(ARCHIVED VERSION)
Exercise
for 2021 summer research candidates
with conditional offers

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1 Warnings

This is a subsample of 2021's project for summer research candidates. The 2022's project is under design, and this document should only be taken as a limited reference: we are expected to have significant changes from the previous year's material. Please refer to our website `https://optimalportfolio.github.io/subpages/Summer.html` for more information.

Given that we aim to offer the exercise to students teamed up to two, we will reduce the content of the exercise. Some solutions could exist already, thus do not expect the same questions to appear in 2022.

2 Task description

Investigate VIX dataset [1] and produce a trading strategy based on VIX+SP500 combination and VIX+Π combination where Π is a portfolio of the leading stocks in SP500. Further discuss the practical aspect of implementing long term holding strategies, and engage the empiric of statistical modelling, time series and machine learning.

2.1 Highlight of requirements and tips

1. You are recommended to fully understand the task before starting to work on it. The bracket next to the subsection title gives an indication of the level of importance, and they are summed up to 100 marks. Notice that, nonetheless, failing to achieve proper results at the earlier stages, e.g. data collection, would unavoidably fail the achievement towards the end. The fortnightly review meetings would be a good place to check with the supervisors for confirmations and comments.

2. The length of the report or presentation need not to be proportional to the marks allocated. There are no limits in terms of the length of the report, but one needs to consistently and logically highlight the importance of the methods and findings and align the standard of the writing to a reasonable academic or financial publication.

3. There is no need for a long literature review. Though, some compulsory and recommanded literature reviews are detailed at **??** and later.

4. Citations should be made for any techniques taken from the literature or other sources. The standard anti-plagiarism framework applies as usual.[2]

5. The coding should be completely implemented in Python. Should one needs R or other codes to help with, a confirmation from the supervisors would be required for formal approval.

6. The report shall be produced in LaTeX. The presentation slides may vary, but are highly recommended to be produced in LaTeX.

2.2 Data [5]

Efficiently and accurately download the VIX dataset from the CBOE website. Efficiently and accurately download the SP500 and individual shares dataset from either the Yahoo Finance website or equivalent.

The frequency of concern is daily, and the period should be from 2013 to now.

Tip: the usual bar chart information should be necessary — open, high, low, close, volume, and open interest if possible. This may not be immediately helpful, but would play a role in the later subsections as the analysis proceeds.

[1] `https://www.cboe.com/us/futures/market_statistics/historical_data/`

[2] Interesting way to find related literature: `https://www.connectedpapers.com/`

2.3 Statistical and financial understanding [5]

Understand the basics of SP500 and the basics of the VIX pricing.[3] Basic statistical observations on the relationships between SP500 and VIX shall be drawn. Further the understanding on the theoretical relationship between SP500 and VIX. This should be supportive to subsection 2.5.

2.4 Portfolio — basics [15]

Construct a portfolio

$$\Pi_1 = \alpha VIX + (1-\alpha)SP500 \tag{1}$$

One may tune $\alpha = 0.25$ to start with. Here VIX can be thought as purchasing a VIX contract, SP500 can be thought as purchasing the SP500 future.

Tip: by noting the word "a VIX contract", one should be able to identify that there are several ways this portfolio can be constructed, as there are a good variety of VIX futures tradable at one time, due to the various expiration dates.

Construct another portfolio

$$\Pi_2 = \alpha VIX + (1-\alpha)\Pi(SP500) \tag{2}$$

where $\Pi(SP500)$ is a selective portfolio of the leading stocks in SP500 — this can be constructed in many ways, typical methods include capital weighted selections, top-10 capitalised stocks, sector selections and etc.

Evaluate the portfolio with reasonable metrics, e.g. Annualised returns, Shapre Ratio, Sortino Ratio, Drawdown, etc.

Consider the actual trading costs — say 0.5% of the actual price, design trading strategies for practical executions.

Clarification: the VIX contracts tradable here would be the one which expires every month, e.g. we trade with VX+VXT U5 rather than VX+VXT36 U5.

Tip: It is reasonable to assume that we can trade SP500 index. However, one shall not trade VIX spot, as it is not reasonable to trade VIX spot (as it underlines a frequent rebalancing) in practice.

2.5 Portfolio — further techniques [20]

Consider the aforementioned strategy of systematically holding Π_i against holding Π_i for some period of time and holding cash for the remaining. The timing here is important as it relates to the statistical properties one may see from the VIX dataset.

Tip: one should observe the behaviour of the difference between the front month contract and the secondary (also known as the term spreads).

Detail theoretical explanations to further this observation — depending on the length of this argument, it may be put into appendix, nonetheless, a structural, no matter how lengthy, argument is awarding, and can be thought as a good groundwork for the summer research, which can be potentially published.

[3] Some Wikipedia (unreliable but basic), CBOE (reliable and basic) and other academic readings are highly encouraged. There are several papers uploaded on Slack.

Tip: such a theoretical explanation requires proper mathematical and theoretic-financial groundings. Members of the group should work together to address this point. Try to utilise the advantage of different members' backgrounds and minds!

Suppose we could only trade at most twice per month [4], discuss the impact to the aforementioned analysis.

3 Q & A

- What is the proper way to approach other members?

  A: Slack or any other suitable online communication. It is not advisable to break government guideline to meet physically for the sake of communication on this project.

- How long will the presentation be?

  A: We can decide this later on. It is again not advisable to assume you have three hours or more to present. This work is not a PhD thesis, and neither is your presentation and PhD defence.

[4] That is, we place all trading tickets at most twice per month — so one should suppose the trading to be done for at most two days in a month.