Risk measurement for portfolios in Fixed-income and Currency markets

Christian Carmona

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Berkeley
UNIVERSITY OF CALIFORNIA

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

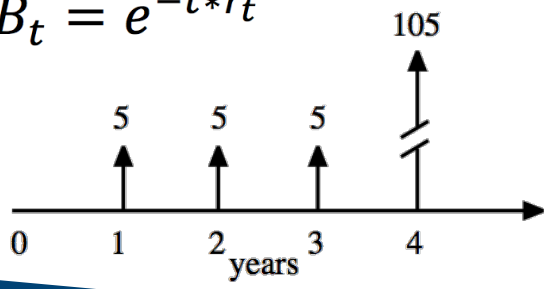
- **Fixed-Income instruments**

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

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

Data set

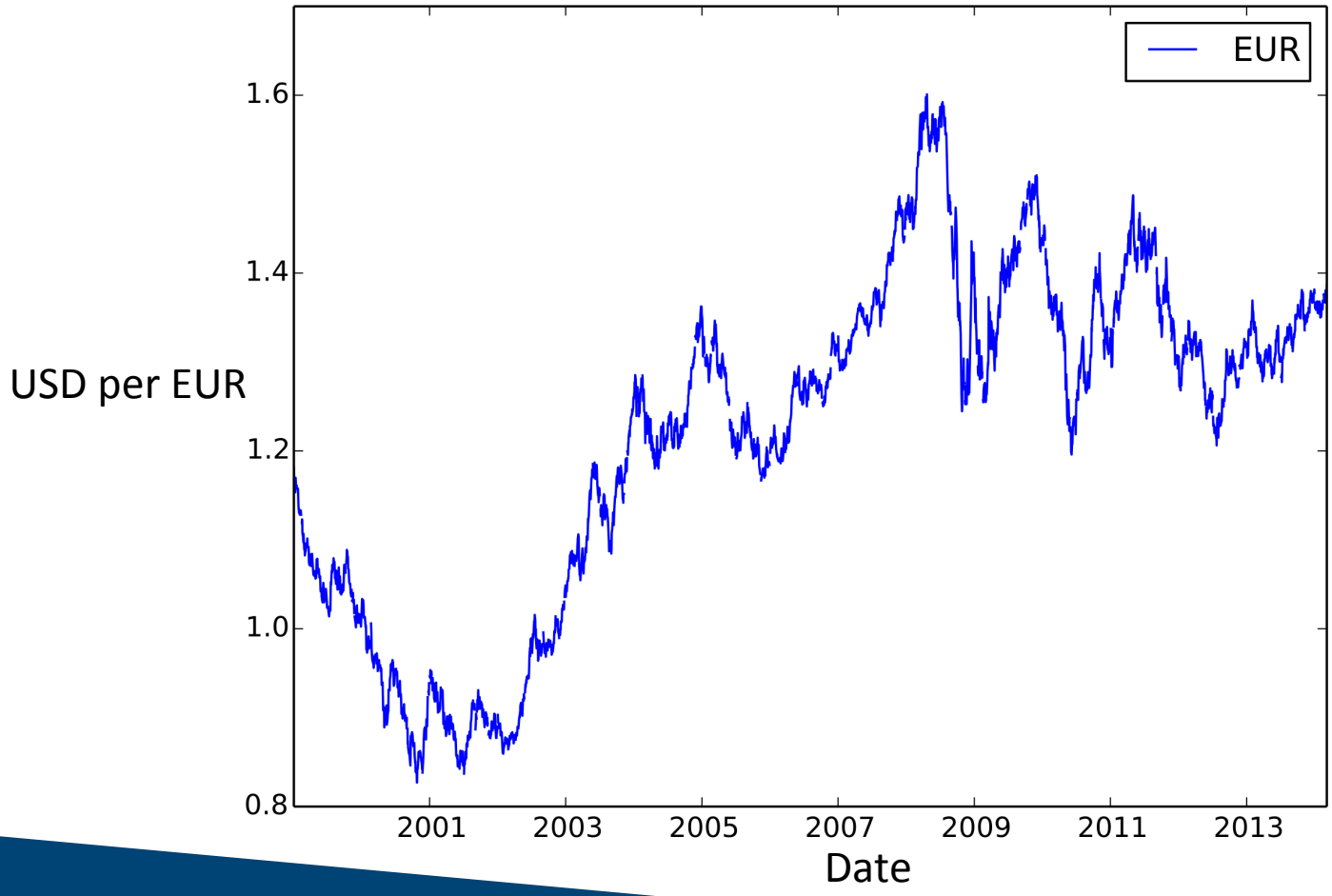
Treasury Yield Curve Rates

- 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

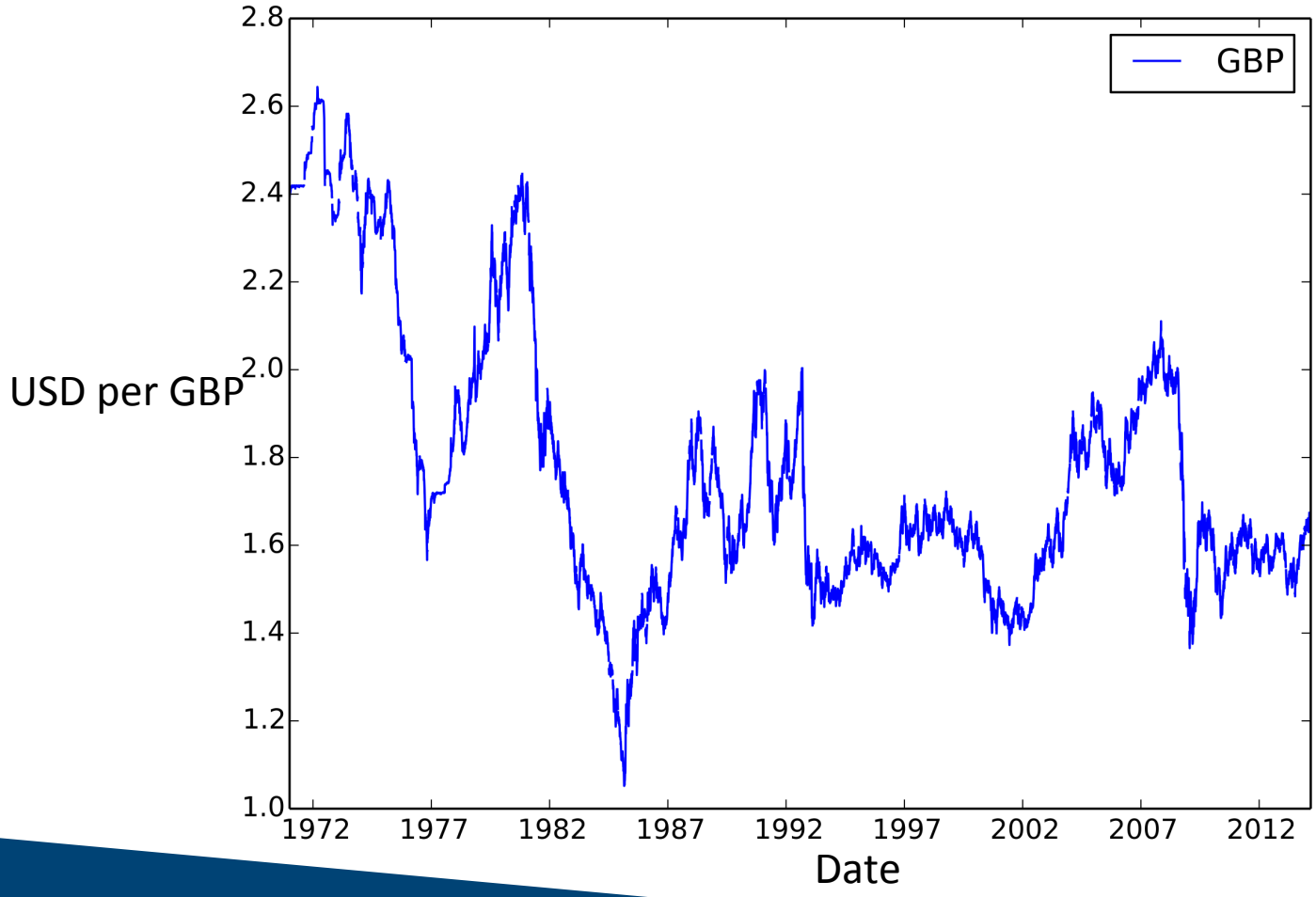
Foreign Exchange Rates

- 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

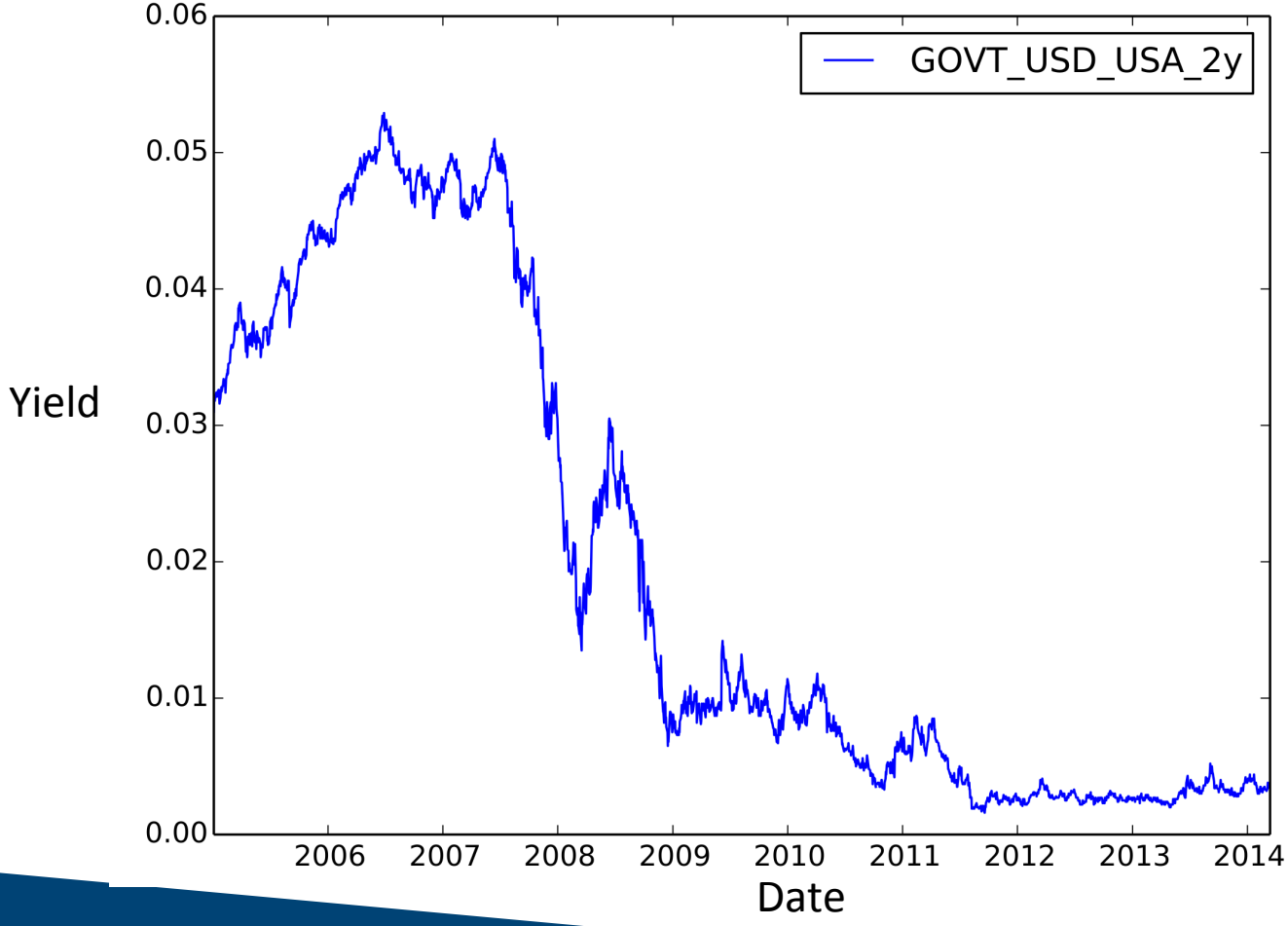
Currencies


EUR
1.6
1.4
1.2
1.0
0.8
USD per EUR
2001
2003
2005
2007
2009
2011
2013
Date

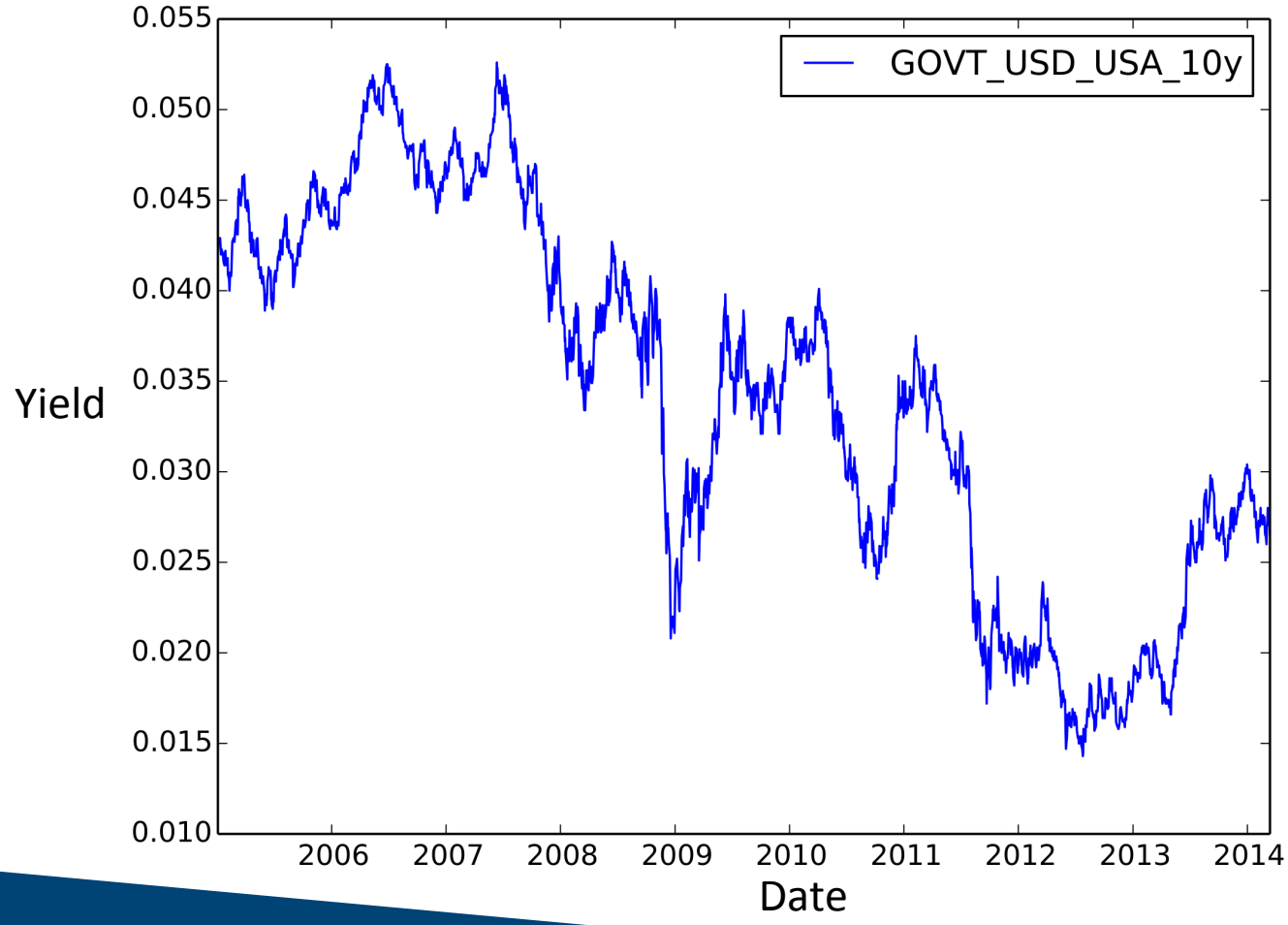
Currencies


GBP
USD per GBP
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
1972
1977
1982
1987
1992
1997
2002
2007
2012
Date

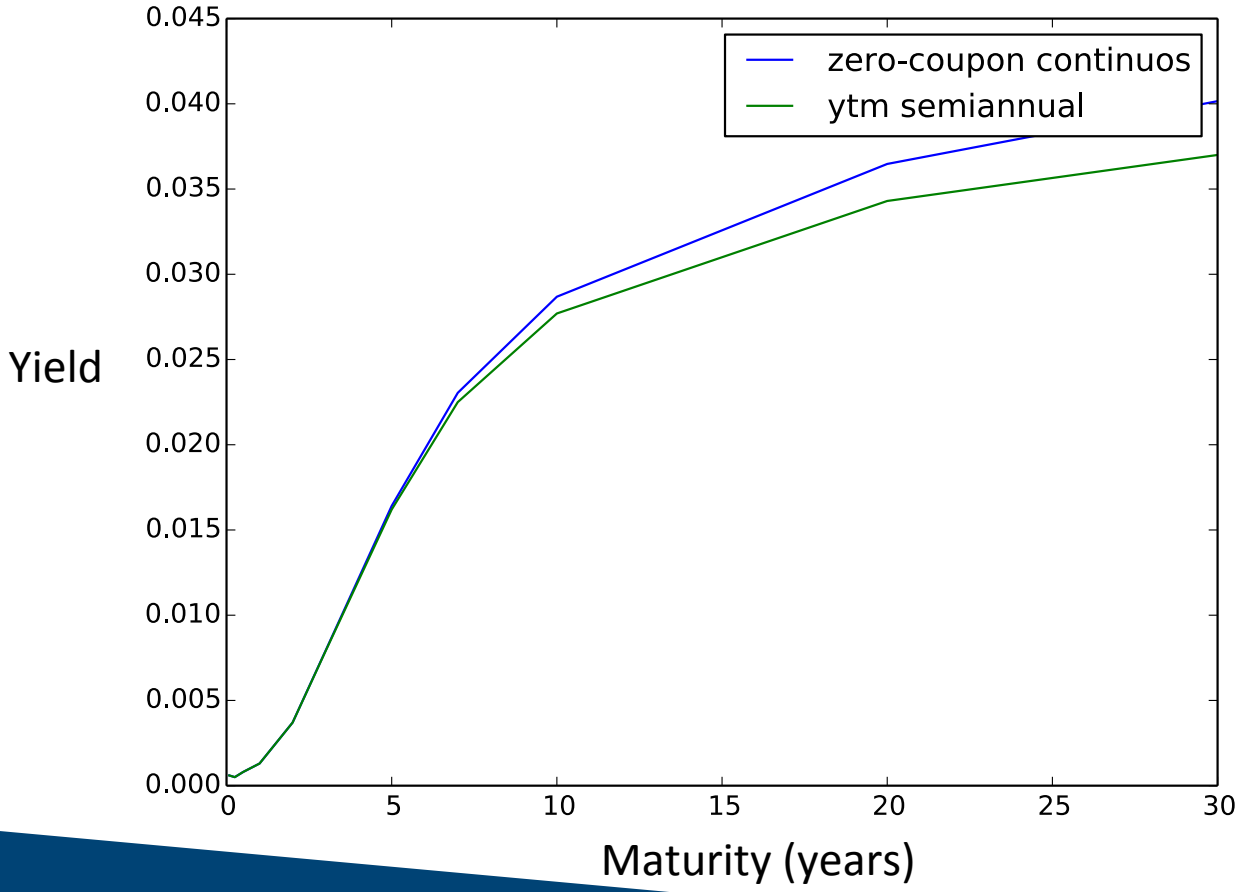
Treasury Rates



Treasury Rates



YTM to zero-coupon yields (Bootstrap method)

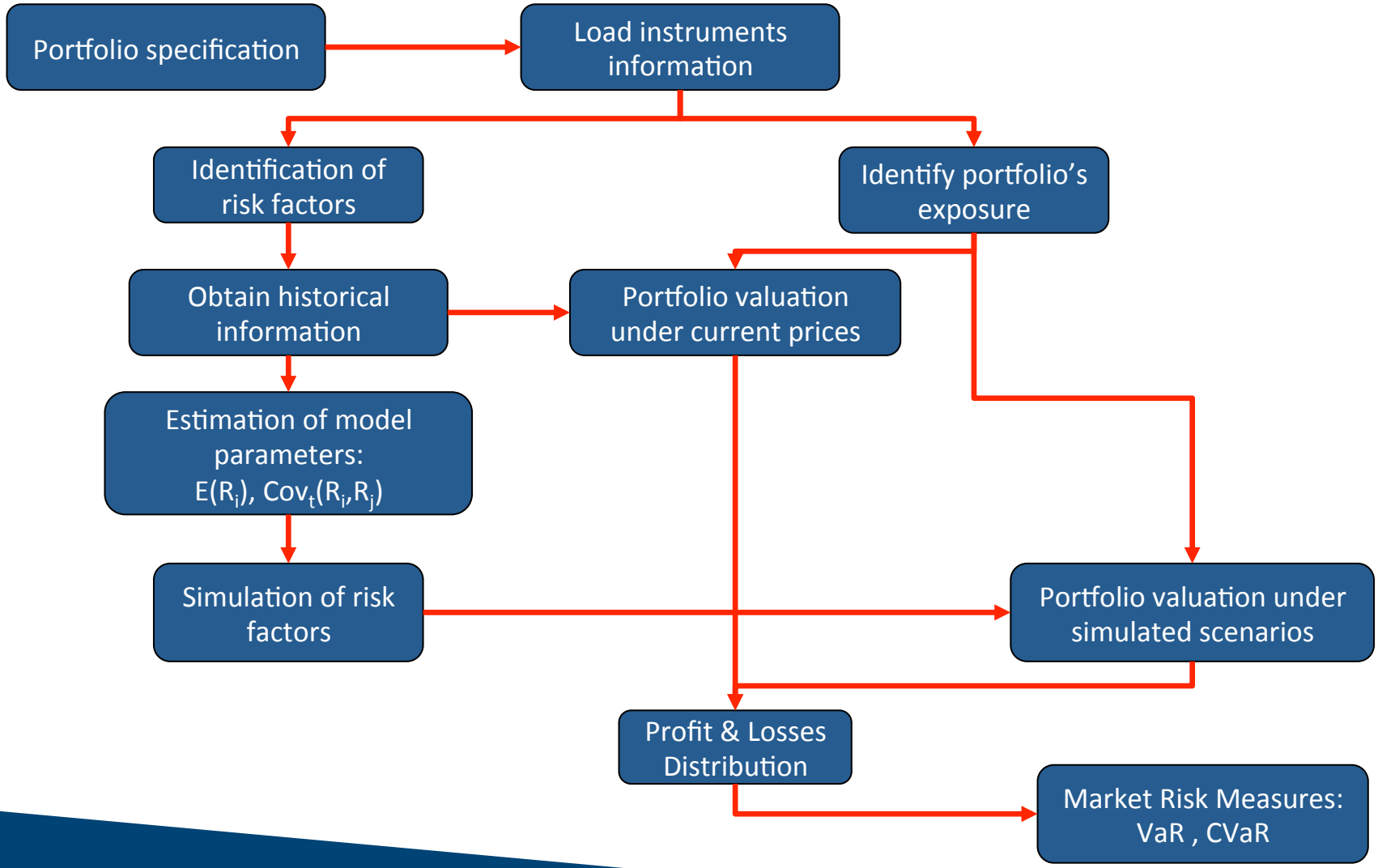


Correlation estimation

	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

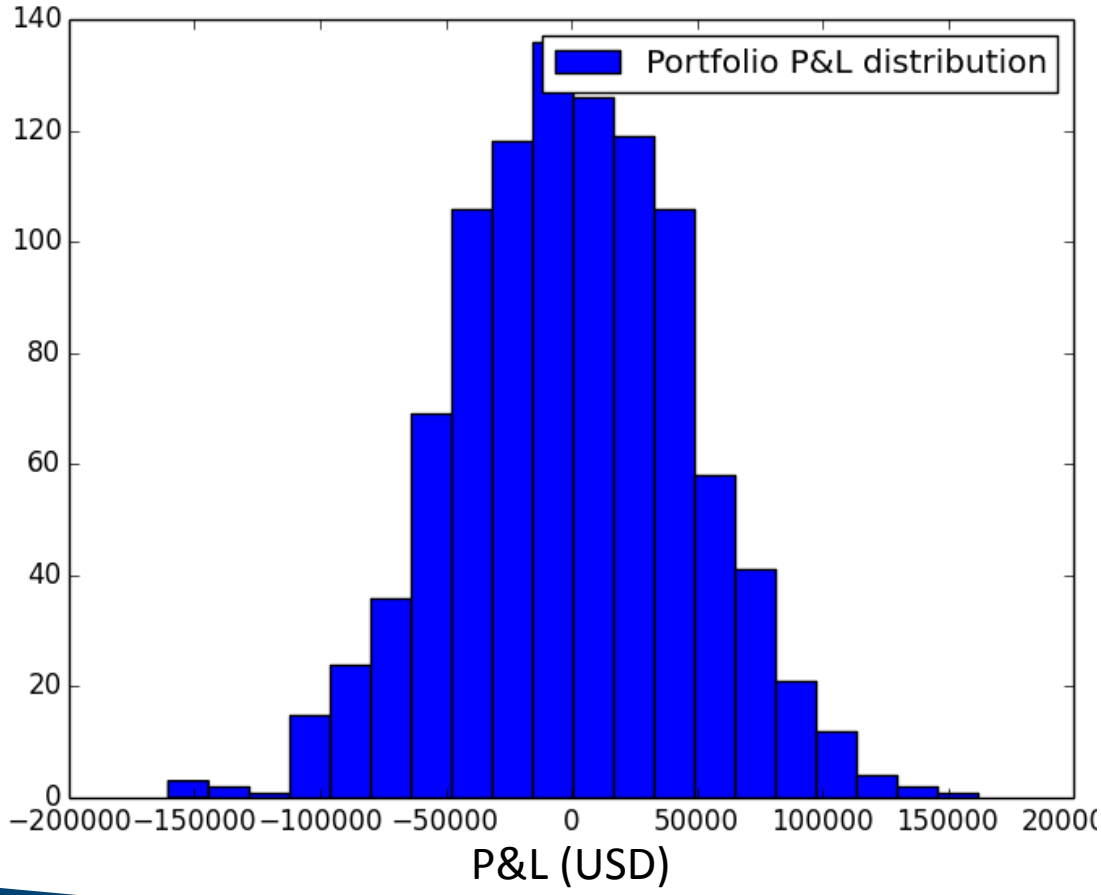
- Indexing properties
- Time Series attributes

Problems

- Visualization of big data frames
- Plotting customization

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