

STA2202 Time Series Analysis Project: Cross-Asset Stable Indices

A: Objectives

The main objective of this project is to evaluate the students' ability to apply theory and basic techniques discussed in the Time Series Analysis class for building market portfolios or indices. Students are expected to demonstrate their ability to prepare, analyze, transform and fit market data, measure association of time series, construct and optimize index/portfolio according to specifications, and present their results of analysis and benchmarking in front of the class and industry practitioners.

B: Cross-Asset Stable Indices

The class is divided on four teams (3 or 4 students in each) that will work separately on the construction of the following four Stable Indices (Precious Metals 10, Construction 11, Energy 12, and Agriculture 12):

Cross-asset Stable Indices				Indices			
##	Asset Classes	Assets	Ticker	Precious Metals 10	Construction 11	Energy 12	Agriculture 12
1	Units of Measure	Special Drawing Rights	XDRUSD	Y	Y	Y	Y
2	Fiat Currencies	USD	USD	Y	Y	Y	Y
3		Euro	EURUSD	Y	Y	Y	Y
4		JPY	JPYUSD	Y	Y	Y	Y
5		China Yuan Renminbi	USDCNY	Y	Y	Y	Y
6	Crypto Currencies	Bitcoin	BTC	Y	Y	Y	Y
7		Ethereum	ETH	Y	Y	Y	Y
8		Ripple	XRP	Y	Y	Y	Y
9		Monero	XMR	Y	Y	Y	Y
10	Precious Metals	Gold	__XAU_BD	Y			
11		Silver	__XAG_HD	Y			
12	Materials	Copper	__CU_NYD		Y		
13		Steel	CHRIS-CME_HR1		Y		
14		Aluminum	CMALSD		Y		
15	Energy	Brent Crude Oil	BRT_D			Y	
16		Gasoline	CMUSGD			Y	
17		Natural Gas	CMLNGM			Y	
18		Uranium	CMU3O8M			Y	
19	Agri Commodities	Wheat	__W_USSD				Y
20		Soy	__SYB_TD				Y
21		Cattle	_ICXD				Y
22		Lumber	CHRIS-CME_LB1				Y

- i. The base currency or Units of Measure for all indices should be the [Special Drawing Rights](#) (XDR) issued by the International Monetary Fund, i.e., the prices of all assets should be converted to values in XDR.
- ii. The goal of all the indices should be constructing a **minimum variance index** denominated in XDR for all calendar quarter ends starting from March 31, 2017 through September 30, 2019
 - a. The index should be calculated as an weighted average of asset prices that compose the

index
$$I(t) = \sum_{n=1}^N (C_n^i \times A_n(t)) = \sum_{n=1}^N \frac{w_n^i \times I(T_i)}{A_n(T_i)} \times A_n(t),$$

where i is the number of a calendar quarter, $I(T_i)$ is the index value at the end of calendar quarter i , $A_n(T_i)$ – the price of the asset n of the index at the end of quarter i , $A_n(t)$ – the market price of the asset n of the index during calendar quarter $(i + 1)$, w_n^i are non-negative weightings of the assets calculated and fixed at the end of i^{th} calendar quarter with constraints $\sum w_n = 1$ and $w_n = [1\%; 25\%]$, C_n^i is the number of units (could be fractional) of the n^{th} asset calculated at the end of i^{th} calendar quarter, $n = 1, \dots, N$ – number of assets (from 10 to 12) in the index.

- b. The index needs to be rebalanced (i.e. weightings will change) at the end of every calendar quarter between March 31, 2017 and September 30, 2019 by minimizing the variance of the index value based on the observations of the log- or other appropriately transformed returns of daily asset prices measured in XDR for the last six months. In other words, you would need to find **a vector of weightings that minimize the variance of the index at each quarter end**:
$$W_i = \min(Var I_i).$$
 - c. The initial index value on March 31, 2017 should be calibrated to 100, i.e. $I(0) = 100$.
 - d. At the end of your work, the index level should be compared with levels of the asset classes that constitute the index by using one major asset from each asset class (e.g. USD, BTC, and Gold for the Precious Metals Index 10, assuming that USD, BTC, and Gold had the highest weightings in the index for their respective asset class at the inception of the index on March 31, 2017) at the ends of each quarter from March 31, 2017 through September 30, 2019. The value of the benchmarked assets should be set to 100 on March 31, 2017. In other words, you will be benchmarking the performance of several portfolios (e.g. Index, USD, BTC, and Gold) assuming that all money at inception were invested in either Index, USD, BTC, or Gold.
- iii. The raw data with asset daily prices given to you in an Excel spreadsheet were obtained for the period from September 30, 2016 through September 30, 2019 from the following sources:
 - a. <https://www.quandl.com/>
 - b. <http://www.globalfinancialdata.com/>
- iv. It is expected that teams would understand and validate the notations, denomination and nature of the raw data prior to using the data sets.
- v. The best judgement should be applied to situations where some data points might be removed or interpolated. The rational of doing that should be provided.

C: Content of Projects

Teams are expected to write a report and make a presentation in front of the class and invited industry practitioners that would include the following *inter alia*:

- Tell comprehensive, but concise story of the time series analysis, construction of the index, and observations or conclusions made at various stages of the work
- Demonstrate the work that is done with consideration of the main topics from the time series analysis course:
 - preparing, cleansing, ordering and transforming (e.g. log) raw data. VERY IMPORTANT: Poorly prepared data might invalidate the project results.
 - univariate analysis, transformation, fitting, bootstrapping and selecting models (distributions)
 - multivariate analysis, covariance matrix construction and testing
 - you may try to use copula, ARMA and GARCH models. Given the tight timeline of our lectures, these topics might be discussed at the very end of the course. It is not required to use these models, at the same time, those teams that would try to use them, would be considered for higher marks
 - calculation of asset weightings given the objective function and constraints
 - benchmarking the index against major single assets per class for each quarter end date.
- Work to be done in **R** with a freedom of using any credible packages and functions.
- Additional analysis and modelling that would be done outside the time series analysis topics, if successful, would give additional credit to the teams.
- The bottom line is that the teams in their work on the project are not constrained by the materials of our course. At the same time, the report and presentation should demonstrate the usage of the theory and concepts discussed at the course.

D: Format

The **group reports** should cover all stages of data treatment, analysis, testing, and modelling and include:

- Description of the work done
- R code used
- Conclusions and observations
- Not more than 20 pages, including appendices, but excluding R code.

The **group presentations** should have the following parameters:

- All teams will be presenting in the classroom **OI G162 from 6:00pm to 9:00pm on Tuesday December 3rd, 2019**
- Each team will have not more than 20' of presentation time, including Q&A
- Every team member would be co-presenting
- A PowerPoint presentation or any other multimedia application is acceptable
- We suggest the slides deck would have not more than 20 slides, given the presentation time constraints. In addition to the slides, teams might create appendices with relevant information.

Appendices could demonstrate the depth of the team's research and analysis and might help to answer possible questions during the Q&A time.

E: Evaluation & Deliverables

The team and individual student's work will be evaluated based on comprehensiveness of the content, quality of the report, successful presentation and ability to answer questions at corresponding Q&A discussions. The Project will contribute 50% to the overall grade for the course.

We expect some industry practitioners will join us at the presentation session to facilitate Q&A discussions after each team's presentation.

All team presentations and reports must be uploaded on Quercus by 11:59pm on December 2nd, 2019.