

Liquidity Risk

Q1)

Consider there's a portfolio including the stocks below

Ticker	فولاد	خودرو	وتجارت	شتران	تشاهد
Number of shares in portfolio	5500000	10000000	6000000	7500000	2500000

Download and install the package "finpy-tse". This is a Python module to access Tehran Stock Exchange historical and real-time data. You can see the documentation [here](#).

- Using "finpy-tse", get the intraday orderbook history of the stocks given from 1403-01-20 to 1403-02-20. Rearrange the data to the form in the file "Orderbook Example.xlsx" for each stock, containing one Dataframe in which each row corresponds to a second in which the market is open. Display the Dataframe.
- Define a function that gets the orderbook data and returns the spread corresponding to each second. Use the function and arbitrarily plot the spread chart (in percent) for one of the stocks above. Explain what does high (and low) spread mean.
- Using the portfolio data, calculate the liquidity risk for the portfolio in Rials. Determine the highest and lowest liquidity risk for the portfolio. Plot the results. (Suppose that the orders volume on the both sides of ask and bid are infinite and there's no orders further.)
- Calculate monthly adjusted VaR considering the risk of liquidation.
- What suggestions do you have for a stockholder when she wants to sell her shares in bulk?
- (Optional) In illiquid markets like what we used to have in Iran, bulk selling can issue some problems, mention a couple of them. Can you offer some solutions?

Credit Risk

Q2)

Suppose you're a risk manager at Moody's. You're going to assess the risk of a given set of companies using Merton's model considering quantitative methods. The debts and the current market values of the companies are listed in the table below:

Company	Debt Value	Market Value
Microsoft (MSFT)	\$88.347 B	\$3.182 T
Apple (AAPL)	\$104.59 B	\$2.927 T
NVIDIA (NVDA)	\$75.901 B	\$2.346 T
Alphabet (GOOGL)	\$87.98 B	\$2.207 T
AMAZON (AMZN)	\$82.865 B	\$1.899 T
Facebook (META)	\$96.573 B	\$1.178 T
Berkshire Hathaway (BRK.A)	\$87.98 B	\$895.07 B
TSMC (TSM)	\$84.392 B	\$809.09 B
Eli Lilly (LLY)	\$82.865 B	\$763.33 B
"Hypothetical 1" (SRG)	\$75.901 B	\$150.41 B
"Hypothetical 2" (DHR)	\$72.112 B	\$125.21 B

Define a function that calculates the distance to default and the default probability for all these companies. Then define another function that ranks the companies based on the table below and the default probabilities. Consider annual risk-free rate equal to 6%, annual volatility of each stock equal to 30% and $T = 1$ year. (Study the attached file named “Merton’s Model in Credit Risk Modeling.pdf”.)

**TABLE Five-Year Corporate Bond
Default Rate, 1920–2011.**

	Default Rate
Aaa	0.16%
Aa	0.80%
A	1.31%
Baa	3.09%
Ba	9.81%
B	22.25%
Caa-C	41.72%

Source: Moody’s Investors Service.

Q3)

Suppose we have a portfolio of bonds for N companies with the probability of default equal to p .

- Write a function that calculates the probability of default of m companies.
- Set $N = 20$ and $p = 0.03$. What’s the probability that none of them defaults.
- Set $N = 30$ and $p = 0.05$. What’s the probability that at least 5 of them default.
- Set $N = 40$ and $p = 0.09$. What’s the probability that at last 3 of them default.

Interest Rate Risk

Q4)

Download the historical time series of U.S treasury bills with maturities 1 year, 2 years, 5 years, 10 years and 30 years. (Your dataset must cover at least 10 years. Use daily observations.)

- Find the variance-covariance matrix.
- Tabulate the PCA factors in descending order. (Note: Do not calculate the factors by using any relating “package”.)
- Find standard deviation of factor scores and represent them in a table. How much of the changes in total variance can be explained by each of the factors?
- Plot the three most important factors in a diagram. Can you interpret these factors intuitively?
- The factors have the property that the factor scores are uncorrelated across the data. Check this property in your data for the three most important factors.

Q5)

Choose 3 of the fixed-income funds from the table below arbitrarily.

آتیه نوین	مشترک یکم ایرانیان	اندوخته پایدار سپهر	درآمد ثابت کمند	سپید دماوند
امین سامان	لوتوس پارسیان	همای آگاه	هدیه فارابی	لبخند فارابی
درآمد ثابت کاردان	امین آشنا ایرانیان	درآمد ثابت کاریزما	یاقوت آگاه	نامی مفید

- Download the most recent portfolio statement of the funds from Codal.ir and extract the bonds portfolio. Report the portfolio.
- Calculate the duration (Macauley and Modified) and the convexity for each bond distinctively. Then calculate these measures for the whole portfolio.
- Determine which bond in the portfolio is the riskiest and which one has the lowest risk (mention why!). Assume you're an investor looking for a fixed-income fund to invest in. Which fund do you choose? Based on what factors?

Operational Risk

Q6)

The Basel Committee on Banking Supervision has identified seven categories of operational risk listed below.

- Internal fraud
- External fraud
- Employment practices
- Business practices
- Damage to physical assets
- Business disruption and system failure
- Execution management

Answer the following questions using the file operation-risk.csv. Suppose that the loss frequency follows a Poisson distribution with parameter λ .

- Calculate λ .
- Generate 1000 random numbers from this Poisson distribution and plot their histogram.
- For the loss-severity, assume a lognormal probability distribution. The parameters of this distribution are the mean and the standard deviation of the logarithm of loss. Fit the lognormal probability distribution and calculate the parameters of interest.
- Plot the histogram of the loss-severity.

- e) Use Monte Carlo simulation to determine the loss distribution assuming that the loss severity is independent of the loss frequency. Set the number of trials equal to 50,000 and obtain the total loss distribution. Plot the histogram of the total loss distribution.
- f) Determine the 98, 99 and 99.9 percentiles of the distribution.
- g) Plot again the histogram of the total loss distribution and represent the 98, 99 and 99.9 percentile with a line.