Politecnico di Milano

Computational Finance

Final Valuation

Asset Allocation
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Ambrosini Fabio
Corti Camilla
Corti Veronica
Fiumi Simone

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1 Performance Analysis

1.1 Absolute Performance

In absolute terms we can state that our portfolio performed well: we kept a return greater than 0 everyday but on the 30th October. However, that day the curve went below zero with a slightly negative value equal to -0.29%. While on the 29th November the curve reached its peak registering a return of almost 18%.

Figure 1: Cumulative Performance

Looking at figure 1 we try to give an explanation of what we observed during the period. At the beginning, with the exception of the 30th October, our portfolio had a positive trend until the 5th November with a further rise in the last day when we had a peak due to the fact that all our stocks had positive returns. Mainly thanks to Enphase, dragged by the news about the US elections, and Alibaba which regained some of the losses of the previous day due to the unsuccessful IPO of a company controlled by the founder of Alibaba.

Date	AMZN	MSFT	ZM	**ENPH**	MRNA	MC.PA	6758.T	**9988.HK**
05/11/20	2.75%	3.45%	2.95%	**13.53%**	2.65%	3.54%	4.03%	**6.53%**

CWBFX	0P0000ZZBQ	BAFWX
1.10%	2.97%	2.39%

In the following days we had negative performances; the news about the effectiveness of a vaccine for the Covid-19 kept our portfolio down since it was composed mainly by companies related to the "stay at home economy". On the other hand, to confirm what we have just said, Moderna and LVMH were positively affected.
On November 10th this unfavourable trend was worsened also because Chinese regulators published new rules aimed at preventing the monopoly of online operators causing the stocks of Alibaba to plummet. These are the returns of the day:

Date	AMZN	MSFT	ZM	ENPH	MRNA	MC.PA	6758.T	9988.HK
10/11/20	-2.92%	-2.84%	-8.50%	-6.05%	-1.63%	1.10%	-4.96%	-4.54%

CWBFX	0P0000ZZBQ	BAFWX
0.41%	-3.17%	-1.72%

Since then and until the end (except for the very last two days) we restarted an overall positive trend with very little decreases in between (always smaller than one percentage point).
In fact, on November 11th, although the effect of the new rules still heavily influenced the Chinese giant of e-commerce, all the other positions regained the losses of the previous days generating thus an initial recovery for our portfolio.

Date	AMZN	MSFT	ZM	ENPH	MRNA	MC.PA	6758.T	**9988.HK**
11/11/20	3.75%	3.00%	10.33%	10.50%	8.80%	2.83%	2.61%	**-9.56%**

CWBFX	0P0000ZZBQ	BAFWX
0.27%	1.53%	2.63%

On November 11th, we made the first change in our portfolio: we sold all our positions in Alibaba. On November 16th, the growth was led by Moderna which announced a 95% effective Covid vaccine and reported a return of 9.06%. However the portfolio obtained a return of only 2%. In fact all the other shares registered small positive and negative returns, except for Enphase which reached the value of 2.38%.

Date	AMZN	MSFT	ZM	ENPH	**MRNA**	MC.PA	6758.T
16/11/20	-0.4%	-0.14%	-1.57%	2.38%	**9.06%**	1.61%	1.82%

CWBFX	0P0000ZZBQ	BAFWX
-0.24%	1.26%	-0.31%

The slight decrease on November 18th was due to the fact that almost all of our stocks had negative returns, except for Zoom; Moderna, after the announcement of the vaccine on 16th November, due to the market adjustment and news about other vaccines, registered a loss of 4.61%.

Date	AMZN	MSFT	**ZM**	ENPH	**MRNA**	MC.PA	6758.T
18/11/20	-1%	-1.35%	**3.3%**	-0.2%	**-4.61%**	2.35%	-1.51%

CWBFX	0P0000ZZBQ	BAFWX
0.04%	0.21%	-1.43%

We stress that the portfolio had an increase of almost 3 points percentage on November 25th thanks to the fact that almost all of our stocks had positive returns and in particular Moderna, dragged by the signing of a contract with the European Union for an anti-Covid vaccine, registered a return higher than 10%.

Date	AMZN	MSFT	ZM	ENPH	**MRNA**	MC.PA	6758.T
25/11/20	1.93%	-0.22%	3.55%	2.01%	**10.53%**	-0.13%	3.26%

CWBFX	0P0000ZZBQ	BAFWX
-0.08%	0.36%	0.62%

Finally, on November 26th, we had the second and last change in our portfolio composition: we sold all our positions in Zoom (here the curve is almost flat since the markets were closed in the US and

our portfolio is mainly composed by companies which are traded there). On the next day our portfolio had an increase of more than 3 points percentage because all of our stocks showed a positive return. Also this time the growth was led by Moderna that registered a return higher than 16%.

Date	AMZN	MSFT	ENPH	**MRNA**	MC.PA	6758.T
27/11/20	0.35%	0.67%	1.11%	**16.39%**	0.05%	0.79%

CWBFX	0P0000ZZBQ	BAFWX
0.27%	0.65%	1.38%

This trend continued and, finally, we reached our peak of **17.85%** on 30th November. Moreover we notice how on this day Moderna was the only factor that allowed us to increase the value of our portfolio since, except for a fund which had a very small weight, all our positions have negative results.

Date	AMZN	MSFT	ENPH	**MRNA**	MC.PA	6758.T
30/11/20	-1.31%	-1.00%	-3.29%	**19.68%**	-2.64%	-1.44%

CWBFX	0P0000ZZBQ	BAFWX
-0.60%	0.54%	-0.41%

In the very last days of our time window we went down of almost two points percentage. As we can see from the table below, the major contribute is due to Enphase and especially Moderna that, differently for the previous days, on the 1th December has worsened its return of 7.42%.

Date	AMZN	MSFT	**ENPH**	**MRNA**	MC.PA	6758.T
01/12/20	1.93%	1.28%	**-5.39%**	**-7.42%**	2.87%	1.05%

CWBFX	0P0000ZZBQ	BAFWX
0.51%	-0.08%	0.95%

In the last day, again, we did not perform well since almost all our stocks had negative returns. In fact, Moderna is the only one that registered a non negative return.

Date	AMZN	MSFT	ENPH	**MRNA**	MC.PA	6758.T
02/12/20	-1.64%	-1.51%	-1.83%	**0.27%**	-0.22%	-2.95%

CWBFX	0P0000ZZBQ	BAFWX
-1.08%	-0.07%	-1.68%

We conclude the section stressing that, for what concerns this last change in the composition, on one hand it introduced very small variations and on the other hand it has been considered only for four days. We should have had few days more to draw more reliable conclusions about its performance.
We collect here our main results:

Date		
28/10/20	Start	0.00%
02/12/20	End	15.02%
30/11/20	Max	17.85%
30/10/20	Min	-0.29%

1.2 Relative Performance

To measure the goodness of our performance we determine whether our activity has added value to the benchmark or not. In order to do this, we quantify the portion of returns that can be attributed to our portfolio business by isolating the value added to the fund from the absolute returns over the entire period.

Here we add two figures: figure 2 reports the daily returns of our fund together with the ones of the benchmark while figure 3 represents the relative cumulative performance.

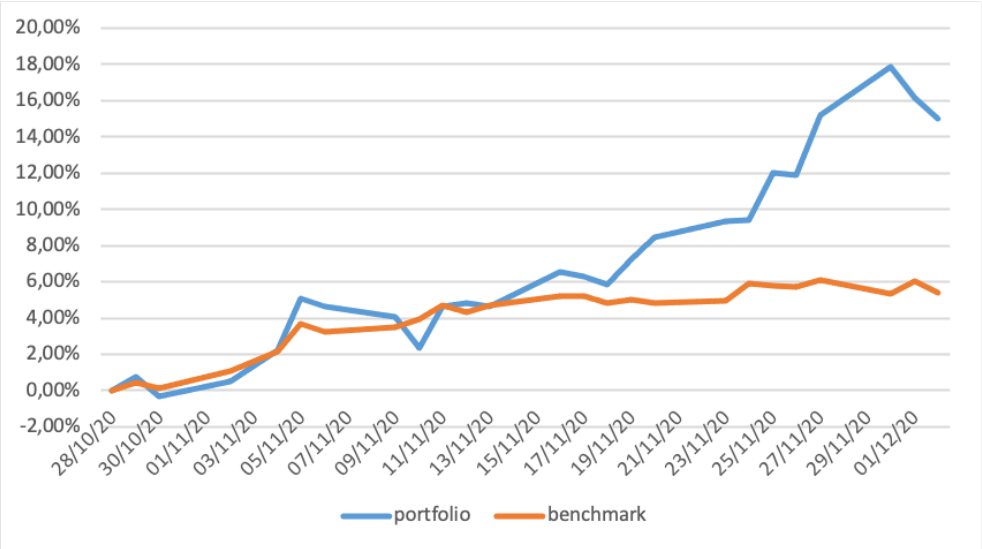

Figure 2: Cumulative performance

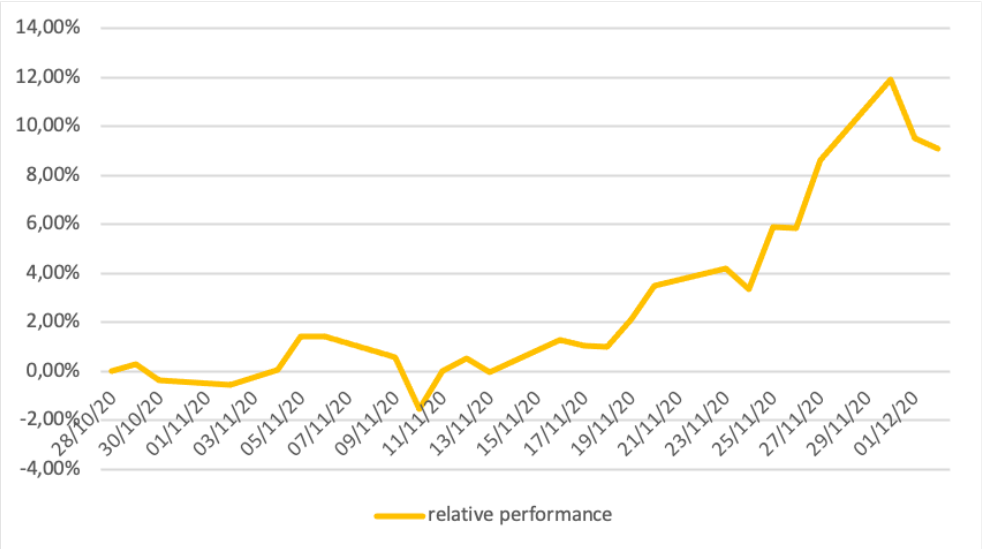

Figure 3: Relative performance with respect to the benchmark

As we can see from the figure 2, the cumulative performance of the benchmark is overall increasing even if it shows some trend reversals. In the first two weeks it was characterized by a clear growth and then this trend continued but the rate of growth is slowed down.
For what concerns the portfolio, remarking what we said in the previous section, it shows a more irregular trend with more evident peaks.
Comparing these two curves, in the first week both portfolio and benchmark returns moved in the

same direction while starting from the 9th November they differed (we underline the fact that it seems that this new behaviour starts from 7th November but this is due to the interpolation since, really in our data we have a gap between 6th and 9th because of the weekend).
More precisely, they were almost overlapping until 5th November (as can be seen in figure 2) when our fund better performed by about one and a half point percentage (in fact in figure 3 the curve increases moving away from 0%). After some days in which the two trends are opposite, overall they started moving together in the same positive direction. Despite this, from then until the end, the rate of growth of our portfolio returns is much more visible. Moreover, we stress two opposite tendencies on 20th and 25th November where benchmark returns registered small decreases while the ones of the fund were always increasing. In the end, looking at figure 3, this behaviour is well described by the fact that starting from the 13th November the curve is always above the 0%.
The change in the composition of our fund in the 11th November should be highlighted since we slightly drifted away from the benchmark composition. At the beginning the 40% of our portfolio was composed by fixed income holdings and 60% by equities then they became 35% and 65% respectively. This means that, starting from that moment, the returns of the fund and the benchmark vary differently in such a way that, in rising market conditions, the returns of the fund are generally more positive than the benchmark ones. Therefore, the fund has a higher degree of relative risk than the benchmark itself. Luckily, as we can see from figure 3, market conditions were favourable for our fund, in fact the offset between the two curves became much more wide.
Finally, on the 26th November the composition of our portfolio changed very little. As we have already stressed at the end of the previous section, in the very last two days the curve of our portfolio started going down. For what concerns the benchmark, if on the 1st December it has a slight increase it also went down on the subsequent day. Overall we can say that our fund performed better than the benchmark and so we succeeded in doing a good work. For what concerns the specific computation of the information ratio we add it in the section below.

We decide to insert a barplot in order to better visualize the behavior of the portfolio and benchmark returns day by day. It is immediate to see that our fund presents evident bigger values than the benchmark ones (both in positive and in negative sense).

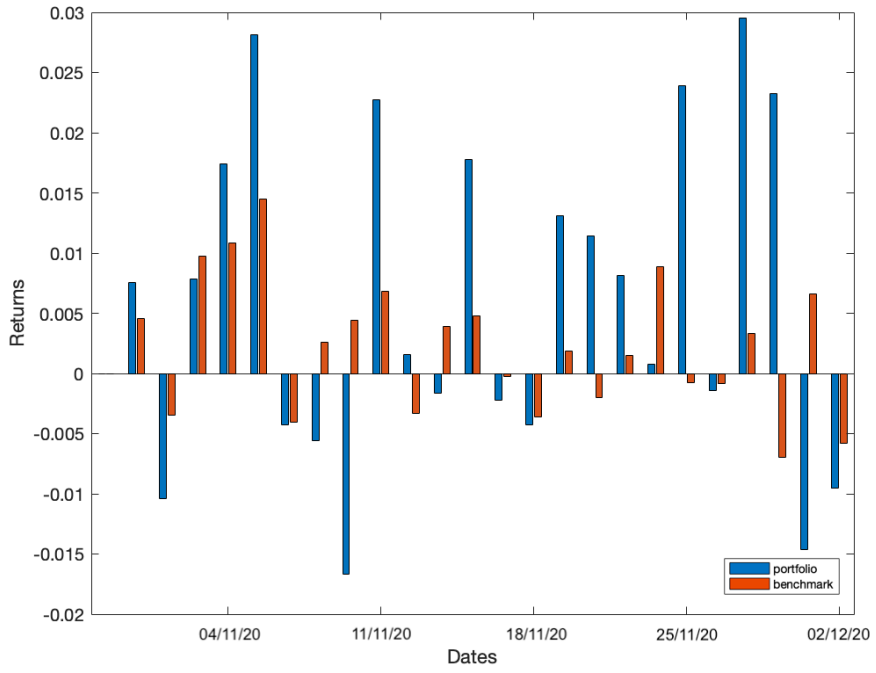

Figure 4: Portfolio returns and Benchmark returns

To better analyze our results, we are interested in quantifying the correlation between our portfolio and the benchmark. We compute it using the set of returns of the entire period through matlab function `RelativePerformance.m`. We are aware that our results are influenced by the size of our sample, too small to get a good estimate. However we still tried to perform this analysis. We get a value for the correlation $\rho = 0.2882$. Then we split our time interval into three parts starting with the dates in which we changed the composition obtaining these results for the correlation:

1. $\rho = 0.7604$ (28/10/20 - 11/11/20)
2. $\rho = 0.0866$ (12/11/20 - 26/11/20)
3. $\rho =$ -0.1881 (27/11/20 - 02/12/20)

For the first period the correlation is high but its value is difficult to be read so, we compute $R^2 = 0.5782$: this indicates that about the 60% of the changes in the return of the portfolio is related to the changes in the benchmark ones.
In the second and last periods the correlation is very close to zero. This may be due to the fact that we drifted away from the benchmark. However we stress again the fact that the small size of the sample could be a source of a bad estimate (as we have already stressed in the third period we have only four days, the sample size is reduced so much with respect to the other cases, already very small).

1.3 Information Ratio

As we have already seen in the previous paragraph, we expect a pretty high IR especially from the period starting with the first change of the portfolio (12/11/20 - 25/11/20). In the following table are represented the values of the IR for each of the three periods and the total one.

Period	IR
29/10/20 - 11/11/20	0.018
12/11/20 - 25/11/20	0.600
26/11/20 - 02/12/20	0.319
29/10/20 - 02/12/20	0.291

These values put in numbers all the good things said in the previous section. After the first period in which we did not exceed the performance of the benchmark by much, after the re-composition of the portfolio and carried by Moderna, we managed to obtain a good result. In fact, generally [1], a fund with IR in between 0.4 and 0.6 is considered a good investment and if we do not consider the period going from October 29th to November 11th in which we based the composition of our portfolio on rather simple heuristic considerations, we obtained, from the 12th November to the 2nd December, an IR of 0.432.

2 Performance Attribution

The performance attribution consists on a series of techniques used to explain the active return: this represents the excess performance of the portfolio compared to the benchmark one.
We are going to present a performance attribution method based on the Brinson model: the basic assumption of the model is that both the portfolio and the benchmark performances are the sum of their components, more precisely:

$$r_p = \sum_{i=1}^{n} w_i r_i \qquad\qquad r_b = \sum_{i=1}^{n} W_i b_i$$

where:

- r_p: portfolio return
- n: number of classes
- w_i: weight of the i-th asset class of the portfolio
- r_i: return of the i-th asset class in the portfolio

- r_b: benchmark return
- W_i: weight of the i-th asset class in the benchmark
- b_i: return of the i-th asset class in the benchmark

Our task here is to quantify the decisions of the portfolio manager which helped to create the difference between r_p and r_b.
The performance attribution aims to break down the result of an investment into three distinct factors:

1. Asset allocation: choice of the categories of assets to invest in
2. Stock picking: selection of individual assets within a certain category
3. Interaction effect: interaction between the first two

2.1 Asset Allocation

Let us analyze how we can quantify the process of choosing the asset categories: we determine an allocation fund in which, within each asset class, we apply the portfolio weights (w_i) to the benchmark returns (b_i).

$$b_A = \sum_{i=1}^{n} w_i b_i$$

We compute the asset allocation contribution as the difference between the allocation fund return and the benchmark one:

$$b_A - b = \sum_{i=1}^{n} w_i b_i - \sum_{i=1}^{n} W_i b_i = \sum_{i=1}^{n} (w_i - W_i) b_i$$

In the Brinson model, we have the following peculiarity: all overweight positions in asset classes (overweight position means with a bigger weight with respect to the benchmark one) with a positive return lead to the computation of positive attribution factors and, on the contrary, all the overweight positions in negative markets lead to negative attribution factors. This aspect does not match with the real investment decision-making process; in fact, the one that makes the asset allocation decisions could have a loss in value if he is overweight in a market that has a positive return and, however, this performance is lower than that of the benchmark as a whole. Obviously you will have the same

problem for categories with negative returns. The Brinson and Fachler model gives us the solution to this problem modifying the asset allocation term.

$$b_A - b = \sum_{i=1}^{n} (w_i - W_i)(b_i - b)$$

2.2 Stock Picking

Similarly to the asset allocation, also for the computation of the security selection to the creation of an excess return, we use an intermediate fund, the so-called selection fund. In this fund we keep the weights of the benchmark (W_i) and we apply them to the portfolio returns (r_i).

$$r_S = \sum_{i=1}^{n} W_i r_i$$

In the same way to the asset allocation, we determine the security selection contribution as the difference between the selection fund and the benchmark one:

$$r_S - b = \sum_{i=1}^{n} W_i r_i - \sum_{i=1}^{n} W_i b_i = \sum_{i=1}^{n} W_i (r_i - b_i)$$

2.3 Interaction Effect

The two terms computed above are not sufficient to fully explain the excess return, it is necessary to introduce a further term which represents their interaction:

$$\sum_{i=1}^{n} (w_i - W_i)(r_i - b_i)$$

From the previous equation, it is possible to observe that the interaction term is the combination of the effects of asset allocation and security selection. In fact, we use the differences between the portfolio weight and the benchmark ones and we apply it to the differences between the portfolio returns and the benchmark ones.

2.4 Results

Asset allocation				
	W1	W2	W3	Tot
Azionario	-0,003%	0,064%	-0,010%	0,052%
Obbligazionario	0,000%	-0,029%	0,006%	-0,024%
	-0,003%	0,035%	-0,005%	0,029%

Stock Picking				
	W1	W2	W3	Tot
Azionario	-1,164%	5,546%	3,268%	8,271%
Obbligazionario	0,337%	-0,187%	-0,319%	-0,212%
	-0,827%	5,358%	2,949%	8,059%

Interaction Effect				
	W1	W2	W3	Tot
Azionario	0,001%	0,462%	0,152%	0,652%
Obbligazionario	0,000%	0,023%	0,024%	0,051%
	0,001%	0,485%	0,176%	0,703%

Figure 5: Performance attribution

As we can see from the figure 5, the Stock Picking part is the most relevant in all the three periods, while both the Asset Allocation and the Interaction Effect are very small.

The global portfolio return is 15.02% while the benchmark one is 5.31%: our portfolio over performed the benchmark of 970 basis points. We try to investigate this result.

The total value added for Asset Allocation (in the whole period) is 0.029%: while in the first and third periods we remained close to the benchmark, in the second one we differed. In fact, we moved to a more risk-oriented attitude because we believed that this strategy could be profitable in the short term: from the 12/11/20 to the 25/11/20 if the benchmark composition was 60% equity and 40% bond, our portfolio was 65% equity and 35% bond. The Asset Allocation value registered is done by:

- over-weighting of equity: $(65\% - 60\%) \cdot (1.28\%)$
- sub-weighting of bond: $(35\% - 40\%) \cdot (0.57\%)$

More precisely, the equity part led to a positive asset allocation contribution while the bond one registered a negative value.

For what concerns the Stock Picking, the total value added is 8,059%. We decide to analyze in details all the three periods of the equity part because, as we can see from the figure 5, the fixed income part has a lower contribute.

- from the 29/10/20 to the 11/11/20: the contribution is negative, $60\% \cdot (-1.94\%)$, this is due to the fact that the portfolio equity part performed worse than the benchmark one. Probably because the companies related to the so called "stay at home economy", which composed the major part of our equity assets, lost value because of the news about the effectiveness of a vaccine. Moreover, Alibaba had a very negative trend in the last days of the period due to some internal politics decisions of the Chinese government.
- from the 12/11/20 to the 25/11/20: the contribution is positive, $60\% \cdot (9.24\%)$, in fact the portfolio equity part, carried by Moderna, managed to over-perform the benchmark.
- from the 26/11/20 to the 02/12/20: the contribution is positive, $60\% \cdot (5.45\%)$, and again, Moderna, gave the major contribute.

The interaction acquires the added value that is not attributable only to asset allocation decisions and to the selection of securities. In our case, the only two remarkable results are those of the second and third periods related to the equity part which are positive since both the weights and the returns of our portfolio are higher than those of the benchmark.

3 FX Rate: multi currency portfolio attribution

We want to deepen the contribution of currency exchange on the performance of our portfolio.
To compute the excess return, instead of considering the base returns (EUR), we adopted a naïve approach calculating separately the contribution provided by local returns and the one due to the exposure to currency exchange.
In order to properly compare each local currency asset with the respective benchmark, we had to divide the portfolio composition and benchmark one. More precisely:

- Equity: the equity part of the portfolio is divided as follows while the equity index is in Euro.

  EUR: MC.PA

  USD: AMZN, MSFT, ZM, ENPH, MRNA, BAFWX

  JPY: 6758.T

  HKD: 9988.HK

  GBP: 0P0000ZZBQ

- Bond: the bond part of the portfolio, CWBFX, is in Dollars as the bond index.

We started by computing the base and the local returns:

1. return of the change EUR/USD:

$$r_{change} = \frac{E_{EUR/USD}(t_1)}{E_{EUR/USD}(t_0)} - 1$$

   Obviously we did the same for the three periods characterized by different compositions and for all the other currencies.

	Cambio EUR-USD	Cambio EUR-JPY	Cambio EUR-HKD	Cambio EUR-GBP	Rendimento EUR-USD	Rendimento EUR-JPY	Rendimento EUR-HKD	Rendimento EUR-GBP
28/10/20	1,1765	121,9512	9,0909	0,9042				
11/11/20	1,1784	123,4568	9,1408	0,8919	0,16%	1,23%	0,55%	-1,36%
26/11/20	1,1920	124,4030	-	0,8906	1,15%	0,77%	-	-0,15%
02/12/20	1,2074	125,9150	-	0,8994	1,30%	1,22%	-	1,00%

Figure 6: Exchange rates and returns

2. Approximated local return of the i-th asset class:

$$r_{local}(i) = r_{base}(i) + r_{change}$$

We proceeded with the approximated value of the "Naïve Currency Attribution" whose approximate value is obtained in this way:

$$NaïveCurrencyAttribution = (r^p_{base} - r^p_{local}) + (r^b_{base} - r^b_{local})$$

The contribution of Asset Allocation, Stock Picking and Interaction Effect is obtained by replacing the base return with the local one. The desired result is the sum of these contributions:

$$r_p - r_b = AssetAllocation_{local} + StockPicking_{local} + InteractionEffect_{local} + NaïveCurrencyAttribution$$

Naïve currency attribution			
W1	W2	W3	Tot
-0,15%	-1,40%	-1,63%	-3,46%

Figure 7: Naive Currency Attribution

The extension of the performance attribution allowed us to observe the currency component.
To do the computation, we started from the base return (EUR) and then we shifted to the local return (other currencies) by adding the EUR/OtherCurrency return. Then we computed the Naïve Currency Attribution in which the local return is taken with the minus sign.

In the period from the 28/10/20 to 11/11/20 the first contribution of the currency is quite negative (-0.15%), in fact all the currencies, except GBP, in average sub-performed compared to EUR. Besides the shares invested in EUR were very lower than those invested in other currencies and, for what concerns the weights, the main contribution in the portfolio was the USD one. These are the reasons why we registered a small negative value.

In the following period, from the 12/11/20 to the 26/11/20 the contribution value was much more negative (-1.40%) and it reached the minimum value (-1.63%) in the third and last period, from the 27/11/10 to the 02/12/20. In fact in the second period, as in the first one, all the currencies, except

GBP, in average sub-performed compared to EUR, even if they did a little worse than in the first period. While in the third one the value registered is the minimum because all the currencies continued in doing worse than EUR and also GBP got worse.

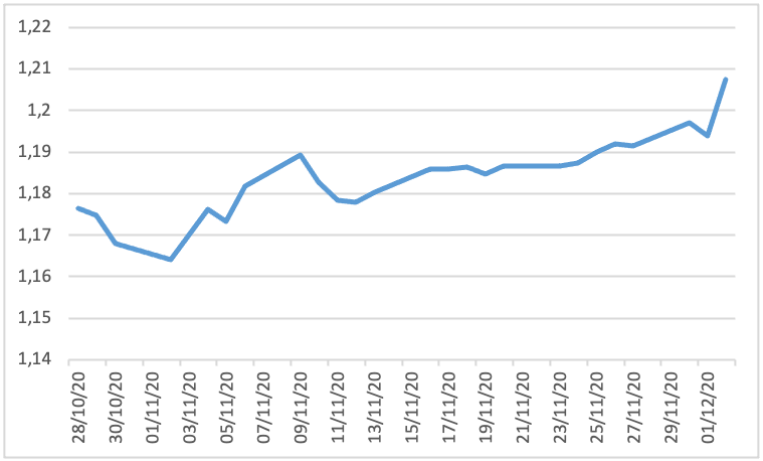

Figure 8: EUR/USD

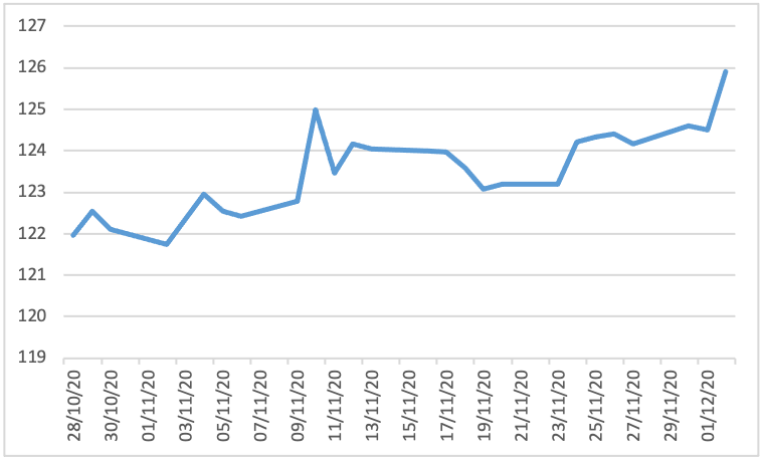

Figure 9: EUR/JPY

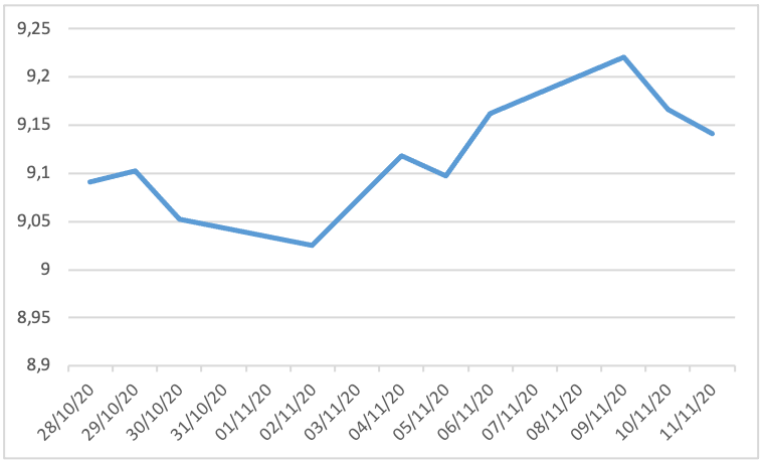

Figure 10: EUR/HKD

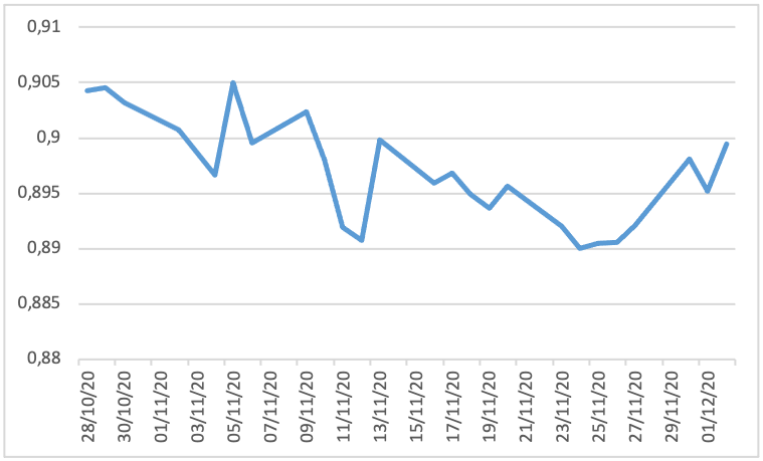

Figure 11: EUR/GPB

4 Transaction costs

Here we analyze the impact of the transaction costs on our changes. To do this, we look at the difference between the value of our portfolio before and after the variations of the composition. We attach the results below:

	EUR	
Date	Costs	%
28/10/20	28960,34982	0,58%
26/11/20	15711,88748	0,30%
11/11/20	3173,237198	0,06%
TOT	47845,4745	0,96%

Figure 12: Transaction costs

As we expected, in the first period the costs impact is bigger than the others since these costs corresponds to the creation of the portfolio and thus the fees are applied on a bigger invested total (5mln EUR). For the first change the total costs were still high, since the new composition of the portfolio was very different with respect to the previous one. However, as we will deepen in the next sections, some of these fees could have been avoided but anyway this is not a major problem since the percentage with respect to the total is low. For the last change, since the period we were about to face was short, we thought that it would have been useless to make a major change in the portfolio, which by the way was performing well, in order to avoid high fees. Besides, in this last transaction, we only moved dollars in order to avoid double fees (we sold all the position we had in Zoom (USD) and we augmented some dollars positions). In fact, another factor which, previously, has contributed to increase our costs were the continuous changes of currency.

5 Single contributions

As shown above, among the assets in our portfolio the major contribute to the performance of the fund is due to Moderna. For this reason, we add a section in order to better analyze the results of the company in the time window considered.

5.1 Moderna, Inc (MRNA)

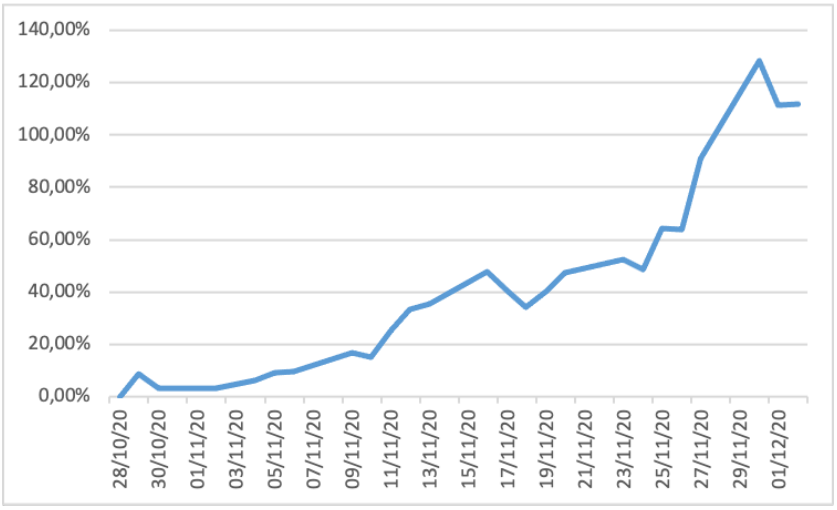

Figure 13: MRNA cumulative performance

Our initial choice came from the will to have a company that could get profit of the situation related to the Covid pandemic. Since the company was already having good results and due to the fact that the previsions about its own vaccine were good, we decided to increase our exposure in Moderna whose weight was almost doubled in the second portfolio composition until the end. Since at the beginning, among our investments, we tried to select also companies which may possibly have exceptional returns due to particularly favourable events, our choice can not completely be considered a lucky strike.

The stock more than doubled its initial value at the end of the period. We find out that on the 30th November reached its best with a 128.33% with respect to its initial amount (28th October). To have a comparison with the others, our second and third best stocks were Enphase with a maximum return of 34.98% (27th November) and LVMH with a maximum of 23.80% (2nd December).

In addition, comparing figure 13 with figure 1 appears quite evident that the two curves have a similar trend. In fact, as stressed in subsection 1.1, from the 16th of November until the end, our exposure to Moderna led the returns of the fund both for the greatness of its results and for the amount of the exposure (13% of the entire composition). Even if already discussed, to be clear we stress again that on the 16th November the so awaited vaccine has been announced and on the 25th there was the signing of the contract with the European Union for the vaccine and also, in the following days, other positive news affected the value of the stock.
Coming back to the curves, you can notice that the peak of the fund corresponds to the peak of Moderna stock curve (30th November) and the decrease of the following days corresponds to a decrease in the return on the stock for the 1st December (-7.42%) and to a 0.27% for the 2nd December (despite this its value remains doubled).

We conclude saying that, even if the time window of our fund is over, we looked at the results of the stock for the subsequent days noticing that they have been always increasing.

6 Composition changes

Since the first portfolio composition was obtained in a naïve way, without the support of any numerical analysis and based on approximate qualitative considerations, a massive change was surely needed despite the high transaction costs we were going to have. At the beginning of the second period of evaluation we set the target to increase our return; as first thing, we decided to drift away from the benchmark of some percentage points so that the riskier, but possibly more remunerative firms, had bigger weight in our portfolio. Of course, some mistakes were made and the first one was to sell all our positions in Alibaba. Following the antitrust rules, imposed by the Chinese regulators, the company reached its low since August and, even though the tech giant did not recovered completely from the losses in the following days, we got ahead of ourselves selling the shares at their lowest.
A similar reasoning can be made for the sale of some shares of Amazon and Microsoft: the two companies just one week before were on some local maxima and we sold the positions nearly 7 days later on local minima.
However most of the proceeds to fund our purchases came from the two equity funds (nearly 940.000 EUR): here the difference in prices with respect to the week before is of course slighter but, due to the large volume, a sale in the previous week would have brought us nearly 70.000 EUR less.
We made some mistakes also in the purchases, especially for what concern LVMH, since we bought new stocks at the end of a positive trend which started at the end of October.

We have computed the difference in money we would have had if we had changed the composition a week before and, as we expect, this difference is negative: if we had taken action earlier we would have had nearly 150.000 EUR more (To see how we obtained this result see DifferentPtfChange.xlsx)! Overall, anyway, even though the change should have been anticipated, we can state that it was worth it. In fact, most of the companies in which we increased our exposition had positive returns in the following period. In particular, for what concern Moderna, we can say that we have done a good work in relying on the news. In fact, after the statement of Pfizer about its Covid vaccine, we discovered that also Moderna was going to release the results about its own tests and that the expectations were good. This move was surely the most profitable one among the ones we made and it allowed us to have very high returns in the following days.
Surely we could have avoided to increase so much our exposure to LVMH, Enphase and Sony which did not perform how we expected (especially LVMH) suggesting that our forecast was too optimistic. In such a way we would have lowered the aforementioned high transaction costs without losing much in mean return. We stress that in order to do these changes we also reduced our exposure to the three funds.
Therefore later we tried not to commit again the previous errors avoiding major changes. In fact, in our third change our only move was to sell all our positions in Zoom, which was not in a good trend and, given the news about the vaccine, was not believed to invert it. In this case, we sold Zoom in the right moment since the stock was in a slight increasing trend; moreover also *a posteriori* this choice turned out to be correct since this positive trend soon reversed. The earnings for the sale were put back again in the three funds in our portfolio, in order to decrease the risk. This move suggests again that our major change in the weights of the three funds in our portfolio at the end of the previous period should have been in part avoided. In fact, by buying again shares of these funds, we lost money both for the increase of the their own value and for the transaction costs. However we remind that we sold the major part of our exposition to the funds trying to increase our mean return despite an higher risk. Then, trying not to loose our gains, we took a step back increasing again our exposition to the funds. Paying attention to the transaction costs, we decided not to buy stocks of the fund 0P0000ZZBQ since it is quoted in GBP in order not to double the costs.

7 Models

We started the quantitative analysis with the basic Markowitz model highlighting that it has some flows: more precisely, the estimates are biased and every time we update our estimates the weights change a lot, moreover these changes are sharp along the frontier. By considering the efficient frontier as a random variable we found out that it is a biased estimator. We managed to understand that one problem is the estimation of the parameters: the covariance matrix can contribute to this problem but the major contribution comes from the expected returns.

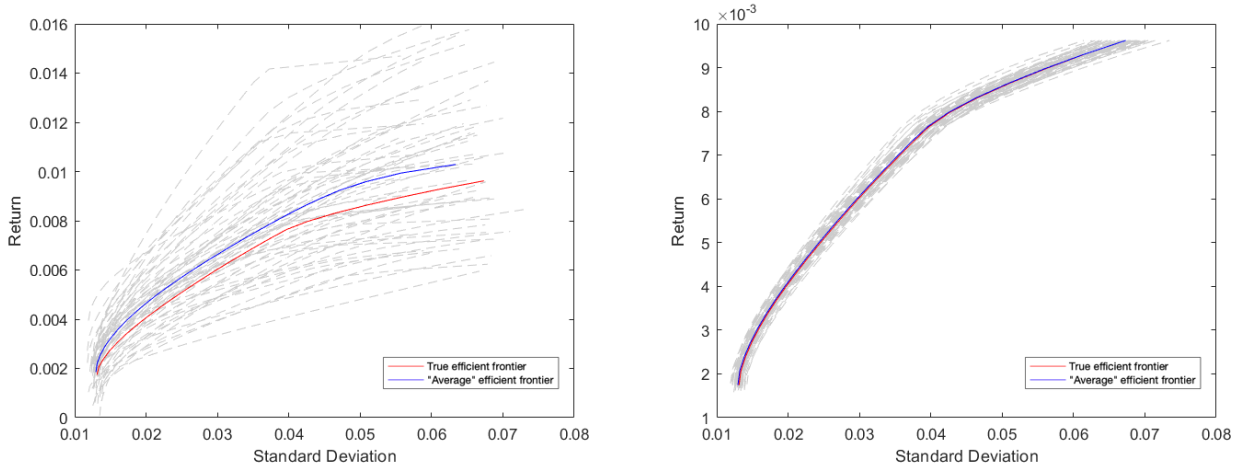

Figure 14: First figure: we resample several times, the mean and the covariance are the sample ones. Second figure: we resample several times, the mean is the true mean obtained from the market while the covariance is the sample one.

As we can see from the picture, the blue line is too optimistic and, more important, the estimates are much more noisy in the first figure with respect to the second one.

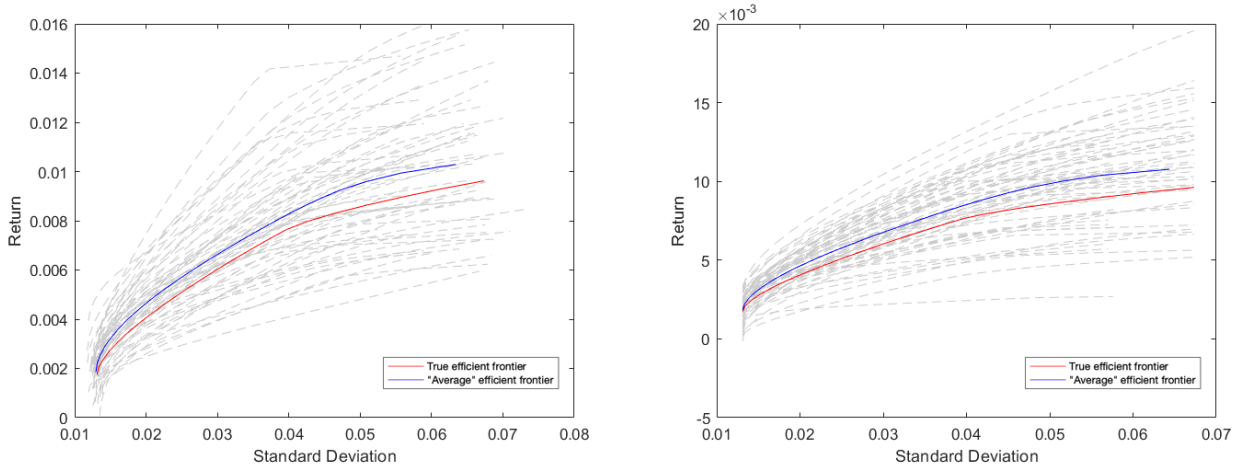

Figure 15: First figure: we resample several times, the mean and the covariance are the sample ones. Second figure: we resample several times, the mean is the sample one while the covariance is the true covariance obtained from the market

Clearly, the worst is to estimate the mean of the returns and not the covariance; as we will soon explain, we try to overcome this problem including views for the average returns.

A heuristic but popular way to address this problem is the resampled frontier method since it allows smoother changes in the composition of the portfolio from period to period and along the frontier.

Another way is try to reduce estimation error in the parameters since the sample mean is unbiased but highly inefficent so we have a huge variance around the average. The estimators are then noisy and this variability is even increased by the optimization process that picks the stocks with higher average return. For these reasons, we computed the efficient frontier using Shrinked estimators both for the variance-covariance and for the mean of our returns. This estimator is the average of two different estimators, one more efficient but biased and the other unbiased and inefficient.
Among the alternatives just presented, as we already verified in the previous reports, we decided to rely more on the resampled frontier method since:

- in figure 16 we can see how the frontiers obtained are too optimistic (i.e. given a value for the standard deviation the expected return is higher with respect to the one of the resampled frontier method).
- Moreover in figure 18, 19:
  - the weights along the frontier change too sharply
  - the portfolios are not much diversified
  - the compositions vary too much from simulation to simulation

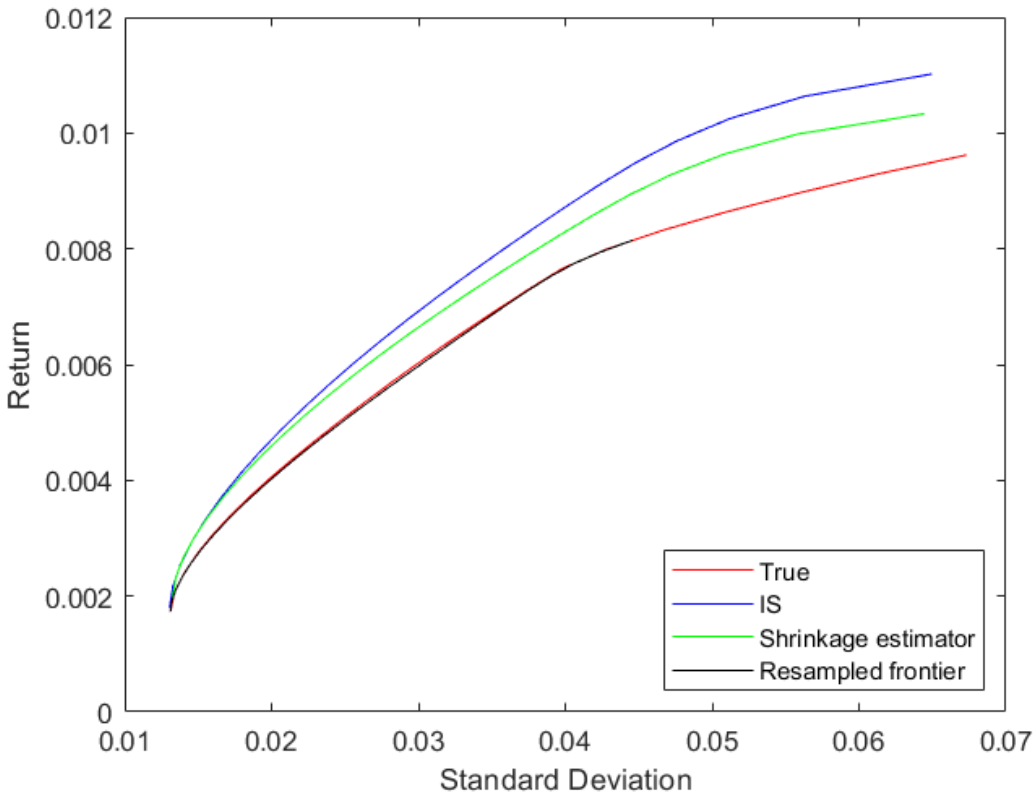

Figure 16: Efficient frontiers in comparison

Figure 17: Legend

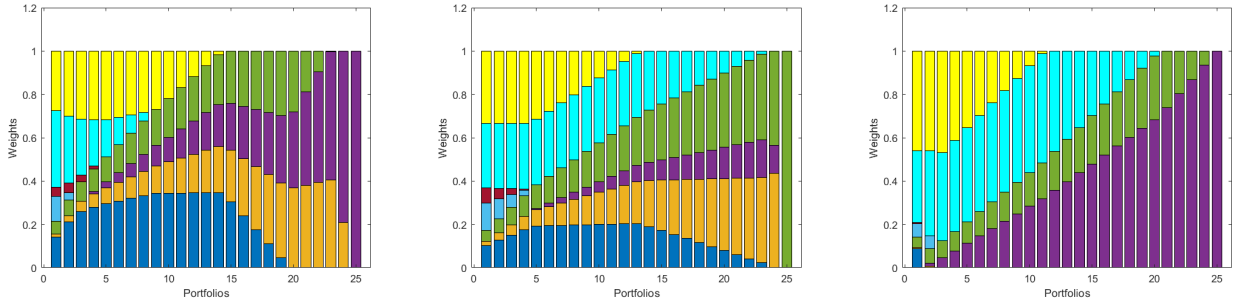

Figure 18: Portfolio composition - IS: here 3 different simulations

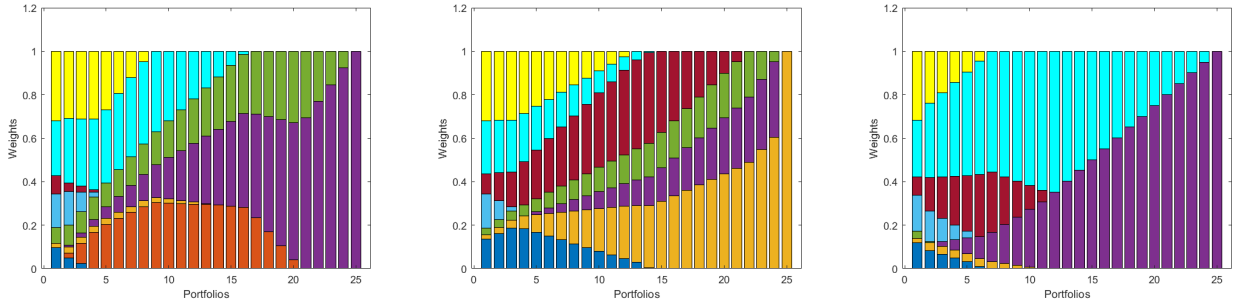

Figure 19: Portfolio composition - Shrinkage estimator: here 3 different simulations

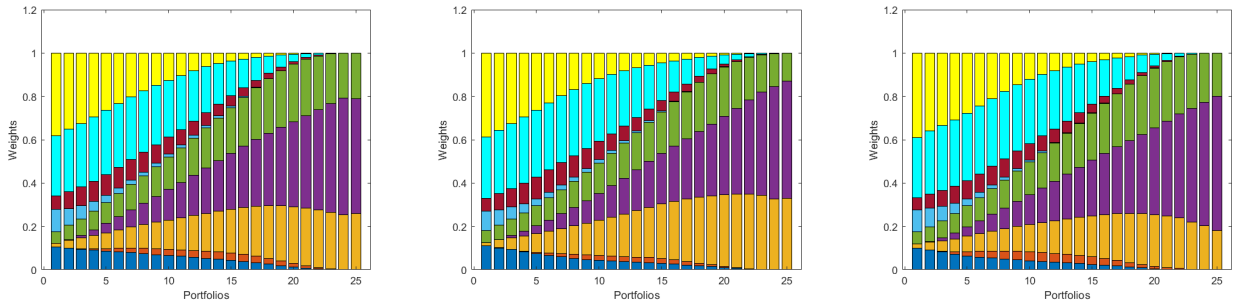

Figure 20: Portfolio composition - resampled frontier: here 3 different simulations

In order to reduce the problem related to the expected returns so far introduced, the last addition we made was trying to blend the estimates obtained from the historical data with some views from some experts. In fact, sometimes it is worth to use the economic intuitions since on one hand you may have better estimates and, on the other you would have forward looking estimates. This could be necessary in order to have a precise result since a representation of the past (got using historical data) is not enough because previously there was not the Covid pandemic.
To confirm this evidence in the previous report we have implemented a VaR backtest showing that our strategy would not perform so well using only historical data. Coming back to the view, to put it on the expected returns in a mathematical way we followed the approach presented by *Attilio Meucci,*

The Black-Litterman Approach: Original Model and Extensions, 2008 assessing a qualitative forecast on the expected return of Amazon. However, since this view was not precise and since it was very difficult to obtain previsions on the returns of our stock, especially on the short-term returns, we decided not to rely so much on this last method.
Another algorithm we used was a simple linear optimization using the past data with objective function the maximization of the IR. We blended the information coming from this model to those coming from the previous ones, in particular selecting on the efficient frontier the portfolio with maximum IR and comparing it with the portfolio computed before.
We now see the changes we did on the outcomes of the numerical algorithms. As we already stated in the previous section for the first composition we did not use any numerical model and we composed our portfolio only with rather simple qualitative intuitions.
For the first change of the weights we made the error to not consider the IR in any of our optimizations. Moreover we only relied on the resampled frontier method, without specifying so much why, and along the frontier which we obtained we selected, also here without a rigorous mathematical motivation, a portfolio which had a relatively high expected return (the 17th). However, considering our good job of looking for information and the fact that the historical data may not be too informative, we manually changed the weights proposed by the model, but also here we did not give rigorous reasons to justify our choices. So we computed, *a posteriori*, the results we would have had if we had trusted the weights of the model to see if our change was worth it. As we have already seen the IR for the period we are now considering was 0.6 while the one computed if we had chosen the weights of the portfolio we selected on the frontier would have been 0.577 (To see how we obtained the result see `OptWeights.xlsx`). As we can see the two values are similar, probably due to the fact that in both portfolios the weight of Moderna was high and thus the major contribute in the IR comes from that. Since the two values are close it is hard to say whether the risk we took by not trusting the numerical output was worth it or not.
For the last change we tried to work in a more rigorous way, considering the maximization of the IR as our goal. However since the weights proposed were too much different from those we already had and since the time period in which we were going to hold our portfolio was too short, we thought that the transaction costs we would have faced were too high to justify a major change and thus we decided to keep our portfolio substantially unchanged except for the aforementioned small changes.

8 Conclusion

Our initial budget was 5mln EUR. On the 2nd December, at the end of the period, the value of our portfolio is 5.717mln EUR with a return equal to 15.02% (figure 1) on our initial value and 9.22% (figure 3) with respect to the benchmark.

Date		
28/10/20	Start	5000000.00 EUR
02/12/20	End	5717639.11 EUR

9 Bibliography

[1] https://www.financialexpress.com/money/mutual-funds-what-information-ratio-tells-about-your-fund-managers-performance/1512745/