THEORY OF FINANCE

Solution Sheet on Problem Set 2

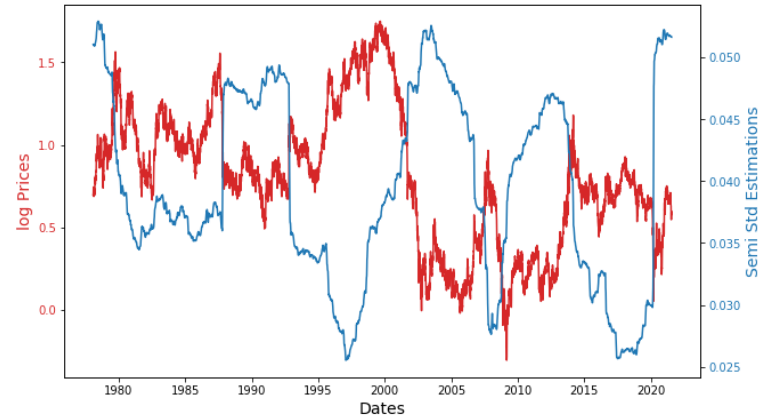## Risk Measures

Deadline: 16.11.2021

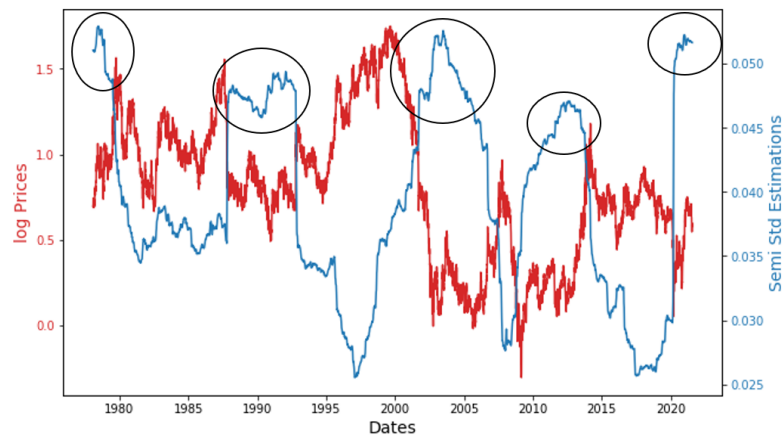## Solved by: Jonas Husmann, Niklas Kampe & Cyril Janak

Task		Points Earned
1. Estimation, Interpretation a) Risk measures of stocks and portfolio returns (12 points)	Risk Measures: 		PORTFOLIO	JP_MORGAN_CHASE	EXXON_MOBIL	INTEL	PFIZER
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Mean Absolute Deviation	0.00979	0.01435	0.01052	0.01865	0.01239
Semi Std	0.00993	0.01486	0.01054	0.01889	0.01204
Empirical VaR	0.02051	0.03047	0.02191	0.03847	0.02559
Empirical ES	0.03094	0.04741	0.03286	0.05986	0.03801	 Portfolio Returns: 		PORTFOLIO RETURN
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03.01.73	0.00548
04.01.73	-0.001029
05.01.73	-0.002
08.01.73	0.001729
09.01.73	0.001744
...	...
20.07.21	0.022429
21.07.21	0.019044
22.07.21	-0.005043
23.07.21	-0.009607
26.07.21	0.015867		
b) Argue: Riskiest and Safest investment of a) (6 points)			PORTFOLIO	JP_MORGAN_CHASE	EXXON_MOBIL	INTEL	PFIZER	BOEING
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Mean Absolute Deviation	0.00979	0.01435	0.01052	0.01865	0.01239	0.01455
Semi Std	0.00993	0.01486	0.01054	0.01889	0.01204	0.01451
Empirical VaR	0.02051	0.03047	0.02191	0.03847	0.02559	0.0299
Empirical ES	0.03094	0.04741	0.03286	0.05986	0.03801	0.04564	 Since Intel stands out in every risk measure (with the highest risk value), we can define it as the riskiest asset, whereas Exxon_Mobile is the safest single stock investment. Overall, the Portfolio is the safest investment, underlining the effect of diversification (reducing risk by diversifying the Portfolio)	
c) VaR/ES of 21-day rolling window (10 points)		21d ROLLING PORTFOLIO RETURN
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Empirical VaR	0.0299
Theoretical VaR	0.08235
Empirical ES	0.0545
Theoretical ES	0.02073		

d) Estimate and plot the 5-year rolling Semi-St.Dev. (10 points)		
e) Identify the 5 riskiest periods (8 points)	 The Semi Std. Estimations shows five periods, where the graph is increasing sharply in a short time, stays at a higher level for a period of time and then sharply decreases again. The first period, right before 1980, relates to the Oil Shock of 1978-1979. Associated with events in the Middle East and driven by a strong global oil demand, oil prices began to rise rapidly. More than doubling between April 1979 and April 1980. Leading to an economical driven stock market crash. The second period begins on October 19, 1987 – so called Black Monday. The Dow Jones decreased by 22.6% (508 points) within one day. The Fed increased (for the first time in three years) the interest rate for short-term lending, leading to increased uncertainty. Additionally, there was a loss of trust into the US-Dollar after James Baker (finance minister of President Reagan) publicly stated, that the would not strengthen the US Dollar and will take a devaluation of the US Dollar into account. The third period marks the dot com bubble, which busted in March 2000. High expected revenues and a lot of speculation into firms, which were not profitable at all, leading to strong growing equity prices. Many firms became insolvent and in March 2000 the equity prices went down, leading to high volume selling on the stock market, leading to a market crash.	

	The fourth period is related to the global financial crisis of 2007 – 2008. On of the reasons for this crisis were the speculative mortgage market in the US in combination with an unexpected increase of the interest rate for interbank foreign exchange market. The last crisis is the – still ongoing – COVID-19 crisis. After an outbreak in China, the virus reached Europe and the USA early 2020 leading to strong losses in Equity markets. However, the Fed and other national banks strongly increased liquidity on the market, leading to fast recovery on the equity market. For example, the SMI reached his pre-COVID-19 Level within 14 months. For comparison, it took almost 12 years to reach the level before the financial crisis 2007.	
f) Difference between mean and median (6 points)	The mean of the return series is 0.01475 The median of the return series is 0.01562 Usually, in stock analysis the median is handy to use, when we observe significant skewness in the data, when the data has a long tail, and it is useful when outliers carry significant weight in the data. In our dataset, the difference between the mean and the median is not very large. Therefore, we can conclude that we do not have many outliers, which are distorting the distribution, nor do we have large tail risks.	
g) Histogram of returns (8 points)	 The plot shows that our monthly returns are not normally distributed. Our results are highly concentrated around the mean (which confirms our results from f) and slightly negatively skewed. We can also observe that we do not have large outliers (positively or negatively).	

h)
Draw and interpret a Q-Q plot
(8 points)
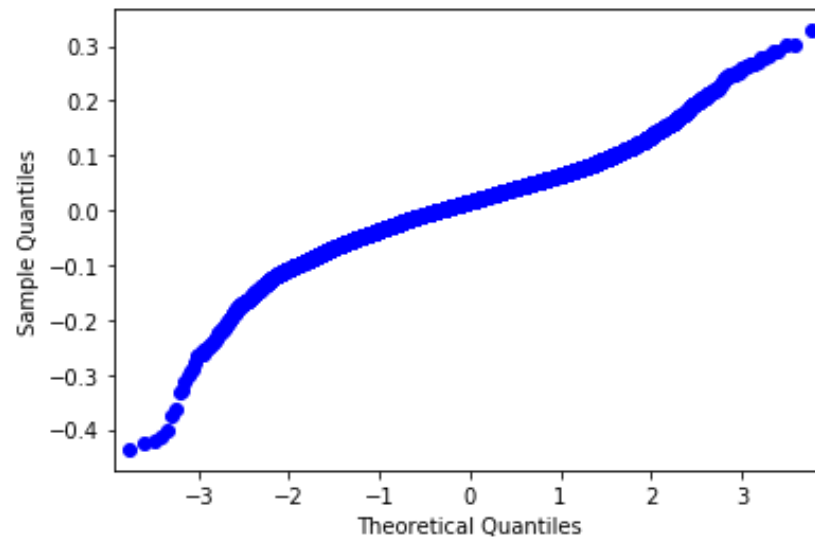
The Q-Q plot shows our assumption that our monthly returns are not normally distributed, but strongly concentrated around the mean. Additionally, we can see the fat tails, which are typical for equity returns.
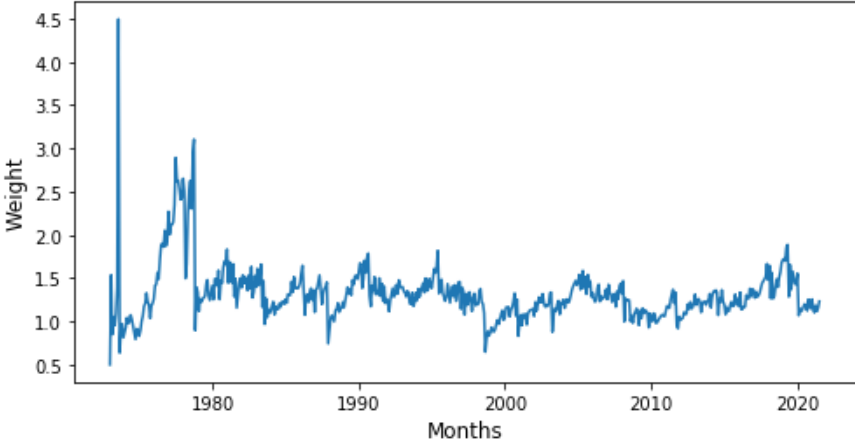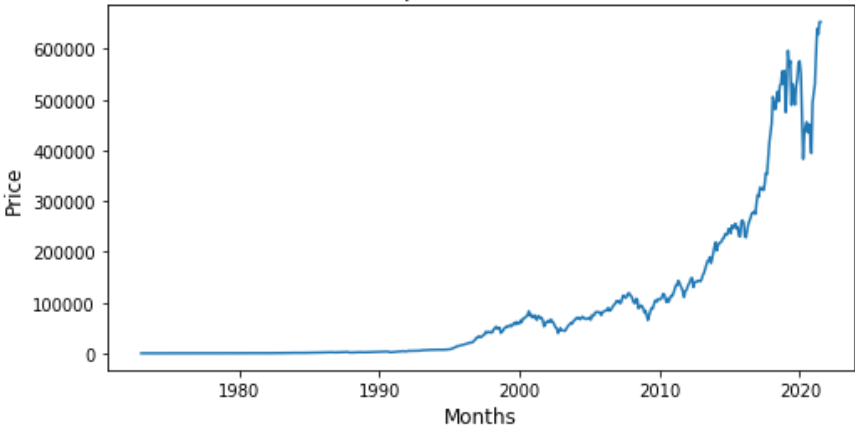
This also translates into the strong kurtosis (3.73). We also observe the slightly negative skewness.

The Skewness of the return series is -0.2990
The Kurtosis of the return series is 3.7303

2. Risk Targeting

a)
Create the risk-targeting strategy, report statistics on mean and volatility
(16 points)

	w_risky	w_rf	Return	Mean_Return	Std	Price
1973-01	0.5	0.5	-0.016497	-0.016497	0.003535	98.35027
1973-02	1.536876	-0.536876	-0.016497	-0.015442	0.005843	96.727756
1973-03	0.850694	0.149306	-0.07057	-0.032967	0.008987	89.901688
1973-04	1.05351	-0.05351	0.005686	-0.023525	0.009726	90.412832
1973-05	0.954646	0.045354	-0.016736	-0.021366	0.011761	88.899715
...	...	...	...	...	...	...
2021-03	1.10224	-0.10224	0.109329	0.016016	0.025811	588205.069
2021-04	1.184924	-0.184924	0.088347	0.016858	0.025573	640171.133
2021-05	1.118411	-0.118411	-0.017121	0.016267	0.02588	629210.887
2021-06	1.157236	-0.157236	0.038977	0.016665	0.025786	653735.692
2021-07	1.232102	-0.232102	-0.000535	0.017208	0.025286	653386.091

Development of Weight in Risky Portfolio

Price Development of Overall Portfolio

Mean Portfolio Return: 0.01783
Portfolio Volatility: 0.07232

| b)
How often was the VaR exceeded? How did the strategy perform?
(10 points) | Number of exceeded months: 40

Exceeded months: 1973-02 - VaR: 0.0539
Exceeded months: 1973-08 - VaR: 0.0619
Exceeded months: 1973-09 - VaR: 0.0568
Exceeded months: 1973-10 - VaR: 0.0525
Exceeded months: 1973-11 - VaR: 0.0631
Exceeded months: 1973-12 - VaR: 0.0585
Exceeded months: 1974-01 - VaR: 0.055
Exceeded months: 1974-03 - VaR: 0.0524
Exceeded months: 1974-04 - VaR: 0.0516
Exceeded months: 1974-07 - VaR: 0.0542
Exceeded months: 1974-08 - VaR: 0.0576
Exceeded months: 1974-09 - VaR: 0.0635
Exceeded months: 1974-10 - VaR: 0.0529
Exceeded months: 1974-11 - VaR: 0.0545
Exceeded months: 1974-12 - VaR: 0.0588
Exceeded months: 1975-01 - VaR: 0.0551 | |

	Exceeded months: 1975-02 - VaR: 0.0504 Exceeded months: 1987-11 - VaR: 0.056 Exceeded months: 1987-12 - VaR: 0.0547 Exceeded months: 1988-01 - VaR: 0.0503 Exceeded months: 1998-08 - VaR: 0.0643 Exceeded months: 1998-09 - VaR: 0.0616 Exceeded months: 1998-10 - VaR: 0.0584 Exceeded months: 1998-11 - VaR: 0.0597 Exceeded months: 1998-12 - VaR: 0.0584 Exceeded months: 1999-01 - VaR: 0.0557 Exceeded months: 1999-02 - VaR: 0.0566 Exceeded months: 1999-03 - VaR: 0.0569 Exceeded months: 1999-04 - VaR: 0.0559 Exceeded months: 1999-05 - VaR: 0.0534 Exceeded months: 1999-06 - VaR: 0.0511 Exceeded months: 1999-07 - VaR: 0.0521 Exceeded months: 1999-08 - VaR: 0.0502 Exceeded months: 2000-11 - VaR: 0.0533 Exceeded months: 2000-12 - VaR: 0.0512 Exceeded months: 2001-02 - VaR: 0.0514 Exceeded months: 2001-06 - VaR: 0.0504 Exceeded months: 2009-02 - VaR: 0.05 Exceeded months: 2009-10 - VaR: 0.0503 Exceeded months: 2011-10 - VaR: 0.0507 Overall, the strategy did perform rather well. Initially, the VaR was frequently exceeded as we did not have as many observations to calculate the standard deviation and mean which were used for the VaR calculation. Moreover, in periods of severe market turmoil and stock market crashes (e.g. 1987/1988 "Black Monday" - 1998/1999 - 2000/2001 "Dot Com bubble" – 2009/2011 "Financial Crisis, Sovereign debt crisis") the VaR was surpassed as well.	
c) Discuss potential improvements (6 points)	VaR is assuming the normal distribution and therefore focuses on the center risks, while not appropriately including the risks of tail events. In reality these tail events, the "fat tails", are more likely to occur for equities and therefore using the normal distribution as part of the risk measure might not be entirely accurate (cf. QQ plots from question 1h). Moreover, the VaR might give a false sense of security to the investor, for example, basing the VaR on a 99% confidence quantile can give the feeling that it will almost certainly not take place – which, of course, is wrong as 99% is still off from 100%. Moreover, in cases where the VaR would be exceeded there is no indication as to how much the VaR would be exceeded and therefore it does not properly account for tail events that can have a huge impact (cf. Taleb's Black Swans). In addition, calculating the VaR for shorter periods (e.g. daily instead of monthly) can increase it's accuracy. However, this is not accounting for potential transaction costs hindering the rebalancing of the portfolio every day based on the previous' day VaR.	