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Python for Finance

Final project

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In this final project, I chose to focus on the Modern Portfolio Theory (MPT), a pioneering concept in financial management developed by economist Harry Markowitz. At the core of this theory lies the essence of contemporary portfolio management. MPT is grounded in fundamental principles such as diversification and maximizing returns.

A central pillar of MPT is diversification, which involves distributing investments across a wide range of assets with low correlation in performance. This intentional diversification enables investors to reduce the overall risk of their portfolio without significantly compromising the anticipated returns.

The theory also considers the balance between expected returns and the level of risk. The goal is to achieve an optimal balance where the return is satisfactory while minimizing the level of risk. This compromise is evaluated through the Sharpe ratio. A ratio between 0 and 1 indicates that the portfolio's excess return over the risk-free rate is lower than the risk incurred. A ratio above 1 signifies that the portfolio outperforms a risk-free investment, demonstrating superior profitability.

Taking into account various indicators such as asset correlation and the risk/return ratio enables investors to make more informed and optimal decisions regarding allocation and setting return and risk objectives.

In this project, my primary objective was to construct a portfolio composed of assets with minimal correlation to the overall market, aiming to significantly minimize the portfolio's risk while targeting an attractive expected return.

Within this study, I developed two distinct portfolios, each aiming for specific objectives.

The first portfolio was primarily designed based on correlations between assets. The underlying strategy was founded on the belief that over the long term, investment risk decreases, particularly when selected actions display no correlation. This approach emphasized maximizing performance without particular attention to risk levels.

As for the second portfolio, the goal was to integrate the notion of risk more prominently. In its construction, I considered both the correlation between assets and the risk/return ratio. The objective was to create a more efficient portfolio, optimizing the relationship between expected returns and the level of risk.

To achieve these objectives, I utilized the Python programming language to acquire and analyze historical asset data. This analysis involved calculating essential parameters such as volatility, expected return, and correlation among different tickers from the period spanning 2000 to 2023. The choice of this timeframe aimed to account for past crises, offering insight into each asset's behavior during these periods of financial disruption.

The entire dataset used consists of historical data sourced from Yahoo Finance. <https://finance.yahoo.com>

I. First portfolio

To create this first portfolio, I selected several tickers that seemed interesting to me. I aimed to emphasize innovative companies heavily investing in artificial intelligence such as Amazon, Microsoft, Nvidia, Meta, Tesla. Other tickers were chosen based on industry sectors: prominent banking entities (BNP), energy sector (Total), aviation (Airbus), automotive (BMW), and retail (Walmart). In total, I selected around thirty tickers.

To define my initial portfolio comprising approximately 10 tickers, I initially made a selection based on correlations. I generated a matrix of all the chosen titles using Python. Then, I manually selected the tickers of interest that displayed negative correlations among themselves (see Appendix 1).

This matrix indicates negative correlations (in green) among several tickers. For instance, DBK.DE and MDLZ stocks are significantly uncorrelated at -0.7577. This negative correlation suggests a tendency to move in opposite directions: when the price of one stock decreases, the other tends to increase. This relationship holds particular importance during sectoral crises, as theoretically, these two stocks would not experience a significant simultaneous decline. This offers some stability to the portfolio, potentially reducing the negative impact of a sectoral crisis on overall investments.

I then created code to calculate both the returns and volatility (risk) of each of these tickers based on historical data (2000-2023). With this information, I computed the Sharpe ratio for the tickers. I utilized this ratio to optimize the weight of each action using Python code. I listed the tickers of interest, and based on the Sharpe ratio, I generated and tested several combinations (2000) to find the most effective combination for my portfolio, aiming for the highest possible Sharpe ratio.

Subsequently, using the proportions obtained from the calculations performed with Python, I assessed the returns, volatility, and overall Sharpe ratio of the portfolio (see Appendix 2). This table presents the fundamental characteristics of the portfolio composed of ten uncorrelated actions. The total risk, evaluated at 0.242, denotes a relatively moderate measure, while the overall return is around 9%, surpassing the risk-free rate estimated at 3% (Livret A rate). However, the Sharpe ratio shows a low value, assessed at 0.262, indicating relatively low excess return for each unit of risk incurred by the portfolio.

Despite the portfolio demonstrating a moderate level of risk (0.242) and an interesting overall return, the Sharpe ratio suggests that the additional return compared to a risk-free asset does not adequately compensate for this volatility, reflected in the low Sharpe ratio. Generally, a higher Sharpe ratio is preferable as it signifies a better trade-off between return and risk, a key goal for investors.

Although the portfolio exhibits a relatively moderate level of risk and an attractive overall return, the Sharpe ratio might suggest inefficiency in managing risk concerning the generated return. This might necessitate rebalancing or reassessing the portfolio composition to optimize this return-risk relationship.

II. Second portfolio

The second portfolio aimed to optimize the Sharpe ratio to surpass the risk-free rate, considering the portfolio's risk level.

Its construction involved a wider selection of assets, comprising nearly fifty values from the CAC40, S&P500, and NASDAQ indices. Similar to the previous portfolio, I calculated returns and risks associated with each asset using Python. Following this, I created the correlation matrix for all assets (see Appendix 3) and produced the Markowitz chart, placing assets on a graph based on their Sharpe ratios (see Appendix 4).

To select the ten assets comprising the portfolio, I initially filtered correlations below 0.4 to ensure adequate diversification. Then, I ranked the Sharpe ratios of these assets to retain only the top ten values. This approach, combining relatively low correlations with the highest possible Sharpe ratios, optimizes the portfolio composition.

For determining the optimal weights for each asset, I used an iterative process again to identify the most performing combination (see Appendix 5). The result of this strategy translates to an expected return of 34%, a risk evaluated at 0.38, and a significantly higher Sharpe ratio than that of the previous portfolio, reaching 0.81. This higher Sharpe ratio reflects a substantial excess return relative to the assumed level of portfolio risk, demonstrating a more favorable risk-adjusted performance.

This second portfolio is theoretically more efficient, making it wiser to consider it over the first one. Its returns are higher, and the overall risk is comparatively lower. In theory, for the same invested amount and duration, the second portfolio would ensure a greater return on investment.

However, it's important to note that these models are based on historical data (2000-2023) to make estimations about the future, assuming that past behaviors of stocks might reflect future behaviors.

III. Appendix

	BABA	BP	DBK.DE	IBM	MDLZ	META	NMS	PYPL	SHL.DE	TTE
BABA	1,0000	-0,0249	-0,5561	-0,1259	0,3202	0,6955	0,3087	0,6804	-0,3844	0,0701
BP	-0,0249	1,0000	-0,0841	0,3835	0,3222	0,0566	-0,1602	-0,1902	-0,2093	0,7801
DBK.DE	-0,5561	-0,0841	1,0000	-0,6542	-0,7577	-0,7408	-0,4365	-0,3975	0,6429	-0,5415
IBM	-0,1259	0,3835	-0,6542	1,0000	0,7252	-0,1505	0,4994	0,1763	0,6225	0,7550
MDLZ	0,3202	0,3222	-0,7577	0,7252	1,0000	0,8373	0,7673	0,6632	0,8117	0,8023
META	0,6955	0,0566	-0,7408	-0,1505	0,8373	1,0000	0,7614	0,9377	0,5500	0,4909
NMS	0,3087	-0,1602	-0,4365	0,4994	0,7673	0,7614	1,0000	0,6411	0,7657	0,3227
PYPL	0,6804	-0,1902	-0,3975	0,1763	0,6632	0,9377	0,6411	1,0000	0,4398	0,1901
SHL.DE	-0,3844	-0,2093	0,6429	0,6225	0,8117	0,5500	0,7657	0,4398	1,0000	0,3881
TTE	0,0701	0,7801	-0,5415	0,7550	0,8023	0,4909	0,3227	0,1901	0,3881	1,0000

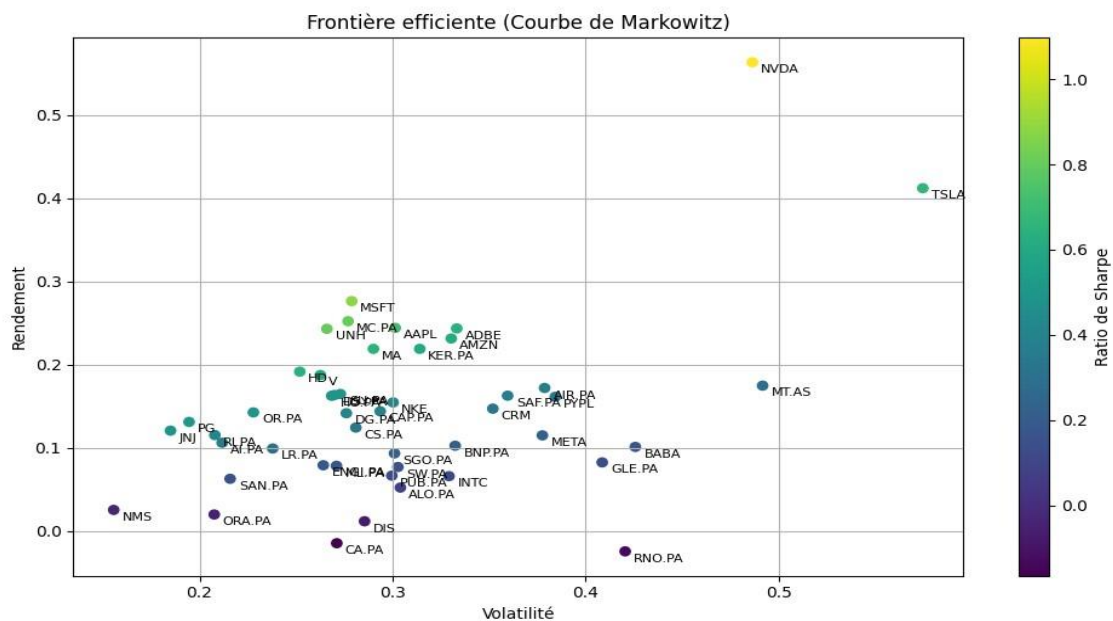
Appendix 1 : correlation relation of the first portfolio

Tickers	Weights	Risk	Return	Sharpe ratio
DBK.DE	1%	0,410	3%	- 0,002
SHL.DE	25%	0,273	13%	0,363
IBM	1%	0,262	7%	0,148
PYPL	1%	0,387	16%	0,346
MDLZ	25%	0,214	10%	0,336
TTE	25%	0,295	12%	0,308
NMS	22%	0,154	2%	0,021
META	1%	0,401	18%	0,397
BABA	1%	0,419	8%	0,116
BP	1%	0,304	7%	0,133
TOTAL Portfolio	100%	0,242	9%	0,262

Appendix 2 : First portfolio result

Appendix 3: Portfolio 2 Correlation Matrix (also available in Excel)

	AAPL	ADBE	ALFA	ARKP	ALOP	AMZN	BABA	BNFP	CA	CPA	CRM	CSPA	DGPA	DIS	DSPA	ENGP	GLEP	HD	HOPA	INTC	JNU	KERP	LRPA	MA	MCPA	META	MILP	MST	MTAS	NE	NMS	NDP	ORP	PG	PUBP	PVLP	RIP	RNDP	SAP	SANP	SCOP	SUP	SWP	TS	UNH	V	
AAPL	1.000	0.947	0.933	0.819	0.666	0.945	0.296	0.602	-0.513	0.809	0.914	0.859	0.846	0.827	0.960	0.188	-0.179	0.962	0.783	0.760	0.911	0.922	0.988	0.940	0.984	0.780	0.830	0.986	-0.338	0.947	0.763	0.959	0.965	-0.045	0.946	0.624	0.698	0.907	-0.029	0.803	0.852	0.715	0.972	0.615	0.952	0.970	0.918
ADBE	0.947	1.000	0.917	0.859	0.210	0.989	0.595	0.595	-0.513	0.797	0.973	0.839	0.868	0.878	0.971	0.150	-0.154	0.965	0.788	0.858	0.906	0.971	0.911	0.966	0.954	0.936	0.847	0.974	-0.345	0.969	0.752	0.932	0.960	-0.015	0.926	0.570	0.902	0.904	0.028	0.856	0.834	0.701	0.937	0.628	0.837	0.931	0.961
ALFA	0.933	0.917	1.000	0.918	0.046	0.932	0.406	0.709	-0.640	0.747	0.956	0.936	0.958	0.930	0.952	0.205	-0.199	0.960	0.869	0.820	0.977	0.931	0.972	0.977	0.945	0.838	0.941	0.917	-0.485	0.967	0.722	0.844	0.973	-0.111	0.985	0.775	0.720	0.979	0.177	0.898	0.950	0.725	0.969	0.818	0.846	0.946	0.975
ARKP	0.819	0.859	0.918	1.000	0.024	0.873	0.405	0.699	-0.603	0.907	0.897	0.925	0.962	0.926	0.921	0.192	-0.157	0.920	0.936	0.912	0.941	0.930	0.955	0.931	0.878	0.768	0.931	0.836	-0.506	0.908	0.443	0.745	0.916	0.648	0.900	0.772	0.477	0.957	0.301	0.984	0.902	0.666	0.867	0.858	0.584	0.993	0.923
ALOP	0.666	0.210	0.046	0.024	1.000	0.177	0.897	0.182	0.241	0.030	0.130	0.046	0.105	0.041	0.070	0.618	0.237	0.054	-0.002	0.179	-0.077	0.094	0.082	0.715	0.041	0.131	0.615	0.087	0.276	0.114	0.063	0.115	0.064	-0.382	0.717	0.033	-0.051	0.061	-0.127	0.177	0.046	-0.168	0.270	0.036	0.223		
AMZN	0.945	0.989	0.932	0.873	0.177	1.000	0.640	0.585	-0.560	0.788	0.932	0.846	0.889	0.898	0.970	0.116	-0.207	0.970	0.820	0.874	0.927	0.974	0.921	0.975	0.949	0.929	0.862	0.963	-0.401	0.972	0.738	0.909	0.964	-0.023	0.934	0.600	0.899	0.916	0.048	0.880	0.852	0.671	0.935	0.671	0.822	0.938	0.969
BABA	0.296	0.595	0.046	0.045	0.897	0.640	1.000	-0.020	-0.772	0.172	0.652	0.663	0.688	0.575	0.400	-0.039	-0.360	0.417	0.120	0.803	0.407	0.633	0.395	0.564	0.321	0.695	0.382	0.381	-0.003	0.476	0.309	0.290	0.363	-0.193	0.373	-0.605	0.680	0.364	-0.360	0.587	0.217	0.063	0.310	-0.090	0.161	0.162	0.579
BNFP	0.602	0.595	0.709	0.699	0.182	0.585	-0.020	1.000	-0.338	0.488	0.536	0.845	0.792	0.682	0.633	0.377	0.446	0.649	0.704	0.501	0.717	0.619	0.620	0.515	0.641	0.565	0.830	0.583	0.052	0.654	0.407	0.576	0.666	-0.201	0.694	0.698	0.138	0.758	0.613	0.624	0.699	0.889	0.704	0.703	0.535	0.666	0.648
CA	-0.513	-0.513	-0.640	-0.603	0.241	-0.560	-0.772	-0.338	1.000	-0.120	-0.605	-0.479	-0.025	-0.575	-0.523	0.249	0.411	-0.544	0.497	-0.407	-0.633	-0.526	-0.548	-0.564	-0.521	-0.420	-0.595	-0.475	0.691	-0.591	-0.343	-0.414	-0.545	0.551	-0.632	-0.490	-0.556	-0.055	-0.029	-0.518	-0.591	-0.251	-0.548	-0.577	-0.229	-0.539	-0.512
CPA	0.809	0.797	0.747	0.907	0.030	0.788	0.172	0.488	-0.120	1.000	0.923	0.793	0.709	0.742	0.862	0.308	-0.155	0.843	0.773	0.816	0.759	0.827	0.958	0.935	0.828	0.824	0.714	0.830	-0.372	0.788	0.734	0.802	0.833	0.498	0.731	0.699	0.591	0.723	0.079	0.808	0.705	0.603	0.797	0.602	0.860	0.815	0.937
CRM	0.914	0.973	0.956	0.897	0.130	0.982	0.652	0.556	-0.605	0.923	1.000	0.862	0.920	0.932	0.971	0.043	-0.328	0.967	0.813	0.932	0.941	0.972	0.947	0.970	0.971	0.943	0.899	0.955	-0.467	0.983	0.704	0.872	0.964	0.563	0.947	0.632	0.904	0.947	-0.023	0.918	0.879	0.618	0.933	0.709	0.792	0.911	0.970
CSPA	0.859	0.839	0.936	0.925	0.046	0.846	0.063	0.845	-0.479	0.793	0.862	1.000	0.958	0.908	0.965	0.321	0.015	0.917	0.922	0.788	0.948	0.875	0.938	0.885	0.891	0.746	0.957	0.846	-0.369	0.904	0.612	0.786	0.925	0.003	0.919	0.833	0.399	0.946	0.393	0.894	0.916	0.816	0.914	0.866	0.724	0.911	0.900
DGPA	0.846	0.868	0.938	0.962	0.105	0.889	0.488	0.792	-0.625	0.709	0.920	0.958	1.000	0.930	0.909	0.223	-0.074	0.923	0.931	0.828	0.969	0.911	0.953	0.941	0.886	0.842	0.968	0.845	-0.447	0.924	0.643	0.759	0.928	-0.106	0.941	0.782	0.581	0.974	0.350	0.927	0.920	0.749	0.903	0.886	0.647	0.909	0.957
DIS	0.827	0.878	0.930	0.926	0.041	0.898	0.575	0.682	-0.575	0.742	0.932	0.908	0.930	1.000	0.909	0.124	-0.197	0.914	0.854	0.886	0.938	0.900	0.947	0.897	0.856	0.918	0.942	0.828	-0.561	0.946	0.647	0.739	0.923	-0.005	0.906	0.818	0.898	0.923	0.331	0.934	0.917	0.690	0.890	0.875	0.644	0.847	0.909
DSPA	0.960	0.971	0.952	0.921	0.070	0.970	0.400	0.633	-0.523	0.862	0.971	0.905	0.909	0.909	1.000	0.168	-0.193	0.990	0.867	0.876	0.948	0.975	0.964	0.976	0.976	0.885	0.895	0.973	-0.430	0.978	0.750	0.925	0.989	0.043	0.948	0.700	0.769	0.946	0.094	0.909	0.893	0.712	0.963	0.730	0.862	0.966	0.974
ENGP	0.188	0.150	0.205	0.192	0.618	0.116	-0.039	0.377	0.249	0.308	0.043	0.321	0.223	0.124	0.168	1.000	0.239	0.144	0.179	0.124	0.145	0.172	-0.155	-0.056	0.200	0.312	0.194	0.178	0.706	0.145	0.214	0.174	0.178	0.264	0.184	0.150	0.259	0.173	0.069	0.144	0.119	0.346	0.231	0.183	0.416	0.168	0.016
GLEP	-0.179	-0.154	-0.199	-0.157	0.237	-0.207	-0.360	0.446	0.411	-0.155	-0.328	0.015	-0.074	-0.197	-0.193	0.239	1.000	-0.183	-0.093	-0.247	-0.180	-0.183	-0.230	-0.255	-0.161	0.162	-0.038	-0.158	0.571	-0.202	-0.037	-0.090	-0.182	-0.130	-0.174	-0.152	-0.290	-0.106	0.530	-0.224	-0.151	0.426	-0.141	-0.172	0.134	-0.124	0.063
HD	0.962	0.965	0.960	0.920	0.054	0.970	0.417	0.649	-0.544	0.843	0.967	0.917	0.923	0.914	0.990	0.144	-0.183	1.000	0.879	0.865	0.964	0.970	0.972	0.980	0.975	0.887	0.906	0.969	-0.452	0.980	0.759	0.918	0.991	0.005	0.960	0.710	0.759	0.952	0.125	0.910	0.910	0.720	0.964	0.748	0.851	0.975	0.980
HOPA	0.783	0.788	0.869	0.936	-0.004	0.820	0.120	0.704	-0.497	0.773	0.813	0.922	0.931	0.854	0.867	0.179	-0.093	0.879	1.000	0.808	0.926	0.858	0.870	0.840	0.828	0.622	0.892	0.787	-0.433	0.841	0.350	0.701	0.872	0.055	0.845	0.766	0.000	0.895	0.376	0.914	0.865	0.653	0.808	0.861	0.519	0.930	0.855
INTC	0.760	0.858	0.820	0.912	0.156	0.874	0.803	0.501	-0.407	0.816	0.932	0.788	0.828	0.886	0.876	0.124	-0.247	0.865	0.808	1.000	0.841	0.902	0.904	0.913	0.797	0.891	0.809	0.802	-0.495	0.858	0.491	0.710	0.848	0.282	0.793	0.654	0.759	0.807	0.184	0.928	0.787	0.543	0.787	0.731	0.550	0.792	0.921
JNU	0.911	0.906	0.977	0.941	-0.002	0.927	0.407	0.717	-0.633	0.759	0.941	0.948	0.969	0.938	0.948	0.145	-0.180	0.964	0.926	0.841	1.000	0.930	0.975	0.958	0.929	0.849	0.954	0.902	-0.510	0.958	0.744	0.825	0.967	-0.088	0.969	0.795	0.665	0.974	0.248	0.918	0.953	0.718	0.943	0.851	0.770	0.954	0.968
KERP	0.922	0.971	0.931	0.930	0.179	0.974	0.633	0.619	-0.526	0.827	0.972	0.875	0.911	0.900	0.975	0.172	-0.183	0.970	0.858	0.902	0.930	1.000	0.937	0.980	0.955	0.905	0.881	0.947	-0.400	0.958	0.666	0.885	0.965	0.043	0.925	0.638	0.823	0.930	0.091	0.926	0.861	0.678	0.930	0.719	0.764	0.940	0.979
LRPA	0.898	0.911	0.972	0.935	-0.077	0.921	0.395	0.620	-0.548	0.958	0.947	0.938	0.953	0.947	0.964	-0.155	-0.230	0.972	0.870	0.904	0.975	0.937	1.000	0.945	0.923	0.910	0.965	0.904	-0.532	0.962	0.790	0.846	0.971	0.618	0.946	0.768	0.765	0.869	0.125	0.931	0.941	0.683	0.944	0.804	0.802	0.927	0.954
MA	0.940	0.966	0.977	0.913	0.094	0.975	0.564	0.515	-0.564	0.935	0.970	0.885	0.941	0.897	0.976	-0.056	-0.255	0.980	0.840	0.913	0.958	0.980	0.945	1.000	0.961	0.875	0.880	0.960	-0.444	0.970	0.700	0.877	0.976	0.550	0.974	0.559	0.798	0.965	-0.069	0.923	0.887	0.603	0.941	0.665	0.800	0.956	0.996
MCPA	0.984	0.954	0.945	0.878	0.082	0.949	0.321	0.641	-0.521	0.828	0.927	0.891	0.886	0.856	0.976	0.200	-0.161	0.975	0.828	0.797	0.929	0.955	0.923	0.961	1.000	0.802	0.863	0.984	-0.350	0.956	0.741	0.942	0.981	-0.022	0.953	0.659	0.709	0.936	0.022	0.857	0.865	0.730	0.976	0.669	0.909	0.980	0.946
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Appendix 4 : Markowitz graph

Tickers	Weights	Return	Risk	Sharpe ratio
NVDA	7%	64%	0,49	1,25
MSFT	3%	29%	0,28	0,95
AAPL	7%	25%	0,29	0,77
UNH	1%	22%	0,26	0,74
ADBE	18%	28%	0,33	0,75
MC.PA	11%	23%	0,28	0,73
AMZN	25%	27%	0,33	0,72
TSLA	12%	44%	0,57	0,72
MA	6%	21%	0,28	0,64
V	10%	19%	0,25	0,61
Total	100%	34%	0,38	0,81

Appendix 5 : Second portfolio result