

Risk measurement for portfolios in Fixed-income and Currency markets

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Research question and Audience

- **Objective**

Estimate the maximum loss generated by fluctuation in market prices for a **portfolio** comprised with **Fixed-Income** instruments and spot position in several foreign **currencies**.

- **Audience**

Portfolio managers, Investors, Investment banks, regulators and general public with interest to invest in the fixed-income and currency markets.

Exposure identification

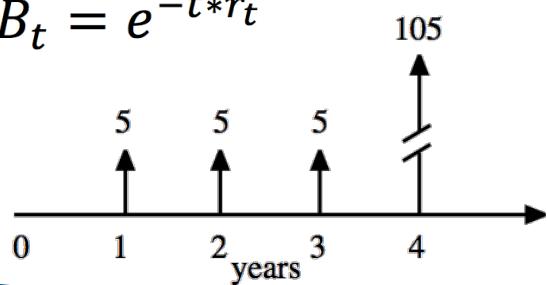
- Fixed-Income instruments

Price=PV of bond cash flows:
coupon + principal

$$P_t = c \sum_{t_i}^T B_{t_i} + B_T$$

where:

$$B_t = e^{-t * r_t}$$



- Spot position in currencies

The risk exposure of these positions are function of the exchange rate.

Bonds denominated in foreign exchange are also under the effect of this factor.

Risk Factor dynamics

- Factors driving the prices of financial securities in the portfolio are **zero-coupon interest rates** and **foreign exchange rates**.
- We suppose that the process generating the changes for the i -th risk factor can be written as:

$$\frac{dP_t^{(i)}}{P_t^{(i)}} = \mu_i dt + \sigma_i dW_t^{(i)},$$

It follows that the return on each asset from time t to time $t+T$ can be written as:

$$r_{t,T}^{(i)} = (\mu_i - \frac{1}{2}\sigma_i^2)(T - t) + \sigma_i \varepsilon_i \sqrt{T - t}$$

With:

$$\varepsilon_i \sim N(0, 1)$$

Volatilities and covariances are estimated using a EWMA

$$\sigma_{1,t+1|t}^2 = (1 - \lambda) \sum_{i=0}^{\infty} \lambda^i r_{1,t-i}^2$$

Data set

Treasury Yield Curve Rates

- Source: US Department of treasury, Resource Center
<http://www.treasury.gov/resource-center>
- Daily quotes with the yield-to-maturity rates for terms covering: 3m, 6m, 1y, 2y, 5y, ..., 30y
- A xml file for each year 2006–2014
- Data located in label text

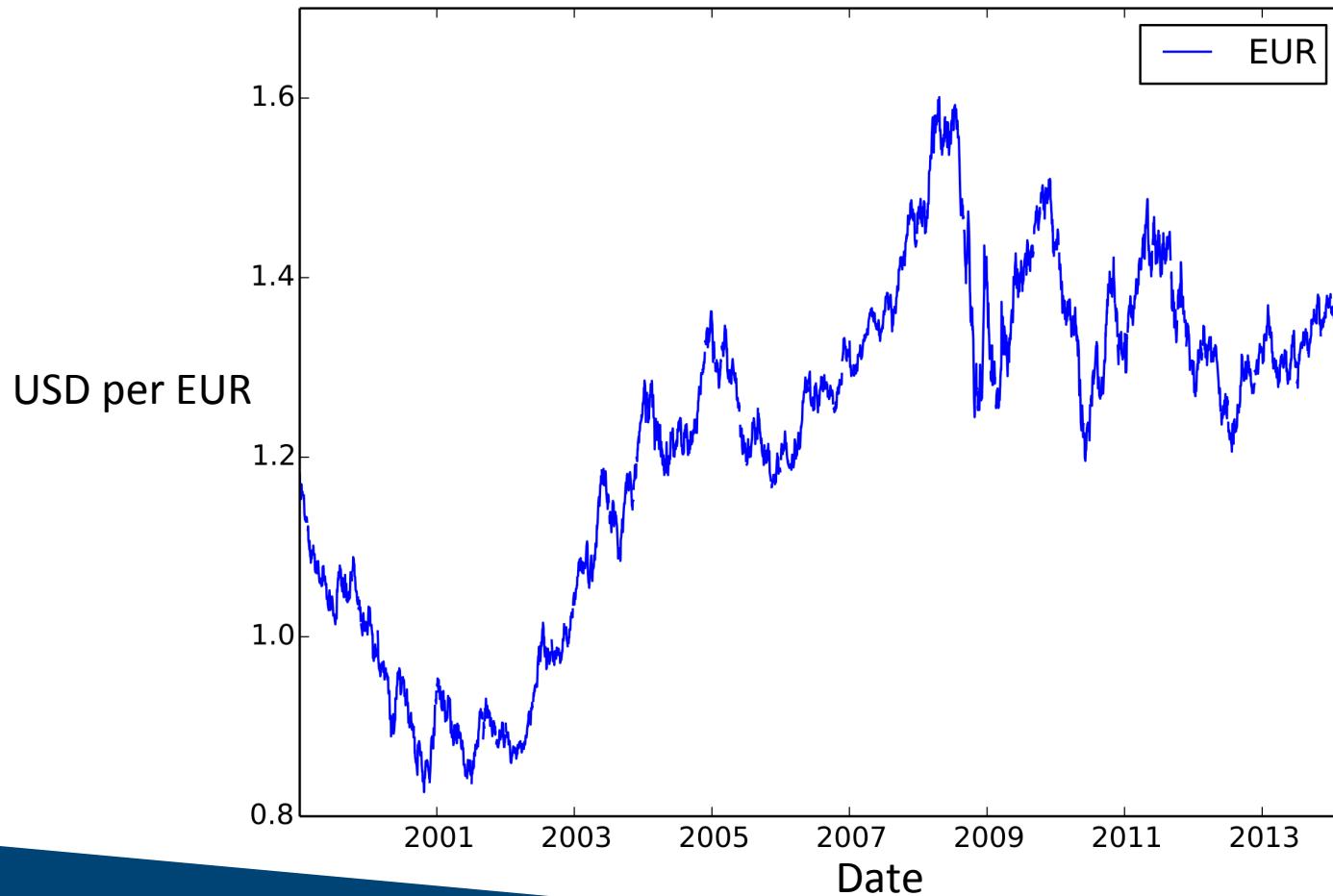
Foreign Exchange Rates

- Source: US Federal Reserve, data download program
<http://www.federalreserve.gov/datadownload>
- Daily exchange rates for most of the currencies in the world.
- Zip file containing one xlm file for historical data
- Data nested inside label attributes

Implementation

Historical Data

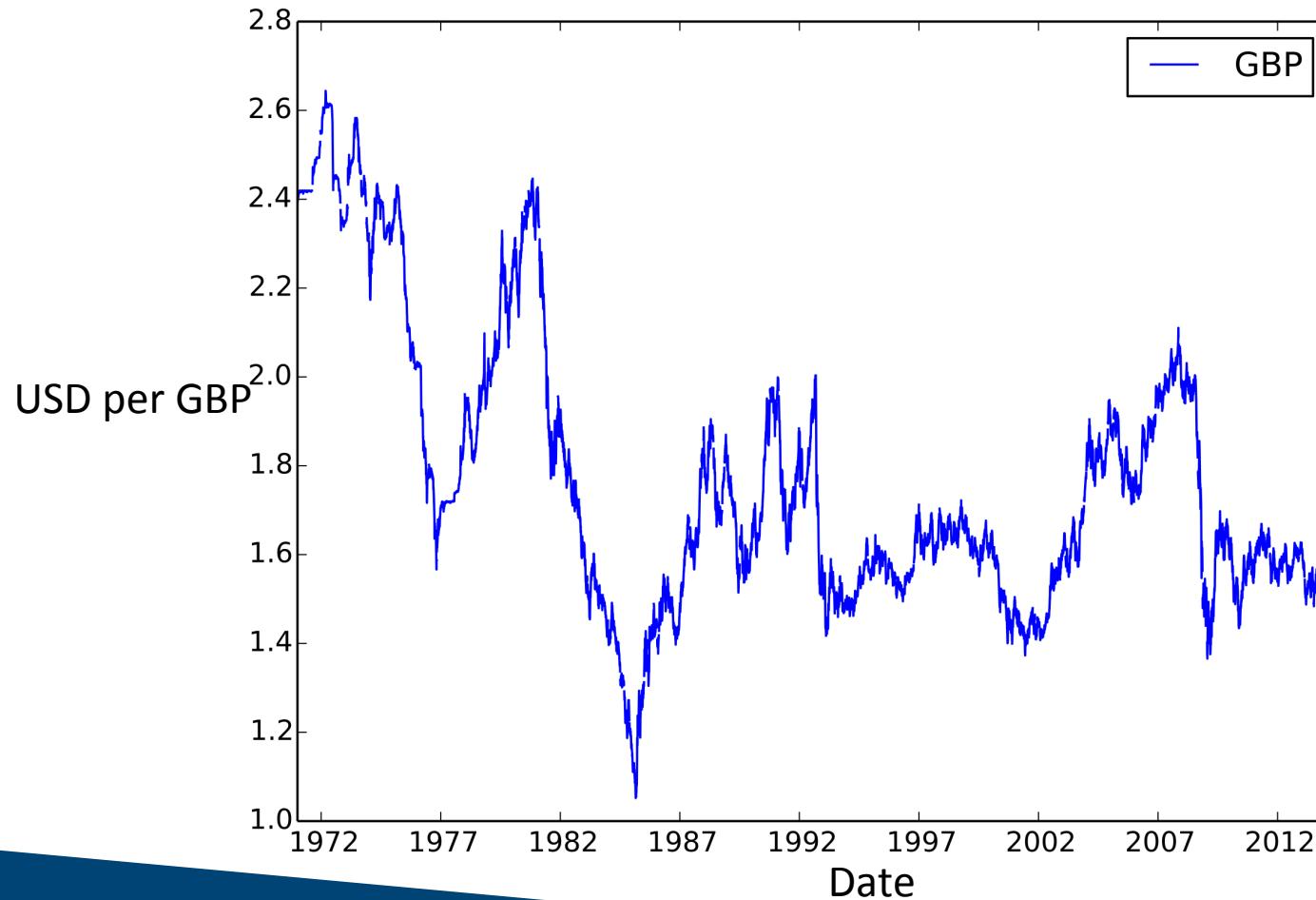
Currencies



Implementation

Historical Data

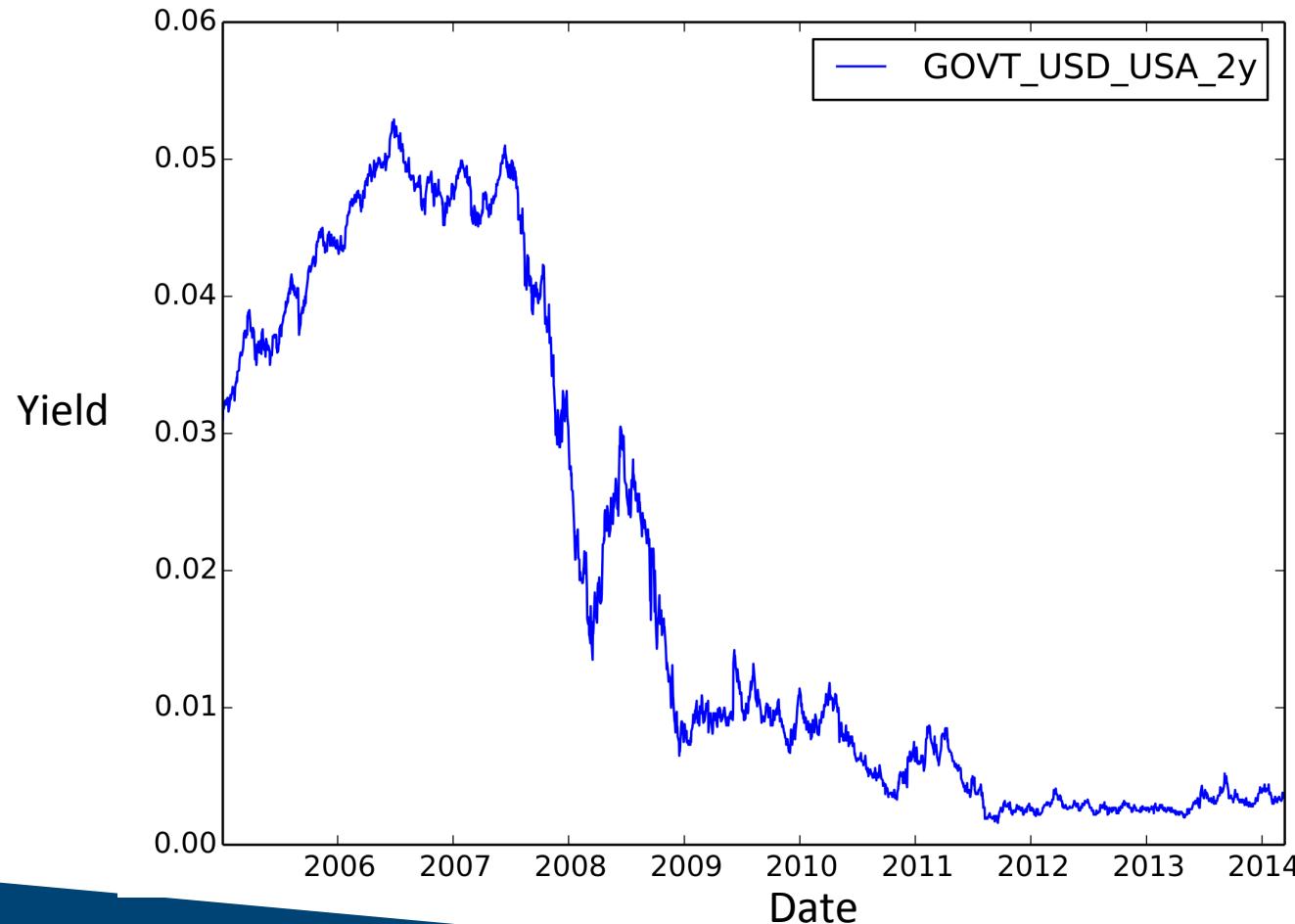
Currencies



Implementation

Historical Data

Treasury Rates



Implementation

Historical Data

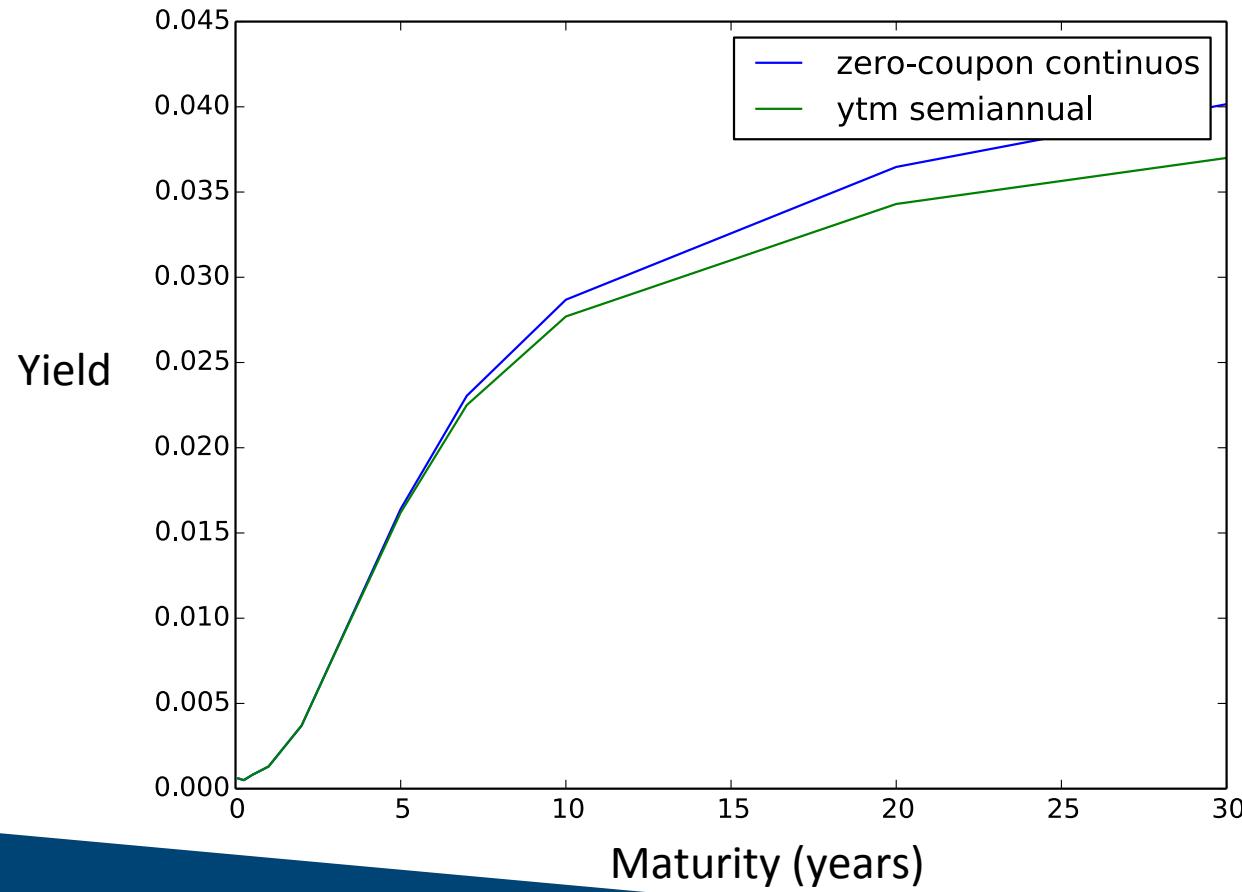
Treasury Rates



Implementation

Historical Data

YTM to zero-coupon yields
(Bootstrap method)



Results

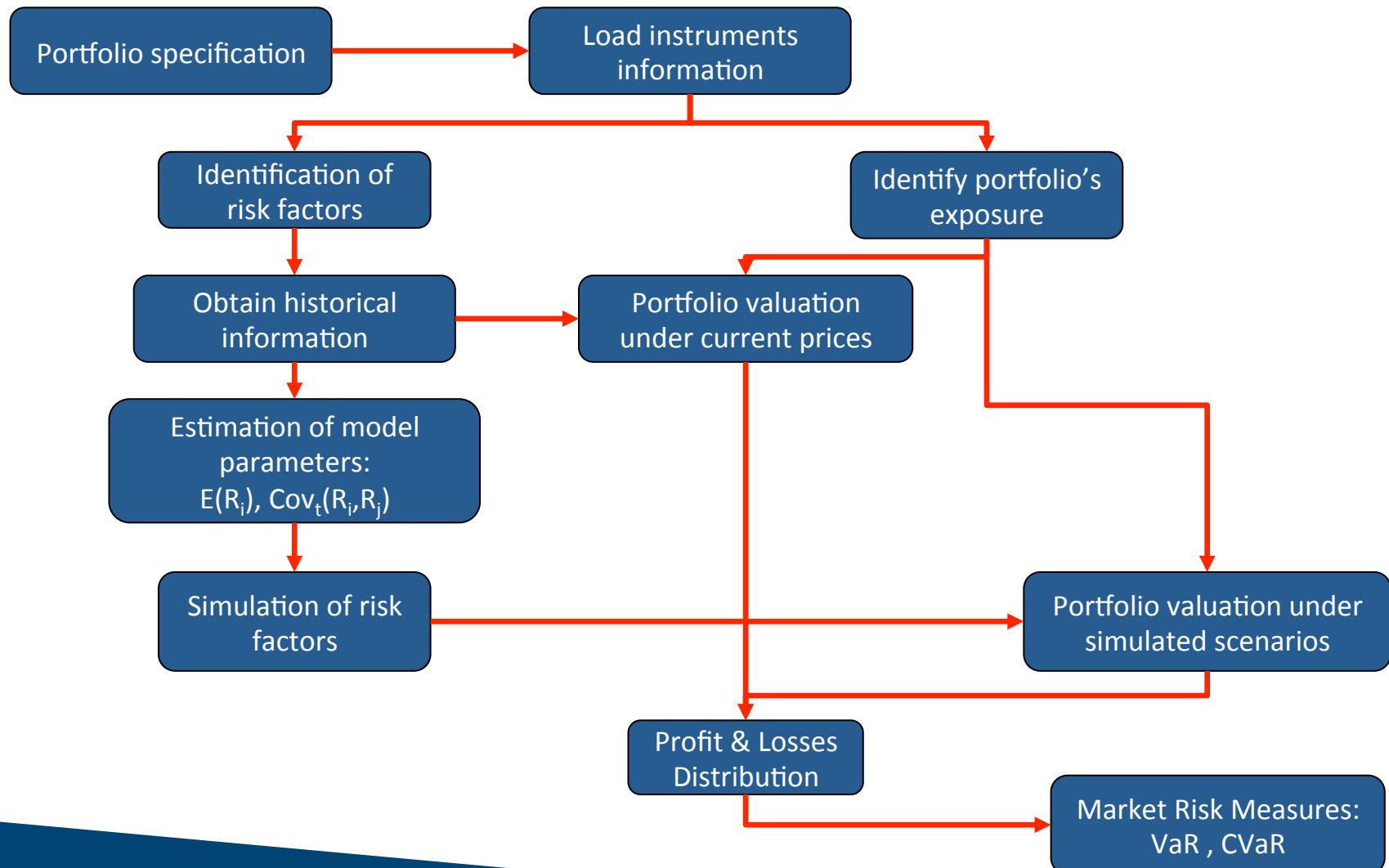
Covariance

Correlation estimation

	AUD	CAD	CHF	CNY	EUR	GBP	JPY	NOK	NZD	SEK	SGD	1m	3m	6m	1y	2y	3y	5y	7y	10y	20y	30y
AUD	1.00	0.59	0.29	0.04	0.30	0.26	0.37	0.54	0.71	0.40	0.64	0.15	0.04	0.15	-0.08	-0.33	-0.17	-0.32	-0.36	-0.33	-0.36	-0.42
CAD	0.59	1.00	0.18	0.05	0.21	-0.02	0.48	0.36	0.48	0.26	0.36	-0.06	0.00	0.08	0.05	-0.22	-0.14	-0.27	-0.22	-0.18	-0.21	-0.23
CHF	0.29	0.18	1.00	0.15	0.95	0.49	0.34	0.61	0.36	0.64	0.58	-0.07	0.04	0.08	-0.26	-0.18	-0.35	-0.39	-0.42	-0.35	-0.26	-0.26
CNY	0.04	0.05	0.15	1.00	0.17	0.22	-0.18	0.08	0.12	0.14	0.14	0.08	0.14	0.16	0.08	-0.03	0.01	-0.02	-0.03	-0.05	-0.09	-0.08
EUR	0.30	0.21	0.95	0.17	1.00	0.50	0.25	0.62	0.34	0.67	0.54	-0.12	0.04	0.10	-0.23	-0.17	-0.30	-0.34	-0.37	-0.30	-0.22	-0.20
GBP	0.26	-0.02	0.49	0.22	0.50	1.00	-0.03	0.44	0.24	0.49	0.36	-0.16	-0.13	0.09	-0.39	-0.27	-0.33	-0.26	-0.17	-0.11	-0.04	-0.07
JPY	0.37	0.48	0.34	-0.18	0.25	-0.03	1.00	0.34	0.23	0.23	0.46	0.03	0.08	0.05	-0.01	-0.35	-0.41	-0.44	-0.44	-0.37	-0.23	-0.23
NOK	0.54	0.36	0.61	0.08	0.62	0.44	0.34	1.00	0.44	0.72	0.54	0.04	-0.04	0.08	-0.22	-0.35	-0.45	-0.51	-0.52	-0.44	-0.38	-0.37
NZD	0.71	0.48	0.36	0.12	0.34	0.24	0.23	0.44	1.00	0.38	0.57	0.10	0.02	0.02	0.02	-0.28	-0.22	-0.37	-0.43	-0.41	-0.42	-0.39
SEK	0.40	0.26	0.64	0.14	0.67	0.49	0.23	0.72	0.38	1.00	0.44	-0.04	-0.03	0.19	-0.14	-0.25	-0.37	-0.39	-0.41	-0.31	-0.26	-0.28
SGD	0.64	0.36	0.58	0.14	0.54	0.36	0.46	0.54	0.57	0.44	1.00	0.17	0.11	0.21	-0.21	-0.40	-0.38	-0.45	-0.43	-0.34	-0.20	-0.23
1m	0.15	-0.06	-0.07	0.08	-0.12	-0.16	0.03	0.04	0.10	-0.04	0.17	1.00	0.35	0.19	0.12	-0.09	0.02	-0.12	-0.17	-0.19	-0.14	-0.21
3m	0.04	0.00	0.04	0.14	0.04	-0.13	0.08	-0.04	0.02	-0.03	0.11	0.35	1.00	0.55	0.13	0.02	0.03	-0.02	-0.06	-0.03	0.01	-0.04
6m	0.15	0.08	0.08	0.16	0.10	0.09	0.05	0.08	0.02	0.19	0.21	0.19	0.55	1.00	0.18	-0.03	-0.07	-0.05	-0.04	0.04	0.09	0.02
1y	-0.08	0.05	-0.26	0.08	-0.23	-0.39	-0.01	-0.22	0.02	-0.14	-0.21	0.12	0.13	0.18	1.00	0.19	0.22	0.10	0.03	-0.02	-0.08	-0.03
2y	-0.33	-0.22	-0.18	-0.03	-0.17	-0.27	-0.35	-0.35	-0.28	-0.25	-0.40	-0.09	0.02	-0.03	0.19	1.00	0.72	0.65	0.54	0.42	0.26	0.24
3y	-0.17	-0.14	-0.35	0.01	-0.30	-0.33	-0.41	-0.45	-0.22	-0.37	-0.38	0.02	0.03	-0.07	0.22	0.72	1.00	0.88	0.77	0.63	0.41	0.33
5y	-0.32	-0.27	-0.39	-0.02	-0.34	-0.26	-0.44	-0.51	-0.37	-0.39	-0.45	-0.12	-0.02	-0.05	0.10	0.65	0.88	1.00	0.94	0.85	0.67	0.57
7y	-0.36	-0.22	-0.42	-0.03	-0.37	-0.17	-0.44	-0.52	-0.43	-0.41	-0.43	-0.17	-0.06	-0.04	0.03	0.54	0.77	0.94	1.00	0.95	0.82	0.74
10y	-0.33	-0.18	-0.35	-0.05	-0.30	-0.11	-0.37	-0.44	-0.41	-0.31	-0.34	-0.19	-0.03	0.04	-0.02	0.42	0.63	0.85	0.95	1.00	0.92	0.85
20y	-0.36	-0.21	-0.26	-0.09	-0.22	-0.04	-0.23	-0.38	-0.42	-0.26	-0.20	-0.14	0.01	0.09	-0.08	0.26	0.41	0.67	0.82	0.92	1.00	0.95
30y	-0.42	-0.23	-0.26	-0.08	-0.20	-0.07	-0.23	-0.37	-0.39	-0.28	-0.23	-0.21	-0.04	0.02	-0.03	0.24	0.33	0.57	0.74	0.85	0.95	1.00

Implementation

Algorithm Flow Diagram



IPython notebook implementation

This project implemented RiskMetrics methodology in IPython notebook.

- Data Loading
- Portfolio loading
- Simulation of risk factors (scenarios)
- Cash flows identification
- Portfolio Valuation
- P&L calculation
- Estimation of Value-at-Risk

- Back testing

Benefits

- Indexing properties
- Time Series attributes

Problems

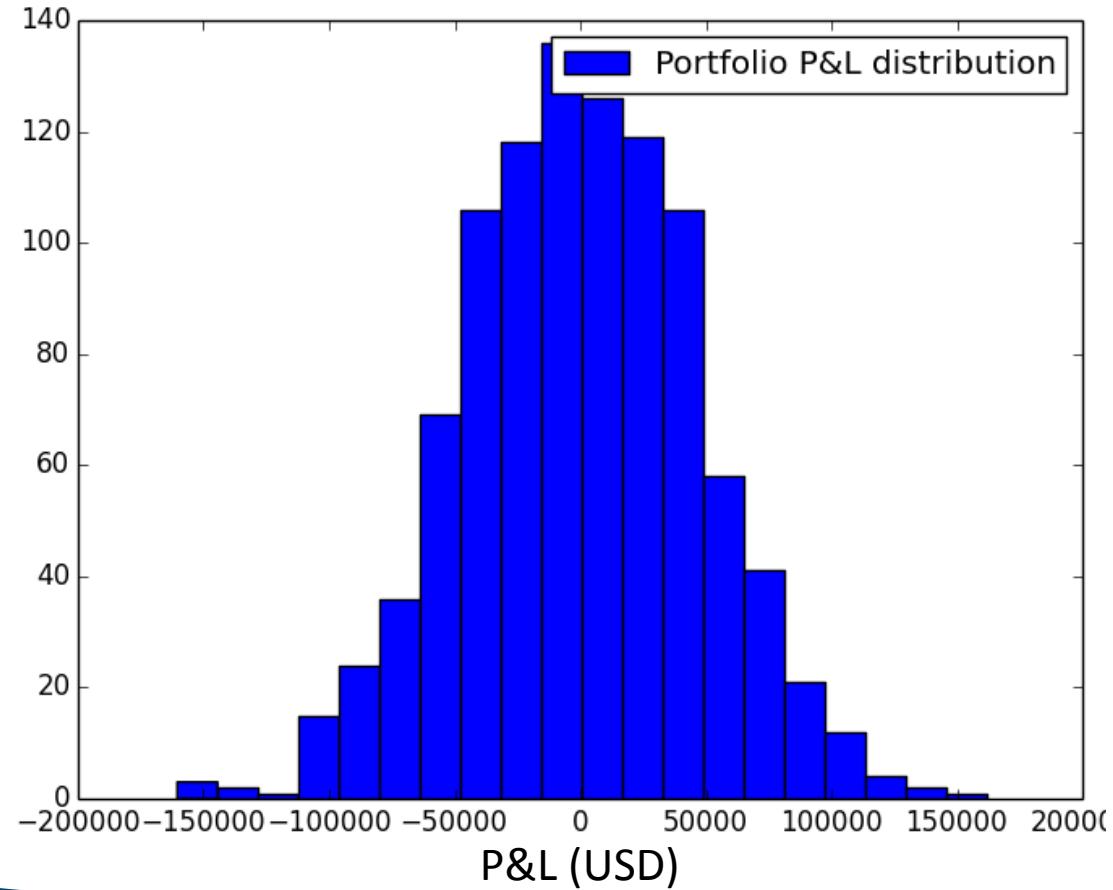
- Visualization of big data frames
- Plotting customization

Results

VaR estimation

Value-at-Risk Estimation

Level (%)	Portfolio Value-at-Risk (USD)
90	60,336
95	74,573
97.5	92,676
99	106,956



Back testing

2013

Back testing

