Analysis of IM & MM Model

FBAC-301001A Group3

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Part I

『Introduction』

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Introduction of Project

Purpose

The purpose of this Final Project is to practically implement the contents covered in Chapter 7 (Efficient Diversification) and Chapter 8 (Index Models) from class material *Investments* By Zvi Bodie.

The project aims to find the regions of permissible portfolios (efficient frontier, minimal ris portfolio, optimal portfolio, and minimal return portfolios frontier) for the five cases of the additional constraints:

Dataset

The dataset acquired from Yahoo! Finance contains recent 20 years of historical daily total return data for ten stocks (introduced as target companies). One equity index (S&P 500) and an Effective Federal Funds rate (risk-free :FEDL01) are introduced.

To simulate a close-to-reality portfolio investment and reduce randomness, the ten target companies come from four diversified industries.

Main Steps

Aggregate the daily data to the monthly observations to lessen the non-Gaussian impacts, and then compute the correct optimization inputs for the entire Markowitz Model and Index Model.

Determine the areas of acceptable portfolios (efficient frontier, minimal risk portfolio, optimal portfolio, and minimal return portfolios frontier) with five extra constraints by optimization of MM and IM models.

Five Constrains

Constraint 1 $\sum_{i=1}^{11} |w_i| \le 2;$

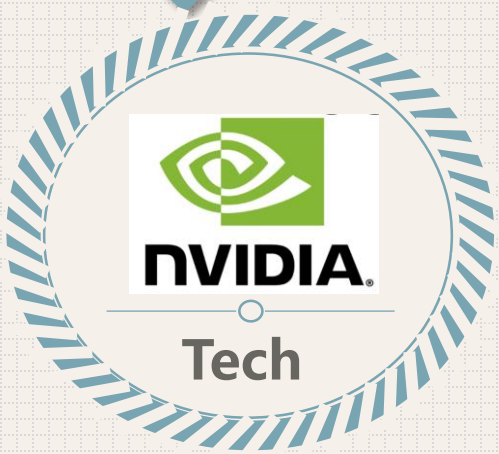
Constraint 2 $|w_i| \le 1, \text{for } \forall i;$

Constraint 3 **A *"free" problem*, without any additional optimization constraints**

Constraint 4 $w_i \ge 0, \text{for } \forall i;$

Constraint 5 $w_1 = 0.$

Target Companies



Nvidia Corporation is a global leader in artificial intelligence hardware and software based in Santa Clara, CA. It is a software and fabless company which designs GPUs and APIs for data science and SoCs for the mobile computing and automotive market.

Cisco Systems is a multinational technology conglomerate corporation headquartered in San Jose, CA. Cisco develops, manufactures, and sells networking hardware, software, and telecommunications equipment.

Intel Corporation, headquartered in San Jose, CA, is the world's largest semiconductor chip manufacturer. Intel supplies microprocessors for PCs and also manufactures motherboard chipsets, network interface controllers and integrated circuits.

Goldman Sachs, headquartered in New York City, is the largest financial services provider in the world who offers services in investment banking, securities, asset management and investment management. It also operates private-equity funds, credit, real estate funds, and hedge funds.

U.S. Bancorp is a leading banking institution in the United States. The company provides banking, investment, mortgage, trust, and payment services products to individuals, businesses, governmental entities, and other financial institutions.

Target Companies

Financial

TD Bank is a leading banking institution primarily operating across the East Coast. Founded by January 1852, TD has 170 years history in financial services. The company provides banking, investment, mortgage and payment services to individuals, governmental entities, and other financial institutions.

Financial

The Allstate Corporation is one of the largest insurance company in North American. The company provides insurance products, (auto insurance, homeowners insurance, healthcare insurance etc.), wealth transfer (business succession planning products etc.) and other financial services.

Consumer Defensive

The Procter & Gamble Company is a consumer goods manufacture specializing in a wide range of personal health/consumer health, personal care and hygiene products and also produce food, snacks, and beverages.

Healthcare

Johnson & Johnson is an American manufacturer of healthcare products, medical devices and pharmaceuticals with global headquarters in New Brunswick, New Jersey, USA. The comapny consists of more than 250 subsidiaries around the world, and its products are sold in more than 170 countries.

Consumer Defensive

Colgate-Palmolive Company is an American consumer products company headquartered on NYC. It specializes in the production, distribution and provision of household, health care, personal care and veterinary products.

Part II

『Data&Methods』

- 『Preview of Data』
- 『Session II』
- 『Session III』
- 『Session IV』

Preview of Dataset

SPX		FEDL01		NVDA		CSCO		JNJ		GS		USB		INTC		TD CN		PGR		ALL		GS	
2001/5/11	1245.67	2001/5/11	4.47	2001/5/11	13.0233	2001/5/11	19.05	2001/5/11	48.63	2001/5/11	92.85	2001/5/11	20.6576	2001/5/11	27.94	2001/5/11	20.05	2001/5/11	9.7317	2001/5/11	41.83	2001/5/11	92.85
2001/5/14	1249.016	2001/5/14	4.43	2001/5/14	13.135	2001/5/14	18.57	2001/5/14	48.895	2001/5/14	94.1	2001/5/14	20.8548	2001/5/14	27.41	2001/5/14	20	2001/5/14	9.83	2001/5/14	42	2001/5/14	94.1
2001/5/15	1249.544	2001/5/15	4.22	2001/5/15	13.6067	2001/5/15	18.74	2001/5/15	48.54	2001/5/15	94.85	2001/5/15	21.1999	2001/5/15	27.2	2001/5/15	20.05	2001/5/15	9.8708	2001/5/15	42.3	2001/5/15	94.85
2001/5/16	1285.295	2001/5/16	4.04	2001/5/16	14.2483	2001/5/16	20	2001/5/16	49.885	2001/5/16	99.95	2001/5/16	21.6337	2001/5/16	28.36	2001/5/16	20.015	2001/5/16	10.0592	2001/5/16	43.27	2001/5/16	99.95
2001/5/17	1288.808	2001/5/17	4.04	2001/5/17	14.5	2001/5/17	19.86	2001/5/17	50.34	2001/5/17	97.95	2001/5/17	21.3576	2001/5/17	28.6	2001/5/17	20.14	2001/5/17	9.9942	2001/5/17	43.04	2001/5/17	97.95
2001/5/18	1292.525	2001/5/18	3.95	2001/5/18	14.3833	2001/5/18	20.2	2001/5/18	50.68	2001/5/18	97.25	2001/5/18	21.5351	2001/5/18	28.76	2001/5/18	20	2001/5/18	10.475	2001/5/18	43.87	2001/5/18	97.25
2001/5/21	1313.404	2001/5/21	4.02	2001/5/21	15.0333	2001/5/21	22.87	2001/5/21	50.4943	2001/5/21	101.9	2001/5/21	21.5943	2001/5/21	29.9	2001/5/22	19.825	2001/5/21	10.8167	2001/5/21	44.89	2001/5/21	101.9
2001/5/22	1309.958	2001/5/22	3.99	2001/5/22	15.4833	2001/5/22	23.48	2001/5/22	49.6764	2001/5/22	103.29	2001/5/22	21.9295	2001/5/22	29.53	2001/5/23	19.9	2001/5/22	10.7	2001/5/22	44.84	2001/5/22	103.29
2001/5/23	1289.668	2001/5/23	3.97	2001/5/23	15.3517	2001/5/23	22.36	2001/5/23	49.0392	2001/5/23	99.3	2001/5/23	22.0183	2001/5/23	28.8	2001/5/24	20.25	2001/5/23	10.6975	2001/5/23	44.25	2001/5/23	99.3
2001/5/24	1293.821	2001/5/24	3.98	2001/5/24	15.5783	2001/5/24	22.91	2001/5/24	48.8987	2001/5/24	99.85	2001/5/24	22.2944	2001/5/24	29.21	2001/5/25	20.175	2001/5/24	10.7692	2001/5/24	44.24	2001/5/24	99.85
2001/5/25	1278.536	2001/5/25	3.94	2001/5/25	15.2833	2001/5/25	22.05	2001/5/25	48.7983	2001/5/25	97.96	2001/5/25	21.9197	2001/5/25	29.1	2001/5/28	20.055	2001/5/25	10.7942	2001/5/25	44.47	2001/5/25	97.96
2001/5/29	1268.648	2001/5/29	4.09	2001/5/29	14.6567	2001/5/29	20.46	2001/5/29	48.8937	2001/5/29	96.88	2001/5/29	21.8112	2001/5/29	27.85	2001/5/29	19.9	2001/5/29	11.0958	2001/5/29	45.05	2001/5/29	96.88
2001/5/30	1249.089	2001/5/30	4.05	2001/5/30	14.3833	2001/5/30	19	2001/5/30	48.723	2001/5/30	94.76	2001/5/30	21.7915	2001/5/30	26.6	2001/5/30	19.6	2001/5/30	10.9833	2001/5/30	45.4015	2001/5/30	94.76
2001/5/31	1256.938	2001/5/31	4.24	2001/5/31	14.2683	2001/5/31	19.26	2001/5/31	48.6478	2001/5/31	95.1	2001/5/31	21.9887	2001/5/31	27.01	2001/5/31	19.975	2001/5/31	10.92	2001/5/31	45.2107	2001/5/31	95.1
2001/6/1	1261.793	2001/6/1	4.14	2001/6/1	15.0583	2001/6/1	18.85	2001/6/1	49.1747	2001/6/1	96.7	2001/6/1	22.1859	2001/6/1	28.74	2001/6/1	20.36	2001/6/1	10.8033	2001/6/1	43.2825	2001/6/1	96.7
2001/6/4	1268.261	2001/6/4	4.03	2001/6/4	14.825	2001/6/4	19.73	2001/6/4	50.2485	2001/6/4	96.51	2001/6/4	22.4324	2001/6/4	28.5	2001/6/4	20.6	2001/6/4	10.9158	2001/6/4	43.1821	2001/6/4	96.51
2001/6/5	1284.749	2001/6/5	3.93	2001/6/5	15.6033	2001/6/5	21.54	2001/6/5	51.2771	2001/6/5	97.35	2001/6/5	22.5212	2001/6/5	29.73	2001/6/5	20.625	2001/6/5	11.1192	2001/6/5	44.096	2001/6/5	97.35
2001/6/6	1271.363	2001/6/6	3.91	2001/6/6	15.67	2001/6/6	20.76	2001/6/6	51.7337	2001/6/6	95.54	2001/6/6	22.7775	2001/6/6	29.82	2001/6/6	20.55	2001/6/6	11.2892	2001/6/6	44.2868	2001/6/6	95.54
2001/6/7	1278.331	2001/6/7	3.92	2001/6/7	16.555	2001/6/7	21.82	2001/6/7	51.7137	2001/6/7	96.9	2001/6/7	22.6789	2001/6/7	31.14	2001/6/7	20.655	2001/6/7	11.245	2001/6/7	43.8248	2001/6/7	96.9
2001/6/8	1266.324	2001/6/8	4.02	2001/6/8	16.125	2001/6/8	20.49	2001/6/8	51.1868	2001/6/8	95.36	2001/6/8	22.4226	2001/6/8	30.67	2001/6/8	20.715	2001/6/8	11.2216	2001/6/8	44.0458	2001/6/8	95.36
2001/6/11	1255.749	2001/6/11	4.03	2001/6/11	15.6533	2001/6/11	20.38	2001/6/11	50.8657	2001/6/11	92.01	2001/6/11	22.4226	2001/6/11	30.33	2001/6/11	20.75	2001/6/11	11.1933	2001/6/11	44.337	2001/6/11	92.01
2001/6/12	1257.221	2001/6/12	3.98	2001/6/12	16.175	2001/6/12	20.37	2001/6/12	51.0814	2001/6/12	91.86	2001/6/12	22.2944	2001/6/12	30.13	2001/6/12	20.915	2001/6/12	11.2316	2001/6/12	44.4876	2001/6/12	91.86
2001/6/13	1243.243	2001/6/13	4.04	2001/6/13	15.6317	2001/6/13	19.02	2001/6/13	50.8907	2001/6/13	89.16	2001/6/13	22.1859	2001/6/13	29.06	2001/6/13	20.915	2001/6/13	11.2225	2001/6/13	44.8592	2001/6/13	89.16
2001/6/14	1221.508	2001/6/14	4.03	2001/6/14	15.5983	2001/6/14	17.74	2001/6/14	51.0915	2001/6/14	87.01	2001/6/14	21.3478	2001/6/14	27.61	2001/6/14	20.4116	2001/6/14	10.9948	2001/6/14	44.7086	2001/6/14	87.01
2001/6/15	1215.994	2001/6/15	3.94	2001/6/15	15.8417	2001/6/15	16.65	2001/6/15	52.2255	2001/6/15	89.29	2001/6/15	21.1999	2001/6/15	27.68	2001/6/15	20.0492	2001/6/15	10.9948	2001/6/15	43.9755	2001/6/15	89.29
2001/6/18	1210.075	2001/6/18	3.91	2001/6/18	15.215	2001/6/18	16.5	2001/6/18	52.2155	2001/6/18	88.65	2001/6/18	21.4957	2001/6/18	27.55	2001/6/18	19.9838	2001/6/18	11.0666	2001/6/18	43.6842	2001/6/18	88.65
2001/6/19	1214.241	2001/6/19	3.91	2001/6/19	14.3833	2001/6/19	16.64	2001/6/19	53.4699	2001/6/19	88.18	2001/6/19	21.9887	2001/6/19	26.67	2001/6/19	20.019	2001/6/19	10.9131	2001/6/19	43.383	2001/6/19	88.18
2001/6/20	1224.862	2001/6/20	3.98	2001/6/20	15.0017	2001/6/20	16.4	2001/6/20	53.8011	2001/6/20	88.4	2001/6/20	22.1859	2001/6/20	27.49	2001/6/20	20.2606	2001/6/20	10.954	2001/6/20	43.8349	2001/6/20	88.4
2001/6/21	1238.809	2001/6/21	4.02	2001/6/21	15.285	2001/6/21	17.68	2001/6/21	53.209	2001/6/21	93	2001/6/21	22.9255	2001/6/21	27.27	2001/6/21	20.6381	2001/6/21	11.1599	2001/6/21	45.1404	2001/6/21	93
2001/6/22	1227.104	2001/6/22	3.98	2001/6/22	15.2167	2001/6/22	17.52	2001/6/22	52.5767	2001/6/22	92.1	2001/6/22	22.6789	2001/6/22	27.51	2001/6/22	20.6331	2001/6/22	11.0891	2001/6/22	43.865	2001/6/22	92.1
2001/6/25	1220.344	2001/6/25	3.97	2001/6/25	15.1867	2001/6/25	18.51	2001/6/25	51.7839	2001/6/25	90.95	2001/6/25	22.6789	2001/6/25	28.58	2001/6/25	20.7338	2001/6/25	10.9482	2001/6/25	43.9855	2001/6/25	90.95
2001/6/26	1218.502	2001/6/26	3.75	2001/6/26	15.625	2001/6/26	18.02	2001/6/26	51.2922	2001/6/26	90.3	2001/6/26	22.1366	2001/6/26	28.97	2001/6/26	19.9838	2001/6/26	11.0065	2001/6/26	44.1864	2001/6/26	90.3
2001/6/27	1212.955	2001/6/27	3.68	2001/6/27	15.1417	2001/6/27	17.93	2001/6/27	50.8807	2001/6/27	87.5	2001/6/27	22.1539	2001/6/27	28.65	2001/6/27	19.2136	2001/6/27	11.1591	2001/6/27	44.1161	2001/6/27	87.5
2001/6/28	1228.121	2001/6/28	3.86	2001/6/28	15.32	2001/6/28	18.58	2001/6/28	52.3861	2001/6/28	86.6	2001/6/28	22.6212	2001/6/28	29.64	2001/6/28	19.2438	2001/6/28	11.3309	2001/6/28	44.4977	2001/6/28	86.6
2001/6/29	1226.338	2001/6/29	3.95	2001/6/29	15.4583	2001/6/29	18.2	2001/6/29	50.1782	2001/6/29	85.8	2001/6/29	22.661	2001/6/29	29.25	2001/6/29	19.4502	2001/6/29	11.2717	2001/6/29	44.1763	2001/6/29	85.8
2001/7/2	1238.649	2001/7/2	4.11	2001/7/2	14.7733	2001/7/2	19.22	2001/7/2	51.3725	2001/7/2	84.6	2001/7/2	23.178	2001/7/2	30.06	2001/7/3	19.7925	2001/7/2	11.2792	2001/7/2	44.6784	2001/7/2	84.6
2001/7/3	1236.588	2001/7/3	3.69	2001/7/3	14.9617	2001/7/3	19.19	2001/7/3	51.2219	2001/7/3	84	2001/7/3	23.0189	2001/7/3	30.46	2001/7/4	19.7573	2001/7/3	11.2642	2001/7/3	44.4173	2001/7/3	84
2001/7/5	1221.588	2001/7/5	3.72	2001/7/5	13.8767	2001/7/5	17.58	2001/7/5	51.0915	2001/7/5	84	2001/7/5	23.1681	2001/7/5	29.84	2001/7/5	19.7371	2001/7/5	11.1783	2001/7/5	43.5035	2001/7/5	84
2001/7/6	1193.121	2001/7/6	3.6	2001/7/6	13.45	2001/7/6	16.79	2001/7/6	50.5897	2001/7/6	82.1	2001/7/6	22.8291	2001/7/6	28.42	2001/7/6	19.5056	2001/7/6	10.9033	2001/7/6	43.011	2001/7/6	82.1

Start With Raw Daily Data for Recent 20 years

Contains price of ten target stock, S&P 500 index and a federal funds rate (FEDL01)

Preview of Dataset

#	Date	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	NRFR	Week	Month
0	5/11/01	1,245.67	13.02	19.05	27.94	92.85	20.66	20.05	41.83	32.75	48.63	29.07	1,000.00	1	1
1	5/14/01	1,249.02	13.14	18.57	27.41	94.10	20.85	20.00	42.00	33.03	48.90	29.10	1,000.18	0	0
2	5/15/01	1,249.54	13.61	18.74	27.20	94.85	21.20	20.05	42.30	32.99	48.54	28.35	1,000.34	0	0
3	5/16/01	1,285.30	14.25	20.00	28.36	99.95	21.63	20.02	43.27	34.15	49.89	29.26	1,000.50	0	0
4	5/17/01	1,288.81	14.50	19.86	28.60	97.95	21.36	20.14	43.04	33.58	50.34	29.03	1,000.66	0	0
5	5/18/01	1,292.52	14.38	20.20	28.76	97.25	21.54	20.00	43.87	33.74	50.68	28.70	1,000.82	1	0
6	5/21/01	1,313.40	15.03	22.87	29.90	101.90	21.59	20.00	44.89	32.63	50.49	28.80	1,000.98	0	0
7	5/22/01	1,309.96	15.48	23.48	29.53	103.29	21.93	19.83	44.84	32.00	49.68	28.11	1,001.14	0	0
8	5/23/01	1,289.67	15.35	22.36	28.80	99.30	22.02	19.90	44.25	32.10	49.04	28.39	1,001.30	0	0
9	5/24/01	1,293.82	15.58	22.91	29.21	99.85	22.29	20.25	44.24	32.13	48.90	28.60	1,001.45	0	0
10	5/25/01	1,278.54	15.28	22.05	29.10	97.96	21.92	20.18	44.47	31.75	48.80	28.39	1,001.61	1	0
11	5/28/01	1,278.54	15.28	22.05	29.10	97.96	21.92	20.06	44.47	31.75	48.80	28.39	1,001.77	0	0
12	5/29/01	1,268.65	14.66	20.46	27.85	96.88	21.81	19.90	45.05	32.32	48.89	28.99	1,001.93	0	0
13	5/30/01	1,249.09	14.38	19.00	26.60	94.76	21.79	19.60	45.40	32.19	48.72	28.77	1,002.09	0	0
14	5/31/01	1,256.94	14.27	19.26	27.01	95.10	21.99	19.98	45.21	32.12	48.65	28.32	1,002.26	0	1
15	6/1/01	1,261.79	15.06	18.85	28.74	96.70	22.19	20.36	43.28	31.76	49.17	28.63	1,002.42	1	0
16	6/4/01	1,268.26	14.83	19.73	28.50	96.51	22.43	20.60	43.18	31.80	50.25	28.73	1,002.59	0	0
17	6/5/01	1,284.75	15.60	21.54	29.73	97.35	22.52	20.63	44.10	32.04	51.28	29.10	1,002.74	0	0
18	6/6/01	1,271.36	15.67	20.76	29.82	95.54	22.78	20.55	44.29	32.34	51.73	29.23	1,002.90	0	0
19	6/7/01	1,278.33	16.56	21.82	31.14	96.90	22.68	20.66	43.82	32.46	51.71	29.38	1,003.05	0	0
20	6/8/01	1,266.32	16.13	20.49	30.67	95.36	22.42	20.72	44.05	32.14	51.19	29.44	1,003.21	1	0
21	6/11/01	1,255.75	15.65	20.38	30.33	92.01	22.42	20.75	44.34	32.18	50.87	29.41	1,003.37	0	0
22	6/12/01	1,257.22	16.18	20.37	30.13	91.86	22.29	20.92	44.49	32.75	51.08	29.42	1,003.53	0	0
23	6/13/01	1,243.24	15.63	19.02	29.06	89.16	22.19	20.92	44.86	32.48	50.89	28.95	1,003.69	0	0
24	6/14/01	1,221.51	15.60	17.74	27.61	87.01	21.35	20.41	44.71	32.43	51.09	28.86	1,003.85	0	0
25	6/15/01	1,215.99	15.84	16.65	27.68	89.29	21.20	20.05	43.98	31.30	52.23	28.95	1,004.01	1	0
26	6/18/01	1,210.08	15.22	16.50	27.55	88.65	21.50	19.98	43.68	31.08	52.22	28.96	1,004.17	0	0
27	6/19/01	1,214.24	14.38	16.64	26.67	88.18	21.99	20.02	43.38	31.21	53.47	29.09	1,004.32	0	0
28	6/20/01	1,224.86	15.00	16.40	27.49	88.40	22.19	20.26	43.83	31.28	53.80	29.60	1,004.48	0	0
29	6/21/01	1,238.81	15.29	17.68	27.27	93.00	22.93	20.64	45.14	31.18	53.21	30.50	1,004.64	0	0
30	6/22/01	1,227.10	15.22	17.52	27.51	92.10	22.68	20.63	43.87	31.64	52.58	29.68	1,004.80	1	0
31	6/25/01	1,220.34	15.19	18.51	28.58	90.95	22.68	20.73	43.99	31.40	51.78	29.45	1,004.96	0	0
32	6/26/01	1,218.50	15.63	18.02	28.97	90.30	22.14	19.98	44.19	31.93	51.29	30.35	1,005.11	0	0
33	6/27/01	1,212.95	15.14	17.93	28.65	87.50	22.15	19.21	44.12	31.70	50.88	30.30	1,005.25	0	0
34	6/28/01	1,228.12	15.32	18.58	29.64	86.60	22.62	19.24	44.50	31.83	52.39	30.48	1,005.41	0	0
35	6/29/01	1,226.34	15.46	18.20	29.25	85.80	22.66	19.45	44.18	31.90	50.18	29.50	1,005.57	1	1
36	7/2/01	1,238.65	14.77	19.22	30.06	84.60	23.18	19.45	44.68	32.24	51.37	29.99	1,005.73	0	0
37	7/3/01	1,236.59	14.96	19.19	30.46	84.00	23.02	19.79	44.42	32.30	51.22	30.13	1,005.88	0	0

Calculating the NRFR with formula :

Previous NRFR * (1+FEDL01/100/252)

	Price										
Date	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	NRFR
5/11/01	1,245.67	13.02	19.05	27.94	92.85	20.66	20.05	41.83	32.75	48.63	29.07	1,000.00
5/31/01	1,256.94	14.27	19.26	27.01	95.10	21.99	19.98	45.21	32.12	48.65	28.32	1,002.26
6/29/01	1,226.34	15.46	18.20	29.25	85.80	22.66	19.45	44.18	31.90	50.18	29.50	1,005.57
7/31/01	1,214.25	13.48	19.22	29.81	83.28	23.61	19.80	35.11	35.71	54.29	27.19	1,008.89
8/31/01	1,138.24	14.12	16.33	27.98	80.21	24.10	20.92	34.26	37.28	53.08	27.17	1,012.26
9/28/01	1,046.31	9.16	12.18	20.45	71.45	22.25	19.69	37.72	36.59	55.78	29.22	1,014.67
10/31/01	1,066.25	14.29	16.92	24.44	78.39	17.84	18.22	31.69	37.29	58.31	28.94	1,016.98
11/30/01	1,148.05	18.21	20.44	32.70	89.26	19.04	20.05	34.77	39.15	58.83	29.37	1,018.84
12/31/01	1,158.10	22.30	18.11	31.49	93.02	21.19	20.97	34.22	40.00	59.69	29.06	1,020.38
1/31/02	1,141.21	21.91	19.80	35.09	87.35	21.07	21.74	32.76	41.49	58.08	28.85	1,022.00
2/28/02	1,119.18	17.00	14.27	28.61	81.28	21.10	21.66	35.78	43.06	61.70	28.26	1,023.42
3/29/02	1,161.27	14.79	16.93	30.47	90.63	23.04	22.42	38.59	45.76	65.80	28.85	1,024.89
4/30/02	1,090.85	11.60	14.65	28.67	79.20	24.19	21.51	40.60	46.04	64.70	26.85	1,026.47
5/31/02	1,082.81	11.15	15.78	27.70	75.88	24.14	19.91	39.53	45.67	62.36	27.45	1,028.12
6/28/02	1,005.77	5.73	13.95	18.32	73.77	24.04	18.60	37.99	45.90	53.12	25.35	1,029.55
7/31/02	927.37	3.69	13.19	18.84	73.70	22.02	17.09	39.05	45.98	53.87	26.10	1,031.18
8/30/02	933.44	3.37	13.82	16.74	77.88	22.13	17.90	38.45	45.80	55.41	27.73	1,032.76
9/30/02	831.99	2.85	10.48	13.95	66.52	19.33	14.52	36.73	46.18	55.18	27.42	1,034.27
10/31/02	905.22	3.97	11.18	17.37	72.26	21.94	15.34	41.10	45.90	59.94	28.03	1,035.93
11/29/02	958.50	5.71	14.92	20.99	79.59	22.79	17.38	40.54	43.87	58.37	26.20	1,037.08
12/31/02	902.19	3.84	13.10	15.65	68.72	22.29	17.92	38.42	44.60	54.99	26.73	1,038.20
1/31/03	878.55	3.44	13.37	15.78	68.84	22.16	16.96	36.55	44.62	54.88	26.05	1,039.39
2/28/03	865.37	4.21	13.98	17.37	70.21	21.97	17.55	33.09	42.69	53.91	25.75	1,040.43
3/31/03	873.77	4.29	12.98	16.38	68.82	20.14	17.22	34.71	46.44	59.48	27.86	1,041.51
4/30/03	945.72	4.76	15.00	18.49	76.85	23.50	18.03	39.54	47.07	57.93	29.38	1,042.66
5/30/03	995.55	8.72	16.41	20.97	82.52	25.15	18.60	37.90	48.10	56.10	30.64	1,043.81
6/30/03	1,008.24	7.64	16.79	20.96	84.80	26.21	20.00	37.54	46.72	53.37	29.78	1,044.88
7/31/03	1,025.98	6.36	19.49	25.07	88.49	26.23	20.07	40.05	46.27	53.46	28.18	1,045.86
8/29/03	1,045.98	6.06	19.14	28.83	89.86	25.57	20.90	37.89	45.96	51.42	28.53	1,046.74
9/30/03	1,034.87	5.32	19.59	27.75	85.20	25.89	20.64	38.72	48.87	51.36	28.84	1,047.66
10/31/03	1,093.36	5.89	20.93	33.22	95.62	29.37	23.67	41.87	52.00	52.20	27.56	1,048.63

Aggregate the daily data to the monthly observations for ten stock, S&P index and NRFR

Session II

	Price												Returns	
Date	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	NRFR	SPX	NVDA
5/11/01	1,245.67	13.02	19.05	27.94	92.85	20.66	20.05	41.83	32.75	48.63	29.07	1,000.00		
5/31/01	1,256.94	14.27	19.26	27.01	95.10	21.99	19.98	45.21	32.12	48.65	28.32	1,002.26	=B4/B3-1	9.560%
6/29/01	1,226.34	15.46	18.20	29.25	85.80	22.66	19.45	44.18	31.90	50.18	29.50	1,005.57	-2.435%	8.340%
7/31/01	1,214.25	13.48	19.22	29.81	83.28	23.61	19.80	35.11	35.71	54.29	27.19	1,008.89	-0.985%	-12.776%
8/31/01	1,138.24	14.12	16.33	27.98	80.21	24.10	20.92	34.26	37.28	53.08	27.17	1,012.26	-6.260%	4.710%
9/28/01	1,046.31	9.16	12.18	20.45	71.45	22.25	19.69	37.72	36.59	55.78	29.22	1,014.67	-8.077%	-35.143%
10/31/01	1,066.25	14.29	16.92	24.44	78.39	17.84	18.22	31.69	37.29	58.31	28.94	1,016.98	1.905%	56.025%
11/30/01	1,148.05	18.21	20.44	32.70	89.26	19.04	20.05	34.77	39.15	58.83	29.37	1,018.84	7.672%	27.484%
12/31/01	1,158.10	22.30	18.11	31.49	93.02	21.19	20.97	34.22	40.00	59.69	29.06	1,020.38	0.876%	22.438%
1/31/02	1,141.21	21.91	19.80	35.09	87.35	21.07	21.74	32.76	41.49	58.08	28.85	1,022.00	-1.458%	-1.734%
2/28/02	1,119.18	17.00	14.27	28.61	81.28	21.10	21.66	35.78	43.06	61.70	28.26	1,023.42	-1.931%	-22.406%
3/29/02	1,161.27	14.79	16.93	30.47	90.63	23.04	22.42	38.59	45.76	65.80	28.85	1,024.89	3.761%	-13.036%
4/30/02	1,090.85	11.60	14.65	28.67	79.20	24.19	21.51	40.60	46.04	64.70	26.85	1,026.47	-6.064%	-21.529%
5/31/02	1,082.81	11.15	15.78	27.70	75.88	24.14	19.91	39.53	45.67	62.36	27.45	1,028.12	-0.737%	-3.878%
6/28/02	1,005.77	5.73	13.95	18.32	73.77	24.04	18.60	37.99	45.90	53.12	25.35	1,029.55	-7.115%	-48.655%
7/31/02	927.37	3.69	13.19	18.84	73.70	22.02	17.09	39.05	45.98	53.87	26.10	1,031.18	-7.795%	-35.565%
8/30/02	933.44	3.37	13.82	16.74	77.88	22.13	17.90	38.45	45.80	55.41	27.73	1,032.76	0.654%	-8.713%
9/30/02	831.99	2.85	10.48	13.95	66.52	19.33	14.52	36.73	46.18	55.18	27.42	1,034.27	-10.868%	-15.295%
10/31/02	905.22	3.97	11.18	17.37	72.26	21.94	15.34	41.10	45.90	59.94	28.03	1,035.93	8.802%	39.021%
11/29/02	958.50	5.71	14.92	20.99	79.59	22.79	17.38	40.54	43.87	58.37	26.20	1,037.08	5.886%	43.948%
12/31/02	902.19	3.84	13.10	15.65	68.72	22.29	17.92	38.42	44.60	54.99	26.73	1,038.20	-5.875%	-32.807%
1/31/03	878.55	3.44	13.37	15.78	68.84	22.16	16.96	36.55	44.62	54.88	26.05	1,039.39	-2.620%	-10.340%
2/28/03	865.37	4.21	13.98	17.37	70.21	21.97	17.55	33.09	42.69	53.91	25.75	1,040.43	-1.500%	22.288%
3/31/03	873.77	4.29	12.98	16.38	68.82	20.14	17.22	34.71	46.44	59.48	27.86	1,041.51	0.970%	2.059%
4/30/03	945.72	4.76	15.00	18.49	76.85	23.50	18.03	39.54	47.07	57.93	29.38	1,042.66	8.235%	10.794%
5/30/03	995.55	8.72	16.41	20.97	82.52	25.15	18.60	37.90	48.10	56.10	30.64	1,043.81	5.268%	83.390%
6/30/03	1,008.24	7.64	16.79	20.96	84.80	26.21	20.00	37.54	46.72	53.37	29.78	1,044.88	1.275%	-12.456%
7/31/03	1,025.98	6.36	19.49	25.07	88.49	26.23	20.07	40.05	46.27	53.46	28.18	1,045.86	1.760%	-16.675%
8/29/03	1,045.98	6.06	19.14	28.83	89.86	25.57	20.90	37.89	45.96	51.42	28.53	1,046.74	1.949%	-4.818%
9/30/03	1,034.87	5.32	19.59	27.75	85.20	25.89	20.64	38.72	48.87	51.36	28.84	1,047.66	-1.062%	-12.109%
10/31/03	1,093.36	5.89	20.93	33.22	95.62	29.37	23.67	41.87	52.00	52.20	27.56	1,048.63	5.652%	10.708%
11/28/03	1,102.97	7.08	22.70	33.84	97.84	29.90	22.10	43.05	50.92	51.36	27.21	1,049.46	0.878%	20.080%

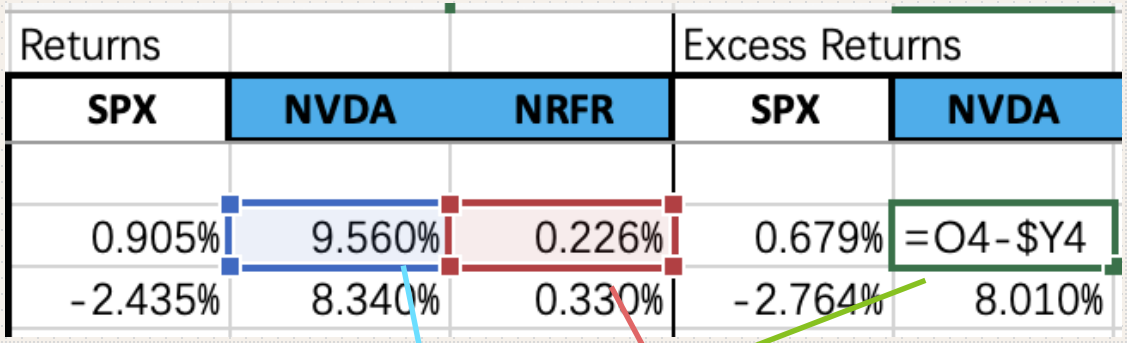
	Price		Returns	
Date	SPX	NVDA	SPX	NVDA
5/11/01	1,245.67	13.02		
5/31/01	1,256.94	14.27	=B4/B3-1	9.560%
6/29/01	1,226.34	15.46	-2.435%	8.340%

Calculating the monthly return with formula :

$$return = \frac{end - date - price}{start - date - price} - 1$$

Session II

Returns			Excess Returns		
SPX	NVDA	NRFR	SPX	NVDA	CSCO
0.905%	9.560%	0.226%	0.679%	9.334%	0.876%
-2.435%	8.340%	0.330%	-2.764%	8.010%	-5.833%
-0.985%	-12.776%	0.330%	-1.316%	-13.107%	5.274%
-6.260%	4.710%	0.334%	-6.594%	4.375%	-15.371%
-8.077%	-35.143%	0.238%	-8.314%	-35.381%	-25.651%
1.905%	56.025%	0.228%	1.677%	55.796%	38.688%
7.672%	27.484%	0.183%	7.489%	27.301%	20.621%
0.876%	22.438%	0.151%	0.725%	22.287%	-11.550%
-1.458%	-1.734%	0.159%	-1.617%	-1.893%	9.173%
-1.931%	-22.406%	0.139%	-2.069%	-22.545%	-28.068%
3.761%	-13.036%	0.144%	3.617%	-13.180%	18.497%
-6.064%	-21.529%	0.154%	-6.218%	-21.682%	-13.621%
-0.737%	-3.878%	0.161%	-0.897%	-4.039%	7.553%
-7.115%	-48.655%	0.139%	-7.254%	-48.794%	-11.736%
-7.795%	-35.565%	0.159%	-7.953%	-35.724%	-5.607%



Calculating excess return with formula :

$$\text{Excess Return} = \text{Return of stock} - \text{Return of Risk-free Funds}$$

Session II

urns			Excess Returns										
SPX	NVDA	NRFR	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
2.659%	-7.365%	0.008%	-2.667%	-7.373%	-8.022%	-14.492%	-5.944%	8.639%	-3.462%	-5.733%	-0.816%	-7.914%	2.815%
0.946%	6.921%	0.007%	10.939%	6.914%	19.826%	9.973%	21.967%	10.930%	18.741%	15.915%	1.284%	6.255%	8.549%
3.841%	-2.556%	0.008%	3.833%	-2.565%	4.013%	3.032%	14.976%	8.795%	3.029%	7.398%	0.186%	8.770%	-0.160%
1.018%	-0.500%	0.007%	-1.025%	-0.507%	0.429%	11.414%	2.822%	-8.035%	1.818%	-2.509%	-7.306%	3.646%	-8.276%
2.758%	5.579%	0.006%	2.752%	5.573%	0.645%	10.135%	17.809%	16.680%	6.453%	-0.547%	-3.656%	-2.263%	-3.596%
4.379%	-2.639%	0.006%	4.373%	-2.646%	15.238%	5.291%	2.735%	11.445%	6.242%	8.564%	9.627%	3.711%	4.821%
5.337%	12.445%	0.006%	5.331%	12.439%	-0.858%	-10.115%	6.554%	7.298%	4.078%	10.351%	-0.854%	-0.992%	2.933%
2.776%	-8.335%	0.002%	-2.778%	-8.337%	1.353%	-6.232%	1.705%	0.352%	1.525%	4.690%	1.587%	3.360%	1.671%
Annualized Average Return			*12	32.802%	9.714%	8.995%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
Annualized StDev			14.850%	55.774%	30.809%	30.503%	29.572%	23.680%	18.134%	24.884%	14.587%	14.785%	15.350%
beta			1	1.978752	1.32058	1.187512	1.410044	0.971191	0.787	1.056243	0.405118	0.539837	0.454431
annualized alpha			0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
dual StDev			0.000%	47.405%	23.762%	24.889%	20.881%	18.781%	13.865%	19.317%	13.288%	12.423%	13.787%

Calculating annualized average return with formula :

$$\text{Annualized Average Return} = \text{AVERAGE(Z4:Z244)*12}$$

Session II

rns			Excess Returns					
PX	NVDA	NRFR	SPX	NVDA	CSCO	INTC	GS	USB
.659%	-7.365%	0.008%	-2.667%	-7.373%	-8.022%	-14.492%	-5.944%	8.639%
.946%	6.921%	0.007%	10.939%	6.914%	19.826%	9.973%	21.967%	10.930%
.841%	-2.556%	0.008%	3.833%	-2.565%	4.013%	3.032%	14.976%	8.795%
.018%	-0.500%	0.007%	-1.025%	-0.507%	0.429%	11.414%	2.822%	-8.035%
.758%	5.579%	0.006%	2.752%	5.573%	0.645%	10.135%	17.809%	16.680%
.379%	-2.639%	0.006%	4.373%	-2.646%	15.238%	5.291%	2.735%	11.445%
.337%	12.445%	0.006%	5.331%	12.439%	-0.858%	-10.115%	6.554%	7.298%
.776%	-8.335%	0.002%	-2.778%	-8.337%	1.353%	-6.232%	1.705%	0.352%
Annualized Average Return			7.542%	32.802%	9.714%	8.905%	10.825%	9.878%
Annualized StDev			14.850%	SQRT(12)	30.809%	30.503%	29.572%	23.680%
beta			1	1.978752	1.32058	1.187512	1.410044	0.971191
annualized alpha			0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%
dual StDev			0.000%	47.405%	23.762%	24.889%	20.881%	18.781%

Calculating annualized StDev with formula :

$$\text{Annualized Standard Deviation} = \text{STDEV(AA4:AA244)*SQRT(12)}$$

Session II

			Excess Returns		
	NVDA	NRFR	SPX	NVDA	CSCO
59%	-7.365%	0.008%	-2.667%	-7.373%	-8.022%
46%	6.921%	0.007%	10.939%	6.914%	19.826%
41%	-2.556%	0.008%	3.833%	-2.565%	4.013%
18%	-0.500%	0.007%	-1.025%	-0.507%	0.429%
58%	5.579%	0.006%	2.752%	5.573%	0.645%
79%	-2.639%	0.006%	4.373%	-2.646%	15.238%
37%	12.445%	0.006%	5.331%	12.439%	-0.858%
76%	-8.335%	0.002%	-2.778%	-8.337%	1.353%
Annualized Average Return			7.542%	32.802%	9.714%
Annualized StDev			14.850%	55.774%	30.809%
beta			1	$Z$244)	1.32058
annualized alpha			0.000%	17.877%	-0.246%
dual StDev			0.000%	47.405%	23.762%

Calculating Beta with formula :

$$\text{Beta} = \text{SLOPE}(AA4{:}AA244, Z4{:}Z244)$$

Session II

rns			Excess Returns			
SPX	NVDA	NRFR	SPX	NVDA	CSCO	INTC
3.800%	1.196%	0.008%	-3.808%	1.188%	-6.711%	1.621%
2.659%	-7.365%	0.008%	-2.667%	-7.373%	-8.022%	-14.492%
0.946%	6.921%	0.007%	10.939%	6.914%	19.826%	9.973%
3.841%	-2.556%	0.008%	3.833%	-2.565%	4.013%	3.032%
1.018%	-0.500%	0.007%	-1.025%	-0.507%	0.429%	11.414%
2.758%	5.579%	0.006%	2.752%	5.573%	0.645%	10.135%
4.379%	-2.639%	0.006%	4.373%	-2.646%	15.238%	5.291%
5.337%	12.445%	0.006%	5.331%	12.439%	-0.858%	-10.115%
2.776%	-8.335%	0.002%	-2.778%	-8.337%	1.353%	-6.232%
	Annualized Average Return		7.542%	32.802%	9.714%	8.905%
	Annualized StDev		14.850%	55.774%	30.809%	30.503%
		beta	1	1.978752	1.32058	1.187512
	annualized alpha		0.000%	12	-0.246%	-0.052%
	dual StDev		0.000%	47.405%	23.762%	24.889%

Calculating Alpha with formula :

$$\text{Alpha} = \text{INTERCEPT}(\text{AA4:AA244}, Z4{:}Z244)*12$$

Session II

rns			Excess Returns		Residual Excess Returns			
PX	NVDA	NRFR	SPX	NVDA	SPX	NVDA	CSCO	INTC
5.638%	11.761%	0.009%	5.630%	11.752%	0.000%	-0.877%	-5.640%	-26.913%
7.188%	25.999%	0.008%	7.180%	25.991%	0.000%	10.293%	-19.830%	-1.059%
3.800%	1.196%	0.008%	-3.808%	1.188%	0.000%	7.232%	-1.662%	6.147%
2.659%	-7.365%	0.008%	-2.667%	-7.373%	0.000%	-3.585%	-4.480%	-11.320%
0.946%	6.921%	0.007%	10.939%	6.914%	0.000%	-16.221%	5.400%	-3.013%
3.841%	-2.556%	0.008%	3.833%	-2.565%	0.000%	-11.639%	-1.028%	-1.515%
1.018%	-0.500%	0.007%	-1.025%	-0.507%	0.000%	0.031%	1.803%	12.635%
2.758%	5.579%	0.006%	2.752%	5.573%	0.000%	-1.361%	-2.969%	6.872%
4.379%	-2.639%	0.006%	4.373%	-2.646%	0.000%	AA$249/12	9.484%	0.103%
5.337%	12.445%	0.006%	5.331%	12.439%	0.000%	0.401%	-7.877%	-16.441%
2.776%	-8.335%	0.002%	-2.778%	-8.337%	0.000%	-4.329%	5.042%	-2.929%
Annualized Average Return			7.542%	32.802%	0.000%	0.000%	0.000%	0.000%
Annualized StDev			14.850%	55.774%	0.000%	47.405%	23.762%	24.889%
beta			1	1.978752				
annualized alpha			0.000%	17.877%				
dual StDev			0.000%	47.405%				

Calculating Residual Excess Returns :

$$\text{Residual of Excess return} = \text{Excess return of stock} - \text{Excess return of SPX} * \text{beta} - \text{alpha}/12$$

Session II

urns			Residual Excess Returns			
SPX	NVDA	NRFR	SPX	NVDA	CSCO	INTC
5.638%	11.761%	0.009%	0.000%	-0.877%	-5.640%	-26.913%
7.188%	25.999%	0.008%	0.000%	10.293%	-19.830%	-1.059%
-3.800%	1.196%	0.008%	0.000%	7.232%	-1.662%	6.147%
-2.659%	-7.365%	0.008%	0.000%	-3.585%	-4.480%	-11.320%
10.946%	6.921%	0.007%	0.000%	-16.221%	5.400%	-3.013%
3.841%	-2.556%	0.008%	0.000%	-11.639%	-1.028%	-1.515%
-1.018%	-0.500%	0.007%	0.000%	0.031%	1.803%	12.635%
2.758%	5.579%	0.006%	0.000%	-1.361%	-2.969%	6.872%
4.379%	-2.639%	0.006%	0.000%	-12.788%	9.484%	0.103%
5.337%	12.445%	0.006%	0.000%	0.401%	-7.877%	-16.441%
-2.776%	-8.335%	0.002%	0.000%	-4.329%	5.042%	-2.929%
	Annualized Average Return		0.000%	0.000%	0.000%	0.000%
	Annualized StDev		0.000%	SQRT(12)	23.762%	24.889%

Calculating Residual stDev Returns :

$$\text{Residual stDev} = \text{STDEV(AL4:AL244)*SQRT(12)}$$

Session II

Excess Returns

NRFR	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
0.008%	-2.667%	-7.373%	-8.022%	-14.492%	-5.944%	8.639%	-3.462%	-5.733%	-0.816%	-7.914%	2.815%
0.007%	10.939%	6.914%	19.826%	9.973%	21.967%	10.930%	18.741%	15.915%	1.284%	6.255%	8.549%
0.008%	3.833%	-2.565%	4.013%	3.032%	14.976%	8.795%	3.029%	7.398%	0.186%	8.770%	-0.160%
0.007%	-1.025%	-0.507%	0.429%	11.414%	2.822%	-8.035%	1.818%	-2.509%	-7.306%	3.646%	-8.276%
0.006%	2.752%	5.573%	0.645%	10.135%	17.809%	16.680%	6.453%	-0.547%	-3.656%	-2.263%	-3.596%
0.006%	4.373%	-2.646%	15.238%	5.291%	2.735%	11.445%	6.242%	8.564%	9.627%	3.711%	4.821%
0.006%	5.331%	12.439%	-0.858%	-10.115%	6.554%	7.298%	4.078%	10.351%	-0.854%	-0.992%	2.933%
0.002%	-2.778%	-8.337%	1.353%	-6.232%	1.705%	0.352%	1.525%	4.690%	1.587%	3.360%	1.671%

correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1	AA$244)	0.63653	0.578128	0.708092	0.609066	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1	0.487198	0.523781	0.343134	0.159845	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.63653	0.487198	1	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1	0.410737	0.279632	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1	0.53916	0.540137	0.33585	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.53916	1	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.33585	0.230974	0.346275	1	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1

Calculating Correlations:

$$\text{Corr}(\text{NVDA}, \text{SPX}) = \text{CORREL}(Z4{:}Z244, \text{AA4} : AA244)$$

$$\text{Corr}(\text{NVDA}, \text{NVDA}) = 1$$

Session III

$$= 1 - SUM(B28 : K28)$$

$$= RAND() * 3 - 1$$

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
Annualized Average Return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
Annualized StDev	14.850%	55.774%	30.809%	30.503%	29.572%	13.680%	18.134%	24.884%	14.587%	14.785%	15.350%
beta	1	1.978752	1.32058	1.187512	1.410044	0.971191	0.787	1.056243	0.405118	0.539837	0.454431
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.153%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.405%	23.762%	24.889%	20.881%	18.781%	13.865%	19.317%	13.288%	12.423%	13.787%

correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1	0.526865	0.63653	0.578128	0.708092	0.609066	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1	0.487198	0.523781	0.343134	0.159845	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.63653	0.487198	1	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1	0.410737	0.279632	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1	0.53916	0.540137	0.33585	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.53916	1	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.33585	0.230974	0.346275	1	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1

M+I	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Markowitz Model Return	Markowitz Model StDev	Markowitz Model Sharpe	Index Model Return	Index Model StDev	Index Model Sharpe
1`	1.261433	1.349575	0.960549	0.78008	0.911129	0.767922	0.663426	1.895086	1.390129	-0.88042	-8.09891	62.04%	184.99%	0.335371	62.04%	176.05%	0.352398
2`	1.992345	1.298458	-0.46485	1.946255	-0.71386	0.055829	-0.46564	0.937466	-0.21359	-0.19419	-3.17823	41.34%	121.85%	0.339269	41.34%	113.37%	0.364672
3`	0.714516	0.828128	0.519438	0.218524	-0.08573	1.425225	-0.33488	1.503302	-0.23528	1.056411	-4.60966	38.13%	105.57%	0.361206	38.13%	107.44%	0.354928
4`	1.292842	1.809288	0.761798	0.318563	-0.01334	1.930454	-0.2932	0.348368	1.952525	1.618418	-6.72571	68.67%	179.06%	0.38352	68.67%	180.22%	0.381054
5`	-0.91897	-0.90022	-0.9839	-0.82769	1.273461	0.075135	-0.09974	1.859461	-0.26324	0.882042	0.90365	-9.81%	92.29%	-0.10634	-9.81%	71.59%	-0.13708
6`	-0.31601	0.487462	0.21004	0.726213	0.223304	-0.33337	0.435257	0.748183	0.240323	1.885084	-3.30649	28.30%	71.06%	0.398312	28.30%	72.35%	0.391201
7`	-0.44382	-0.43169	1.765872	-0.52453	0.379534	0.884558	0.906699	1.312019	-0.35035	-0.37547	-2.12283	9.46%	76.24%	0.124123	9.46%	76.65%	0.123467
8`	-0.98357	0.728648	1.497943	0.585287	1.093105	-0.40406	1.828442	0.930076	1.976474	0.854643	-7.10699	48.98%	143.05%	0.34243	48.98%	139.86%	0.350232
9`	1.186887	-0.67675	0.87597	0.63324	0.565984	-0.27702	-0.14423	0.675895	-0.26078	-0.78868	-0.7905	-5.24%	53.39%	0.09807	-5.24%	56.19%	-0.09318
10`	1.752787	0.69088	0.243908	0.661197	-0.17423	-0.99732	1.11964	1.489798	0.446389	0.308405	-4.54146	34.30%	99.49%	0.344709	34.30%	99.42%	0.345039
11`	0.559697	-0.2254	0.609727	-0.52842	-0.28168	-0.22853	-0.56818	0.179175	-0.74372	0.325431	1.901903	-2.46%	37.01%	-0.06653	-2.46%	37.83%	-0.06508
12`	1.650306	-0.58124	0.990371	0.503343	1.305882	1.549944	1.429073	-0.3541	-0.78998	0.120363	-4.82397	8.39%	117.98%	0.071079	8.39%	108.00%	0.077647
13`	0.290953	1.815794	1.14538	0.178937	1.535282	0.736099	-0.49783	0.285992	1.932255	-0.99068	-5.43218	67.02%	165.30%	0.405469	67.02%	155.90%	0.429915
14`	1.495268	1.397251	-0.28287	-0.37588	1.326549	0.81236	0.455604	-0.26274	0.354996	-0.8521	-3.06844	50.10%	113.74%	0.440502	50.10%	109.16%	0.458998
15`	0.637733	1.199887	0.164159	-0.24261	1.773175	-0.66836	-0.20379	1.014769	0.9379	-0.37733	-3.23553	46.85%	106.62%	0.439401	46.85%	107.99%	0.433829
16`	1.334728	-0.24035	-0.17682	-0.12822	1.716001	0.811705	-0.76037	1.57416	1.261823	0.74946	-5.14212	15.13%	96.97%	0.15605	15.13%	102.67%	0.147379
17`	1.574013	1.380641	1.218121	0.015115	-0.21629	0.355865	-0.88731	1.043607	-0.57081	1.079281	-3.99224	46.44%	123.07%	0.377325	46.44%	119.74%	0.387816
18`	-0.20491	-0.56551	1.370222	-0.91213	1.85663	-0.42926	1.334566	1.242268	-0.57166	1.145171	-3.26539	9.26%	88.72%	0.104419	9.26%	94.24%	0.098301
19`	-0.09067	1.823065	1.445693	0.052093	1.92099	1.934771	-0.13	1.444088	1.749205	-0.49543	-8.6538	77.49%	210.75%	0.367673	77.49%	203.26%	0.381225
20`	-0.2486	1.468331	1.929939	1.729505	1.837387	0.333479	-0.29629	0.95897	1.426153	0.193645	-8.33252	65.92%	214.66%	0.307106	65.92%	194.48%	0.338972
21`	0.739969	0.273871	0.297069	-0.50858	1.875902	-0.13969	0.173006	1.560466	-0.92512	1.537318	-3.88422	26.17%	95.58%	0.273783	26.17%	99.21%	0.263764
22`	0.668311	1.127549	0.99661	-0.8228	0.630718	-0.2228	-0.04119	0.399592	-0.65556	0.107329	-1.18776	38.87%	84.64%	0.459209	38.87%	84.96%	0.457432
23`	-0.93152	0.786263	-0.13035	1.553103	-0.06434	1.185906	1.80772	1.118202	-0.97308	0.131398	-3.48331	40.70%	113.25%	0.359386	40.70%	102.90%	0.395545
24`	1.930919	0.178906	0.363131	-0.96157	-0.76738	1.151782	-0.73882	0.873637	-0.83027	0.670452	-0.87079	10.79%	46.45%	0.232353	10.79%	52.49%	0.20562
25`	1.559713	-0.43076	1.850317	-0.34153	0.177575	-0.21171	-0.13656	-0.46474	0.51883	0.989023	-2.51016	1.64%	61.32%	0.026806	1.64%	68.14%	0.024124
26`	-0.99289	-0.32076	1.09832	0.921897	-0.628	-0.85381	1.042255	0.385931	0.870092	0.177734	-0.70077	5.74%	47.65%	0.120414	5.74%	49.33%	0.116313
27`	0.377537	-0.8908	0.790838	-0.80349	-0.96015	0.346104	-0.58629	1.846699	1.462898	-0.32264	-0.2607	-11.44%	77.45%	-0.14766	-11.44%	69.18%	-0.16532
28`	-0.93143	1.473241	-0.15481	1.445658	-0.44337	0.781055	0.294061	-0.67776	0.027314	-0.99789	0.18394	45.11%	99.81%	0.451931	45.11%	91.89%	0.490909
29`	1.98909	0.826773	-0.84154	-0.03102	-0.5835	1.297567	1.761851	0.573004	0.615585	1.553847	-6.16165	40.53%	108.61%	0.373144	40.53%	115.34%	0.35137
30`	1.0443	0.624467	1.86271	0.233967	0.98292	1.021969	1.08034	0.415503	-0.12801	1.433552	-7.57172	42.49%	160.52%	0.264683	42.49%	151.71%	0.28005

The expected return of such portfolio :

$$E(r_p) = w_D \times E(r_D) + w_E \times E(r_E).$$

Annualized average return

Weight of each stock

$$Return = SUMPRODUCT(B28 : L28, \$B\$2 : \$L\$2)$$

Random Generating data for MM&IM models

and Calculating Return, StDev, Sharpe value for both models

MM Session III

Calculating stDev, sharpe

$$sharpe = Return/stDev$$

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
Annualized Average Return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
Annualized StDev	14.850%	55.774%	30.809%	30.503%	29.572%	23.680%	18.134%	24.884%	14.587%	14.785%	15.350%
beta	1	1.978752	1.32058	1.187512	1.410044	0.971191	0.787	1.056243	0.405118	0.539837	0.454431
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.405%	23.762%	24.889%	20.881%	18.781%	13.865%	19.317%	13.288%	12.423%	13.787%

correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1	0.526865	0.63653	0.578128	0.708092	0.609066	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1	0.487198	0.523781	0.343134	0.159845	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.63653	0.487198	1	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1	0.410737	0.279632	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1	0.53916	0.540137	0.33585	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.53916	1	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.33585	0.230974	0.346275	1	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1

M+I	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Markowitz Model Return	Markowitz Model StDev	Markowitz Model Sharpe	Index Model Return	Index Model StDev	Index Model Sharpe
1`	1.261433	1.349575	0.960549	0.78008	0.911129	0.767922	0.663426	1.895086	1.390129	-0.88042	-8.09891	62.04%	184.99%	0.335371	62.04%	176.05%	0.352398
2`	1.992345	1.298458	-0.46485	1.946255	-0.71386	0.055829	-0.46564	0.937466	-0.21359	-0.19419	-3.17823	41.34%	121.85%	0.339269	41.34%	113.37%	0.364672
3`	0.714516	0.828128	0.519438	0.218524	-0.08573	1.425225	-0.33488	1.503302	-0.23528	1.056111	-4.60966	38.13%	105.57%	0.361206	38.13%	107.44%	0.354928
4`	1.292842	1.809288	0.761798	0.318563	-0.01334	1.930454	-0.2932	0.348368	1.952525	1.618418	-6.72571	68.67%	179.06%	0.38352	68.67%	180.22%	0.381054
5`	-0.91897	-0.90022	-0.9839	-0.82769	1.273461	0.075135	-0.09974	1.859461	-0.26324	0.882012	0.90365	-9.81%	92.29%	-0.10634	-9.81%	71.5%	-0.13708
6`	-0.31601	0.487462	0.21004	0.726213	0.223304	-0.33337	0.435257	0.748183	0.240323	1.885084	-3.30649	28.30%	71.06%	0.398312	28.30%	72.35%	0.391201
7`	-0.44382	-0.43169	1.765872	-0.52453	0.379534	0.884558	0.906699	1.312019	-0.35035	-0.37547	-2.12283	9.46%	76.24%	0.124123	9.46%	76.65%	0.123467
8`	-0.98357	0.728648	1.497943	0.585287	1.093105	-0.40406	1.828442	0.930076	1.976474	0.854643	-7.10699	48.98%	143.05%	0.34243	48.98%	139.16%	0.350232
9`	1.186887	-0.67675	0.87597	0.63324	0.565984	-0.27702	-0.14423	0.675895	-0.26078	-0.78868	-0.7905	-5.24%	53.39%	0.09807	-5.24%	56.19%	-0.09318
10`	1.752787	0.69088	0.243908	0.661197	-0.17423	-0.99732	1.11964	1.489798	0.446389	0.308405	-4.54146	34.30%	99.49%	0.344789	34.30%	99.42%	0.345039
11`	0.559697	-0.2254	0.609727	-0.52842	-0.28168	-0.22853	-0.56818	0.179175	-0.74372	0.325431	1.901903	-2.46%	37.01%	-0.06653	-2.46%	37.83%	-0.06508
12`	1.650306	-0.58124	0.990371	0.503343	1.305882	1.549944	1.429073	-0.3541	-0.78998	0.120363	-4.82397	8.39%	117.98%	0.071079	8.39%	108.00%	0.077647
13`	0.290953	1.815794	1.14538	0.178937	1.535282	0.736099	-0.49783	0.285992	1.932255	-0.99068	-5.43218	67.02%	165.30%	0.405469	67.02%	159.90%	0.429915
14`	1.495268	1.397251	-0.28287	-0.37588	1.326549	0.81236	0.455604	-0.26274	0.354996	-0.8521	3.06844	50.10%	113.74%	0.440502	50.10%	109.16%	0.458998
15`	0.637733	1.199887	0.164159	-0.24261	1.773175	-0.66836	-0.20379	1.014769	0.9379	-0.37733	3.23553	46.85%	106.62%	0.439401	46.85%	107.99%	0.433829
16`	1.334728	-0.24035	-0.17682	-0.12822	1.716001	0.811705	-0.76037	1.57416	1.261823	0.74946	-5.14212	15.13%	96.97%	0.15605	15.13%	102.67%	0.147372
17`	1.574013	1.380641	1.218121	0.015115	-0.21629	0.355865	-0.88731	1.043607	-0.57081	1.079281	-3.99224	46.44%	123.07%	0.377325	46.44%	119.74%	0.387816
18`	-0.20491	-0.56551	1.370222	-0.91213	1.85663	-0.42926	1.334566	1.242268	-0.57166	1.145171	-3.26539	9.26%	88.72%	0.104419	9.26%	94.24%	0.098301
19`	-0.09067	1.823065	1.445693	0.052093	1.92099	1.934771	-0.13	1.444088	1.749205	-0.49543	-4.16538	77.49%	210.75%	0.367673	77.49%	203.26%	0.381225
20`	-0.2486	1.468331	1.929939	1.729505	1.837387	0.333479	-0.29629	0.95897	1.426153	0.193645	-8.33252	65.92%	214.66%	0.307106	65.92%	194.48%	0.338972
21`	0.739969	0.273871	0.297069	-0.50858	1.875902	-0.13969	0.173006	1.560466	-0.92512	1.537318	-3.83422	26.17%	95.58%	0.273783	26.17%	99.21%	0.263764
22`	0.668311	1.127549	0.99661	-0.8228	0.630718	-0.2228	-0.04119	0.399592	-0.65556	0.107329	-1.13776	38.87%	84.64%	0.459209	38.87%	84.96%	0.457432
23`	-0.93152	0.786263	-0.13035	1.553103	-0.06434	1.185906	1.80772	1.118202	-0.97308	0.131398	-3.48331	40.70%	113.25%	0.359386	40.70%	102.90%	0.395545
24`	1.930919	0.178906	0.363131	-0.96157	-0.76738	1.151782	-0.73882	0.873637	-0.83027	0.670452	-0.87079	10.79%	46.45%	0.232353	10.79%	52.49%	0.20562
25`	1.559713	-0.43076	1.850317	-0.34153	0.177575	-0.21171	-0.13656	-0.46474	0.51883	0.989023	-2.51016	1.64%	61.32%	0.026806	1.64%	68.14%	0.024124
26`	-0.99289	-0.32076	1.09832	0.921897	-0.628	-0.85381	1.042255	0.385931	0.870092	0.177734	-0.70077	5.74%	47.65%	0.120414	5.74%	49.33%	0.116313
27`	0.377537	-0.8908	0.790838	-0.80349	-0.96015	0.346104	-0.58629	1.846699	1.462898	-0.32264	-0.2607	-11.44%	77.45%	-0.14766	-11.44%	69.18%	-0.16532
28`	-0.93143	1.473241	-0.15481	1.445658	-0.44337	0.781055	0.294061	-0.67776	0.027314	-0.99789	0.18394	45.11%	99.81%	0.451931	45.11%	91.89%	0.490909
29`	1.98909	0.826773	-0.84154	-0.03102	-0.5835	1.297567	1.761851	0.573004	0.615585	1.553847	-6.16163	40.53%	108.61%	0.373144	40.53%	115.34%	0.35137
30`	1.0443	0.624467	1.86271	0.233967	0.98292	1.021969	1.08034	0.415503	-0.12801	1.433552	-7.57172	42.49%	160.52%	0.264683	42.49%	151.71%	0.28005

The variance:

$$\sigma_p^2 = w_D^2 \times \sigma_D^2 + w_E \times \sigma_E^2 + 2 \times w_D \times w_E \times Cov(r_D, r_E).$$

Weight of each stock

Annualized average return

Correlation

$$stDev == SQRT(MMULT(MMULT((B28:L28 * \$B\$3:\$L\$3), (\$C\$9:\$M\$19)), TRANSPOSE(B28:L28 * \$B\$3:\$L\$3)))$$

IM Session III

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
Annualized Average Return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
Annualized StDev	14.850%	55.774%	30.809%	30.503%	29.572%	23.680%	18.134%	24.884%	14.587%	14.785%	15.350%
beta	1	1.978752	1.32058	1.187512	1.410044	0.971191	0.787	1.056243	0.405118	0.539837	0.454431
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.405%	23.762%	24.889%	20.881%	18.781%	13.865%	19.317%	13.288%	12.423%	13.787%

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Markowitz Model Return	Markowitz Model StDev	Markowitz Model Sharpe	Index Model Return	Index Model StDev	Index Model Sharpe
1`	1.261433	1.349575	0.960549	0.78008	0.911129	0.767922	0.663426	1.895086	1.390129	-0.88042	-8.09891	62.04%	184.99%	0.335371	$B$5:$L$5)	176.05%	0.352398
2`	1.992345	1.298458	-0.46485	1.946255	-0.71386	0.055829	-0.46564	0.937466	-0.21359	-0.19419	-3.17823	41.34%	121.85%	0.339269	41.34%	113.37%	0.364672

$$R_P = \frac{1}{n}\sum_{i=1}^{n}(\alpha_i + \beta_i \cdot R_M + e_i) = \frac{1}{n}\sum_{i=1}^{n}\alpha_i + \left(\frac{1}{n}\sum_{i=1}^{n}\beta_i\right)\cdot R_M + \frac{1}{n}\sum_{i=1}^{n}e_i$$

Annualized Av Return

Weight of each stock

Beta

Weight of each stock

Alpha

Calculating Return

$$Return = SUMPRODUCT(B28:L28, \$B\$4:\$L\$4) * \$B\$2 + SUMPRODUCT(B28:L28, \$B\$5:\$L\$5)$$

IM Session III

Calculating stDev & Sharpe

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
Annualized Average Return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
Annualized StDev	14.850%	55.774%	30.809%	30.503%	29.572%	23.680%	18.134%	24.884%	14.587%	14.785%	15.350%
beta	1	1.978752	1.32058	1.187512	1.410044	0.971191	0.787	1.056243	0.405118	0.539837	0.454431
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.405%	23.762%	24.889%	20.881%	18.781%	13.865%	19.317%	13.288%	12.423%	13.787%

M+I	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Markowitz Model			Index Model		
												Return	StDev	Sharpe	Return	StDev	Sharpe
1`	0.213952	1.360232	1.762414	1.792035	0.467095	1.911949	1.148042	-0.88753	0.468307	1.217094	-8.45359	61.61%	209.65%	0.293848	61.61%	$L$6))	0.333983
2`	0.459085	0.830458	1.871273	1.228015	1.760445	0.601933	0.574397	0.092787	-0.35222	0.076928	-6.1431	45.76%	176.18%	0.259738	45.76%	152.54%	0.299989

The portfolio's variance is :

$$\sigma_P^2 = \beta_P^2 \sigma_M^2 + \sigma^2(e_P).$$

The firm-specific risk is diversifiable :

$$\sigma^2(e_P) = \sum_{i=1}^{n} \left(\frac{1}{n}\right)^2 \sigma^2(e_i) = \frac{1}{n} \cdot \bar{\sigma}^2(e).$$

Weight of each stock

Beta

Annualized stdev of s&p

Residual StDev

$$StDev = SQRT((SUMPRODUCT(B28:L28 * \$B\$4:\$L\$4) * \$B\$3)^2 + SUMPRODUCT(B28:L28, B28:L28, \$B\$6:\$L\$6, \$B\$6:\$L\$6))$$

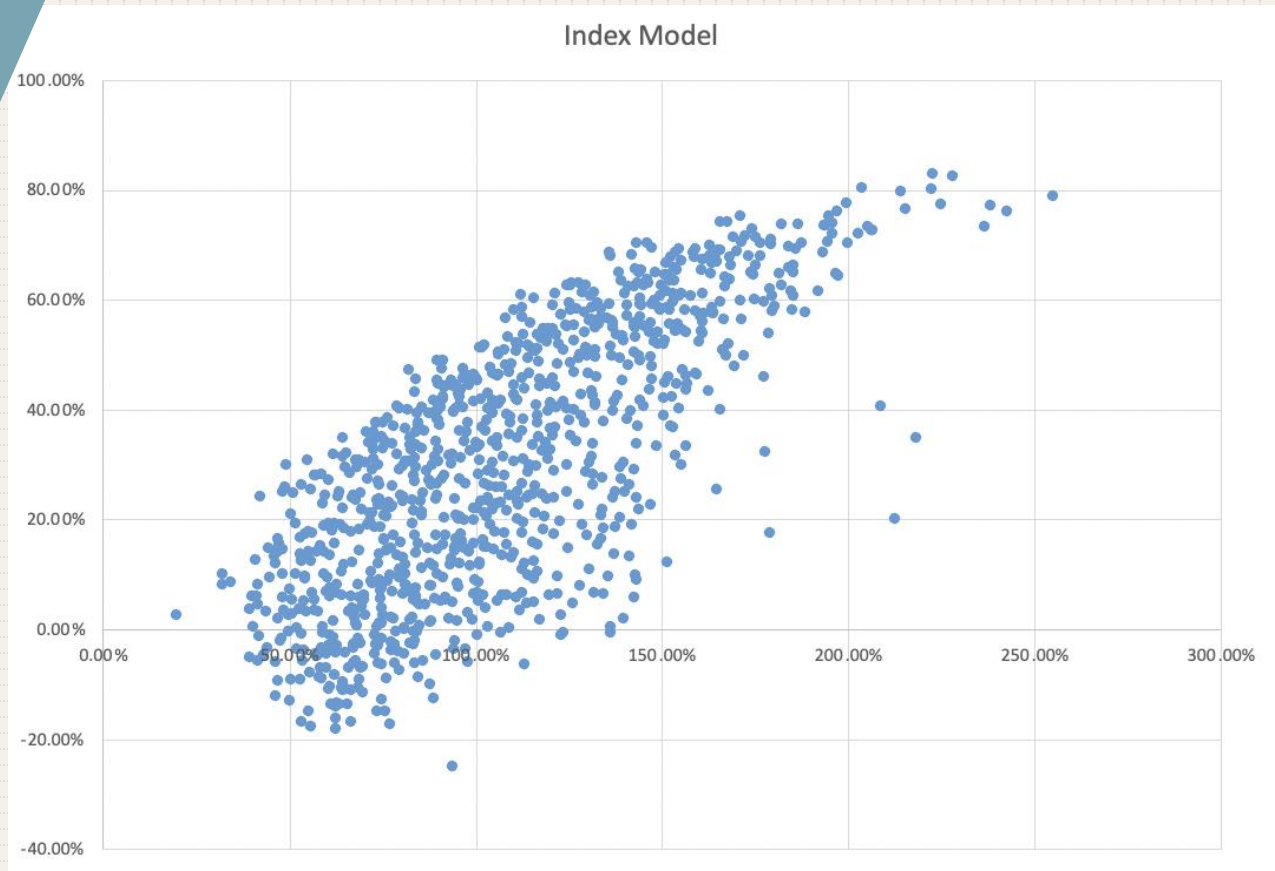
$$sharpe = Return/stDev$$

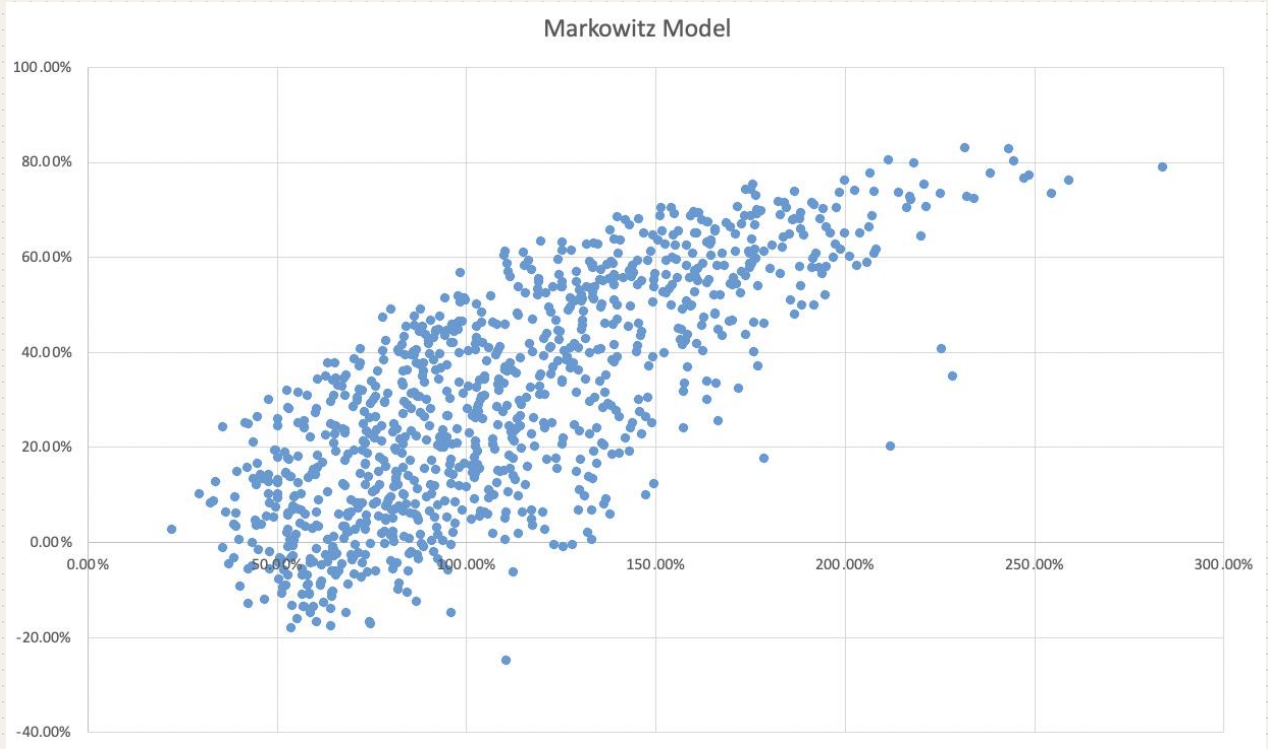
Session III

Plotting scatterplot for MM & IM model according to randomly generating data

IM

MM



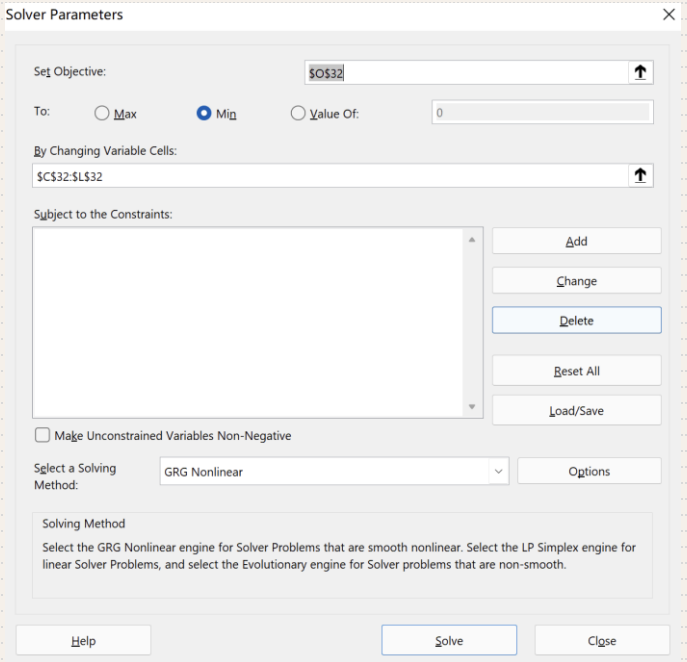


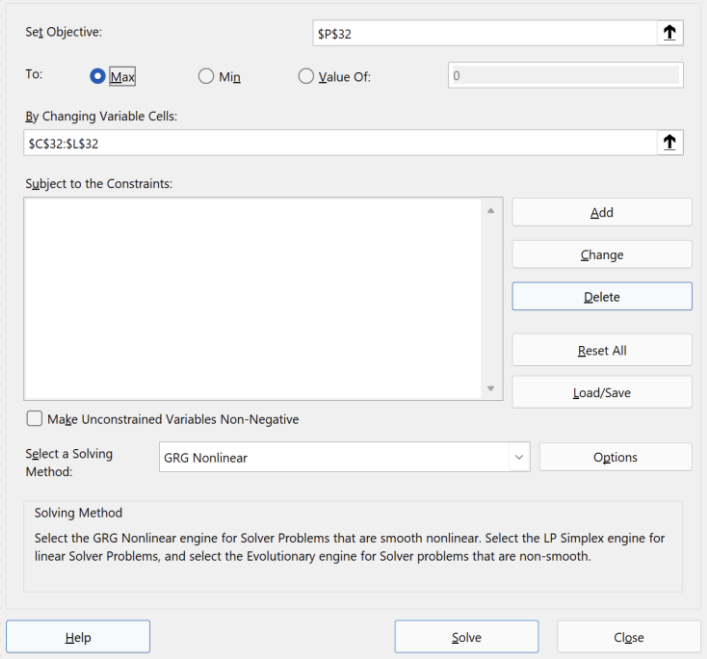
MM Session IV

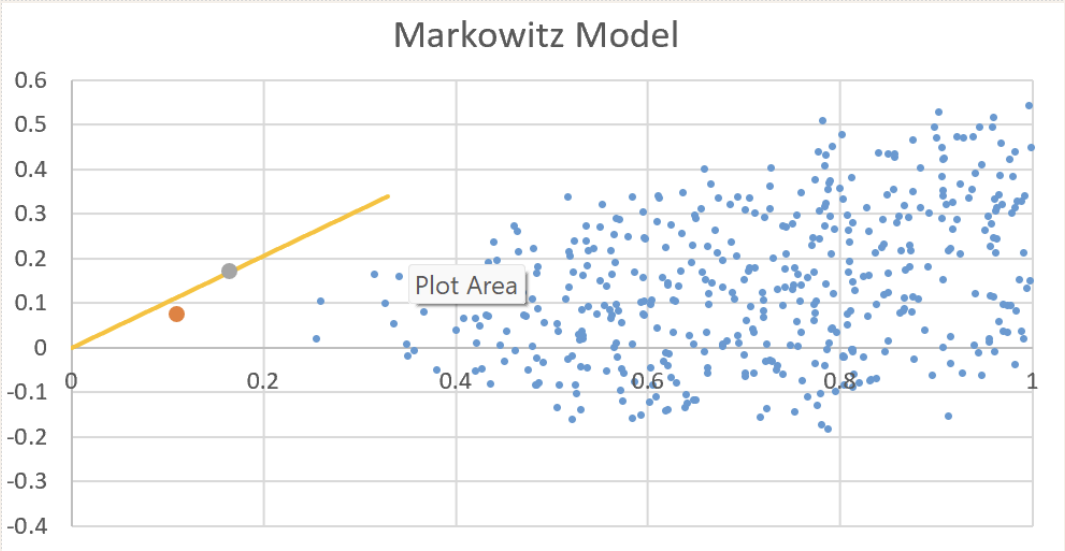
Employ Solver to find MinVariance and Maxsharp of Markowitz Model

Calculate capital allocation line

Markowitz	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
MinVarian	0.383666	-0.02968	-0.02893	0.013271	-0.05899	-0.00305	0.194149	-0.11481	0.259307	0.188331	0.196738	0.075077	0.10953	0.685445
Maxsharp	-1.09974	0.224573	0.008931	-0.08186	0.127252	0.132127	0.464596	0.078969	0.534975	0.427165	0.183007	0.169875	0.164758	1.031061
											CAL	0	0	
											2.5	0.424688	0.411894	







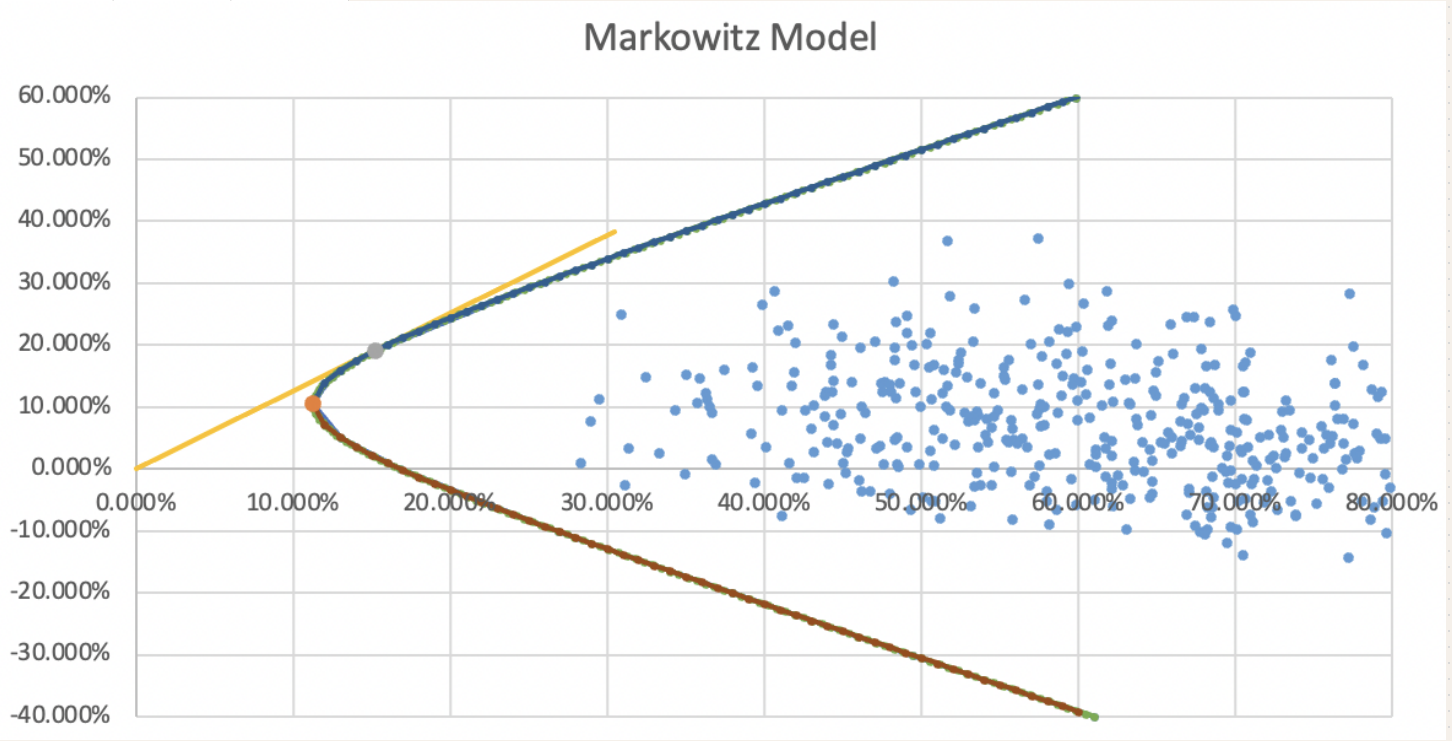
MM Session IV

Employ Solver to find StDev for 13 or 14 different returns

Name it as Minvar Frontier

	Minvarfront		Min variance front		Min return front		Max return front	
Return	StDev		Return	Stdev	Return	Stdev	Return	Stdev
-40%	0.626449		-0.4	0.62818	0.07868	0.11	0.075077	0.10953
-30%	0.499134		-0.395	0.621776	0.037319	0.12	0.082867	0.11
-20%	0.373555		-0.39	0.615374	0.021143	0.13	0.10207	0.115
-10%	0.252318		-0.385	0.608974	0.007916	0.14	0.112478	0.12
0%	0.146622		-0.38	0.602576	-0.00386	0.15	0.121471	0.125
5%	0.114267		-0.375	0.59618	-0.01476	0.16	0.12901	0.13
0.075077	0.10953		-0.37	0.589787	-0.02506	0.17	0.135862	0.135
15%	0.146489		-0.365	0.583397	-0.03494	0.18	0.142238	0.14
0.169875	0.164758		-0.36	0.577009	-0.0445	0.19	0.148261	0.145
30%	0.312145		-0.355	0.570623	-0.052	0.2	0.154014	0.15
40%	0.436354		-0.35	0.564241	-0.06293	0.21	0.15955	0.155
50%	0.563232		-0.345	0.557861	0.016158	0.22		
60%	0.691312		-0.34	0.551484	-0.0807	0.23		
70%	0.820031		-0.335	0.54511	-0.0894	0.24		
80%			-0.33	0.53874	-0.00066	0.25		
90%			-0.325	0.532372	-0.10655	0.26		
100%			-0.32	0.526008	-0.115	0.27		
			-0.315	0.519648	-0.1234	0.28		
			-0.31	0.513291	-0.13175	0.29		

Employ solvertable to find Min Variance Frontier, Min Return Frontier, Max Return Frontier



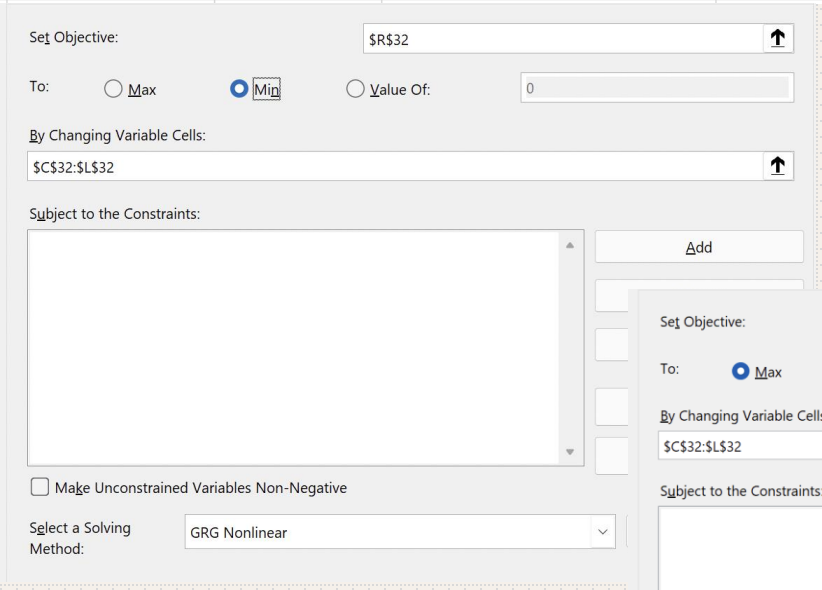
Incorporate Minvar Frontier, Min Variance Frontier, Min Return Frontier, Max Return Frontier to original plot

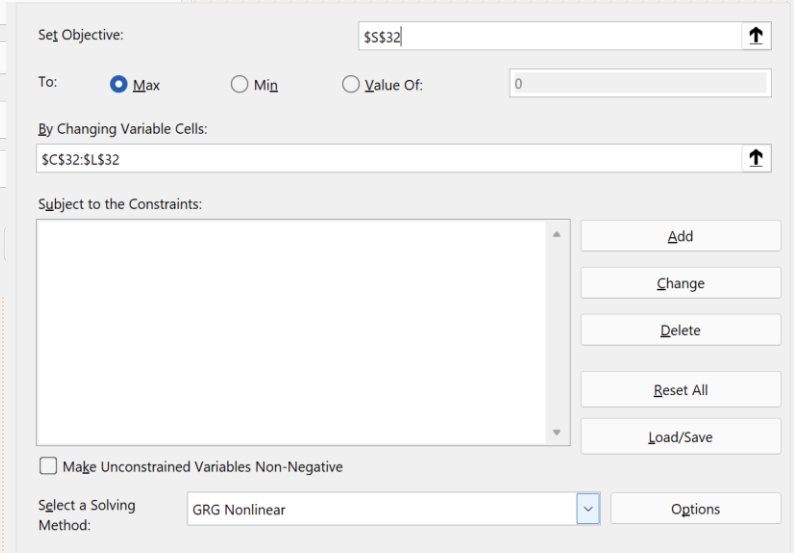
IM Session IV

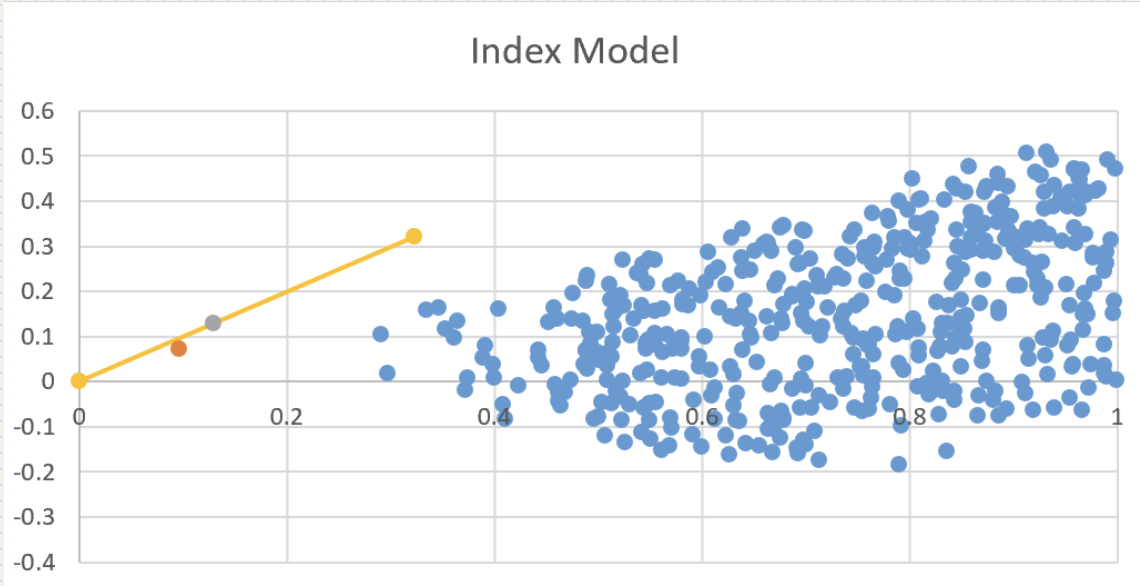
Employ Solver to find MinVariance and Maxsharp of Index Model

Calculate capital allocation line

index model	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
minVariace	0.256224	-0.04042	-0.0527	-0.02809	-0.08728	0.007581	0.102837	-0.01399	0.312696	0.276746	0.266405	0.071517	0.09634	0.742339
Maxsharp	-0.70158	0.103244	-0.00565	-0.00109	0.005655	0.09393	0.342518	0.073503	0.46903	0.369359	0.251081	0.128677	0.129227	0.995744
											CAL	0	0	
											2.5	0.321692	0.323067	







IM Session IV

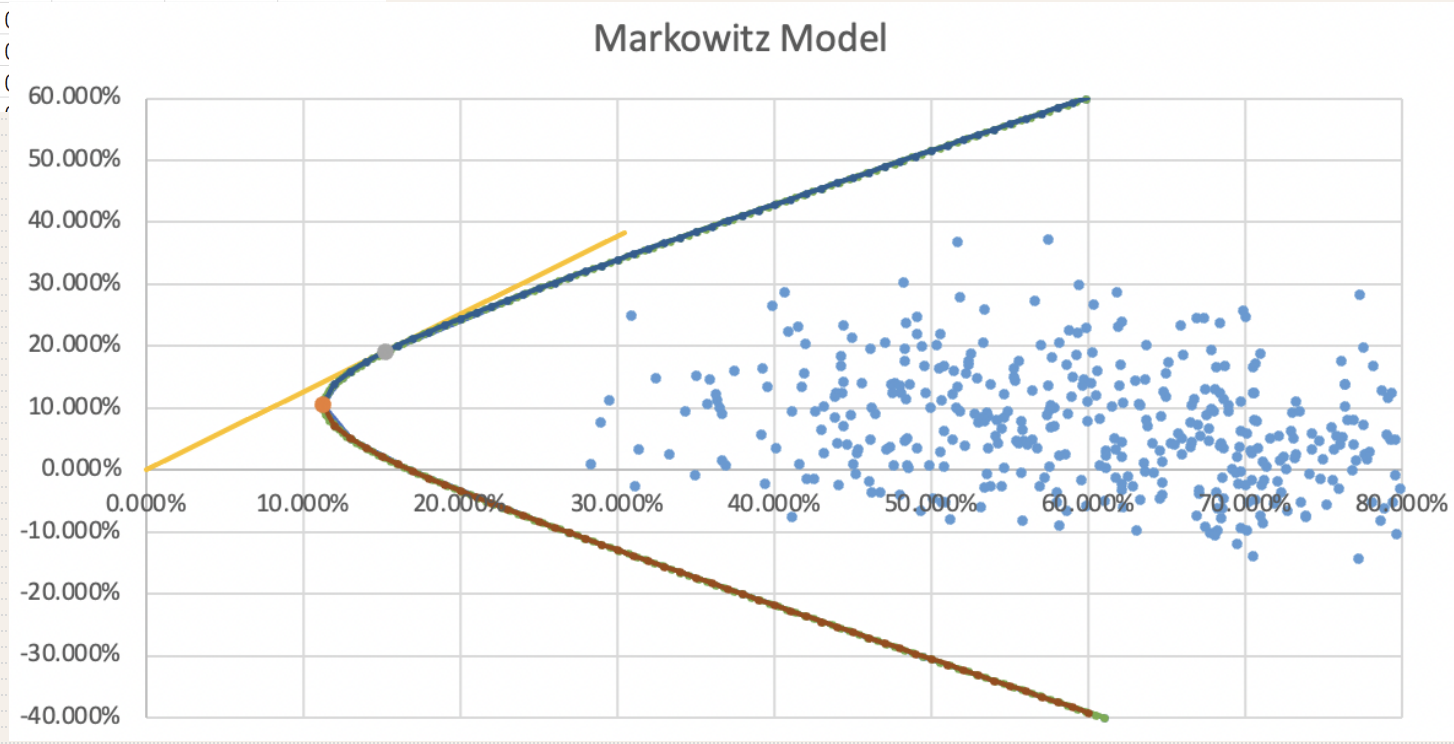
Employ Solver to find StDev for 13 or 14 different returns

Name it as Minvar Frontier

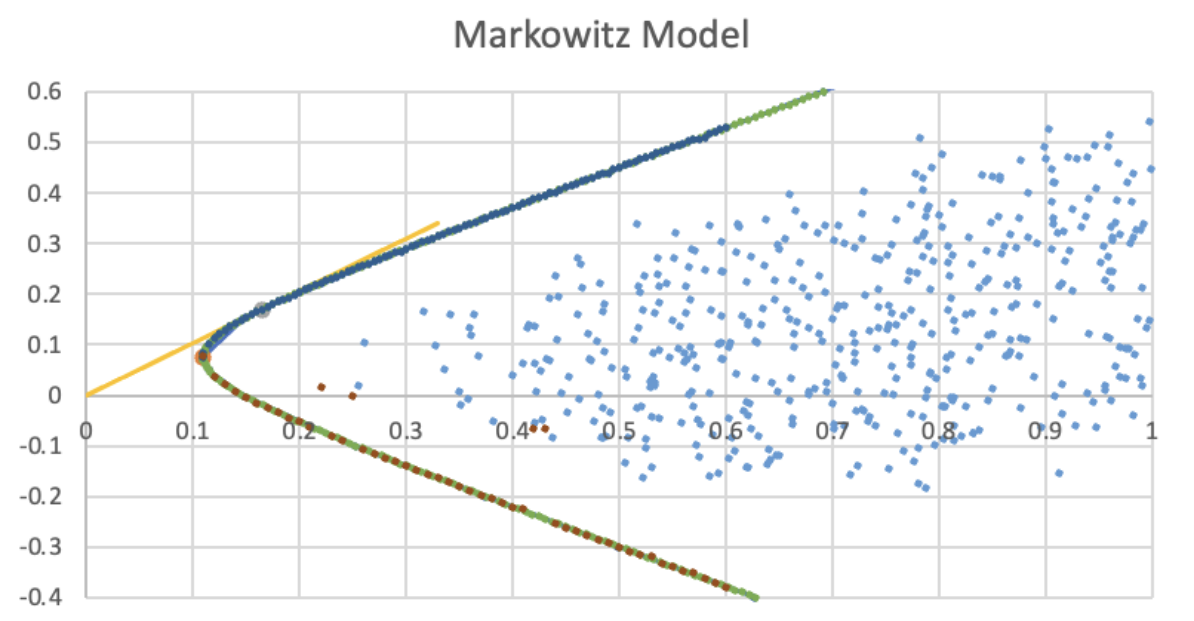
	Minvarfront		Min variance frontier		Min return front		Max return front	
Return	StDev		Return	Stdev	Return	Stdev	Return	Stdev
-40%	0.719886		-0.4	0.716987	0.088798	0.1	0.053897	0.1
-30%	0.568033		-0.395	0.709522	0.105941	0.11	0.036847	0.11
-20%	0.420315		-0.39	0.702058	0.117972	0.12	0.024724	0.12
-10%	0.275816		-0.385	0.694596	0.128233	0.13	0.014463	0.13
0%	0.146184		-0.38	0.687136	0.137551	0.14	0.005144	0.14
5%	0.101649		-0.375	0.679677	0.146281	0.15	-0.00359	0.15
7.15%	0.09634		-0.37	0.67222	0.154606	0.16	-0.01191	0.16
13%	0.129227		-0.365	0.664765	0.162638	0.17	-0.01994	0.17
20%	0.216245		-0.36	0.657311	0.170448	0.18	-0.02775	0.18
30%	0.357505		-0.355	0.649859	0.178085	0.19	-0.03539	0.19
40%	0.504249		-0.35	0.642409	0.185583	0.2	-0.04289	0.2
50%	0.652789		-0.345	0.634962	0.192968	0.21	-0.04189	0.21
60%	0.802128		-0.34	0.627516	0.200259			
70%			-0.335	0.620072	0.207473			
80%			-0.33	0.612631	0.214619			

Employ solvertable to find Min Variance Frontier, Min Return Frontier, Max Return Frontier

Incorporate Minvar Frontier, Min Variance Frontier, Min Return Frontier, Max Return Frontier to original plot



Session IV MM & IM plot



MM

IM

Part III

『Markowitz Model』

Formulas

▷Portfolios return

$$E(R_p) = \sum_{i=1}^{N} w_i * E(r_i)$$

▷Portfolios risk

$$\sigma_p^2 = \sum_{i=1}^{N} \sum_{J=1}^{N} w_i w_j Cov(r_i, r_j)$$

=SUMPRODUCT(C24:M24,$C$2:$M$2)

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
annualized average return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
annualized stdev	0.148503	0.557735	0.308093	0.305035	0.295719	0.236797	0.181337	0.248835	0.145865	0.14785	0.153498
beta	1	1.9788	1.3206	1.1875	1.4100	0.9712	0.7870	1.0562	0.4051	0.5398	0.4544
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.4%	23.8%	24.9%	20.9%	18.8%	13.9%	19.3%	13.3%	12.4%	13.8%

correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1.000000	0.526865	0.636530	0.578128	0.708092	0.609066	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1.000000	0.487198	0.523781	0.343134	0.159845	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.636530	0.487198	1.000000	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1.000000	0.410737	0.279632	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1.000000	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1.000000	0.539160	0.540137	0.335850	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.539160	1.000000	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1.000000	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.335850	0.230974	0.346275	1.000000	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1.000000	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1.000000

Markowitz Model

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0.85988	-0.17844	-0.06476	-0.02255	-0.13597	-0.02093	-0.02967	-0.0472	0.161411	0.189452	0.288781	$M$2)	14.3%	0.174747

=SQRT(MMULT(MMULT((C24:M24*$C$3:$M$3),($C$9:$M$19)),TRANSPOSE(C24:M24*$C$3:$M$3)))

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
annualized average return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
annualized stdev	0.148503	0.557735	0.308093	0.305035	0.295719	0.236797	0.181337	0.248835	0.145865	0.14785	0.153498
beta	1	1.9788	1.3206	1.1875	1.4100	0.9712	0.7870	1.0562	0.4051	0.5398	0.4544
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.4%	23.8%	24.9%	20.9%	18.8%	13.9%	19.3%	13.3%	12.4%	13.8%

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CSCO	0.636530	0.487198	1.000000	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
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GS	0.708092	0.343134	0.487495	0.410737	1.000000	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1.000000	0.539160	0.540137	0.335850	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.539160	1.000000	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1.000000	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.335850	0.230974	0.346275	1.000000	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1.000000	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1.000000

Markowitz Model

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0.85988	-0.17844	-0.06476	-0.02255	-0.13597	-0.02093	-0.02967	-0.0472	0.161411	0.189452	0.288781	2.5%	$M$3)))	0.174747

Constraint 1

This additional optimization constraint is designed to simulate the *Regulation T by FINRA* (https://www.finra.org/rules-guidance/key-topics/margin-accounts), which allows broker-dealers to allow their customers to have positions, 50% or more of which are funded by the customer's account equity:

$$\sum_{i=1}^{11} |w_i| \le 2;$$

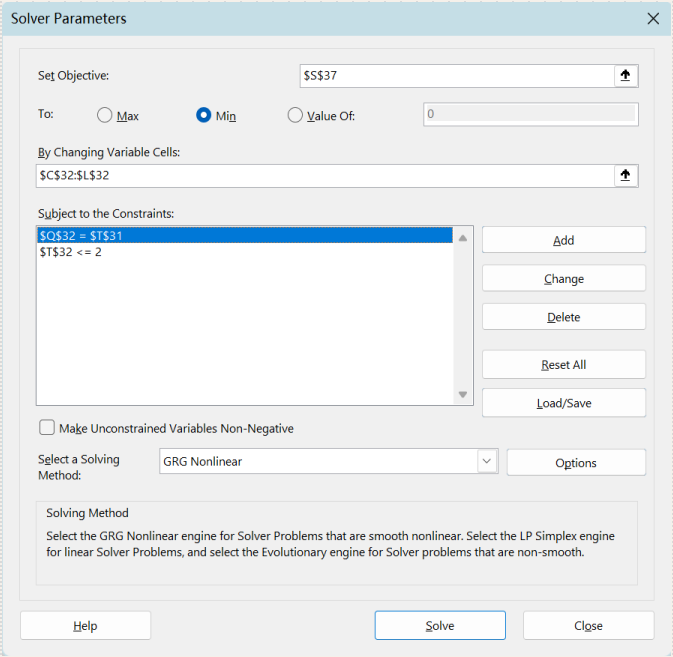
▷Method

=SQRT(C32^2+$B$33)

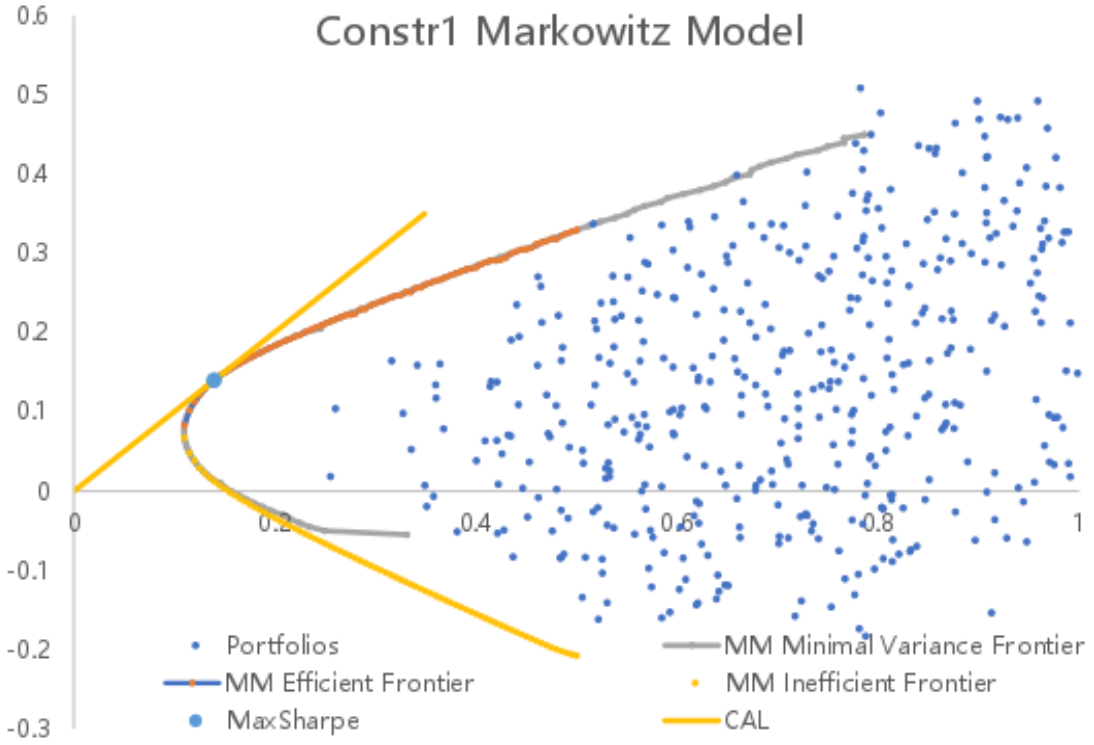
												Markowitz Model			Index Model			
	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp	Return	StDev	Sharp	3%
Weights	0.85988	-0.17844	-0.06476	-0.02255	-0.13597	-0.02093	-0.02967	-0.0472	0.161411	0.189452	0.288781	2.5%	14.3%	0.174747	2.5%	12.1%	0.206779	2
0.00001	$B$33)	0.178463	0.064833	0.022775	0.136008	0.021172	0.029837	0.04731	0.161442	0.189478	0.288798							

$$|w_i| \approx \sqrt{(w_i)^2 + 0.00001}$$

$$\sum_{i=1}^{11} |w_i| \le 2;$$



IM Constraint 1



StdDev	MM Efficie	MM Ineffic	MM Minin	Ret
10.0%				-10.0%
10.5%				-9.5%
11.0%	8.3%	6.7%		-9.0%
11.5%	10.2%	4.8%		-8.5%
12.0%	11.3%	3.8%		-8.0%
12.5%	12.1%	3.0%		-7.5%
13.0%	12.9%	2.4%		-7.0%
13.5%	13.5%	1.8%		-6.5%
14.0%	14.1%	1.3%		-6.0%
14.5%	14.5%	0.9%	33.1%	-5.5%
15.0%	15.0%	0.5%	25.0%	-5.0%
15.5%	15.4%	0.1%	23.4%	-4.5%
16.0%	15.8%	-0.3%	22.4%	-4.0%
16.5%	16.1%	-0.6%	21.5%	-3.5%
17.0%	16.5%	-0.9%	20.8%	-3.0%
17.5%	16.8%	-1.2%	19.7%	-2.5%
18.0%	17.1%	-1.5%	18.8%	-2.0%
18.5%	17.5%	-1.8%	17.9%	-1.5%
19.0%	17.8%	-2.1%	17.1%	-1.0%
19.5%	18.1%	-2.4%	16.4%	-0.5%
20.0%	18.4%	-2.7%	15.6%	0.0%
20.5%	18.7%	-3.0%	15.0%	0.5%
21.0%	19.0%	-3.2%	14.6%	1.0%
21.5%	19.2%	-3.5%	13.8%	1.5%
22.0%	19.5%	-3.8%	13.3%	2.0%
22.5%	19.7%	-4.0%	12.9%	2.5%
23.0%	20.1%	-4.3%	12.5%	3.0%
23.5%	20.3%	-4.5%	12.2%	3.5%
24.0%	20.6%	-4.8%	11.9%	4.0%
24.5%	20.9%	-4.9%	11.6%	4.5%
25.0%	21.1%	-5.0%	11.4%	5.0%
25.5%	21.4%	-5.1%	11.3%	5.5%
26.0%	21.7%	-5.1%	11.1%	6.0%
26.5%	21.9%	-5.2%	11.0%	6.5%
27.0%	22.2%	-5.2%	11.0%	7.0%
27.5%	22.2%	-5.2%	11.0%	7.5%
28.0%	22.4%	-5.3%	11.0%	8.0%
28.5%	22.9%	-5.3%	11.0%	8.5%
29.0%	23.0%	-5.3%	11.1%	9.0%
29.5%	23.4%	-5.3%	11.3%	9.5%
30.0%	23.7%	-5.4%	11.4%	10.0%

StdDev	MM Efficie	MM Ineffic	MM Minin	Ret
30.5%	23.9%	-5.4%	11.6%	10.5%
31.0%	24.2%	-5.4%	11.9%	11.0%
31.5%	24.4%	-5.4%	12.1%	11.5%
32.0%	24.7%	-5.5%	12.4%	12.0%
32.5%	24.7%	-5.5%	12.7%	12.5%
33.0%	25.1%	-5.5%	13.1%	13.0%
33.5%	25.1%	-5.5%	13.5%	13.5%
34.0%	25.6%	-5.5%	13.9%	14.0%
34.5%	25.7%		14.5%	14.5%
35.0%	26.1%		15.0%	15.0%
35.5%	26.3%		15.7%	15.5%
36.0%	26.6%		16.3%	16.0%
36.5%	26.7%		17.0%	16.5%
37.0%	27.0%		17.8%	17.0%
37.5%	27.3%		18.6%	17.5%
38.0%	27.5%		19.4%	18.0%
38.5%	27.7%		20.2%	18.5%
39.0%	28.0%		21.1%	19.0%
39.5%	28.1%		21.9%	19.5%
40.0%	28.2%		22.9%	20.0%
40.5%	28.7%		24.6%	20.5%
41.0%	28.9%		24.7%	21.0%
41.5%	29.1%		25.7%	21.5%
42.0%	29.1%		26.7%	22.0%
42.5%	29.2%		27.6%	22.5%
43.0%	29.5%		28.6%	23.0%
43.5%	30.0%		29.6%	23.5%
44.0%	30.3%		30.7%	24.0%
44.5%	30.5%		31.7%	24.5%
45.0%	30.5%		32.8%	25.0%
45.5%	30.7%		33.7%	25.5%
46.0%	31.2%		34.8%	26.0%
46.5%	31.4%		35.9%	26.5%
47.0%	31.6%		36.9%	27.0%
47.5%	31.8%		38.0%	27.5%
48.0%	31.8%		39.1%	28.0%
48.5%	32.2%		40.2%	28.5%
49.0%	32.5%		41.3%	29.0%
49.5%	32.7%		42.3%	29.5%
50.0%	33.0%		43.4%	30.0%

MM (Constr1):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	38.37%	-2.97%	-2.89%	1.33%	-5.90%	-0.30%	19.41%	-11.48%	25.93%	18.83%	19.67%	7.51%	10.95%	0.685	CAL:	0.0%	0.0%
MaxSharpe	-42.64%	15.74%	-1.21%	-6.09%	3.25%	6.44%	35.27%	1.14%	45.73%	29.95%	12.42%	14.01%	13.95%	1.004	2.5	35.0%	34.9%

MM Constraint 2

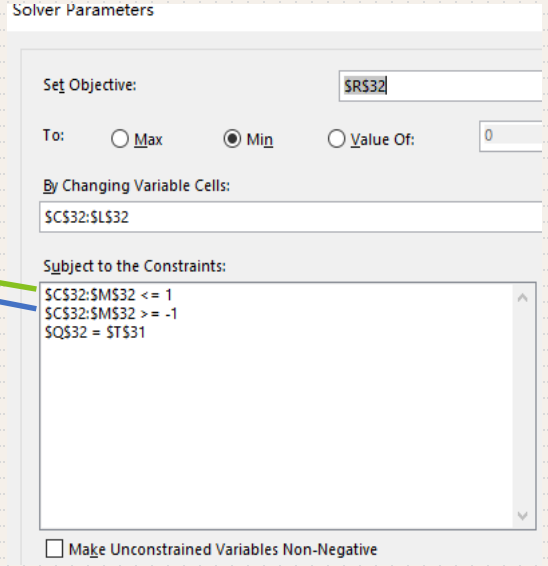
This additional optimization constraint is designed to simulate some *arbitrary "box" constraints* on weights, which may be provided by the client:

$$|w_i| \leq 1, \text{for } \forall i;$$

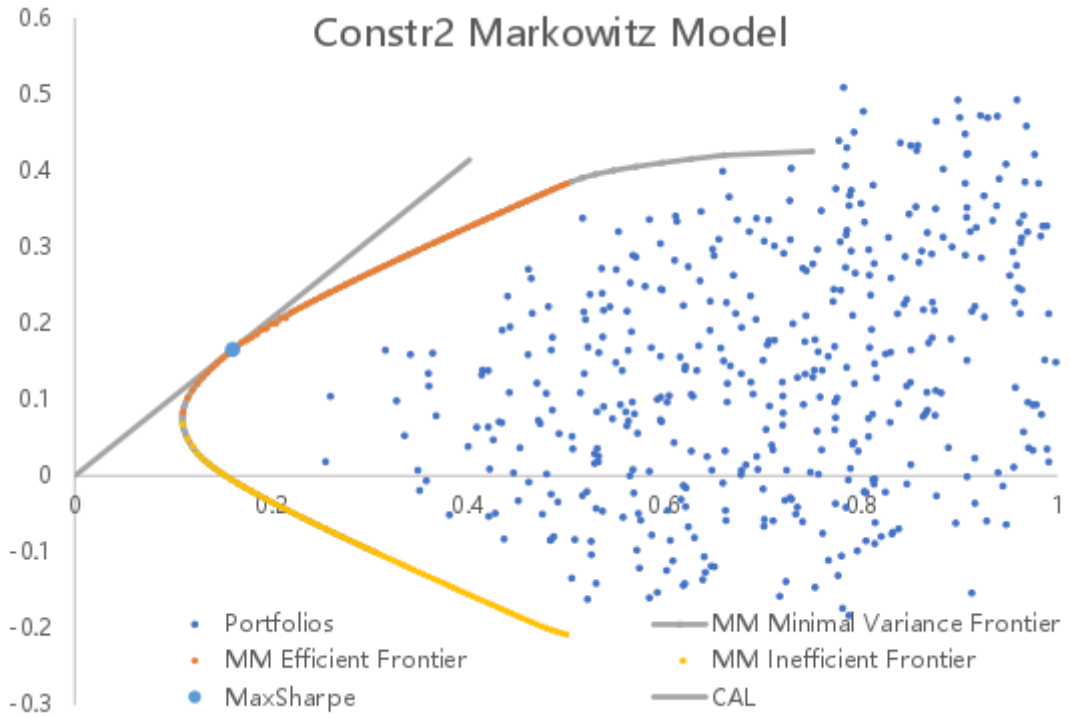
▷Method

Markowitz Model

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0.85988	-0.17844	-0.06476	-0.02255	-0.13597	-0.02093	-0.02967	-0.0472	0.161411	0.189452	0.288781	2.5%	14.3%	0.174747



MM Constraint 2

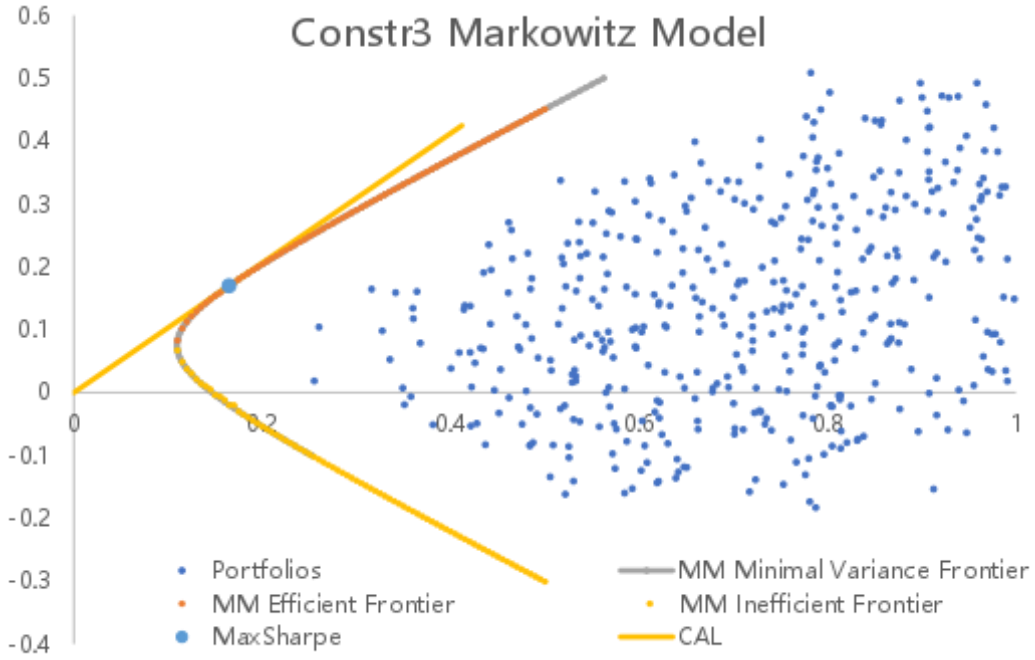


StdDev	MM Efficie	MM Ineffi	MM Minin	Ret
10.0%			30.5%	-10.0%
10.5%			29.7%	-9.5%
11.0%	8.3%	6.7%	28.9%	-9.0%
11.5%	10.2%	4.8%	28.0%	-8.5%
12.0%	11.3%	3.9%	27.2%	-8.0%
12.5%	12.1%	2.9%	26.4%	-7.5%
13.0%	12.9%	2.3%	25.6%	-7.0%
13.5%	13.5%	1.7%	24.8%	-6.5%
14.0%	14.2%	1.2%	24.0%	-6.0%
14.5%	14.8%	0.7%	23.2%	-5.5%
15.0%	15.3%	0.3%	22.4%	-5.0%
15.5%	15.9%	-0.1%	21.6%	-4.5%
16.0%	16.4%	-0.5%	20.9%	-4.0%
16.5%	16.9%	-0.9%	20.1%	-3.5%
17.0%	17.5%	-1.3%	19.4%	-3.0%
17.5%	17.7%	-1.7%	18.7%	-2.5%
18.0%	18.1%	-2.0%	18.0%	-2.0%
18.5%	18.5%	-2.4%	17.3%	-1.5%
19.0%	19.1%	-2.7%	16.6%	-1.0%
19.5%	19.3%	-3.1%	16.0%	-0.5%
20.0%	19.9%	-3.4%	15.3%	0.0%
20.5%	20.0%	-3.8%	14.8%	0.5%
21.0%	20.7%	-4.1%	14.2%	1.0%
21.5%	20.7%	-4.4%	13.7%	1.5%
22.0%	21.4%	-4.7%	13.2%	2.0%
22.5%	21.7%	-5.1%	12.8%	2.5%
23.0%	22.1%	-5.4%	12.4%	3.0%
23.5%	22.4%	-5.7%	12.1%	3.5%
24.0%	22.7%	-6.0%	11.9%	4.0%
24.5%	23.1%	-6.3%	11.6%	4.5%
25.0%	23.4%	-6.6%	11.4%	5.0%
25.5%	23.7%	-6.9%	11.3%	5.5%
26.0%	24.0%	-7.3%	11.1%	6.0%
26.5%	24.4%	-7.6%	11.0%	6.5%
27.0%	24.7%	-7.9%	11.0%	7.0%
27.5%	25.0%	-8.2%	11.0%	7.5%
28.0%	25.3%	-8.5%	11.0%	8.0%
28.5%	25.6%	-8.8%	11.0%	8.5%
29.0%	25.9%	-9.1%	11.1%	9.0%
29.5%	26.3%	-9.4%	11.3%	9.5%
30.0%	26.6%	-9.7%	11.4%	10.0%

StdDev	MM Efficie	MM Ineffi	MM Minin	Ret
30.5%	26.9%	-10.0%	11.6%	10.5%
31.0%	27.2%	-10.3%	11.9%	11.0%
31.5%	27.5%	-10.6%	12.1%	11.5%
32.0%	27.8%	-10.9%	12.4%	12.0%
32.5%	28.1%	-11.2%	12.7%	12.5%
33.0%	28.4%	-11.4%	13.1%	13.0%
33.5%	28.7%	-11.7%	13.4%	13.5%
34.0%	29.0%	-12.0%	13.8%	14.0%
34.5%	29.3%	-12.3%	14.2%	14.5%
35.0%	29.6%	-12.6%	14.6%	15.0%
35.5%	29.9%	-12.9%	15.1%	15.5%
36.0%	30.2%	-13.2%	15.5%	16.0%
36.5%	30.5%	-13.5%	16.0%	16.5%
37.0%	30.8%	-13.8%	16.5%	17.0%
37.5%	31.1%	-14.1%	17.0%	17.5%
38.0%	31.4%	-14.4%	17.6%	18.0%
38.5%	31.7%	-14.6%	18.2%	18.5%
39.0%	32.0%	-14.9%	18.8%	19.0%
39.5%	32.3%	-15.2%	19.5%	19.5%
40.0%	32.5%	-15.5%	20.1%	20.0%
40.5%	32.8%	-15.8%	20.8%	20.5%
41.0%	33.1%	-16.1%	21.5%	21.0%
41.5%	33.4%	-16.4%	22.2%	21.5%
42.0%	33.7%	-16.7%	22.9%	22.0%
42.5%	34.0%	-16.9%	23.7%	22.5%
43.0%	34.3%	-17.2%	24.4%	23.0%
43.5%	34.6%	-17.5%	25.2%	23.5%
44.0%	34.9%	-17.8%	25.9%	24.0%
44.5%	35.1%	-18.1%	26.7%	24.5%
45.0%	35.4%	-18.3%	27.5%	25.0%
45.5%	35.7%	-18.6%	28.3%	25.5%
46.0%	36.0%	-18.9%	29.1%	26.0%
46.5%	36.3%	-19.2%	29.9%	26.5%
47.0%	36.6%	-19.5%	30.7%	27.0%
47.5%	36.9%	-19.7%	31.5%	27.5%
48.0%	37.1%	-20.0%	32.3%	28.0%
48.5%	37.4%	-20.2%	33.2%	28.5%
49.0%	37.7%	-20.4%	34.0%	29.0%
49.5%	38.0%	-20.6%	34.8%	29.5%
50.0%	38.3%	-20.8%	35.7%	30.0%

MM (Constr2):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	38.37%	-2.97%	-2.89%	1.33%	-5.90%	-0.30%	19.41%	-11.48%	25.93%	18.83%	19.67%	7.51%	10.95%	0.685	CAL:	0.0%	0.0%
MaxSharpe	-100.00%	21.50%	0.31%	-8.15%	11.46%	12.25%	44.92%	6.87%	52.33%	41.02%	17.48%	16.56%	16.06%	1.031	2.5	41.4%	40.2%

MM Constraint 3(free portfolio)



StdDev	MM Efficie	MM Ineffi	MM Minin	Ret
10.0%			25.2%	-10.0%
10.5%			24.6%	-9.5%
11.0%	8.3%	6.7%	24.1%	-9.0%
11.5%	10.2%	4.9%	23.5%	-8.5%
12.0%	11.3%	3.7%	22.9%	-8.0%
12.5%	12.1%	3.0%	22.4%	-7.5%
13.0%	12.9%	2.1%	21.8%	-7.0%
13.5%	13.6%	1.4%	21.2%	-6.5%
14.0%	14.2%	1.0%	20.7%	-6.0%
14.5%	14.8%	0.5%	20.1%	-5.5%
15.0%	15.4%	-0.4%	19.6%	-5.0%
15.5%	15.8%	-0.6%	19.1%	-4.5%
16.0%	16.5%	-1.2%	18.5%	-4.0%
16.5%	17.0%	-2.0%	18.0%	-3.5%
17.0%	17.5%	-2.0%	17.5%	-3.0%
17.5%	18.0%	-3.0%	17.0%	-2.5%
18.0%	18.5%	-3.5%	16.5%	-2.0%
18.5%	19.0%	-4.0%	16.0%	-1.5%
19.0%	19.5%	-4.5%	15.6%	-1.0%
19.5%	19.9%	-4.9%	15.1%	-0.5%
20.0%	20.4%	-5.4%	14.7%	0.0%
20.5%	20.9%	-5.8%	14.2%	0.5%
21.0%	21.3%	-6.3%	13.8%	1.0%
21.5%	21.8%	-6.7%	13.4%	1.5%
22.0%	22.2%	-7.2%	13.1%	2.0%
22.5%	22.6%	-7.6%	12.7%	2.5%
23.0%	23.1%	-8.1%	12.4%	3.0%
23.5%	23.5%	-8.5%	12.1%	3.5%
24.0%	24.0%	-8.9%	11.9%	4.0%
24.5%	24.4%	-9.4%	11.6%	4.5%
25.0%	24.8%	-9.8%	11.4%	5.0%
25.5%	25.2%	-10.2%	11.3%	5.5%
26.0%	25.7%	-10.7%	11.1%	6.0%
26.5%	26.1%	-11.1%	11.0%	6.5%
27.0%	26.5%	-11.5%	11.0%	7.0%
27.5%	26.9%	-11.9%	11.0%	7.5%
28.0%	27.4%	-12.3%	11.0%	8.0%
28.5%	27.8%	-12.8%	11.0%	8.5%
29.0%	28.2%	-13.2%	11.1%	9.0%
29.5%	28.6%	-13.6%	11.3%	9.5%
30.0%	29.0%	-14.0%	11.4%	10.0%

StdDev	MM Efficie	MM Ineffi	MM Minin	Ret
30.5%	29.4%	-14.4%	11.6%	10.5%
31.0%	29.8%	-14.8%	11.9%	11.0%
31.5%	30.3%	-15.2%	12.1%	11.5%
32.0%	30.7%	-15.7%	12.4%	12.0%
32.5%	31.1%	-16.1%	12.7%	12.5%
33.0%	31.5%	-16.5%	13.1%	13.0%
33.5%	31.9%	-16.9%	13.4%	13.5%
34.0%	32.3%	-17.3%	13.8%	14.0%
34.5%	32.7%	-17.7%	14.2%	14.5%
35.0%	33.1%	-18.1%	14.6%	15.0%
35.5%	33.5%	-18.5%	15.1%	15.5%
36.0%	33.9%	-18.9%	15.5%	16.0%
36.5%	34.3%	-19.3%	16.0%	16.5%
37.0%	34.7%	-19.7%	16.5%	17.0%
37.5%	35.1%	-20.1%	17.0%	17.5%
38.0%	35.5%	-20.5%	17.5%	18.0%
38.5%	35.9%	-20.9%	18.0%	18.5%
39.0%	36.3%	-21.3%	18.5%	19.0%
39.5%	36.7%	-21.7%	19.0%	19.5%
40.0%	37.1%	-22.1%	19.6%	20.0%
40.5%	37.5%	-22.5%	20.1%	20.5%
41.0%	37.9%	-22.9%	20.7%	21.0%
41.5%	38.3%	-23.3%	21.2%	21.5%
42.0%	38.7%	-23.7%	21.8%	22.0%
42.5%	39.1%	-24.1%	22.3%	22.5%
43.0%	39.5%	-24.5%	22.9%	23.0%
43.5%	39.9%	-24.9%	23.5%	23.5%
44.0%	40.3%	-25.3%	24.1%	24.0%
44.5%	40.7%	-25.7%	24.6%	24.5%
45.0%	41.1%	-26.1%	25.2%	25.0%
45.5%	41.5%	-26.5%	25.8%	25.5%
46.0%	41.9%	-26.9%	26.4%	26.0%
46.5%	42.3%	-27.3%	27.0%	26.5%
47.0%	42.7%	-27.7%	27.6%	27.0%
47.5%	43.1%	-28.1%	28.2%	27.5%
48.0%	43.5%	-28.5%	28.8%	28.0%
48.5%	43.9%	-28.9%	29.4%	28.5%
49.0%	44.3%	-29.3%	30.0%	29.0%
49.5%	44.7%	-29.7%	30.6%	29.5%
50.0%	45.1%	-30.1%	31.2%	30.0%

MM (Constr3):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	38.37%	-2.97%	-2.89%	1.33%	-5.90%	-0.30%	19.41%	-11.48%	25.93%	18.83%	19.67%	7.51%	10.95%	0.685	CAL:	0.0%	0.0%
MaxSharpe	-109.97%	22.46%	0.89%	-8.19%	12.73%	13.21%	46.46%	7.90%	53.50%	42.72%	18.30%	16.99%	16.48%	1.031	2.5	42.5%	41.2%

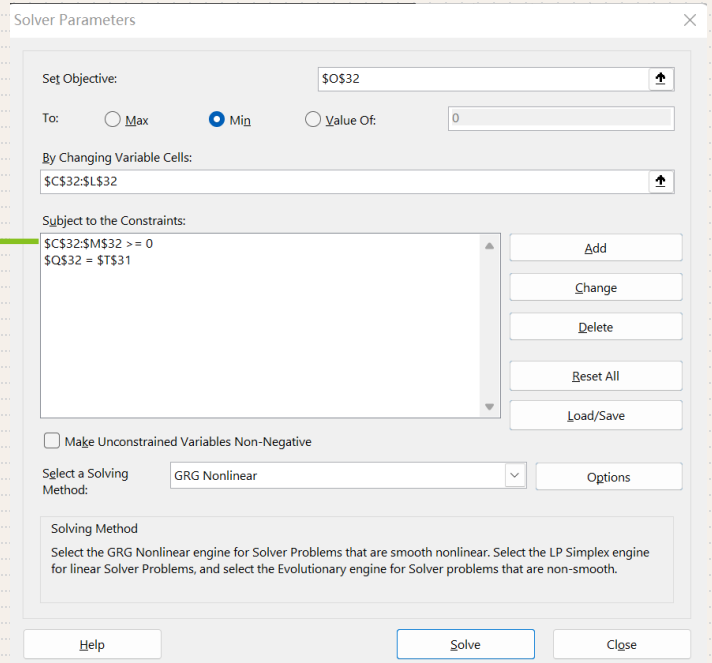
Constraint 4

This additional optimization constraint is designed to simulate the typical limitations existing in the U.S. mutual fund industry: a U.S. open-ended mutual fund is *not allowed to have any short positions*, for details see the Investment Company Act of 1940, Section 12(a)(3) (https://www.law.cornell.edu/uscode/text/15/80a-12):

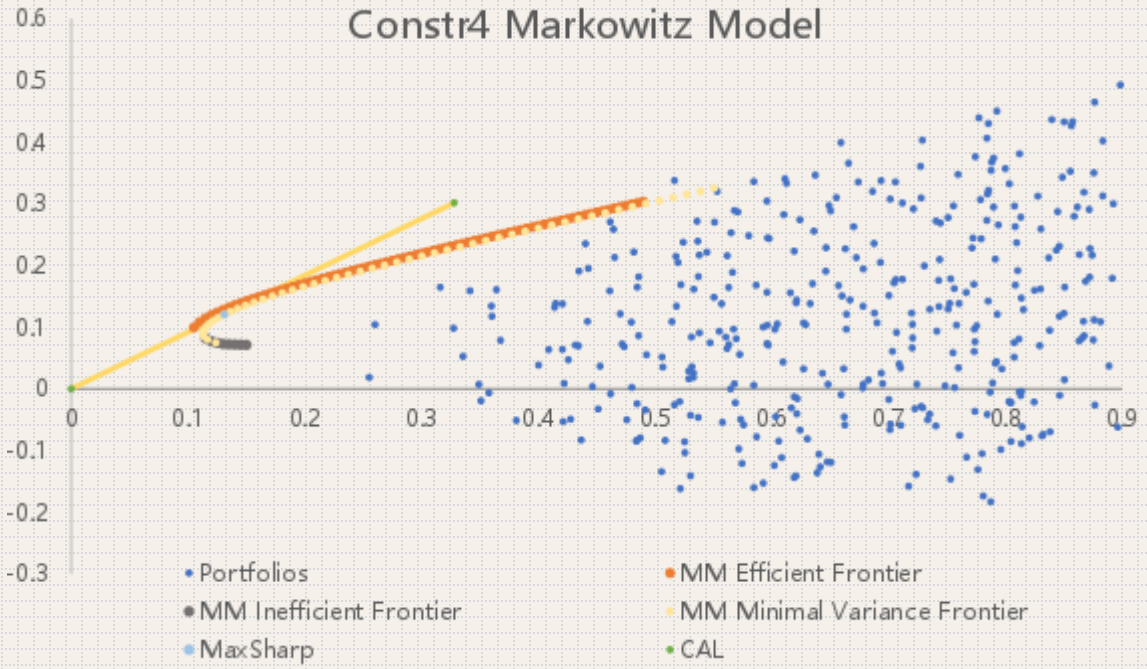
$$w_i \geq 0, \text{for } \forall i;$$

▹Method

												Markowitz Model		
	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0	0.107381	0	0	0	0	0.237415	0	0.42327	0.163069	0.068865	12.6%	13.1%	0.919011



MM Constraint 4



StdDev	MM Efficient	MM Inefficie	MM Minimal V	Ret
10.0%				-10.0%
10.5%				-9.5%
11.0%				-9.0%
11.5%	9.9%	8.2%		-8.5%
12.0%	10.8%	7.7%		-8.0%
12.5%	11.4%	7.4%		-7.5%
13.0%	11.9%	7.3%		-7.0%
13.5%	12.4%	7.2%		-6.5%
14.0%	12.8%	7.2%		-6.0%
14.5%	13.2%	7.2%		-5.5%
15.0%	13.6%	7.1%		-5.0%
15.5%	13.9%			-4.5%
16.0%	14.2%			-4.0%
16.5%	14.5%			-3.5%
17.0%	14.9%			-3.0%
17.5%	15.2%			-2.5%
18.0%	15.5%			-2.0%
18.5%	15.7%			-1.5%
19.0%	16.0%			-1.0%
19.5%	16.3%			-0.5%
20.0%	16.6%			0.0%
20.5%	16.8%			0.5%
21.0%	17.1%			1.0%
21.5%	17.4%			1.5%
22.0%	17.6%			2.0%
22.5%	17.9%			2.5%
23.0%	18.1%			3.0%
23.5%	18.4%			3.5%
24.0%	18.6%			4.0%
24.5%	18.9%			4.5%
25.0%	19.1%			5.0%
25.5%	19.4%			5.5%
26.0%	19.6%			6.0%
26.5%	19.8%			6.5%
27.0%	20.1%			7.0%
27.5%	20.3%		12.4%	7.5%
28.0%	20.6%		11.7%	8.0%
28.5%	20.8%		11.3%	8.5%
29.0%	21.0%		11.3%	9.0%
29.5%	21.3%		11.4%	9.5%
30.0%	21.5%		11.5%	10.0%

StdDev	MM Efficient	MM Inefficie	MM Minimal V	Ret
30.5%	21.7%		11.8%	10.5%
31.0%	21.9%		12.1%	11.0%
31.5%	22.2%		12.6%	11.5%
32.0%	22.4%		13.1%	12.0%
32.5%	22.6%		13.6%	12.5%
33.0%	22.9%		14.3%	13.0%
33.5%	23.1%		14.9%	13.5%
34.0%	23.3%		15.7%	14.0%
34.5%	23.5%		16.4%	14.5%
35.0%	23.8%		17.2%	15.0%
35.5%	24.0%		18.1%	15.5%
36.0%	24.2%		19.0%	16.0%
36.5%	24.4%		19.9%	16.5%
37.0%	24.7%		20.8%	17.0%
37.5%	24.9%		21.8%	17.5%
38.0%	25.1%		22.7%	18.0%
38.5%	25.3%		23.7%	18.5%
39.0%	25.6%		24.8%	19.0%
39.5%	25.8%		25.8%	19.5%
40.0%	26.0%		26.8%	20.0%
40.5%	26.2%		27.9%	20.5%
41.0%	26.4%		29.0%	21.0%
41.5%	26.7%		30.0%	21.5%
42.0%	26.9%		31.1%	22.0%
42.5%	27.1%		32.2%	22.5%
43.0%	27.3%		33.3%	23.0%
43.5%	27.5%		34.4%	23.5%
44.0%	27.7%		35.5%	24.0%
44.5%	28.0%		36.6%	24.5%
45.0%	28.2%		37.8%	25.0%
45.5%	28.4%		38.9%	25.5%
46.0%	28.6%		40.0%	26.0%
46.5%	28.8%		41.2%	26.5%
47.0%	29.0%		42.3%	27.0%
47.5%	29.3%		43.4%	27.5%
48.0%	29.5%		44.6%	28.0%
48.5%	29.7%		45.7%	28.5%
49.0%	29.9%		46.9%	29.0%
49.5%	30.1%		48.1%	29.5%
50.0%	30.3%		49.2%	30.0%

MM (Constr4):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	9.49%	0.00%	0.00%	0.00%	0.00%	0.00%	19.85%	0.00%	28.91%	20.62%	21.13%	8.88%	11.27%	0.788	CAL:	0.0%	0.0%
MaxSharpe	0.00%	10.95%	0.00%	0.00%	0.00%	0.00%	23.73%	0.00%	42.56%	16.17%	6.60%	12.06%	13.12%	0.919	2.5	30.1%	32.8%

Constraint 5

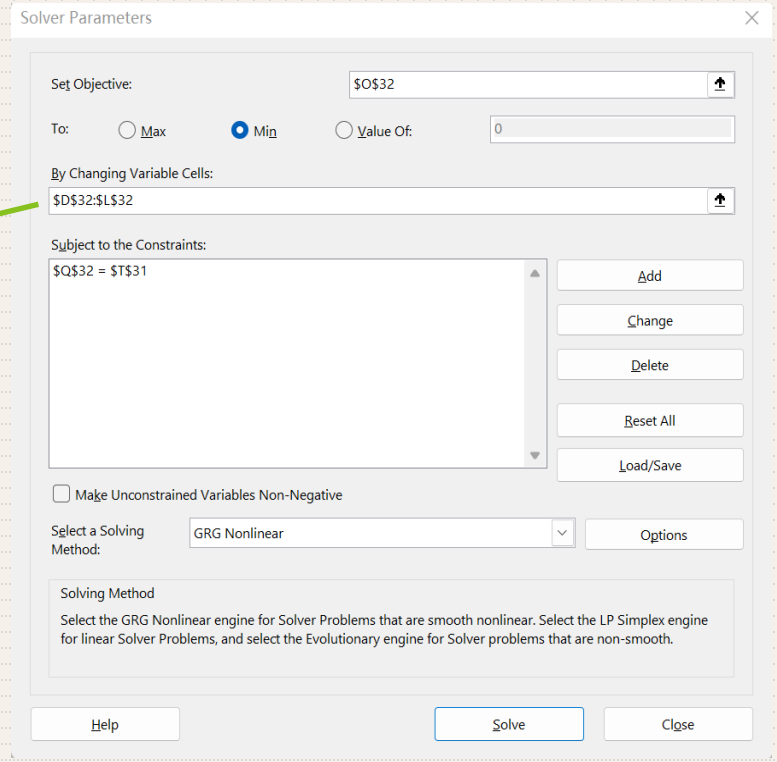
Lastly, we would like to see if the *inclusion of the broad index* into our portfolio has positive or negative effect, for that we would like to consider an additional optimization constraint:

$$w_1 = 0.$$

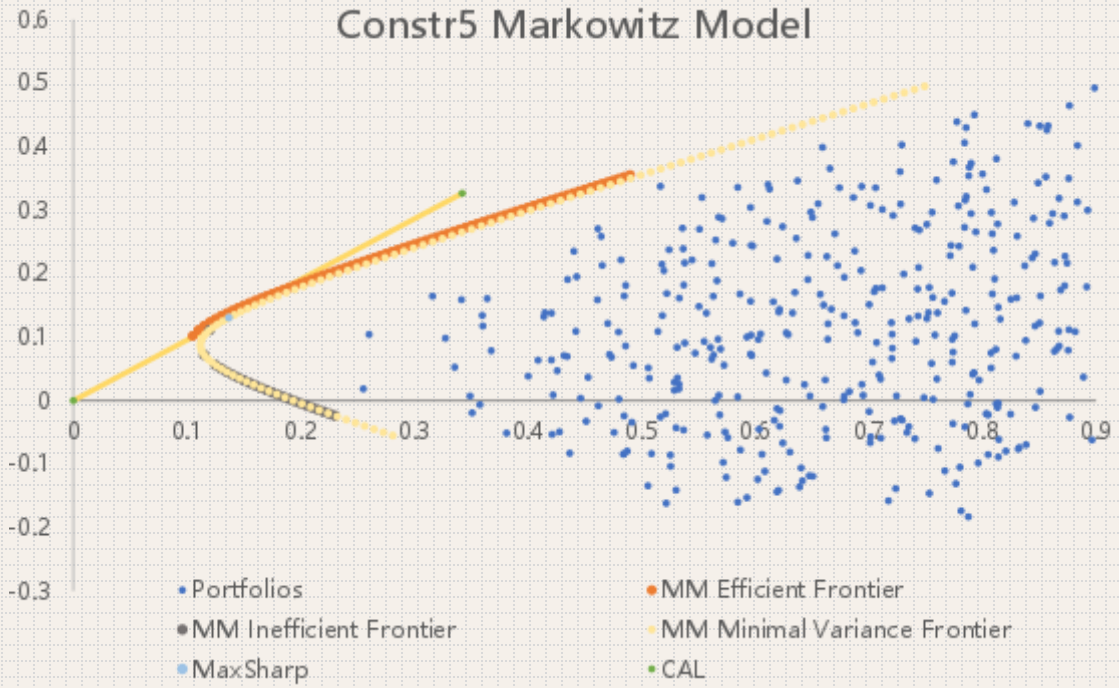
▷Method

Markowitz Model

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0	0.110613	-0.05165	-0.07067	-0.01228	0.026918	0.291996	-0.03705	0.398098	0.240897	0.103133	12.0%	12.7%	0.946632



MM Constraint 5



StdDev	MM Efficient	MM Inefficie	MM Minimal V	Ret
10.0%			35.8%	-10.0%
10.5%			34.9%	-9.5%
11.0%			34.0%	-9.0%
11.5%	10.2%	7.2%	33.2%	-8.5%
12.0%	11.1%	11.1%	32.3%	-8.0%
12.5%	11.8%	5.6%	31.5%	-7.5%
13.0%	12.4%	5.0%	30.6%	-7.0%
13.5%	12.9%	4.5%	29.8%	-6.5%
14.0%	13.3%	4.1%	28.9%	-6.0%
14.5%	13.8%	3.6%	28.1%	-5.5%
15.0%	14.2%	3.2%	27.3%	-5.0%
15.5%	14.6%	2.8%	26.5%	-4.5%
16.0%	15.0%	2.4%	25.6%	-4.0%
16.5%	15.4%	2.0%	24.8%	-3.5%
17.0%	15.8%	1.7%	24.0%	-3.0%
17.5%	16.1%	1.3%	23.2%	-2.5%
18.0%	16.5%	0.9%	22.4%	-2.0%
18.5%	16.8%	0.6%	21.6%	-1.5%
19.0%	17.2%	0.2%	20.9%	-1.0%
19.5%	17.5%	-0.1%	20.1%	-0.5%
20.0%	17.8%	-0.4%	19.4%	0.0%
20.5%	18.2%	-0.8%	18.6%	0.5%
21.0%	18.5%	-1.1%	17.9%	1.0%
21.5%	18.8%	-1.4%	17.2%	1.5%
22.0%	19.1%	-1.7%	16.5%	2.0%
22.5%	19.5%	-2.0%	15.9%	2.5%
23.0%	19.8%	-2.4%	15.2%	3.0%
23.5%	20.1%	-2.7%	14.6%	3.5%
24.0%	20.4%	-3.0%	14.1%	4.0%
24.5%	20.7%	-3.3%	13.5%	4.5%
25.0%	21.0%	-3.6%	13.0%	5.0%
25.5%	21.3%	-3.9%	12.6%	5.5%
26.0%	21.6%	-4.2%	12.2%	6.0%
26.5%	21.9%	-4.5%	11.9%	6.5%
27.0%	22.2%	-4.8%	11.6%	7.0%
27.5%	22.5%	-5.1%	11.4%	7.5%
28.0%	22.8%	-5.4%	11.3%	8.0%
28.5%	23.1%	-5.7%	11.2%	8.5%
29.0%	23.4%	-6.0%	11.2%	9.0%
29.5%	23.7%	-6.3%	11.3%	9.5%
30.0%	24.0%	-6.6%	11.4%	10.0%

StdDev	MM Efficient	MM Inefficie	MM Minimal V	Ret
30.5%	24.3%	-6.9%	11.6%	10.5%
31.0%	24.6%	-7.2%	11.9%	11.0%
31.5%	24.9%	-7.5%	12.3%	11.5%
32.0%	25.2%	-7.8%	12.7%	12.0%
32.5%	25.5%	-8.1%	13.1%	12.5%
33.0%	25.8%	-8.3%	13.6%	13.0%
33.5%	26.1%	-8.7%	14.2%	13.5%
34.0%	26.4%	-9.0%	14.7%	14.0%
34.5%	26.7%	-9.3%	15.3%	14.5%
35.0%	27.0%	-9.6%	16.0%	15.0%
35.5%	27.3%	-9.9%	16.6%	15.5%
36.0%	27.6%	-10.1%	17.3%	16.0%
36.5%	27.8%	-10.4%	18.0%	16.5%
37.0%	28.1%	-10.7%	18.8%	17.0%
37.5%	28.4%	-11.0%	19.5%	17.5%
38.0%	28.7%	-11.3%	20.2%	18.0%
38.5%	29.0%	-11.6%	21.0%	18.5%
39.0%	29.3%	-11.9%	21.8%	19.0%
39.5%	29.6%	-12.2%	22.6%	19.5%
40.0%	29.9%	-12.4%	23.4%	20.0%
40.5%	30.1%	-12.7%	24.2%	20.5%
41.0%	30.4%	-13.0%	25.0%	21.0%
41.5%	30.7%	-13.3%	25.8%	21.5%
42.0%	31.0%	-13.6%	26.6%	22.0%
42.5%	31.3%	-13.9%	27.4%	22.5%
43.0%	31.6%	-14.2%	28.3%	23.0%
43.5%	31.9%	-14.4%	29.1%	23.5%
44.0%	32.1%	-14.7%	29.9%	24.0%
44.5%	32.4%	-15.0%	30.8%	24.5%
45.0%	32.7%	-15.3%	31.6%	25.0%
45.5%	33.0%	-15.6%	32.5%	25.5%
46.0%	33.3%	-15.9%	33.3%	26.0%
46.5%	33.6%	-16.2%	34.2%	26.5%
47.0%	33.8%	-16.4%	35.0%	27.0%
47.5%	34.1%	-16.7%	35.9%	27.5%
48.0%	34.4%	-17.0%	36.8%	28.0%
48.5%	34.7%	-17.3%	37.6%	28.5%
49.0%	35.0%	-17.6%	38.5%	29.0%
49.5%	35.3%	-17.9%	39.4%	29.5%
50.0%	35.5%	-18.1%	40.2%	30.0%

MM (Constr5):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	0.00%	-0.97%	0.08%	2.51%	-0.99%	3.50%	24.70%	-8.17%	28.91%	25.58%	24.85%	8.71%	11.18%	0.779	CAL:	0.0%	0.0%
MaxSharpe	0.00%	14.93%	-6.85%	-10.14%	-1.30%	2.43%	30.65%	-2.27%	43.31%	23.61%	5.64%	13.06%	13.69%	0.954	2.5	32.6%	34.2%

Part IV

『Index Model』

Formulas

▷Portfolios return

$$E(R_i) = \alpha_i + \beta_i \cdot E(Rm)$$

=SUMPRODUCT(C23:M23,$C$5:$M$5)*$C$3+SUMPRODUCT(C23:M23,$C$6:$M$6)

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
annualized average return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
annualized stdev	0.148503	0.557735	0.308093	0.305035	0.295719	0.236797	0.181337	0.248835	0.145865	0.14785	0.153498
beta	1	1.9788	1.3206	1.1875	1.4100	0.9712	0.7870	1.0562	0.4051	0.5398	0.4544
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.4%	23.8%	24.9%	20.9%	18.8%	13.9%	19.3%	13.3%	12.4%	13.8%

correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1.000000	0.526865	0.636530	0.578128	0.708092	0.609066	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1.000000	0.487198	0.523781	0.343134	0.159845	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.636530	0.487198	1.000000	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1.000000	0.410737	0.279632	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1.000000	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1.000000	0.539160	0.540137	0.335850	0.234128	0.217803
TD CN	0.644503	0.338001	0.410049	0.411503	0.493822	0.539160	1.000000	0.416709	0.230974	0.272732	0.211711
ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1.000000	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.335850	0.230974	0.346275	1.000000	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1.000000	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1.000000

Index Model

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	$M$6)	0.137003	0.692341

▷Portfolios risk

$$\sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma^2(e_i)$$

$$= \left(\sum_{i=1}^{N} w_i \beta_i\right)^2 \sigma_m^2 + \sum_{i=1}^{N} w_i^2 \sigma_{\varepsilon i}^2$$

=SQRT((SUMPRODUCT(C23:M23*$C$5:$M$5)*$C$4)^2+SUMPRODUCT(C23:M23,C23:M23,$C$7:$M$7,$C$7:$M$7))

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
annualized average return	7.542%	32.802%	9.714%	8.905%	10.825%	9.878%	11.010%	10.080%	9.437%	8.464%	7.105%
annualized stdev	0.148503	0.557735	0.308093	0.305035	0.295719	0.236797	0.181337	0.248835	0.145865	0.14785	0.153498
beta	1	1.9788	1.3206	1.1875	1.4100	0.9712	0.7870	1.0562	0.4051	0.5398	0.4544
annualized alpha	0.000%	17.877%	-0.246%	-0.052%	0.190%	2.553%	5.074%	2.113%	6.381%	4.392%	3.677%
Residual StDev	0.000%	47.4%	23.8%	24.9%	20.9%	18.8%	13.9%	19.3%	13.3%	12.4%	13.8%

correlations	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL
SPX	1.000000	0.526865	0.636530	0.578128	0.708092	0.609066	0.644503	0.630359	0.412445	0.542222	0.439645
NVDA	0.526865	1.000000	0.487198	0.523781	0.343134	0.159845	0.338001	0.156912	0.059558	0.165279	0.069448
CSCO	0.636530	0.487198	1.000000	0.614181	0.487495	0.328141	0.410049	0.297266	0.220244	0.238795	0.164964
INTC	0.578128	0.523781	0.614181	1.000000	0.410737	0.279632	0.411503	0.285682	0.136363	0.324896	0.110064
GS	0.708092	0.343134	0.487495	0.410737	1.000000	0.471678	0.493822	0.417367	0.173108	0.295535	0.203125
USB	0.609066	0.159845	0.328141	0.279632	0.471678	1.000000	0.539160	0.540137	0.335850	0.234128	0.217803
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ALL	0.630359	0.156912	0.297266	0.285682	0.417367	0.540137	0.416709	1.000000	0.346275	0.451773	0.406645
PG	0.412445	0.059558	0.220244	0.136363	0.173108	0.335850	0.230974	0.346275	1.000000	0.493743	0.483308
JNJ	0.542222	0.165279	0.238795	0.324896	0.295535	0.234128	0.272732	0.451773	0.493743	1.000000	0.526761
CL	0.439645	0.069448	0.164964	0.110064	0.203125	0.217803	0.211711	0.406645	0.483308	0.526761	1.000000

Index Model

	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharp
Weights	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.5	0.094853	$M$7))	0.692341

IM Constraint 1

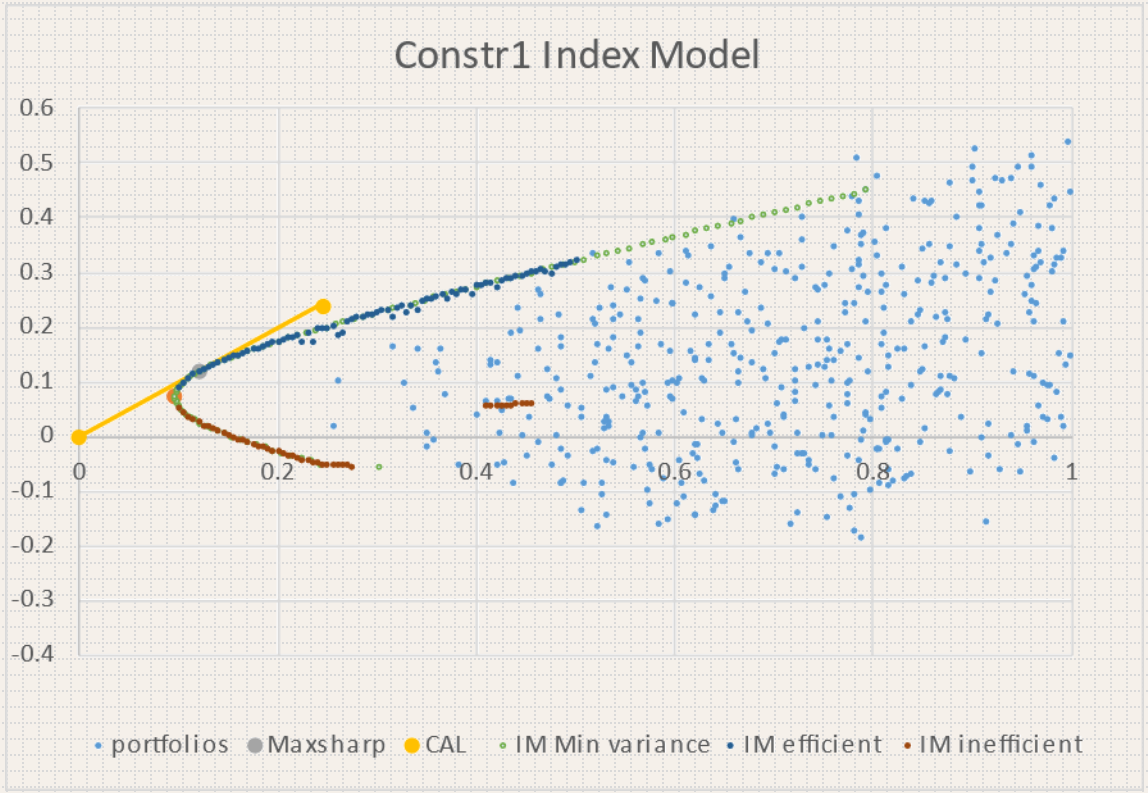
This additional optimization constraint is designed to simulate the *Regulation T by FINRA* (https://www.finra.org/rules-guidance/key-topics/margin-accounts), which allows broker-dealers to allow their customers to have positions, 50% or more of which are funded by the customer's account equity:

$$\sum_{i=1}^{11} |w_i| \le 2;$$

▷Method

		SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe	22.0%	Dummy Variable
	MM	84.7%	-12.9%	-8.2%	-4.5%	-14.5%	-4.6%	-4.5%	-6.8%	21.7%	21.9%	27.6%	3.6%	13.5%	0.268	120.8%	With Regularization
	IM	10.0%	-1.4%	-2.4%	11.6%	7.2%	-6.6%	12.9%	37.4%	0.9%	24.0%	6.3%	9.0%	15.7%	0.572	120.8%	Without Regularization
0.000001		$A$27)	1.4%	2.4%	11.6%	7.2%	6.6%	12.9%	37.4%	1.0%	24.0%	6.3%					

IM Constraint 1



StdDev	IM efficient	IM inefficient	IM Min variance	Ret
10.0%	8.9%	5.4%		-10.0%
10.5%	9.9%	4.4%		-9.5%
11.0%	10.7%	3.6%		-9.0%
11.5%	11.3%	3.1%		-8.5%
12.0%	11.9%	2.6%		-8.0%
12.5%	12.4%	2.1%		-7.5%
13.0%	12.8%	1.7%		-7.0%
13.5%	13.2%	1.3%		-6.5%
14.0%	13.6%	1.0%		-6.0%
14.5%	14.0%	0.6%	30.2%	-5.5%
15.0%	14.3%	0.3%	24.3%	-5.0%
15.5%	14.7%	-0.1%	23.3%	-4.5%
16.0%	15.0%	-0.4%	22.3%	-4.0%
16.5%	15.3%	-0.7%	21.3%	-3.5%
17.0%	15.6%	-1.0%	20.4%	-3.0%
17.5%	15.9%	-1.3%	19.5%	-2.5%
18.0%	16.2%	-1.6%	18.6%	-2.0%
18.5%	16.5%	-1.9%	17.8%	-1.5%
19.0%	16.8%	-2.2%	17.0%	-1.0%
19.5%	17.1%	-2.5%	16.2%	-0.5%
20.0%	17.4%	-2.8%	15.4%	0.0%
20.5%	17.7%	-3.0%	14.7%	0.5%
21.0%	18.0%	-3.3%	14.0%	1.0%
21.5%	18.3%	-3.6%	13.3%	1.5%
22.0%	18.5%	-3.9%	12.7%	2.0%
22.5%	17.2%	-4.1%	12.1%	2.5%
23.0%	19.1%	-4.4%	11.6%	3.0%
23.5%	17.4%	-4.6%	11.1%	3.5%
24.0%	19.6%	-4.9%	10.7%	4.0%
24.5%	19.9%	-5.1%	10.4%	4.5%
25.0%	19.8%	-5.2%	10.2%	5.0%

25.5%	20.4%	-5.2%	10.0%	5.5%
26.0%	18.7%	-5.3%	9.8%	6.0%
26.5%	18.8%	-5.3%	9.7%	6.5%
27.0%	21.2%	-5.3%	9.6%	7.0%
27.5%	21.5%	-5.4%	9.6%	7.5%
28.0%	21.7%		9.7%	8.0%
28.5%	22.0%		9.8%	8.5%
29.0%	22.2%		10.0%	9.0%
29.5%	22.5%		10.3%	9.5%
30.0%	22.7%		10.5%	10.0%
30.5%	23.0%		10.9%	10.5%
31.0%	23.2%		11.2%	11.0%
31.5%	21.8%		11.7%	11.5%
32.0%	23.7%		12.1%	12.0%
32.5%	23.9%		12.6%	12.5%
33.0%	22.8%		13.2%	13.0%
33.5%	24.0%		13.9%	13.5%
34.0%	23.1%		14.5%	14.0%
34.5%	24.9%		15.3%	14.5%
35.0%	25.1%		16.0%	15.0%
35.5%	25.4%		16.8%	15.5%
36.0%	25.6%		17.6%	16.0%
36.5%	25.9%		18.4%	16.5%
37.0%	25.0%		19.3%	17.0%
37.5%	26.3%		20.1%	17.5%
38.0%	25.9%		21.0%	18.0%
38.5%	26.8%		21.9%	18.5%
39.0%	27.0%		22.8%	19.0%
39.5%	26.1%		23.8%	19.5%
40.0%	27.5%		24.9%	20.0%
40.5%	27.7%		25.8%	20.5%
41.0%	28.0%	5.6%	26.6%	21.0%
41.5%	28.2%	5.6%	27.6%	21.5%
42.0%	27.1%	5.7%	28.6%	22.0%
42.5%	28.7%	5.8%	29.6%	22.5%
43.0%	28.8%	5.8%	31.1%	23.0%
43.5%	29.1%	5.9%	31.6%	23.5%
44.0%	29.2%	5.9%	33.4%	24.0%
44.5%	29.5%	6.0%	33.9%	24.5%
45.0%	29.8%	6.0%	34.7%	25.0%
45.5%	30.1%	6.1%	35.8%	25.5%
46.0%	30.3%		36.8%	26.0%
46.5%	30.5%		37.9%	26.5%
47.0%	30.4%		38.9%	27.0%
47.5%	29.6%		40.0%	27.5%
48.0%	31.2%		41.1%	28.0%
48.5%	31.4%		42.1%	28.5%
49.0%	31.6%		43.2%	29.0%
49.5%	31.8%		44.3%	29.5%
50.0%	32.1%		45.4%	30.0%

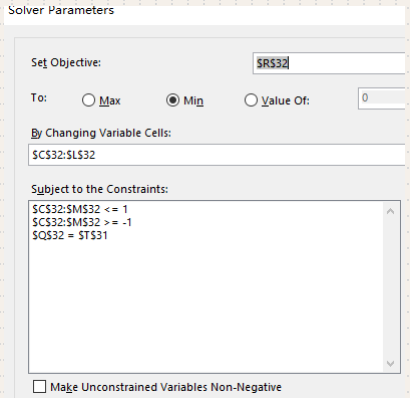
IM (Constr1):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	25.62%	-4.04%	-5.27%	-2.81%	-8.73%	0.76%	10.28%	-1.40%	31.27%	27.67%	26.64%	7.15%	9.63%	0.742	CAL:	0.0%	0.0%
MaxSharpe	-47.36%	8.88%	-1.26%	-0.56%	-0.71%	6.66%	29.53%	4.57%	43.93%	33.33%	22.99%	12.06%	12.18%	0.990	2.5	30.2%	30.4%

Constraint 2

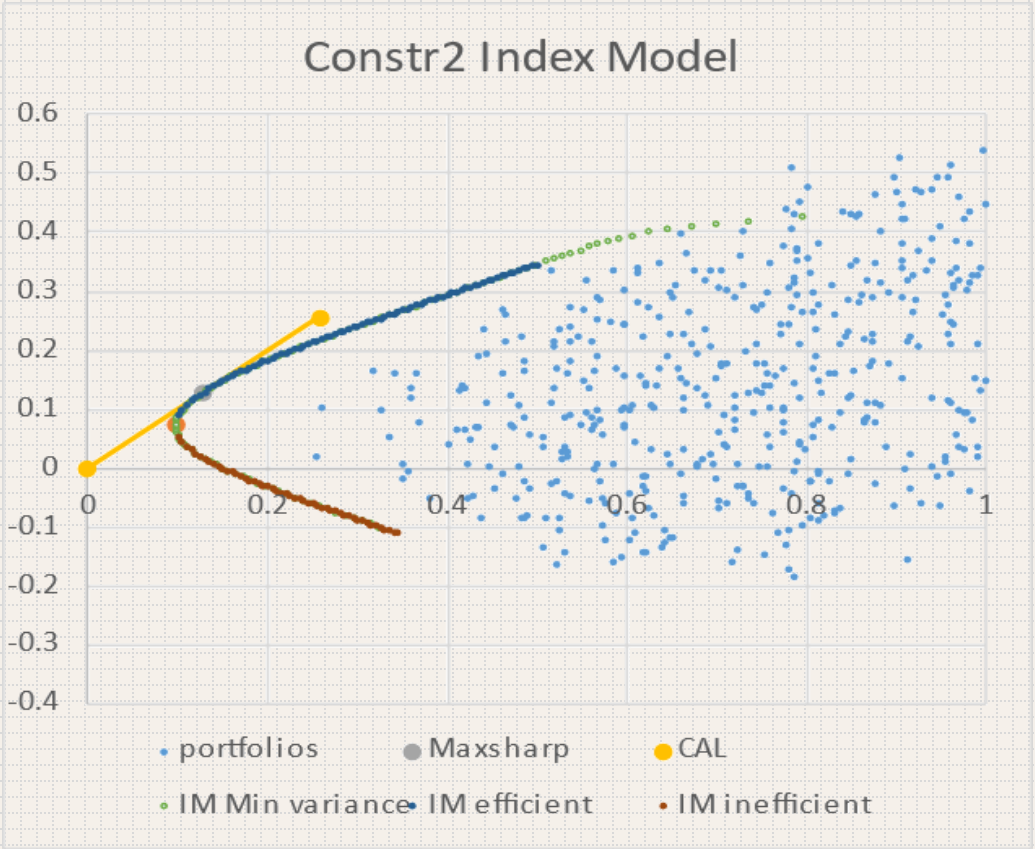
This additional optimization constraint is designed to simulate some *arbitrary "box" constraints* on weights, which may be provided by the client:

$$|w_i| \leq 1, \text{for } \forall i;$$

▷Method



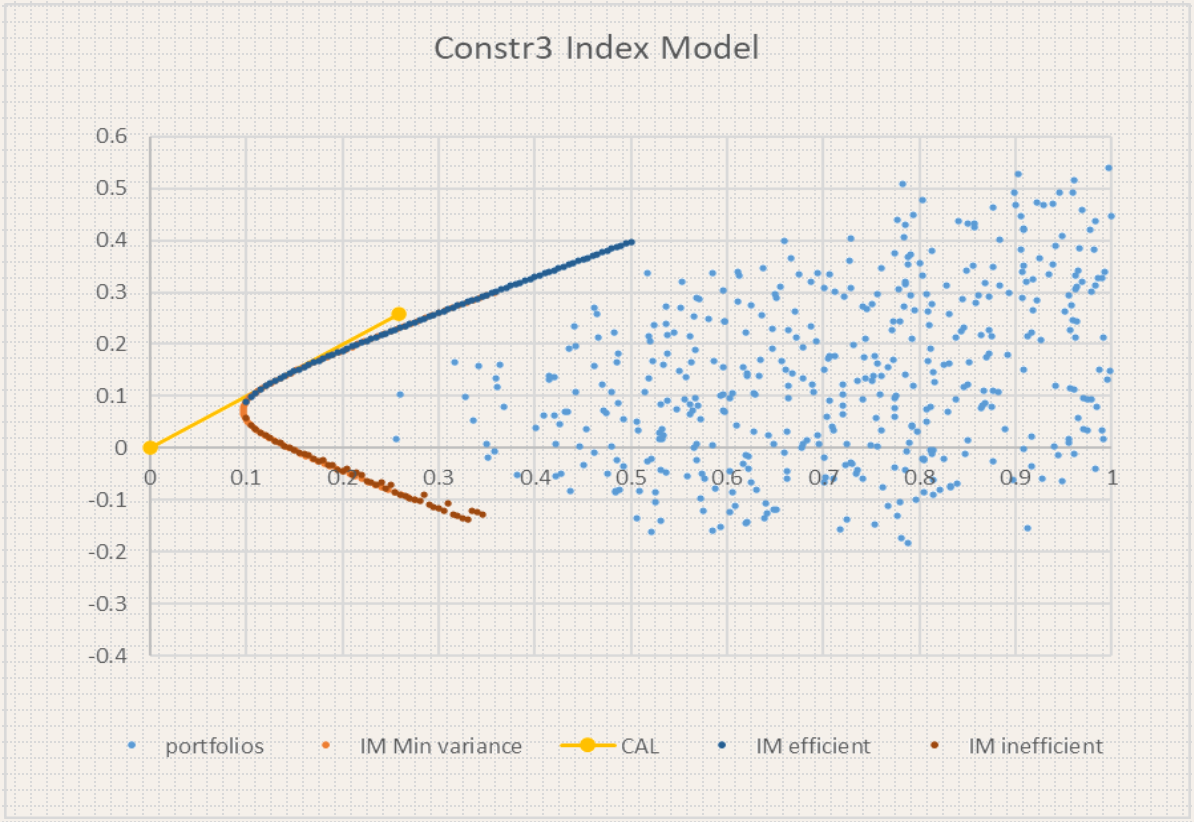
IM Constraint 2



StdDev	IM efficient	IM inefficient	IM Min variance	Ret
10.0%	8.9%	5.4%	32.3%	-10.0%
10.5%	9.9%	4.4%	31.4%	-9.5%
11.0%	10.7%	3.6%	30.4%	-9.0%
11.5%	11.3%	3.0%	29.5%	-8.5%
12.0%	11.9%	2.4%	28.6%	-8.0%
12.5%	12.4%	1.9%	27.6%	-7.5%
13.0%	12.9%	1.5%	26.7%	-7.0%
13.5%	13.4%	1.0%	25.8%	-6.5%
14.0%	13.9%	0.7%	24.9%	-6.0%
14.5%	14.3%	0.3%	24.0%	-5.5%
15.0%	14.8%	-0.1%	23.1%	-5.0%
15.5%	15.2%	-0.4%	22.2%	-4.5%
16.0%	15.6%	-0.8%	21.3%	-4.0%
16.5%	16.0%	-1.1%	20.5%	-3.5%
17.0%	16.3%	-1.4%	19.6%	-3.0%
17.5%	16.7%	-1.7%	18.8%	-2.5%
18.0%	17.0%	-2.0%	17.9%	-2.0%
18.5%	17.4%	-2.3%	17.1%	-1.5%
19.0%	17.7%	-2.6%	16.4%	-1.0%
19.5%	18.0%	-2.9%	15.6%	-0.5%
20.0%	18.3%	-3.2%	14.9%	0.0%
20.5%	18.6%	-3.5%	14.2%	0.5%
21.0%	18.9%	-3.8%	13.6%	1.0%
21.5%	19.2%	-4.1%	13.0%	1.5%
22.0%	19.5%	-4.4%	12.4%	2.0%
22.5%	19.8%	-4.7%	11.9%	2.5%
23.0%	20.1%	-5.0%	11.5%	3.0%
23.5%	20.4%	-5.2%	11.1%	3.5%
24.0%	20.7%	-5.5%	10.7%	4.0%
24.5%	21.0%	-5.8%	10.4%	4.5%
25.0%	21.3%	-6.1%	10.2%	5.0%
25.5%	21.6%	-6.3%	10.0%	5.5%
26.0%	21.9%	-6.6%	9.8%	6.0%
26.5%	22.1%	-6.9%	9.7%	6.5%
27.0%	22.4%	-7.2%	9.6%	7.0%
27.5%	22.7%	-7.4%	9.6%	7.5%
28.0%	23.0%	-7.7%	9.7%	8.0%
28.5%	23.3%	-8.0%	9.8%	8.5%
29.0%	23.5%	-8.2%	10.0%	9.0%
29.5%	23.8%	-8.5%	10.3%	9.5%
30.0%	24.1%	-8.8%	10.5%	10.0%
30.5%	24.3%	-9.0%	10.9%	10.5%
31.0%	24.6%	-9.3%	11.2%	11.0%
31.5%	24.9%	-9.6%	11.7%	11.5%
32.0%	25.2%	-9.8%	12.1%	12.0%
32.5%	25.4%	-10.1%	12.6%	12.5%
33.0%	25.7%	-10.3%	13.1%	13.0%
33.5%	26.0%	-10.6%	13.6%	13.5%
34.0%	26.2%	-10.9%	14.1%	14.0%
34.5%	26.5%	-11.1%	14.7%	14.5%
35.0%	26.8%	-11.4%	15.3%	15.0%
35.5%	27.0%	-11.7%	15.9%	15.5%
36.0%	27.3%	-11.9%	16.5%	16.0%
36.5%	27.6%	-12.2%	17.2%	16.5%
37.0%	27.8%	-12.4%	18.0%	17.0%
37.5%	28.1%	-12.7%	18.7%	17.5%
38.0%	28.3%	-13.0%	19.5%	18.0%
38.5%	28.6%	-13.2%	20.3%	18.5%
39.0%	28.9%	-13.5%	21.1%	19.0%
39.5%	29.1%	-13.7%	21.9%	19.5%
40.0%	29.4%	-14.0%	22.8%	20.0%
40.5%	29.7%	-14.2%	23.6%	20.5%
41.0%	29.9%	-14.5%	24.5%	21.0%
41.5%	30.2%	-14.8%	25.4%	21.5%
42.0%	30.4%	-15.0%	26.2%	22.0%
42.5%	30.7%	-15.3%	27.1%	22.5%
43.0%	31.0%	-15.5%	28.0%	23.0%
43.5%	31.2%	-15.8%	28.9%	23.5%
44.0%	31.5%	-16.0%	29.9%	24.0%
44.5%	31.7%	-16.3%	30.8%	24.5%
45.0%	32.0%	-16.6%	31.7%	25.0%
45.5%	32.3%	-16.8%	32.6%	25.5%
46.0%	32.5%	-17.1%	33.6%	26.0%
46.5%	32.8%	-17.3%	34.5%	26.5%
47.0%	33.0%	-17.6%	35.4%	27.0%
47.5%	33.3%	-17.8%	36.4%	27.5%
48.0%	33.5%	-18.1%	37.3%	28.0%
48.5%	33.8%	-18.3%	38.3%	28.5%
49.0%	34.1%	-18.6%	39.2%	29.0%
49.5%	34.3%	-18.9%	40.2%	29.5%
50.0%	34.6%	-19.1%	41.2%	30.0%

IM (Constr2):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
IM inVar	25.62%	-4.04%	-5.27%	-2.81%	-8.73%	0.76%	10.28%	-1.40%	31.27%	27.67%	26.64%	7.15%	9.63%	0.742	CAL:	0.0%	0.0%
IM axSharpe	-70.16%	10.32%	-0.57%	-0.11%	0.57%	9.39%	34.25%	7.35%	46.90%	36.94%	25.11%	12.87%	12.92%	0.996	2.5	32.2%	32.3%

IM Constraint 3



StdDev	M efficient	M inefficient	M M in variance	Ret
10.0%	8.9%	5.7%	27.6%	-10.0%
10.5%	9.9%	4.4%	26.9%	-9.5%
11.0%	10.7%	3.6%	26.2%	-9.0%
11.5%	11.3%	3.0%	25.5%	-8.5%
12.0%	11.9%	2.4%	24.8%	-8.0%
12.5%	12.4%	1.9%	24.1%	-7.5%
13.0%	12.9%	1.4%	23.4%	-7.0%
13.5%	13.4%	1.0%	22.7%	-6.5%
14.0%	13.9%	0.4%	22.0%	-6.0%
14.5%	14.3%	0.0%	21.4%	-5.5%
15.0%	14.8%	-0.5%	20.7%	-5.0%
15.5%	15.2%	-0.9%	20.0%	-4.5%
16.0%	15.6%	-1.1%	19.4%	-4.0%
16.5%	16.0%	-1.4%	18.7%	-3.5%
17.0%	16.4%	-2.1%	18.1%	-3.0%
17.5%	16.8%	-2.5%	17.4%	-2.5%
18.0%	17.2%	-2.4%	16.8%	-2.0%
18.5%	17.6%	-3.3%	16.2%	-1.5%
19.0%	18.0%	-3.3%	15.6%	-1.0%
19.5%	18.4%	-4.1%	15.0%	-0.5%
20.0%	18.8%	-4.5%	14.5%	0.0%
20.5%	19.2%	-4.1%	13.9%	0.5%
21.0%	19.5%	-5.2%	13.4%	1.0%
21.5%	19.9%	-4.7%	12.9%	1.5%
22.0%	20.3%	-5.2%	12.4%	2.0%
22.5%	20.6%	-6.3%	11.9%	2.5%
23.0%	21.0%	-6.7%	11.5%	3.0%
23.5%	21.4%	-7.1%	11.1%	3.5%
24.0%	21.7%	-6.6%	10.7%	4.0%
24.5%	22.1%	-7.8%	10.4%	4.5%
25.0%	22.5%	-7.1%	10.2%	5.0%

25.5%	22.8%	-8.5%	10.0%	5.5%
26.0%	23.2%	-8.9%	9.8%	6.0%
26.5%	23.5%	-9.2%	9.7%	6.5%
27.0%	23.9%	-9.6%	9.6%	7.0%
27.5%	24.2%	-9.9%	9.6%	7.5%
28.0%	24.6%	-10.3%	9.7%	8.0%
28.5%	25.0%	-9.0%	9.8%	8.5%
29.0%	25.3%	-11.0%	10.0%	9.0%
29.5%	25.7%	-11.4%	10.3%	9.5%
30.0%	26.0%	-11.7%	10.5%	10.0%
30.5%	26.4%	-12.1%	10.9%	10.5%
31.0%	26.7%	-10.7%	11.2%	11.0%
31.5%	27.1%	-12.8%	11.7%	11.5%
32.0%	27.4%	-13.1%	12.1%	12.0%
32.5%	27.8%	-13.4%	12.6%	12.5%
33.0%	28.1%	-13.8%	13.1%	13.0%
33.5%	28.4%	-12.1%	13.6%	13.5%
34.0%	28.8%	-12.4%	14.1%	14.0%
34.5%	29.1%	-12.8%	14.7%	14.5%
35.0%	29.5%	-15.2%	15.3%	15.0%
35.5%	29.8%	-13.4%	15.8%	15.5%
36.0%	30.2%	-15.9%	16.4%	16.0%
36.5%	30.5%	-16.2%	17.1%	16.5%
37.0%	30.9%	-16.6%	17.7%	17.0%
37.5%	31.2%	-16.9%	18.3%	17.5%
38.0%	31.5%	-17.2%	19.0%	18.0%
38.5%	31.9%	-17.6%	19.6%	18.5%
39.0%	32.2%	-17.9%	20.3%	19.0%
39.5%	32.6%	-18.3%	21.0%	19.5%
40.0%	32.9%	-18.6%	21.6%	20.0%
40.5%	33.3%	-19.0%	22.3%	20.5%
41.0%	33.6%	-19.3%	23.0%	21.0%
41.5%	33.9%	-19.6%	23.7%	21.5%
42.0%	34.3%	-20.0%	24.4%	22.0%
42.5%	34.6%	-20.3%	25.1%	22.5%
43.0%	35.0%	-20.7%	25.8%	23.0%
43.5%	35.3%	-18.3%	26.5%	23.5%
44.0%	35.6%	-18.2%	27.2%	24.0%
44.5%	36.0%	-21.7%	27.9%	24.5%
45.0%	36.3%	-19.0%	28.6%	25.0%
45.5%	36.7%	-19.3%	29.3%	25.5%
46.0%	37.0%	-22.7%	30.0%	26.0%
46.5%	37.3%	-23.0%	30.7%	26.5%
47.0%	37.7%	-20.1%	31.4%	27.0%
47.5%	38.0%	-23.7%	32.1%	27.5%
48.0%	38.4%	-24.1%	32.9%	28.0%
48.5%	38.7%	-21.1%	33.6%	28.5%
49.0%	39.0%	-24.7%	34.3%	29.0%
49.5%	39.4%	-25.1%	35.0%	29.5%
50.0%	39.7%	-21.9%	35.8%	30.0%

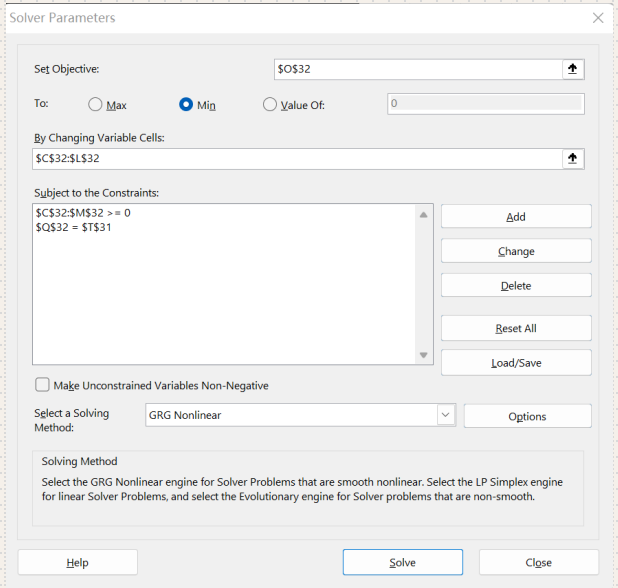
M (Constr3):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
M inVar	25.62%	-4.04%	-5.27%	-2.81%	-8.73%	0.76%	10.28%	-1.40%	31.27%	27.67%	26.64%	7.15%	9.63%	0.742	CAL:	0.0%	0.0%
M axSharpe	-70.16%	10.32%	-0.57%	-0.11%	0.57%	9.39%	34.25%	7.35%	46.90%	36.94%	25.11%	12.87%	12.92%	0.996	2.5	32.2%	32.3%

Constraint 4

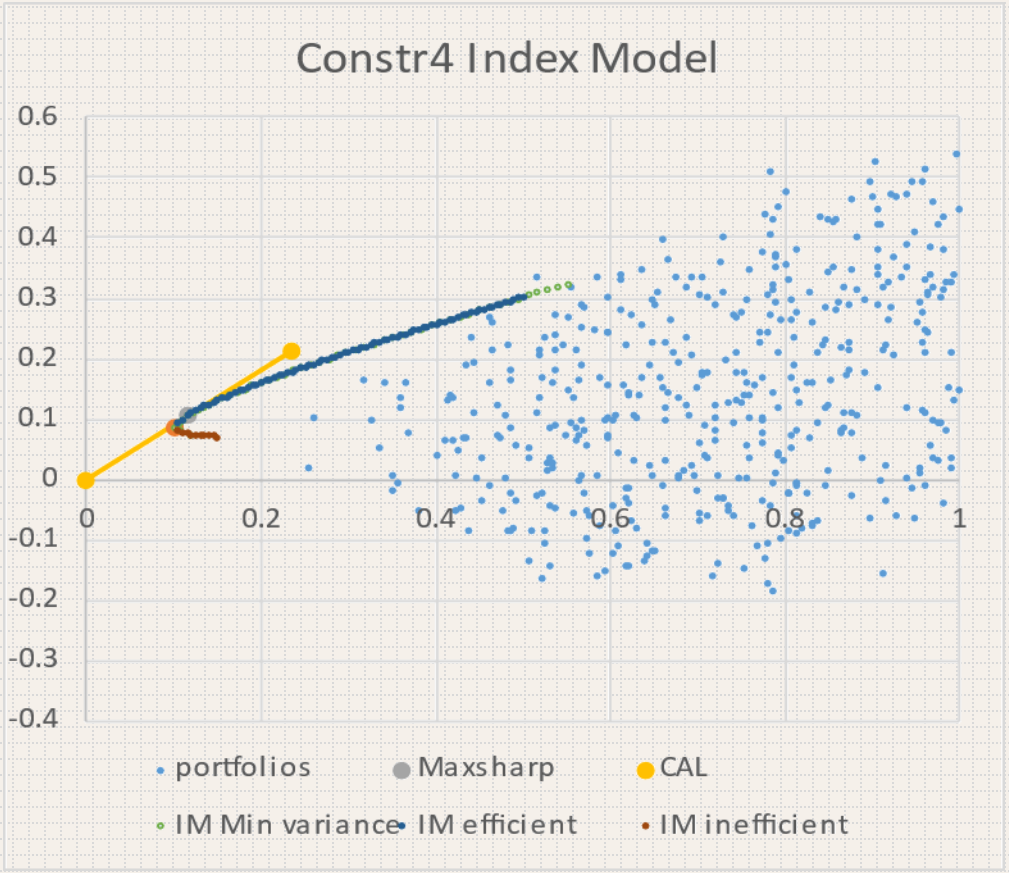
This additional optimization constraint is designed to simulate the typical limitations existing in the U.S. mutual fund industry: a U.S. open-ended mutual fund is *not allowed to have any short positions*, for details see the Investment Company Act of 1940, Section 12(a)(3) (https://www.law.cornell.edu/uscode/text/15/80a-12):

$$w_i \geq 0, \text{for } \forall i;$$

▷**Method**



IM Constraint 4



StdDev	IM efficient	IM inefficient	IM Min variance	Ret
10.0%				-10.0%
10.5%	9.3%	8.1%		-9.5%
11.0%	10.0%	7.8%		-9.0%
11.5%	10.5%	7.6%		-8.5%
12.0%	11.0%	7.5%		-8.0%
12.5%	11.4%	7.4%		-7.5%
13.0%	11.8%	7.3%		-7.0%
13.5%	12.1%	7.2%		-6.5%
14.0%	12.5%	7.2%		-6.0%
14.5%	12.8%	7.2%		-5.5%
15.0%	13.1%	7.1%		-5.0%
15.5%	13.5%			-4.5%
16.0%	13.8%			-4.0%
16.5%	14.1%			-3.5%
17.0%	14.4%			-3.0%
17.5%	14.7%			-2.5%
18.0%	15.0%			-2.0%
18.5%	15.3%			-1.5%
19.0%	15.5%			-1.0%
19.5%	15.8%			-0.5%
20.0%	16.1%			0.0%
20.5%	16.4%			0.5%
21.0%	16.6%			1.0%
21.5%	16.9%			1.5%
22.0%	17.2%			2.0%
22.5%	17.4%			2.5%
23.0%	17.7%			3.0%
23.5%	17.9%			3.5%
24.0%	18.2%			4.0%
24.5%	18.4%			4.5%
25.0%	18.7%			5.0%

25.5%	18.9%			5.5%													
26.0%	19.2%			6.0%													
26.5%	19.4%			6.5%													
27.0%	19.7%			7.0%													
27.5%	19.9%		12.0%	7.5%													
28.0%	20.2%		10.6%	8.0%													
28.5%	20.4%		10.2%	8.5%													
29.0%	20.6%		10.3%	9.0%													
29.5%	20.9%		10.6%	9.5%													
30.0%	21.1%		11.0%	10.0%													
30.5%	21.4%		11.5%	10.5%													
31.0%	21.6%		12.1%	11.0%													
31.5%	21.8%		12.7%	11.5%													
32.0%	22.1%		13.3%	12.0%													
32.5%	22.3%		14.0%	12.5%													
33.0%	22.5%		14.8%	13.0%													
33.5%	22.8%		15.6%	13.5%													
34.0%	23.0%		16.4%	14.0%													
34.5%	23.2%		17.2%	14.5%													
35.0%	23.5%		18.1%	15.0%													
35.5%	23.7%		18.9%	15.5%													
36.0%	23.9%		19.8%	16.0%													
36.5%	24.2%		20.8%	16.5%													
37.0%	24.4%		21.7%	17.0%													
37.5%	24.6%		22.7%	17.5%													
38.0%	24.8%		23.6%	18.0%													
38.5%	25.1%		24.6%	18.5%													
39.0%	25.3%		25.6%	19.0%													
39.5%	25.5%		26.6%	19.5%													
40.0%	25.8%		27.7%	20.0%													
40.5%	26.0%		28.7%	20.5%													
41.0%	26.2%		29.7%	21.0%													
41.5%	26.4%		30.8%	21.5%													
42.0%	26.7%		31.9%	22.0%													
42.5%	26.9%		32.9%	22.5%													
43.0%	27.1%		34.0%	23.0%													
43.5%	27.3%		35.1%	23.5%													
44.0%	27.6%		36.2%	24.0%													
44.5%	27.8%		37.3%	24.5%													
45.0%	28.0%		38.3%	25.0%													
45.5%	28.2%		39.4%	25.5%													
46.0%	28.5%		40.5%	26.0%													
46.5%	28.7%		41.6%	26.5%													
47.0%	28.9%		42.8%	27.0%													
47.5%	29.1%		43.9%	27.5%													
48.0%	29.4%		45.0%	28.0%													
48.5%	29.6%		46.1%	28.5%													
49.0%	29.8%		47.2%	29.0%													
49.5%	30.0%		48.3%	29.5%													
50.0%	30.2%		49.4%	30.0%													

IM (Constr4):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe
MinVar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.21%	0.00%	33.55%	28.89%	28.35%	8.64%	10.16%	0.850
MaxSharpe	0.00%	6.74%	0.00%	0.00%	0.00%	0.00%	17.75%	0.00%	37.34%	22.75%	15.41%	10.71%	11.72%	0.914

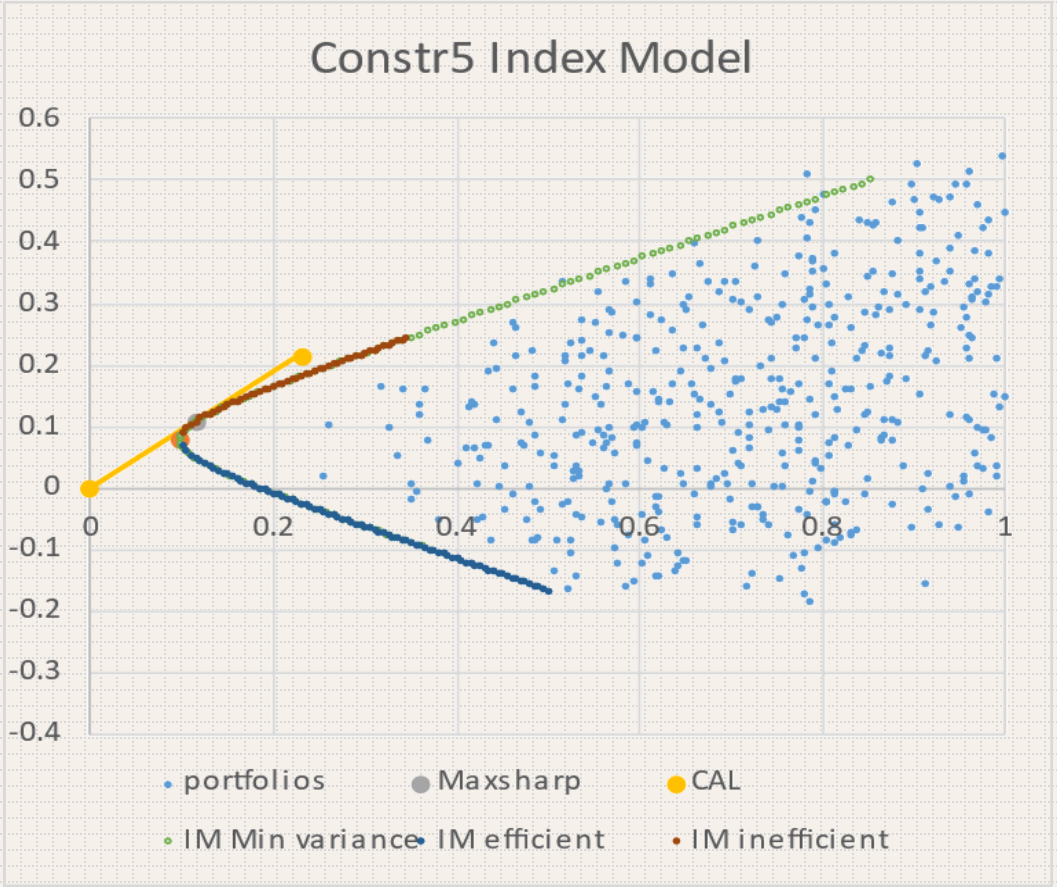
CAL:		
2.5	26.8%	29.3%

Constraint 5

Lastly, we would like to see if the *inclusion of the broad index* into our portfolio has positive or negative effect, for that we would like to consider an additional optimization constraint:

$$w_1 = 0\,.$$

IM Constraint 5



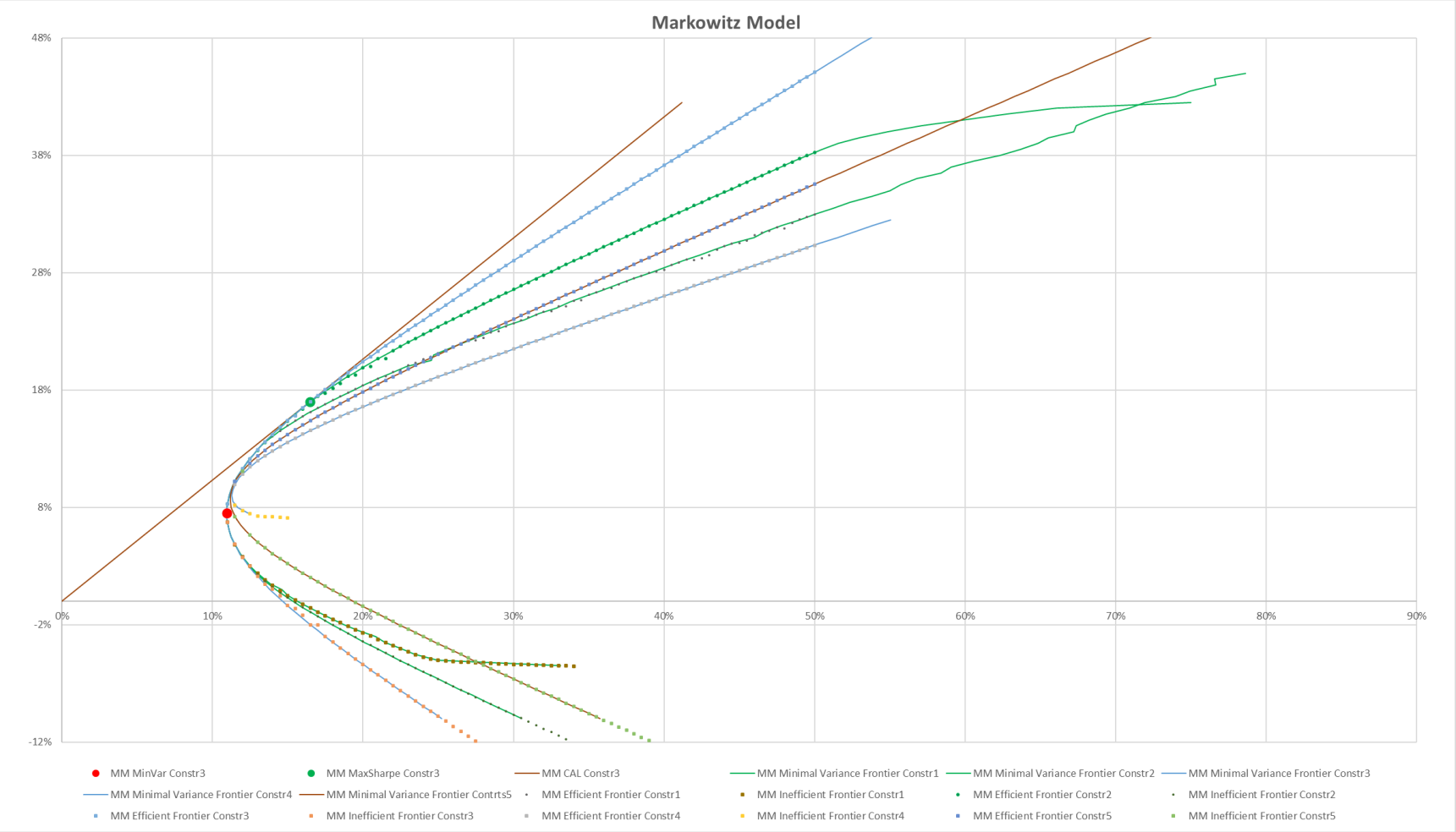
StdDev	IM efficient	IM inefficient	IM Min variance	Ret
10.0%	6.7%	8.9%	37.1%	-10.0%
10.5%	5.9%	9.8%	36.1%	-9.5%
11.0%	5.3%	10.4%	35.2%	-9.0%
11.5%	4.8%	10.9%	34.2%	-8.5%
12.0%	4.3%	11.3%	33.2%	-8.0%
12.5%	3.9%	11.7%	32.3%	-7.5%
13.0%	3.5%	12.1%	31.3%	-7.0%
13.5%	3.2%	12.5%	30.4%	-6.5%
14.0%	2.8%	12.8%	29.4%	-6.0%
14.5%	2.5%	13.2%	28.5%	-5.5%
15.0%	2.1%	13.5%	27.5%	-5.0%
15.5%	1.8%	13.8%	26.6%	-4.5%
16.0%	1.5%	14.1%	25.7%	-4.0%
16.5%	1.2%	14.4%	24.7%	-3.5%
17.0%	0.9%	14.8%	23.8%	-3.0%
17.5%	0.6%	15.1%	22.9%	-2.5%
18.0%	0.3%	15.4%	22.0%	-2.0%
18.5%	0.0%	15.6%	21.1%	-1.5%
19.0%	-0.3%	15.9%	20.2%	-1.0%
19.5%	-0.6%	16.2%	19.4%	-0.5%
20.0%	-0.9%	16.5%	18.5%	0.0%
20.5%	-1.2%	16.8%	17.6%	0.5%
21.0%	-1.4%	17.1%	16.8%	1.0%
21.5%	-1.7%	17.4%	16.0%	1.5%
22.0%	-2.0%	17.6%	15.2%	2.0%
22.5%	-2.3%	17.9%	14.5%	2.5%
23.0%	-2.5%	18.2%	13.7%	3.0%
23.5%	-2.8%	18.5%	13.1%	3.5%
24.0%	-3.1%	18.7%	12.4%	4.0%
24.5%	-3.4%	19.0%	11.8%	4.5%
25.0%	-3.6%	19.3%	11.3%	5.0%
25.5%	-3.9%	19.6%	10.8%	5.5%
26.0%	-4.2%	19.8%	10.4%	6.0%
26.5%	-4.4%	20.1%	10.1%	6.5%
27.0%	-4.7%	20.4%	9.9%	7.0%
27.5%	-5.0%	20.6%	9.8%	7.5%
28.0%	-5.2%	20.9%	9.8%	8.0%
28.5%	-5.5%	21.2%	9.8%	8.5%
29.0%	-5.8%	21.4%	10.0%	9.0%
29.5%	-6.0%	21.7%	10.3%	9.5%
30.0%	-6.3%	21.9%	10.7%	10.0%
30.5%	-6.6%	22.2%	11.1%	10.5%
31.0%	-6.8%	22.5%	11.7%	11.0%
31.5%	-7.1%	22.7%	12.2%	11.5%
32.0%	-7.4%	23.0%	12.9%	12.0%
32.5%	-7.6%	23.3%	13.5%	12.5%
33.0%	-7.9%	23.5%	14.3%	13.0%
33.5%	-8.1%	23.8%	15.0%	13.5%
34.0%	-8.4%	24.0%	15.8%	14.0%
34.5%	-8.7%	24.3%	16.6%	14.5%
35.0%	-8.9%	24.6%	17.4%	15.0%
35.5%	-9.2%	24.8%	18.3%	15.5%
36.0%	-9.4%	25.1%	19.1%	16.0%
36.5%	-9.7%	25.3%	20.0%	16.5%
37.0%	-9.9%	25.6%	20.9%	17.0%
37.5%	-10.2%	25.8%	21.8%	17.5%
38.0%	-10.5%	26.1%	22.7%	18.0%
38.5%	-10.7%	26.4%	23.6%	18.5%
39.0%	-11.0%	26.6%	24.5%	19.0%
39.5%	-11.2%	26.9%	25.4%	19.5%
40.0%	-11.5%	27.1%	26.3%	20.0%
40.5%	-11.7%	27.4%	27.3%	20.5%
41.0%	-12.0%	27.6%	28.2%	21.0%
41.5%	-12.3%	27.9%	29.2%	21.5%
42.0%	-12.5%	28.2%	30.1%	22.0%
42.5%	-12.8%	28.4%	31.1%	22.5%
43.0%	-13.0%	28.7%	32.0%	23.0%
43.5%	-13.3%	28.9%	33.0%	23.5%
44.0%	-13.5%	29.2%	33.9%	24.0%
44.5%	-13.8%	29.4%	34.9%	24.5%
45.0%	-14.1%	29.7%	35.9%	25.0%
45.5%	-14.3%	29.9%	36.8%	25.5%
46.0%	-14.6%	30.2%	37.8%	26.0%
46.5%	-14.8%	30.5%	38.8%	26.5%
47.0%	-15.1%	30.7%	39.7%	27.0%
47.5%	-15.3%	31.0%	40.7%	27.5%
48.0%	-15.6%	31.2%	41.7%	28.0%
48.5%	-15.8%	31.5%	42.7%	28.5%
49.0%	-16.1%	31.7%	43.6%	29.0%
49.5%	-16.3%	32.0%	44.6%	29.5%
50.0%	-16.6%	32.2%	45.6%	30.0%

IM (Constr5):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	0.00%	-3.35%	-3.28%	-1.14%	-6.02%	3.27%	14.25%	1.13%	34.13%	31.54%	29.47%	7.82%	9.75%	0.802	CAL:	0.0%	0.0%
MaxSharpe	0.00%	7.68%	-5.84%	-4.45%	-6.81%	2.56%	22.82%	0.47%	38.76%	26.69%	18.11%	10.84%	11.48%	0.944	2.5	27.1%	28.7%

Part V

『Conclusion』

MM All constraints



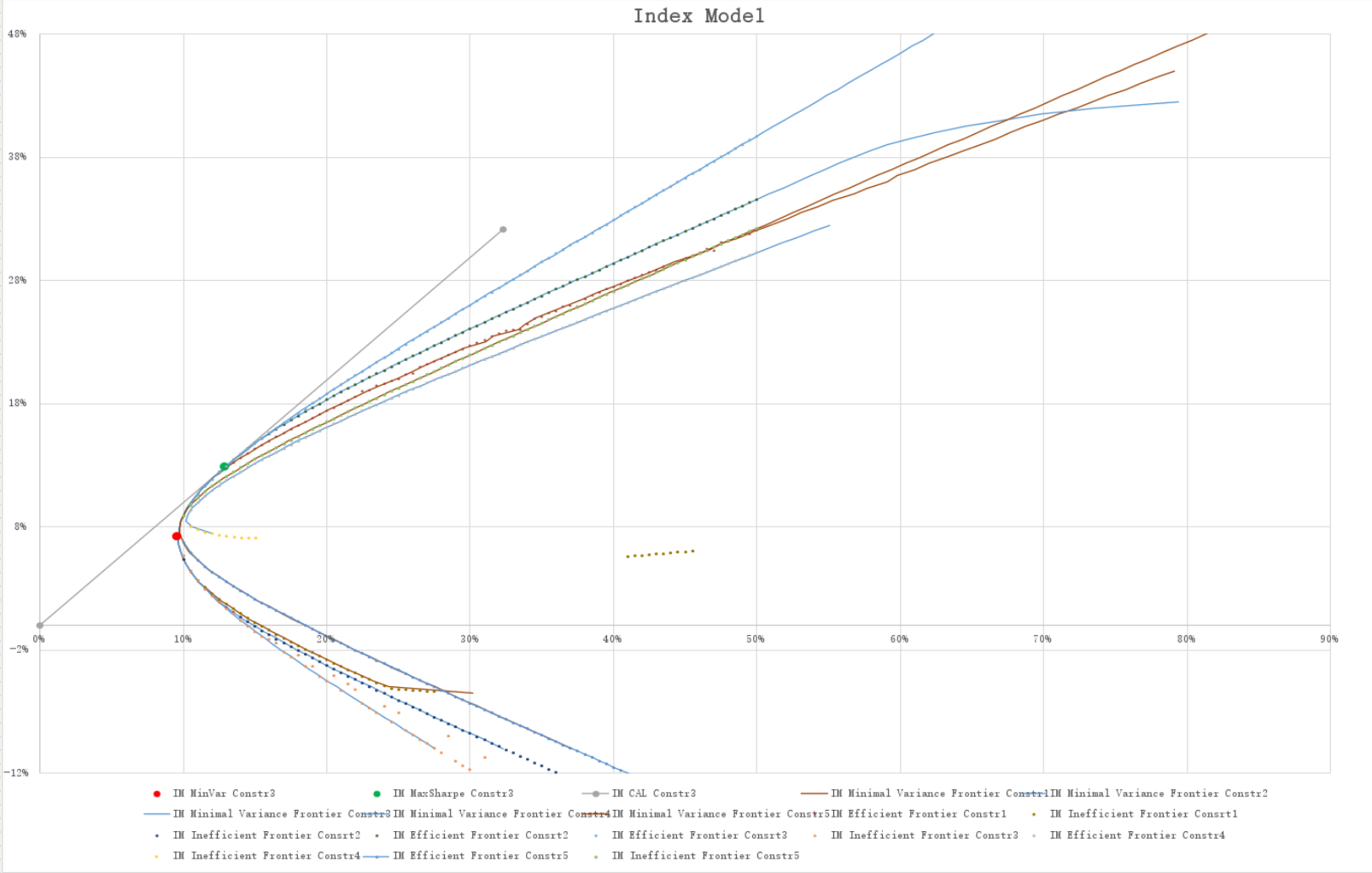
From outer to inner

- ✓ Constr 3(No constraint)
- ✓ Constr 2
- ✓ Constr 5
- ✓ Constr 1
- ✓ Constr 4

- Compared with other constraints, the asset allocation of MM under **constraint 4** is quite different, because short position is not allowed to exist, and it is greatly restricted by the principal, which leads to a great difference between the asset allocation and other combinations.
- And the exclusion of a broad index had negative effect.

IM

All constraints



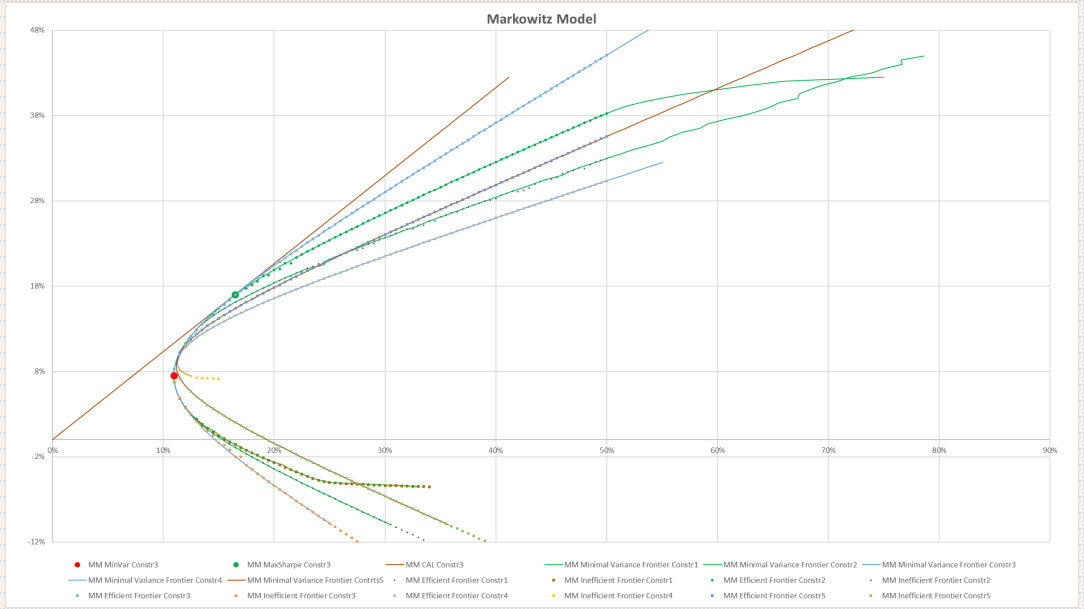
From outer to inner

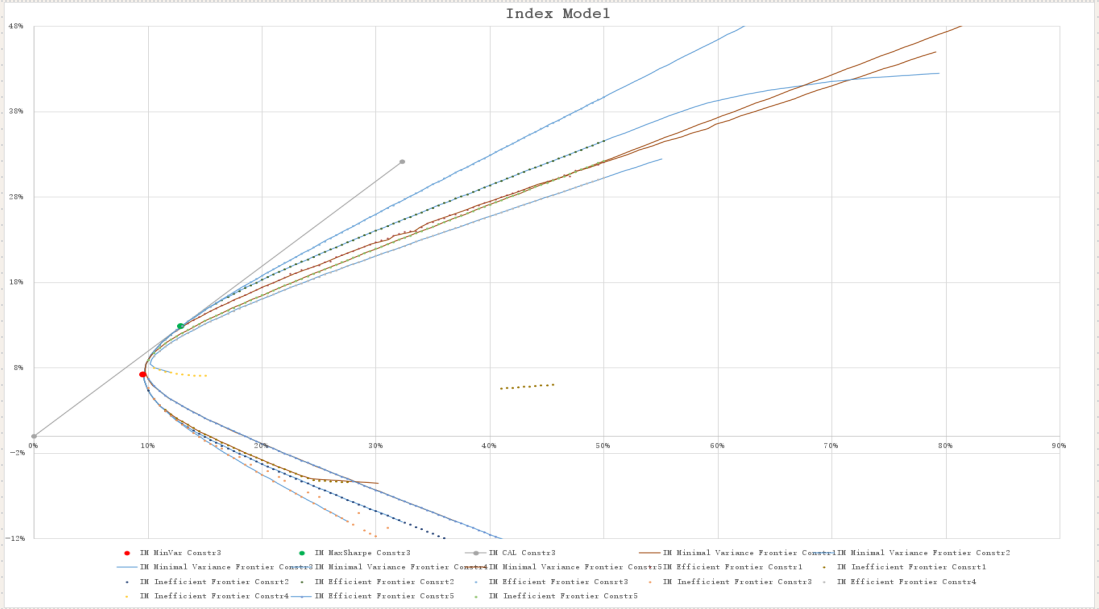
- ✓ Constr 3(No constraint)
- ✓ Constr 2
- ✓ Constr 5
- ✓ Constr 1
- ✓ Constr 4

- For the portfolios return, in the comparison of constraint 1, constraint 2, and constraint 3, it can be seen that almost all portfolios return showing a trend of reduction in return But the weight was close between different constraints.
- And also constraint 4 shows a limited area.
- And the exclusion of a broad index also had negative effect in index model.

IM
MM

Comparison





From the optimal asset allocation obtained by MM and IM, we can see that the

Two models are showing highly consistent in the trend but slightly different on the specific portfolios chosen. Overall, The index model tend to have higher return in low risk area when seeking efficient frontier. And a lower return as well as a lower loss when seeking inefficient frontier. We prefer that index model can perform better in low risk area.

IM
MM

Comparison

MM (Constr1):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	38.37%	-2.97%	-2.89%	1.33%	-5.90%	-0.30%	19.41%	-11.48%	25.93%	18.83%	19.67%	7.51%	10.95%	0.685	CAL:	0.0%	0.0%
MaxSharpe	-42.64%	15.74%	-1.21%	-6.09%	3.25%	6.44%	35.27%	1.14%	45.73%	29.95%	12.42%	14.01%	13.95%	1.004	2.5	35.0%	34.9%
MM (Constr2):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	38.37%	-2.97%	-2.89%	1.33%	-5.90%	-0.30%	19.41%	-11.48%	25.93%	18.83%	19.67%	7.51%	10.95%	0.685	CAL:	0.0%	0.0%
MaxSharpe	-100.00%	21.50%	0.31%	-8.15%	11.46%	12.25%	44.92%	6.87%	52.33%	41.02%	17.48%	16.56%	16.06%	1.031	2.5	41.4%	40.2%
MM (Constr3):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	38.37%	-2.97%	-2.89%	1.33%	-5.90%	-0.30%	19.41%	-11.48%	25.93%	18.83%	19.67%	7.51%	10.95%	0.685	CAL:	0.0%	0.0%
MaxSharpe	-109.97%	22.46%	0.89%	-8.19%	12.73%	13.21%	46.46%	7.90%	53.50%	42.72%	18.30%	16.99%	16.48%	1.031	2.5	42.5%	41.2%
MM (Constr4):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	9.49%	0.00%	0.00%	0.00%	0.00%	0.00%	19.85%	0.00%	28.91%	20.62%	21.13%	8.88%	11.27%	0.788	CAL:	0.0%	0.0%
MaxSharpe	0.00%	10.95%	0.00%	0.00%	0.00%	0.00%	23.73%	0.00%	42.56%	16.17%	6.60%	12.06%	13.12%	0.919	2.5	30.1%	32.8%
MM (Constr5):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	0.00%	-0.97%	0.08%	2.51%	-0.99%	3.50%	24.70%	-8.17%	28.91%	25.58%	24.85%	8.71%	11.18%	0.779	CAL:	0.0%	0.0%
MaxSharpe	0.00%	14.93%	-6.85%	-10.14%	-1.30%	2.43%	30.65%	-2.27%	43.31%	23.61%	5.64%	13.06%	13.69%	0.954	2.5	32.6%	34.2%

IM (Constr1):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	25.62%	-4.04%	-5.27%	-2.81%	-8.73%	0.76%	10.28%	-1.40%	31.27%	27.67%	26.64%	7.15%	9.63%	0.742	CAL:	0.0%	0.0%
MaxSharpe	-47.36%	8.88%	-1.26%	-0.56%	-0.71%	6.66%	29.53%	4.57%	43.93%	33.33%	22.99%	12.06%	12.18%	0.990	2.5	30.2%	30.4%
IM (Constr2):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	25.62%	-4.04%	-5.27%	-2.81%	-8.73%	0.76%	10.28%	-1.40%	31.27%	27.67%	26.64%	7.15%	9.63%	0.742	CAL:	0.0%	0.0%
MaxSharpe	-70.16%	10.32%	-0.57%	-0.11%	0.57%	9.39%	34.25%	7.35%	46.90%	36.94%	25.11%	12.87%	12.92%	0.996	2.5	32.2%	32.3%
IM (Constr3):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	25.62%	-4.04%	-5.27%	-2.81%	-8.73%	0.76%	10.28%	-1.40%	31.27%	27.67%	26.64%	7.15%	9.63%	0.742	CAL:	0.0%	0.0%
MaxSharpe	-70.16%	10.32%	-0.57%	-0.11%	0.57%	9.39%	34.25%	7.35%	46.90%	36.94%	25.11%	12.87%	12.92%	0.996	2.5	32.2%	32.3%
IM (Constr4):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.21%	0.00%	33.55%	28.89%	28.35%	8.64%	10.16%	0.850	CAL:	0.0%	0.0%
MaxSharpe	0.00%	6.74%	0.00%	0.00%	0.00%	0.00%	17.75%	0.00%	37.34%	22.75%	15.41%	10.71%	11.72%	0.914	2.5	26.8%	29.3%
IM (Constr5):	SPX	NVDA	CSCO	INTC	GS	USB	TD CN	ALL	PG	JNJ	CL	Return	StDev	Sharpe			
MinVar	0.00%	-3.35%	-3.28%	-1.14%	-6.02%	3.27%	14.25%	1.13%	34.13%	31.54%	29.47%	7.82%	9.75%	0.802	CAL:	0.0%	0.0%
MaxSharpe	0.00%	7.68%	-5.84%	-4.45%	-6.81%	2.56%	22.82%	0.47%	38.76%	26.69%	18.11%	10.84%	11.48%	0.944	2.5	27.1%	28.7%

And further compare the Minimal variance portfolios and max sharp portfolios for these ten stocks gaven by these two models:

1. The Markowitz model performs better on finding more risk efficient portfolios for every constraint.
2. The index model performs better on finding the lowest risk portfolios fot every constraint.
3. The differences might arise from the index model could be considered to have a improvement over the Markowitz model in a way that it reduces the estimations needed (The correlation between each stocks) by relating them to a single index.

Thanks for Listening !

PRESENTED BY GROUP 3

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Presentation Time : 08/12/2022