEX(Fund!\$H:\$H,\$F\$4):INDEX(Fund!\$H:\$H,\$G\$4))	A	B	C	D	E	F	G	H	I	J	K	L
1	Metric	Fund	Benchmark Portfolio				Start Date	End Date		Date	Fund Excess	Downside Excess	Downside Squared	
2	Average Return	0.01333195	0.016543654				31/01/2025	30/11/2025		31/12/2022	-0.070984738	-0.070984738	0.005038833	
3	Average Excess Return	0.00997558	0.01318728				Start Row	End Row		31/01/2023	0.00829438	0	0	
4	Standard Deviation	0.04386877	0.034574292				28	38		28/02/2023	-0.042237	-0.04223698	0.001783963	
5	Sharpe Ratio	0.22739589	0.38141865							31/03/2023	0.07763344	0	0	
6	Beta (vs Benchmark Portfol	0.83377956	1							30/04/2023	0.02756668	0	0	
7	Treynor Ratio	0.01196429	0.01318728							31/05/2023	0.03402626	0	0	
8	Downside Deviation	0.02401844 N/A								30/06/2023	0.01852283	0	0	
9	Sortino Ratio	0.41532996 N/A								31/07/2023	0.02248334	0	0	
10	Jensen's Alpha	-0.0010197 N/A								31/08/2023	-0.027686098	0.00076652		
11										30/09/2023	-0.043868145	0.001924414		
12										31/10/2023	-0.011186628	0.000125141		
13										30/11/2023	0.05307606	0	0	
14										31/12/2023	-0.004430301	-0.004430063	1.96255E-05	
15										31/01/2024	-0.0112677	-0.01126771	0.000126961	
16										29/02/2024	-0.007397009		5.47157E-05	
17										31/03/2024	0.00985924	0	0	
18										30/04/2024	-0.0316265	-0.031626524	0.001000237	
19										31/05/2024	0.06442415	0	0	
20										30/06/2024	0.04109072	0	0	
21										31/07/2024	0.01953217	0	0	
22										31/08/2024	-0.0047478	-0.00474778	2.25414E-05	
23										30/09/2024	0.00490486	0	0	
24										31/10/2024	-0.0245522	-0.02455225	0.000602813	
25										30/11/2024	0.00862945	0	0	
26										31/12/2024	-0.003509116		1.23139E-05	
27										31/01/2025	0.01263833	0	0	

Figure 11: Risk-adjusted performance comparison between investment fund and benchmark (Jan–Nov 2025).

## 5. Performance Attribution Analysis

The performance attribution analysis carried out for the investment fund has yielded valuable insights regarding the creation of value over the evaluation period of January to November 2025. From the analysis carried out on the investment fund's performance relative to the

benchmark, it is apparent that the decisions regarding industry allocation were the key contributors to the relative performance of the fund. This is due to the strategic nature of the fund's creation and is a reflection of the decisions regarding the allocation of the fund's weight that were made at the onset.

The allocation effect was positive over the evaluation period. This suggests that the decision to overweight the industries relative to their benchmark weight was a key contributor to the excess returns obtained by the fund. These industries have shown relatively better performance in terms of their risk-adjusted returns over the evaluation period. This reflects structural trends aligned with socially responsible investing. This has allowed the fund to reap the benefits of the returns that have exceeded the benchmark portfolio constructed with the same industry weights.

In contrast, the relative contribution of the selection effect was relatively modest, which implies that individual stock selection decisions within each of the industries were less significant contributors to the overall portfolio outperformance. This, therefore, implies that while individual security selection decisions did not hurt portfolio performance, the dominant driver of portfolio value added was strategic asset allocation, as opposed to individual stock selection decisions. This outcome is, therefore, similar to the empirical evidence offered by Brinson, Hood, and Beebower (1986), which shows that decisions around asset allocation are significant determinants of portfolio return volatility over time.

In terms of fund management, therefore, this attribution outcome is significant from a strategic perspective, as it implies that, within the context of socially responsible investing, industry positioning is critical to portfolio outcome determinants, particularly where risks and opportunities around ESG considerations vary significantly across industries. Moreover, the relatively modest contribution of individual selection effects implies that the portfolio's performance was not significantly dependent on individual stock selection decisions, which would have introduced significant firm-specific risks.

Based on the results of the analysis, any future tactical moves in the investment fund would be best targeted towards dynamic industry rebalancing in response to changing macroeconomic conditions, regulatory environments, or ESG standards. This could potentially improve the fund's performance while maintaining the social responsibility focus. The attribution analysis has demonstrated the efficacy of a strategic allocation process, aided

by a set of sustainability-based investment criteria, in providing competitive performance without relying on active stock selection.

	A	B	C	D	E	F	
1	Date	Tech Contribution (monthly)	Health Contribution (monthly)	Fund Return (monthly)	Benchmark Portfolio Retu	Active Return (Fund - Benchmark Portfolio)	Tech Bench
2	30/11/2022						
3	31/12/2022	-0.065481891	-0.002034374	-0.067516265	-0.060626526	-0.006889739	
4	31/01/2023	0.050231704	-0.038237362	0.011994342	0.045727305	-0.033732963	
5	28/02/2023	-0.012226483	-0.026222892	-0.038449375	-0.016548318	-0.021901057	
6	31/03/2023	0.079661509	0.001791387	0.081452895	0.06898891	0.012463985	
7	30/04/2023	0.025290588	0.006280419	0.031571007	0.01166498	0.019906027	
8	31/05/2023	0.049770501	-0.011567361	0.03820314	0.033806349	0.004396791	
9	30/06/2023	0.020068099	0.002647467	0.022715565	0.050296964	-0.027581399	
10	31/07/2023	0.020457698	0.006289671	0.026747369	0.019561312	0.007186056	
11	31/08/2023	-0.008020602	-0.015361894	-0.023382495	-0.011935929	-0.011446567	
12	30/09/2023	-0.033993832	-0.005554883	-0.039548715	-0.053836404	0.014287688	
13	31/10/2023	0.002527571	-0.009378946	-0.006851375	-0.012970677	0.006119301	
14	30/11/2023	0.057920446	0.009435475	0.067355921	0.093940504	-0.026584583	
15	31/12/2023	0.011700529	-0.011874486	-0.000173958	0.039745432	-0.039919389	
16	31/01/2024	0.003095857	-0.0101233	-0.007027442	0.027556256	-0.034583698	
17	29/02/2024	0.00219157	-0.005332474	-0.003140903	0.040039934	-0.043180838	
18	31/03/2024	0.010112375	0.00400297	0.014115345	0.012679385	0.00143596	
19	30/04/2024	-0.001738047	-0.025632371	-0.027370418	-0.056165512	0.028795095	
20	31/05/2024	0.04927617	0.019412001	0.068688171	0.044072436	0.024615735	
21	30/06/2024	0.04413935	0.001207474	0.045346825	0.057374681	-0.012027856	
22	31/07/2024	-0.014632079	0.038388675	0.023756596	-0.009525339	0.033281935	
23	31/08/2024	-0.003599631	0.002957371	-0.00064226	0.023924175	-0.024566435	
24	30/09/2024	0.012941828	-0.004193645	0.008748183	0.007505613	0.001242571	
25	31/10/2024	-0.011388868	-0.009487333	-0.020876202	-0.028446707	0.007570505	
26	30/11/2024	0.016191262	-0.003957563	0.012233699	0.031718028	-0.019484329	
27	31/12/2024	0.032101526	-0.032126183	-2.46575E-05	-0.029764497	0.029739839	

Figure 12: Performance attribution analysis by industry (allocation and selection effects).

## **Conclusion:**

This project was designed to apply the theory of portfolio management in a realistic and relevant fund management context, where a total capital base of £1,350,000 was used to construct and quantitatively optimise a series of portfolios and a socially responsible investment fund. The results of the analysis were able to illustrate the impact of various portfolio construction decisions, constraints, and risk exposures on actual portfolio performance when tested out of sample.

In Task One, the results of the mean-variance optimisation were able to illustrate the trade-offs between efficiency and risk management. Although the unconstrained portfolios were found to have a higher Sharpe ratio, they were also found to have a higher level of concentration in weights and estimation risk. The results of the constrained short selling portfolios were found to have a more stable level of diversification and downside risk. The comparison of the high-beta and low-beta portfolios was also able to illustrate that higher levels of systematic risk were not necessarily associated with higher levels of risk-adjusted return.

In Task Two, it was demonstrated from the investment fund analysis that strategic industry allocation was the key contributor to relative investment performance, as opposed to individual stock selection. The performance attribution analysis confirmed that well-disciplined top-down investment decisions can indeed add value within a socially responsible investment process without compromising risk-adjusted investment returns.

In conclusion, it is submitted that the above analysis reinforces the importance of quantitative optimisation as an investment decision support tool, used in conjunction with economic judgment, proper constraints, and performance attribution, as a means of effectively applying portfolio management frameworks.

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## **Appendix A1 – Task One: Mean–Variance Portfolio Construction.**

Excel file: [task 1.xlsx](#)

This file contains:

Monthly closing prices for 20 equities, benchmark, and risk-free asset (Nov 2019 – Nov 2024)

Calculation of monthly returns and excess returns

Covariance matrix of excess returns

Mean–variance optimisation under unconstrained and restricted short-selling conditions

Efficient frontier plots and identification of tangency portfolios

CAPM beta estimation and high-beta vs low-beta portfolio classification

Out-of-sample performance evaluation (Jan 2025 – Nov 2025) using Sharpe, Treynor, Sortino ratios and Jensen's alpha

## **Appendix A2 – Task Two: Investment Fund Construction and Attribution**

Excel file: [Tasktwo.xlsx](#)

This file contains:

Monthly closing prices for socially responsible investment fund assets and industry benchmarks

Strategic industry and asset allocation weights

Construction of the investment fund and benchmark portfolio

Out-of-sample performance evaluation (Jan 2025 – Nov 2025)

Performance attribution analysis decomposing returns by industry allocation and selection effects