

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

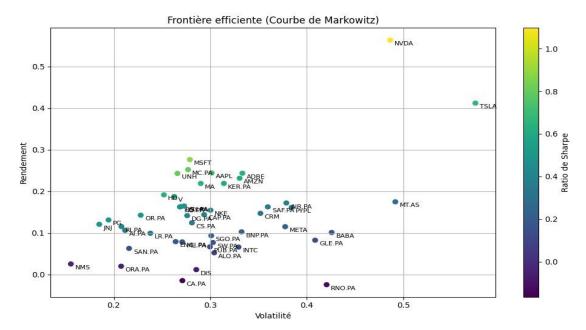
	BABA	ВР	DBK.DE	IBM	MDLZ	META	NMS	PYPL	SHL.DE	TTE	
BABA	1,0000	-0,0249	-0,5561	-0,1259	0,3202	0,6955	0,3087	0,6804	-0,3844	0,0701	
ВР	-0,0249	1,0000	-0,0841	0,3835	0,3222	0,0566	-0,1602	-0,1902	-0,2093	0,7801	
DBK.DE	-0,5561	-0,0841	1,0000	-0,6542	-0,7577	-0,7408	-0,4365	-0,3975	0,6429	-0,5415	
IBM	-0,1259	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	

<u>Appendix 1 : correlation relation of the first portfolio</u>

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
ВР	1%	0,304	7%	0,133
TOTAL Portfolio	100%	0,242	9%	0,262

Appendix 2 : First portfolio result

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>	0,918	0,961		0,923	0,223	696'0	0,579	0,648	-0,512	0,937	0/6/0	006'0	0,957	0,909	0,974	0,016	0,063	0,980	0,855	0,921	896′0	0,979	0,954	966'0	0,946	0,895	0)600	0,947	-0,398	896′0	0,706	0,860	0,975	0,577	996'0		0,812		0,100	0,935	0,893	0,763	0,925	699'0	0,772	0,952	1,000
暑		_						999'0 9	9 -0,539	0 0,815	116'0 2	4 0,911	606'0 /	4 0,847	996'0 2	.6 0,168	4 -0,124	1 0,975	068'0 6	0 0,792	0 0,954	4 0,940	12 0,927	956'0 0	086'0 6	07.70 21	7 0,875	996'0 0	0 -0,372	4 0,942	0 0,684	7 0,918	1 0,972		9 0,952		3 0,570		7 0,101	8 0,865	888'0 8	727,0 71	8 0,954	10,701	998'0 0	1,000	2 0,952
		0,628 0,837		_		_	_	0,703 0,535	577 -0,229	0,602 0,860	0,709 0,792	0,866 0,724	0,886 0,647	0,875 0,644	0,730 0,862	0,183 0,416	172 0,134	0,748 0,851	0,861 0,519	0,731 0,550	0,851 0,770	0,719 0,764	0,804 0,802	008'0 599	0,669 0,909	0,378 0,692	0,899 0,687	0,592 0,920	-0,619 0,080	0,756 0,854	77'0 650	493 0,947	0,760 0,871	-0,022 0,157	0,771 0,859		-0,375 0,653		0,512 -0,337	0,852 0,548	0,854 0,698	0,593 0,797	0,728 0,938	1,000 0,182	0,182 1,000	0,701 0,866	0,669 0,772
							0,310 -0,090	0,704 0,	0,548 0,577	0,797 0,	0,933 0,	0,914 0,	0,903 0,	0,890 0,	0,963	0,231 0,	-0,141 -0,	0,964 0,	0,808 0,	0,787 0,	0,943 0,	0,930 0,	0,944 0,	0,941 0,	0,976 0,	0,806 0,	0,909 0,	0,956 0,	0,376 -0,	0,964 0,	0,782 -0,	0,922 0,	0,978 0,	0'069 0'			0,739 -0,		0,105 0,	0,845 0,	0,902 0,	0,783 0,	1,000 0,	0,728 1,	0,938 0,	0,954 0,	0,925 0,
RNO.PA SAF.PA SAN.PA SGO.PA SU.PA					0,17	0,671	0,063	0,889	-0,251 -(0,603	0,618	0,816	0,749 (069'0	0,712	0,346	0,426	0,720	0,653	0,543 (0,718	0,678	0,683	0,603	0,730	0,743	0,815	0,706	950'0	0,724 (0,744 (0,732	0,736		0,731		0,519	0,755 (0,480	0,597	869'0	1,000 (0,783	0,593	0,797	0,727	0,763
SAN.PA S								69'0	-0,591	0,705	0,879	0,916	0,920	0,917	0,893	0,119	-0,151	0,910	0,865	0,787	0,953	0,861	0,941	0,887	0,865	0,719	0,921	0,832	-0,613	0,907	0,648	0,748	0,924		0,930	0,833	0,521		0,300	0,874	1,000	869'0	0,902	0,854	869'0	0,888	0,893
SAF.PA								3 0,624	9 -0,518	908'0 6	3 0,918	3 0,894	0,927	1 0,934	4 0,909	9 0,144	0 -0,224	5 0,910	6 0,914	4 0,928	8 0,918	1 0,926	5 0,931	9 0,923	2 0,857	4 0,803	0 0,892	2 0,821	2 -0,549	2 0,898	5 0,417	9 0,714	7 0,903						0 0,272	1,000	0 0,874	0 0,597	5 0,845	2 0,852	7 0,548	1 0,865	0,935
								8 0,613	5 -0,029	3 0,079	7 -0,023	6 0,393	4 0,350	3 0,331	6 0,094	3 0,069	0,530	2 0,125	5 0,376	7 0,184	4 0,248	0,091	9 0,125	90'0- 5	6 0,022	0 -0,22	3 0,430	9 -0,042	5 -0,012	4 0,137	5 -0,585	90'0-	77 0,127	0 -0,072			0,632		3 1,000	7 0,272	8 0,300	5 0,480	9 0,105	3 0,512	8 -0,337	7 0,101	0 0,100
-								0,138 0,758	9550 - 0,655	0,591 0,723	0,904 0,947	0,399 0,946	0,581 0,974	0,898 0,923	0,769 0,94	0,259 0,173	0,290 -0,10	0,759 0,952	000 0,895	0,759 0,807	0,665 0,974	0,823 0,930	0,765 0,969	96'0 86'0	0,709 0,93	0,938 0,830	0,634 0,953	0,760 0,899	0,231 -0,46	0,870 0,954	0,641 0,675	0,696 0,83	0,766 0,962	-0,638 -0,15	0,690 0,972		1,000 0,656		-0,632 0,263	0,572 0,907	0,521 0,938	0,519 0,755	0,739 0,949	-0,375 0,833	0,653 0,798	0,570 0,947	0,812 0,970
PUB.PA PYPL		0,570 0,9		_		_		0,698 0,1	0,490 -0,5	0,699 0,5	0,632 0,9	0,833 0,3	0,782 0,5	0,818 0,8	0,700 0,7	0,150 0,2	0,152 -0,2	0,710 0,7	0,766 0,0	0,654 0,7	9'0 562'0	8'0 859'0	0,768 0,7	0,559 0,7	0,659 0,7	0,104 0,9	9'0 858'0	0,574 0,7	0,582 0,	0,720	9'0 810'0	0,527 0,6	0,733 0,7				0,174 1,0		0,503 -0,6	0,762 0,5	0,833 0,5	0,643 0,5	0,743 0,7	0,902 -0,3	0,370 0,6	0,674 0,5	0,535 0,8
=		0,926						0,694	-0,632 -0	0,731	0,947	0,919	0,941	906'0	0,948	0,184	-0,174	0,960	0,845	0,793	0 696'0	0,925	0,946	0,974	0,953	0,809	0,917	0,935	-0,442 -1	0,965	0,768	0,866	0,971	-0,140	1,000		0690		0,130	0,873	0,930	0,731	0,970	0,771	0,859	0,952	0,966
								-0,201	0,551	0,488	0,563	0,003	-0,106	-0,005	0,043	0,264	-0,130 4	0,005	0,055	0,282	-0,088	0,043	0,618	0,550	-0,022	0,447	-0,103	-0,001	-0,298	-0,061	-0,383	-0,019	-0,020	1,000	-0,140		-0,638		-0,072	0,158	-0,113	-0,132	690'0-	-0,022	0,157	-0,045	0,577
OR.PA	96'0	096'0					0,363	999'0	-0,545	0,833	0,964	0,925	0,928	0,923	686'0	0,178	-0,182	0,991	0,872	0,848	296'0	996'0	0,971	926'0	0,981	698'0	0,916	296'0	-0,438	0,983	0,781	0,911	1,000	-0,020	0,971		0,766	0,962	0,127	0,903	0,924	0,736	0,978	092'0	0,871	0,972	0,975
NDA	3 0,959							0,576	3 -0,414	4 0,802	4 0,872	2 0,786	3 0,759	7 0,739	0 0,925	4 0,174	7 -0,090	9 0,918	0,701	1 0,710	4 0,825	9 0,885	0 0,846	0,877	1 0,942	1 0,810	5 0,764	7 0,968	0 -0,213	7 0,897	0,769	9 1,000	1 0,911	3 -0,019	998'0 8		1 0,696		5 -0,069	7 0,714	8 0,748	4 0,732	2 0,922	9 0,493	0 0,947	4 0,918	098'0 9
_								0,654 0,407	591 -0,343	0,788 0,734	0,983 0,704	0,904 0,612	0,924 0,643	0,946 0,647	0,978 0,750	0,145 0,214	-0,202 -0,03	0,980 0,759	0,841 0,350	0,858 0,491	0,958 0,744	999'0 856'0	0,962 0,790	0,970 0,90	0,956 0,741	0,923 0,761	0,918 0,735	777,0 036,0	458 0,360	1,000 0,757	0,757 1,000	0,897 0,769	0,983 0,781	-0,061 -0,383			0,870 0,641		0,137 -0,585	0,898 0,417	0,907 0,648	0,724 0,744	0,964 0,782	0,756 -0,059	0,854 0,770	0,942 0,684	90,068 0,706
		-0,345 0,9						0,052 0,6	0,691 -0,591	-0,372 0,7	1,467 0,5	-0,369 0,9	7,447 0,5	0,561 0,9	0,430 0,5	0,706 0,1	0,571 -0,2	1,452 0,5	1,433 0,8	1,495 0,8	0,510 0,5	1,400 0)5	1,532 0,5	7,444 0,5	350 055(0,161 0,9	1,439 0,5	318 0,5	1,000 -0,4	1,458 1,0	1,360 0;	3,0 812,0	1,438 0,5	0,298 -0,0	0,442 0,9		0,231 0,8		-0,012 0,1	-0,549 0,8	-0,613 0,9	0,056 0,7	-0,376 0,9	,619 0,7	0,080 0,8	-0,372 0,9	398 0,5
MSFT	986'0	0,974	0,917	0,836	0,131	0,963	0,381	0,583	-0,475	0,830	0,935 -0	0,846	0,845 -0	0,828	0,973 -0	0,178	-0,158	0,969	0,787 0	0,802 -0	0,902	0,947 -0	0,904) 096′0	0,984	0,844	0,819 -0	1,000	-0,318	0,950 -0) ////0	0,968	0,967	-0,001	0,935 -0	0,574	0,760	0,899		0,821	0,832	90,70	926'0	0,592 -0	0,920	996'0	0,947 -0
ML.PA	0,830		0,941	0,931	0,041		0,382	0,830	-0,593	0,714	0,899	0,957	896'0	3 0,942	0,895	0,194	-0,038	906'0	0,892	608'0	0,954	0,881	0,965	0880	0,863	0,881	1,000	0,819	-0,439	8 0,918	0,735	0,764	0,916	-0,103			0,634	0,953	0,430 -0,042	0,892	0,921	0,815	606'0	0,899	789'0	0,875	006'0
MC.PA META		54 0,936						41 0,565	21 -0,420	28 0,824	27 0,943	91 0,746	86 0,842	56 0,918	76 0,885	00 0,312	61 0,162	75 0,887	28 0,622	97 0,891		55 0,905	23 0,910	61 0,875	00 0,802	00/1 70	63 0,881	84 0,844	50 0,161	56 0,923	41 0,761	42 0,810	81 0,869		53 0,809		09 0,938		22 -0,224	57 0,803	65 0,719	30 0,743	908'0 92	69 0,378	09 0,692	0/1/0 08	46 0,895
						0,975 0,949		0,515 0,641	-0,564 -0,521	0,935 0,828	0,970 0,927	0,885 0,891	0,941 0,886	0,897 0,856	976,0 976,0	-0,056 0,200	-0,255 -0,161	0,980 0,975	0,840 0,828	0,913 0,797	0,958 0,929	0,980 0,955	0,945 0,923	1,000 0,961	0,961 1,000	0,875 0,802	0,880 0,863	0,960 0,984	-0,444 -0,350	956'0 026'0	0,700 0,741	0,877 0,942	0,976 0,981	0,550 -0,022	0,974 0,953		0,798 0,709		-0,069 0,022	0,923 0,857	0,887 0,865	0,603 0,730	0,941 0,976	0,665 0,669	0,800 0,909	0,956 0,980	0,996 0,946
Æ	88		972	335	120	371	33	0,620 0,	-0,548 -0,	0,958 0,9	347	0,938 0,	0,953 0,9	0,947 0,8		155	-0,230 -0,	0,972 0,9	0,870 0,	0,904 0,9	0,975 0,9	0,937 0,9	1,000 0,	0,945 1,0	0,923 0,9	0,910 0,	0,965 0,8	0,904 0,9	-0,532 -0,	0,962 0,9	0,790 0;	0,846 0,8	0,971 0,9			28		96	0,125 -0,0	0,931 0,9	0,941 0,8	0,683 0,	0,944 0,9	0,804 0,	0,802 0,8	0,927 0,9	0,954 0,9
	0,922	0,971	0,931		0,179			0,619	-0,526	0,827	0,972 0,9	0,875	0,911	006'0	0,975	0,172 -0,	-0,183	0/6/0	0,858	0,902	0,930	1,000	0,937	0%6'0	0,955	0,905	0,881	0,947	-0,400	0,958	999'0	0,885	0,965	0,043	0,925	0,638	0,823	0,930	0,091	976'0	0,861	8/9'0	0,930	0,719	0,764	0,940	0,979
Z	0,911							1 0,717	7 -0,633	6 0,759	0,941	3 0,948	96'0 8	5 0,938	0,948	0,145	7 -0,180	0,964	3 0,926	0,841	1,000	0,930	1 0,975	3 0,958	7 0,929	0,849	9 0,954	2 0,902	5 -0,510	8 0,958	1 0,744	0,825	296'0 8				99'0		1 0,248	3 0,918	7 0,953	3 0,718	7 0,943	1 0,851	0,770	2 0,954	896'0 1
HO.PA INTC	83 0,760							04 0,501	97 -0,407	73 0,816	13 0,932	22 0,788	31 0,828	54 0,886	928'0 29	79 0,124	93 -0,247	79 0,865	00 0,808	000′1 80	26 0,841	58 0,902	70 0,904	40 0,913	28 0,797	22 0,891	92 0,809	87 0,802	33 -0,495	41 0,858	50 0,491	017,0 10	72 0,848				00 0,759		76 0,184	14 0,928	65 0,787	53 0,543	08 0,787	61 0,731	19 0,550	90 0,792	55 0,921
P.	0,962 0,783 0,760 0,911							0,649 0,704	-0,544 -0,497	0,843 0,773	0,967 0,813	0,917 0,922	0,923 0,931	0,914 0,854	298'0 066'0	0,144 0,179	-0,183 -0,093	1,000 0,879	0,879 1,000	0,865 0,808	0,964 0,926	0,970 0,858	0,972 0,870	0,980 0,840	0,975 0,828	0,887 0,622	0,906 0,892	0,969 0,787	-0,452 -0,433	0,980 0,841	0,759 0,350	0,918 0,701	0,991 0,872				0,759 0,000		0,125 0,376	0,910 0,914	0,910 0,865	0,720 0,653	0,964 0,808	0,748 0,861	0,851 0,519	0,975 0,890	0,980 0,855
							0)360	0,446	0,411	-0,155 0,	-0,328 0,		-0,074 0,	-0,197 0,	0,193	0,239	1,000 -0,		-0,093 0,	-0,247 0,	-0,180 0,	-0,183 0,	-0,230 0,	-0,255 0,	-0,161 0,	0,162	-0,038 0,	-0,158 0,	0,571 -0,	-0,202 0,	-0,037 0,	-0,090 0,	-0,182 0,					-0,106	0,530	-0,224 0,	-0,151 0,	0,426		-0,172 0,	0,134	-0,124 0,	0,063 0,
NGI.PA G			0,205	0,192			-0'036	0,377	0,249	0,308	0,043	0,321 0,015	0,223	0,124	0,168	1,000	0,239 1,000	0,144 -0,183	0,179	0,124	0,145	0,172	-0,155	- 950′0-	0,200	0,312	0,194	0,178	90,70	0,145	0,214	0,174	0,178					0,173	690'0	0,144	0,119	0,346	0,231 -0,141	0,183	0,416	0,168	0,016
DSY.PA E	096'0							0,633	-0,523	0,862	0,971	906'0	606'0	606'0	1,000	0,168	-0,193	066'0	0,867	9/8/0	0,948	0,975	0,964	9/6'0	926'0	0,885	0,895	0,973	-0,430	8/6'0	0,750	0,925	686'0						0,094	606'0	0,893	0,712	0,963	0,730	0,862	996'0	0,974
DG.PA DIS	16 0,827	8/8/0 89						789′0 76	25 -0,575	0,742	0,932	806'0 89	06'0 00	30 1,000	606'0 60	3 0,124	74 -0,197	3 0,914	1 0,854	988'0 87	86'0 69	11 0,900	3 0,947	11 0,897	958'0 98	12 0,918	8 0,942	15 0,828	17 -0,561	9460 46	13 0,647	9 0,739	8 0,923				0,898		0,331	7 0,934	0,917	069'0 61	068'0 81	36 0,875	17 0,644	0,847	606'0 29
A DG.PA								0,845 0,792	-0,479 -0,625	0,793 0,709	0,862 0,920	1,000 0,958	0,958 1,000	0,908 0,930	0,905 0,909	0,321 0,223	0,015 -0,074	0,917 0,923	0,922 0,931	0,788 0,828	0,948 0,969	0,875 0,911	0,938 0,953	0,885 0,941	0,891 0,886	0,746 0,842	896'0 26'0	0,846 0,845	-0,369 -0,447	0,904 0,924	0,612 0,643	0,786 0,759	0,925 0,928	0,003 -0,106			0,399 0,581		0,393 0,350	0,894 0,927	0,916 0,920	0,816 0,749	0,914 0,903	988'0 998'0	0,724 0,647	0,911 0,909	0,900 0,957
	0)914 0,4							0,536 0,8	-0,605 -0,4	0,923 0,7	1,000 0,8	0,862 1,0	0,920 0,9			0,043 0,3	-0,328 0,0	0,967	0,813 0,9	0,932 0,7	0,941 0,9	0,972 0,8	0,947 0,9	9,0 076,0	0,927 0,8	0,943 0,7	60860	0,935 0,8	-0,467 -0,3	0,983 0,9	0,704 0,6	0,872 0,7	0,964 0,9							0,918 0,8	0,879 0,9	0,618 0,8	0,933 0,9	0,709 0,8	0,792 0,7	0,911 0,9	0,970 0,9
AP.PA CR	0,809		0,747 0					0,488 0	-0,120 -0	1,000	0,923	0,793 0	0,709 0	0,742 0	0,862 0	0,308 0	-0,155	0,843 0	0,773 0	0,816 0	0,759 0	0,827 0	0,958 0	0,935 0	0,828 0	0,824 0	0,714 0	0,830	-0,372 -0	0,788 0	0,734 0	0,802 0	0,833 0	0,488 0			0,591	0,723 0	0,079 -0,023	0,808 0	0,705 0	0,603 0	0,797 0	0,602 0	0,860	0,815 0	0,937 0
CA.PA C	-0,513	-0,513	-0,640	-0'603	0,241	-0,560	-0,772	-0,338	1,000	-0,120	-0,605	-0,479	-0,625	-0,575		0,377 0,249	0,446 0,411	-0,544	-0,497	-0,407	-0,633	-0,526	-0,548	-0,564	-0,521	-0,420	-0,593	-0,475	0,691	-0,591	-0,343	-0,414	-0,545	0,551	-0,632	-0,490	0,556	-0,655	-0,029	0,518	-0,591	0,251	-0,548	-0,577	0,229	-0,539	-0,512
NP.PA	0,602							1,000	-0,338	0,488	0,536	0,845	0,792	0,682				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	999'0		_		0,138		0,613	0,624	0,699	0,889	0,704	0,703	0,535	999'0	0,648
BABA		39 0,595					1,000	35 -0,020	50 -0,772	38 0,172	32 0,652	6 0,063	39 0,488	98 0,575	00,400	0,618 0,116 -0,039	098'0- 70	70 0,417	20 0,120	74 0,803	27 0,407	74 0,633	21 0,395	75 0,564	1321	29 0,695	52 0,382	53 0,381	11 -0,003	72 0,476	38 0,309	067'0	54 0,363	23 -0,193	34 0,373	0,600 -0,605	99 0'0	16 0,364	18 -0,360	0,880 0,587	52 0,217	71 0,063	35 0,310	0,671 -0,090	22 0,161	38 0,262	9 0,579
AIR.PA ALO.PA AMZN BABA	96 0,94		0,046 0,932		1,000 0,177	0,177 1,000		0,182 0,585	0,241 -0,560	0,030 0,788	0,130 0,982	0,046 0,846	0,105 0,889	0,041 0,898	0,070 0,970	518 0,11	0,237 -0,207	0,054 0,970	-0,004 0,820	0,156 0,874	-0,002 0,927	0,179 0,974	0,077 0,921	0,094 0,975	0,082 0,949	0,715 0,929	0,041 0,862	0,131 0,963	0,615 -0,401	0,087 0,972	0,276 0,738	0,114 0,909	0,063 0,964	0,115 -0,023		0,382 0,60	0,717 0,899		-0,051 0,048	0,061 0,88	-0,127 0,852	0,177 0,671	0,046 0,935	-0,168 0,67	0,270 0,822	0,036 0,938	0,223 0,969
								0,699	-0,603 0,2	0,00 706,0	0,897 0,1	0,925 0,0	0,962 0,1	0,926 0,0	0,921 0,0	0,192 0,6	-0,157 0,2	0,920 0,0	0,936 -0,0	0,912 0,1	0,941 -0,0	0,930 0,1	0,935 -0,0	0,913 0,0	0,0 878,0	0,768 0,7	0,931 0,0	0,836 0,1	9'0 905'0-	0,008 0,0	0,443 0,2	0,745 0,1	0,916 0,0				0,477 0,7		0,301 -0,0	0,984 0,0	0,902 -0,1	0,666 0,1	0,0 798,0	0,858 -0,1	0,584 0,2	0,893 0,0	0,923 0,2
A.	0,933							0,709 0,	-0,640 -0,	0,747 0,	0,956 0,	0,936 0,	0,958 0,	0,930 0,	0,952 0,	0,205 0,	-0,199 -0,	0)0960	0,869 0,	0,820 0,	0,977 0,	0,931 0,	0,972 0,	0,977 0,	0,945 0,	0,838 0,	0,941 0,	0,917 0,	-0,485 -0,	0,967	0,722 0,	0,844 0,	0,973 0,						0,177 0,	0,898 0,	0,950 0,	0,725 0,	0 696'0	0,818 0,	0,846 0,	0,946 0,	0,975 0,
漫	0,947	1,00	0,917	0,859	0,210	0,989	0,595	0,595	-0,513	0,797	0,973	0,839	898'0	0,878	0,971	0,150	-0,154	0,965	0,788	0,858	906'0	0,971	0,911	996′0	0,954	986'0	0,847	0,974	-0,345	696'0	0,752	0,932	096'0	-0,015	0,926	0,570	0,902	0,904	0,028	958'0	0,834	0,701	0,937	0,628	0,837	0,931	0,961
AAPL	1,000	0,947	_	_	_	0,945	_	0)602	-0,513	080	0,914	0,859	0,846	0,827	096′0	0,188	-0,179	0,962	0,783	0,760	0,911	0,922	0,898	0,940	0,984	0,780	0,830	986′0	-0,338	0,947	0,763	0,959	0,965		-	_	0,698	_	-0,029	0,803	0,852	0,715	0,972	0,615	0,952	0/6/0	0,918
	AAPL	ADBE	AI.PA	AIR.PA	ALO.PA	AMZN	BABA	BNP.PA	CA.PA	CAP.PA	CRM	CS.PA	DG.PA	Si	DSY.PA	ENGI.PA	GLE.PA	全	HO.PA	JM	2	KER.PA	LR.PA	MA	MC.PA	META	ML.PA	MSFI	MT.AS	NKE	NMS	NVDA	OR.PA	ORA.PA	2	PUB.PA	몵	RI.PA	RNO.PA	SAF.PA	SAN.PA	SGO.PA	SU.PA	SW.PA	TST A	롤	>



<u>Appendix 4 :</u> 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
٧	10%	19%	0,25	0,61
Total	100%	34%	0,38	0,81

Appendix 5 : Second portfolio result