Investment Analysis and Risk Management. Lecture 3. Recap. Investment Analysis. Financial instruments: fundamental analysis.

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St Petersburg, December 12, 2025

Course content

1. **Recap:** Russian market statistics, infrastructure, institutional background (already covered)
2. **Investment analysis recap:** discounting, NPV/IRR/PI, returns basics, basic risk metrics
3. **Fundamental analysis:** fixed income (pricing, YTM, duration/convexity) + equity basics (DCF, multiples)
4. **Portfolio theory fundamentals:** diversification, covariance/correlation, efficient frontier
5. **Portfolio optimization & CAPM:** constraints, Sharpe/Treynor/Jensen, benchmarking
6. **Multifactor models:** APT intuition, Fama–French-style factors, factor exposures & alpha
7. **Risk metrics:** VaR & Expected Shortfall, backtesting, stress/scenario testing
8. **Risk modelling & management toolkit:** time-varying volatility (EWMA/GARCH intuition), risk budgeting, hedging basics

Assessment and Communication

Grading formula and assessment components

- In-class participation — 30%
- Cases and problem sets — 30%
- Exam[1] — 40%

$$\textbf{\textit{Final grade}} = 0.20 \times \textit{Participation} + 0.40 \times \textit{Cases and problem sets} + 0.40 \times \textit{Exam}$$

- **Scale:** 10-point[2] scale with conversion to the 103-point scale and the A–F scale (ITMO).
- 10–8 — **excellent**; 7–6 — **good**; 5–4 — **satisfactory**; 3–1 — **unsatisfactory**; 0 — **no credit**.
- **Communication:** Telegram chat, email, or any other channel.
- I would appreciate **your feedback** throughout the course: we will adapt the content. Please tell me if something is unclear or feels too easy!

[1] We will discuss the exam format later.

[2] Rounding: the final grade is rounded to an integer using standard arithmetic rounding (to the nearest integer); intermediate grades are rounded to three decimals.

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Operational Forecasting and Cash Flow (Jul–Dec 2025)

Context

NordicPro is a small B2B manufacturer of modular equipment for commercial facilities (warehouses, retail, and light industrial sites). After signing a few new contracts in summer 2025, the CFO is asked to prepare a **six-month rolling plan** to answer three practical questions: *(i) How fast can the company grow without running out of cash? (ii) How much working capital will growth absorb? (iii) Will additional debt financing be needed, and when?*

Operational Forecasting and Cash Flow (Jul–Dec 2025)

Given (inputs; grey-highlighted cells)

- Planning horizon: **Jul–Dec 2025**, where **t=0 corresponds to Jul 2025**.
- The operational baseline month is **Aug 2025**:
  - **Units sold (Aug 2025):** 110 pcs
  - **Price per unit (Aug 2025):** \$120
  - **CoGS per unit (Aug 2025):** \$50
  - **Operating costs (Aug 2025):** \$2,800
- Working capital policy (in days):
  - **Collection period (DSO):** 15 days
  - **Inventory turnover (DIO):** 15 days
  - **Credit period (DPO):** 5 days
- **Investing cash flow (t=0, Jul 2025):** −\$1,000 (initial capex to expand capacity / upgrade equipment).

Task

- Specify assumptions for **unit sales growth** in **Sep–Dec 2025** and inflation adjustments for: **price**, **CoGS**, and **operating costs**.
- Build the monthly forecast of **revenue, costs, and operating profit**, and compute **Operating CF** including working capital effects (AR, Inventories, AP).
- Determine whether (and when) the firm needs external financing by filling **Net debt issued**, and evaluate the resulting **monthly cash balance**.

The discount rate in investment analysis

- In NPV analysis, the discount rate r acts as the **hurdle rate**: below this required return, the project is unattractive.
- In practice:
  - for **typical projects** firms often use the **Weighted Average Cost of Capital** (WACC),
  - for **riskier** or **non-standard** projects, the appropriate rate may be **above** the baseline.
- Logic:
  - if the project's risk is similar to the firm's overall business risk,
  - then the discount rate should be close to the firm's "cost of money".

Important: selecting the discount rate is not a formality; it is a **key assumption** in investment analysis.

Why does the discount rate matter for a firm?

Economic meaning for the business

For a firm, the **discount rate** is essentially the **cost of capital** used to finance projects:

- the cost of **debt financing**;
- the cost of **equity financing**.

- Firms typically finance projects from two sources:
  - debt (loans, bonds),
  - equity (share capital, retained earnings).
- Each source has its own **required return**:
  - creditors require **interest on debt**,
  - shareholders require **returns on equity**.
- The **project discount rate** should reflect this **cost of funding**, adjusted for the project's risk.

Weighted Average Cost of Capital (WACC): intuition

Intuitive definition

WACC (Weighted Average Cost of Capital) is the firm's **average cost of capital**, reflecting:

- the share of equity financing,
- the share of debt financing,
- the cost of each component.

- A firm uses a **mix** of funding sources.
- Therefore, the discount rate for cash flows attributable to **the entire firm** should reflect the **average cost** of this mix.
- If a project is **similar in risk** to the firm's existing business, **WACC** is a reasonable discount rate for the project.

WACC: formula and notation

WACC formula

$$WACC = \frac{E}{D+E} \cdot k_e + \frac{D}{D+E} \cdot k_d \cdot (1 - T)$$

- E — market value of **equity**.
- D — market value of **debt**.
- k_e — **cost of equity** (required return on equity).
- k_d — **cost of debt** (effective borrowing rate).
- T — **corporate income tax rate**: interest is tax-deductible, hence $k_d(1 - T)$.

Interpretation: WACC is the minimum average return projects must generate to **avoid destroying firm value**.

Cost of equity (k_e): intuition

What is k_e?

The **cost of equity** is the return that **shareholders require** for investing in the firm's equity, given the risk of the business.

- Shareholders are **residual claimants**:
  - debt service is paid first,
  - taxes are paid,
  - and only then shareholders receive residual profits.
- Therefore, the required return on equity is typically **higher** than the cost of debt.
- In practice:
  - k_e is commonly estimated using **market-based risk–return models** (e.g., CAPM),
  - with adjustments for industry risk, country risk, and business mix.

CAPM: a baseline model for k_e

CAPM formula

$$k_e = r_f + \beta \cdot (E(R_m) - r_f)$$

- r_f — **risk-free rate** (e.g., yield on government securities).
- $E(R_m)$ — expected return on the **market portfolio**.
- $(E(R_m) - r_f)$ — **market risk premium**.
- β — the stock's **sensitivity** to market movements (systematic risk).

Interpretation for students:

- The higher the stock's market risk (higher β),
- the higher the required return k_e,
- and the higher the discount rate applied to equity cash flows.

(CAPM can be covered in more detail later in the course.)

Cost of debt (k_d): how to interpret it

What is k_d?

The **cost of debt** is the **effective rate** at which the firm can raise borrowed funds in the market.

- Typical sources:
  - bank loans,
  - corporate bonds,
  - other debt instruments.
- In practice:
  - analysts use a **weighted average** across debt instruments,
  - and consider **market yields** on outstanding bonds, not only historical coupons.
- In WACC:
  - the **after-tax** cost of debt is used:

$$k_d(1 - T)$$

because interest expenses reduce taxable income.

WACC as a discount rate in business valuation

- In the **DCF (Discounted Cash Flow)** approach:
  - firm value is estimated from **forecast cash flows**,
  - which are then **discounted** at an appropriate rate.
- If we discount cash flows **to all capital providers** (Free Cash Flow to the Firm, FCFF), then:
  - a natural discount rate is **WACC**.
- If we discount cash flows **to equity holders only** (FCFE), then:
  - the discount rate equals the **cost of equity** k_e.

Link to capital budgeting

- Project analysis: WACC is a baseline rate for "typical" projects.
- Firm valuation: WACC is the firm's cost of capital applied in DCF.

Selecting a discount rate for a specific project

- If the project risk is **similar to the firm's current business**:
  - using the firm's **WACC** is a defensible choice.
- If the project is **materially riskier**:
  - it is reasonable to **increase** the discount rate (e.g., adjust k_e, add a project-specific risk premium).
- If the project is **safer** than the core business:
  - the discount rate may be **below** WACC.
- Importantly:
  - the discount rate should reflect the **risk of the cash flows**,
  - not merely an "average" firm-wide situation.

Practical takeaway: discount-rate selection is a **discipline of economic reasoning**: it should be consistent with project risk and the investor's alternatives.

Mini-case: capital budgeting project at AlphaStroy LLC

Context

The construction company **AlphaStroy LLC** is considering a project to launch a new production line for modular structures for commercial real estate.

- Project objective: expand production capacity and increase revenues in the B2B segment.
- Planning horizon: **4 years** after the initial investment.
- The project is implemented as an **add-on** to the existing business (a new line at the current production site).
- At the end of year 4, it is assumed that:
  - the equipment can be sold on the secondary market,
  - the working capital invested in the project is fully released.

The next slides provide numerical inputs for the project and a simplified balance sheet **prior** to project implementation.

Project inputs

Investment and project life

- Initial investment in equipment (Year 0): **RUB 12 million**.
- Additional working capital (inventories, receivables): **RUB 2 million** in Year 0.
- Economic life of the project: **4 years** (Years 1–4).
- Salvage value of equipment at the end of Year 4: **RUB 2 million**.
- Working capital is **fully released** at the end of Year 4.

Additional assumptions

- Depreciation: **straight-line** over 4 years.
- Corporate income tax rate: **20%**.
- Baseline discount rate (required return): **15%**.
- Financing will be introduced later: for now **ignore financing structure** and compute unlevered cash flows (FCF to the firm).

Revenue and operating cost forecast

Expected annual figures (RUB million)

Item	Year 1	Year 2	Year 3	Year 4
Project revenue	8	9	9	8
Operating costs (excl. dep.)	4	4	4	4
Equipment depreciation	3	3	3	3

- Assumptions:
  - the cost structure is **stable** over the horizon,
  - depreciation is independent of output (straight-line method).
- In Year 4, additionally:
  - **RUB 2 million** is received from equipment sale,
  - **RUB 2 million** is released from working capital.

Based on these inputs, you can construct the project's **annual free cash flows**.

Simplified balance sheet of AlphaStroy LLC before the project (RUB million)

Assets

Non-current assets

- Property, plant and equipment: **30**

Current assets

- Inventories: **6**
- Accounts receivable: **4**
- Cash: **2**

Total assets: 42

Equity and liabilities

Equity

- Share capital: **20**
- Retained earnings: **8**

Liabilities

- Long-term loans and borrowings: **10**
- Short-term loans and borrowings: **4**

Total equity and liabilities: 42

This balance sheet represents the firm's position **prior** to the project. The project is assumed to be additive to the existing business and **does not replace** current operations.

Mini-case: investment analysis tasks

Part 1. Project cash flows

Using the revenue, cost, depreciation, and tax inputs:

1. Construct a **project income statement** for Years 1–4 (EBIT, corporate income tax, net income).
2. Compute the project's **free cash flows (FCF)** for Years 0–4:
   - include the initial investment and working capital in Year 0;
   - include working capital release and equipment sale in Year 4.

Part 2. Performance metrics

Using the discount rate of **15%**:

1. Compute the project's **NPV**.
2. Determine the project's **IRR**.
3. Compute the **PI** (profitability index).
4. Compute the **payback period** and the **discounted payback period**.

Mini-case: firm-level financial analysis tasks

Part 3. Baseline balance sheet analysis (pre-project)

Based on AlphaStroy's balance sheet before the project:

1. Compute:
   - the current ratio (current assets / current liabilities);
   - the financial leverage ratio (total liabilities / equity);
   - the share of non-current assets in total assets.
2. Provide a **qualitative assessment** of liquidity and financial stability.

Part 4. How the project may affect key ratios

Assume:

- half of the investment (RUB 7 million out of RUB 14 million) is financed by a **new long-term loan** at 11% per year,
- the remainder is financed with **internal equity funds**.

1. Assess how the following may change:
   - financial leverage (liabilities / equity),
   - asset structure (share of non-current assets),
   - the firm's interest burden (using project EBIT and the loan rate).
2. Discuss how to integrate **investment analysis** (NPV, IRR) and **financial analysis** (ratios) in a project approval decision.

Exercise

A 3-year deposit at an annual rate of 24%, principal = 100 rubles.
How much do you expect to have in the account at maturity? (Assume **simple interest** and no other cash inflows/outflows.)

You deposit RUB 100,000 at 16% per year for 6 months.
How much do you expect to have in the account at maturity? (Assume **simple interest** and no other cash inflows/outflows.)

Exercise

Suppose you have just received $100.
You plan to spend $30 immediately.
You are also offered the opportunity to invest $50 in an entrepreneurial project and receive $58 in one year.
The expected return in financial markets is 15%.
How much money do you expect to have in your account in one year? (Assume no other cash inflows/outflows.)

Exercise

You expect to receive five payments of $500 at the end of each of the next five years.
The expected return in financial markets is 20%.
What is the Present Value of these cash inflows?

Exercise

A firm pays dividends quarterly. Dividend amounts exhibit seasonality. In the first year, an investor expects the following quarterly dividends: RUB 10 at the end of Q1, RUB 18 at the end of Q2, RUB 5 at the end of Q3, and RUB 12 at the end of Q4. The investor expects that business growth will increase each quarterly dividend by 4% each year relative to the dividend paid in the same quarter one year earlier. The project is risk-free. The risk-free bond rate is 7% per year.

Compute the current value of the stock for the investor.

Exercise

A company is considering the project that requires investments of \$10 000 000. It is expected to generate CFs over its lifespan: \$1 200 000 at the end of 1st year and \$1 800 000 at the end of the 2nd year. Subsequently, from the 3rd through 7th years, the project will generate payments \$2 500 000 each year in annuity. The company uses a discount rate of 11% for such investments. **Calculate NPV.**

Exercise

The initial investment required for the project is \$15 000 000. In the 1st year the project is expected to generate CF of \$850 000. Starting from the 2nd year and continuing infinity, it will provide constant annual CF of \$2 200 000. The company's cost of capital is 11% per annum. **Calculate NPV of the project.**

Exercise

The product you want to launch will cost $900 000 to develop, and you expect CF in the 1st year of $700 000, and $900 000 in year 2. From the 3rd year, the CFs will follow a Gordon model: the 1st CF of growth perpetuity is $970 000, the next CF is $970 000*(1+g) and so on. Growth rate is 3% per year. What is the PV of future CFs if the discount rate is 10%?

Exercise

Nexus Robotics can invest $7 million in a new facility for producing autonomous delivery drones. The project has an expected life of six years, with projected sales of 8 million units annually. Fixed operational costs are $2.5 million per year, and variable production costs are $1.5 per unit. The production equipment will be depreciated straight-line over six years to a salvage value of zero. The opportunity cost of capital is 16%, and the corporate tax rate is 25%.

At what price per unit would the project's NPV equal zero?

Introduction to Fundamental Analysis of Stocks

What is Fundamental Analysis?

Fundamental analysis is a method of evaluating a stock by analyzing its intrinsic value. This approach focuses on evaluating the financial health of a company and its stock performance based on various factor.

- **Financial Statements**: Analyzing a company's income statement, balance sheet, and cash flow statement.
- **Earnings Reports**: Reviewing quarterly and annual earnings to determine profitability.
- **Economic Indicators**: Evaluating factors such as interest rates, inflation, and GDP that may impact a company's performance.
- **Management**: Assessing the company's leadership, strategy, and corporate governance.
- **Industry and Market Conditions**: Understanding the company's market position, competition, and industry trends.

Introduction to Fundamental Analysis of Stocks

Economic Analysis	Industrial Analysis	Company Analysis
GDP of the country	Growth rate of Industry	Competitive Advantage
Level of Savings & Investment	Type of Industry – Growth, cyclical, defensive, cyclical growth	Financial Stability & Performance
Inflation Rate	Nature of Competition	Growth Rate/Sales
Interest Rate	Nature of Product	Market Share
Growth in Primary, Secondary and tertiary Sectors	Subsidies, incentives, concessions	Financial Leverage and Borrowing Capacity
Tax Structure	Tax framework	Previous track record
Economic Forecasts	Import and export policies	Profits of the company
Infrastructural Facilities	Financing norms	Corporate Image
Demographic Factors	State of technology	SWOT Analysis profits
Climatic Conditions	Industrial Policies	Management
State of Economy	Socio-Demographic Trends	Operating Efficiency
Balance of Payments Situation	Government programs and projects	Future estimates of sales
Government Budget	Supply Sector	
Linkage with World Economy	Industry Life cycle	
	SWOT Analysis	

Introduction to Fundamental Analysis of Stocks

Quantitative fundamental analysis analyzes an investment according to easily measured factors, such as the earnings or assets of the company that issued a stock. **Qualitative** analysis looks at harder to measure factors such as the quality of a company's management or the strength of its brand.

Fundamental analysis aims to determine the fair value of a stock, comparing it to the current market price. If a stock is undervalued, it may present a good buying opportunity, whereas an overvalued stock may suggest a potential sell or hold decision.

Equity Returns: Holding Period Return and Total Shareholder Return

One-period equity return (total shareholder return)

For a stock with price P_0 today, price P_1 next period, and dividend D_1 paid during the period:

$$R^{eq}_{0\to 1} = \frac{P_1 - P_0 + D_1}{P_0}$$

- **Decomposition**:

$$R^{eq}_{0\to 1} = \underbrace{\frac{P_1 - P_0}{P_0}}_{\text{capital gain}} + \underbrace{\frac{D_1}{P_0}}_{\text{dividend yield}}$$

- **Multi-period total return** (without reinvestment):

$$R^{eq}_{0\to H} = \frac{P_H - P_0 + \sum_{t=1}^{H} D_t}{P_0}$$

- In practice, stock indices often report **price return** vs. **total return** (dividends reinvested).

Equity Return with Dividend Reinvestment: Wealth Index Approach

Wealth index with dividend reinvestment (discrete time)

Let W_t be the value of a self-financing position where dividends are reinvested into the stock:

$$W_t = W_{t-1}\left(1 + \frac{P_t - P_{t-1} + D_t}{P_{t-1}}\right)$$

Equivalently:

$$W_t = W_{t-1}(1 + R_t), \quad R_t = \frac{P_t - P_{t-1} + D_t}{P_{t-1}}$$

Cumulative total return (with reinvestment)

$$R_{0\to H}^{TR} = \frac{W_H}{W_0} - 1 = \prod_{t=1}^{H}(1 + R_t) - 1$$

Key Financial Ratios in Stock Analysis

- **Price-to-Earnings (P/E) Ratio**: Measures the price of a stock relative to its earnings.

$$\text{P/E} = \frac{\text{Market Price per Share}}{\text{Earnings per Share (EPS)}}$$

- **Price-to-Book (P/B) Ratio**: Compares a company's market value to its book value.

$$\text{P/B} = \frac{\text{Market Price per Share}}{\text{Book Value per Share}}$$

- **Return on Equity (ROE)**: Measures a company's ability to generate profits from its shareholders' equity.

$$\text{ROE} = \frac{\text{Net Income}}{\text{Shareholder's Equity}}$$

Key Financial Ratios in Stock Analysis

- **Debt-to-Equity (D/E) Ratio**: Measures a company's financial leverage by comparing its total liabilities to shareholders' equity.

$$\text{D/E} = \frac{\text{Total Debt}}{\text{Shareholder's Equity}}$$

- **Net Profit Margin**: Measures the percentage of revenue that remains as profit after expenses.

$$\text{Net Profit Margin} = \frac{\text{Net Income}}{\text{Revenue}} \times 100$$

- **Dividend Yield**: Indicates how much income a company generates for its shareholders in the form of dividends.

$$\text{Dividend Yield} = \frac{\text{Annual Dividends per Share}}{\text{Price per Share}}$$

Equity Securities Valuation

What is Stock Valuation?

Stock valuation is the process of determining the intrinsic value of a company's stock. This is done by estimating the present value of future cash flows that the stock will generate.

The two most widely used approaches to stock valuation are:

- **Dividend Discount Model (DDM)**
- **Discounted Cash Flow (DCF) Model**

Please note: these two models are the same except for one uses CF's per share and the other uses Dividends per share. In the real world we mostly use the CF's model given some firms do not pay dividends and the CF's model is considered more accurate.

One-Stage Constant Growth Model

The One-Stage Constant Growth Model (also known as the terminal value model) is used to calculate the price of a stock assuming constant growth of dividends or cash flows at a fixed rate (g) in perpetuity.

Formula:

$$P_t = \frac{CF_1}{k - g}$$

Where:

- P_t = Price at time t
- CF_1 = Cash flow or dividend in the next period
- k = Discount rate (required rate of return)
- g = Growth rate of cash flows or dividends

Notes:

- This model assumes that the growth rate g is constant and that $g < k$ in the long run.
- As g approaches k, the price of the stock increases without bound.

Two-Stage Growth Model

The Two-Stage Growth Model is used to estimate the value of a stock by taking into account two different growth stages: - A high growth phase (Super Growth Stage). - A stable, perpetual growth phase (Terminal Value Stage).

Formula:

$$P_0 = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} + \frac{CF_{n+1}}{(r-g_n)} \cdot \frac{1}{(1+r)^n}$$

Where:

- P_0 = Price at time 0 (current stock price)
- CF_t = Cash flow or dividend at time t
- r = Required rate of return (Cost of equity)
- g_n = Growth rate after year n (perpetual growth rate)
- n = Number of years of high growth (Super Growth Stage)
- P_n = Price at the end of year n (Terminal Value)

Fixed-income Securities Valuation

What is Bond Valuation?

Bond valuation is the process of determining the fair value of a bond, which involves calculating the present value of its future cash flows (coupon payments and face value).

The bond price is the sum of two components:

- **Present Value of Coupon Payments**: The present value of the periodic coupon payments the bondholder will receive.
- **Present Value of Face Value (Par Value)**: The present value of the face value (the principal amount) that will be paid back to the bondholder at maturity.

The formula for bond valuation is:

$$\text{Bond Price} = \sum_{t=1}^{T} \frac{C}{(1+r)^t} + \frac{F}{(1+r)^T}$$

Where:

- C = Coupon payment
- r = Discount rate or Yield to Maturity (YTM)
- F = Face value of the bond
- T = Time to maturity

Key Concepts in Bond Valuation:

- **Coupon Rate**: The interest rate paid by the bond, based on its face value.
- **Yield to Maturity (YTM)**: The discount rate that equates the bond's current price to the present value of its future cash flows.
- **Discount Rate**: The rate used to discount the future cash flows of the bond.

Bond Returns: Holding Period Return (HPR) vs. Yield Measures

Holding Period Return (total return over a horizon)

For a bond bought at price P_0 and sold at price P_H after H periods, with coupons C_t received during the holding period:

$$R_{0\to H}^{bond} = \frac{P_H - P_0 + \sum_{t=1}^{H} C_t}{P_0}$$

- **Interpretation**: bond return over a holding period comes from **(i) price change** (interest-rate movements / spread changes) and **(ii) coupon income**.
- **Yield to Maturity (YTM)** (a *quote*, not realized return): the IRR that equates price to PV of promised cash flows:

$$P_0 = \sum_{t=1}^{T} \frac{C}{(1+y)^t} + \frac{F}{(1+y)^T}$$

- **Key nuance**: YTM equals the realized return *only if*
  - the bond is held to maturity, **and**
  - coupons are reinvested at the same yield, **and**
  - no default / call / liquidity frictions.

Bond Return with Coupon Reinvestment: Effective Holding-Period Return

Future value of coupons under reinvestment

If each coupon C_t is reinvested at rate r_{reinv} from its payment date to horizon H:

$$FV(\text{coupons}) = \sum_{t=1}^{H} C_t \, (1 + r_{reinv})^{H-t}$$

Effective holding-period return (with reinvestment)

$$R_{0\to H}^{bond,\ reinv} = \frac{P_H + FV(\text{coupons}) - P_0}{P_0}$$

- **Reinvestment risk**: realized return depends on r_{reinv}, which is generally uncertain.
- **Special case**: holding to maturity ($H = T$) gives:

$$R_{0\to T} = \frac{F + FV(\text{coupons}) - P_0}{P_0}$$

- For annualization over H periods:

$$r_{eff} = (1 + R_{0\to H})^{1/H} - 1$$

Exercise 1. Bond Valuation

Consider a bond with the maturity of 2 years and a face value of 1000 RUB. Its annual coupon rate is 15%. Bond's yield to maturity is 21%. Will you be willing to buy this bond for 1050 RUB? Explain.

Exercise 2. Returns

You bought a stock for 100 RUB. In the first year you owned it the price dropped to 50 RUB. In the second year the price rebounded to 100 RUB.

What is your average rate of return?

Exercise 3. Returns

Suppose a stock had the following details over the past year:

- Initial Price: \$64 per share
- Dividend Paid: \$1.20 per share
- Ending Price: \$73 per share

Calculate the percentage total return for the stock. What is your capital gain yield? What is your dividend yield gain?

Exercise 4. Fair price

A bond with face value of 100, maturity of 4 years and an annual coupon of 5.5 is issued today. The Yield To Maturity of this bond is 7%. **Find the fair price of this bond today**

Exercise 5. YTM

A bond with face value of 100, maturity of 4 years and an annual coupon of 5.5 is issued today. Fair price is 99.10. **Find the yield to maturity of this bond**

Exercise 6. Fair price

Your CFO reports that your company expects dividends of \$100, \$110 and \$150 per share over next three years, respectively. At the end you are planning to sell your share at a market for \$1000. **What is the fair price of the share given 10% expected return?**

Sources of Risk in a Portfolio

Consider a portfolio consisting of a single stock, such as Sberbank. The primary sources of risk include:

- **Macroeconomic Factors:**
  - These are broad economic forces that can affect the entire market, such as the business cycle, inflation, interest rates, and exchange rates.
  - These factors can lead to significant fluctuations in stock prices, but their exact impact is difficult to predict.
- **Firm-Specific Factors:**
  - These factors pertain specifically to the company, such as management decisions, changes in leadership, performance in research and development, and operational efficiency.
  - While these risks affect Sberbank directly, they may not influence other companies in the same way or to the same extent.

Diversification with Two Stocks

Now consider a simple diversification strategy involving two stocks: Sberbank and Lukoil.

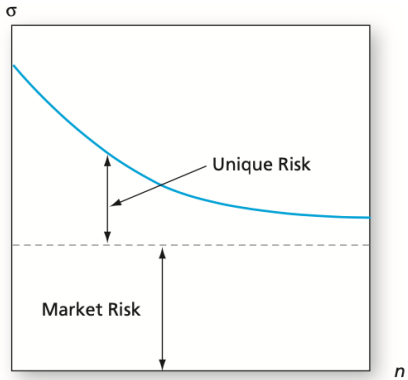
- **Diversification helps to reduce portfolio risk** by spreading exposure to company-specific risks.
- **Example:**
  - **Lukoil:** Sensitive to fluctuations in global oil prices, which directly impact its profitability.
  - **Sberbank:** Primarily influenced by banking sector trends, such as interest rates and demand for loans, less correlated with oil prices.
- **Diversification works when different stocks are exposed to different risks.** If Lukoil suffers from falling oil prices, Sberbank may experience growth due to rising credit demand, reducing the overall portfolio risk.

Diversifying Further

What happens when we diversify further into more stocks?

- As more stocks are added, exposure to **firm-specific risks** is spread more widely, thus reducing the portfolio's overall volatility.
- However, diversification has limits:
  - No matter how many stocks are added, **market risk** (systematic risk) cannot be eliminated. This is risk associated with broader economic factors such as market-wide changes, geopolitical events, or global recessions.
  - Common risks, like those from the business cycle, affect all stocks in a similar way, meaning that diversification cannot fully protect against such risks.

Effect of Diversification



Portfolio standard deviation as a function of the number of stocks in the portfolio.

Key Takeaway: Diversification reduces risk, but the effect becomes limited as the number of stocks increases due to market (systematic) risk.

Two Asset Portfolio

Consider a portfolio with two assets:

- **Asset A**: A financial instrument with specific risk and return characteristics.
- **Asset B**: A second financial instrument with different risk and return characteristics.

The proportion invested in Asset A is denoted by w_A, and the proportion in Asset B is $w_B = 1 - w_A$.
The rate of return on the portfolio r_p is given by:

$$r_p = w_A r_A + w_B r_B$$

where r_A and r_B are the returns on Asset A and Asset B, respectively.

Expected Return of Portfolio

The expected return on the portfolio is the weighted average of the expected returns on the individual assets:

$$E(r_p) = w_A E(r_A) + w_B E(r_B)$$

where $E(r_A)$ and $E(r_B)$ are the expected returns on Asset A and Asset B, respectively.

Variance of the Two-Asset Portfolio

The variance of the portfolio is:

$$\sigma_p^2 = w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + 2w_A w_B \text{Cov}(r_A, r_B)$$

where:

- σ_A^2 and σ_B^2 are the variances of returns on Asset A and Asset B.
- $\text{Cov}(r_A, r_B)$ is the covariance between the returns on Asset A and Asset B.

Understanding Portfolio Variance

The variance can also be written as:

$$\sigma_p^2 = w_A^2 \text{Cov}(r_A, r_A) + w_B^2 \text{Cov}(r_B, r_B) + 2 w_A w_B \text{Cov}(r_A, r_B)$$

Here, $\text{Cov}(r_A, r_A) = \sigma_A^2$ and $\text{Cov}(r_B, r_B) = \sigma_B^2$.
Thus, the variance of the portfolio is a weighted sum of covariances.

Effect of Correlation on Portfolio Risk

The covariance between returns can be computed using the correlation coefficient r_{AB}:

$$\text{Cov}(r_A, r_B) = r_{AB}\sigma_A\sigma_B$$

The portfolio variance then becomes:

$$\sigma_p^2 = w_A^2\sigma_A^2 + w_B^2\sigma_B^2 + 2w_A w_B r_{AB}\sigma_A\sigma_B$$

The portfolio standard deviation is reduced when the correlation is lower than 1.

Example

Assume two assets, Asset A and Asset B, with the following characteristics:

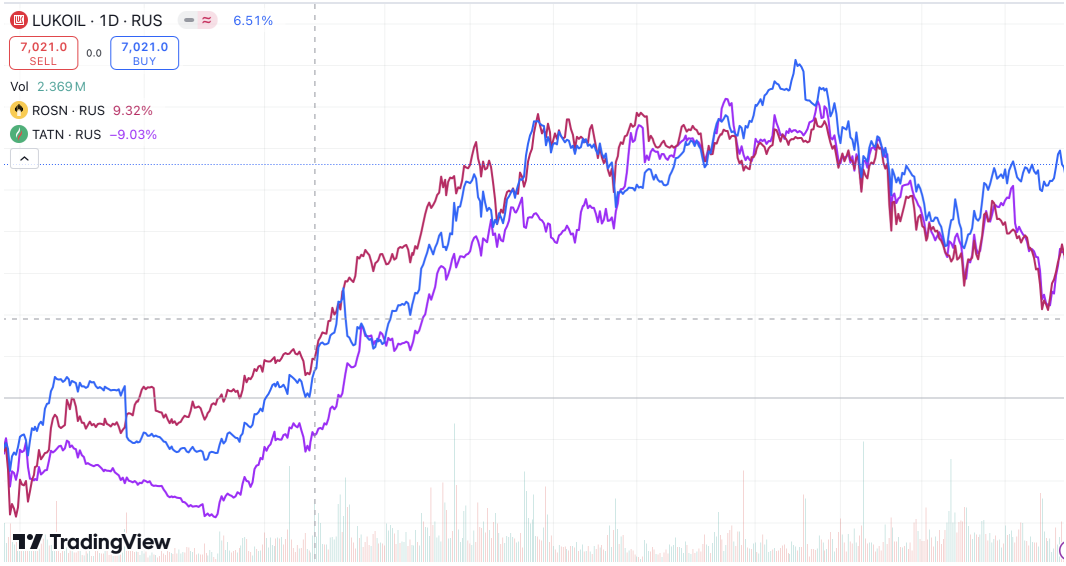
- **Asset A:**
  - Expected Return: $E(r_A) = 8\%$
  - Standard Deviation: $\sigma_A = 15\%$
- **Asset B:**
  - Expected Return: $E(r_B) = 10\%$
  - Standard Deviation: $\sigma_B = 20\%$
- **Correlation between Assets:** $r_{AB} = 0.2$ (low correlation)

Correlation

- The **correlation** between two assets indicates how their returns move in relation to each other.
- A **positive correlation** means that the assets tend to move in the same direction (both go up or both go down).
- A **negative correlation** means that when one asset goes up, the other tends to go down.
- In this example, a correlation of $r_{AB} = 0.2$ means that the returns of Asset A and Asset B have a **weak positive relationship**. They are not strongly tied to each other, so there is some level of risk reduction when combining them in a portfolio.

Correlation

Correlation



Correlation

Perfect Positive Correlation

When the correlation between the assets is perfectly positive ($r_{AB} = 1$), the portfolio standard deviation simplifies to:

$$\sigma_p = w_A\sigma_A + w_B\sigma_B$$

In this case, there is no diversification benefit, and the risk is simply the weighted average of the individual risks.

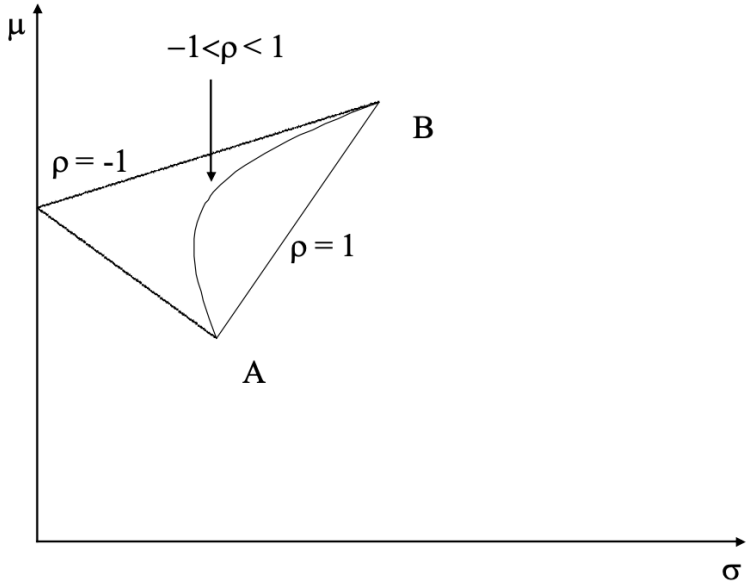
Perfect Negative Correlation

When the correlation between the assets is perfect negative ($r_{DE} = -1$), the portfolio standard deviation is:

$$\sigma_p = |w_D\sigma_D - w_E\sigma_E|$$

In this case, the portfolio can be perfectly hedged, and the portfolio risk can be minimized to zero.

Correlation



Minimum Variance Portfolio

The minimum variance portfolio occurs when the portfolio's standard deviation is minimized. For two assets with negative correlation, the weights for the minimum variance portfolio are:

$$w_A^{\min} = \frac{\sigma_B}{\sigma_A + \sigma_B}, \quad w_B^{\min} = 1 - w_A^{\min}$$

The minimum variance portfolio can have a standard deviation lower than that of either individual asset.

Summary

- The expected return of a portfolio is the weighted average of the individual asset returns.
- The standard deviation of a portfolio is less than the weighted average of the individual asset standard deviations unless the correlation is perfect.
- Diversification benefits arise when the correlation between assets is less than 1, with the greatest benefit from perfect negative correlation.
- The optimal portfolio depends on risk aversion, balancing expected return and risk.

Asset Allocation in Portfolio Optimization

We generalize the portfolio construction problem to the case of many risky securities. We need to determine the risk-return opportunities:

- These are summarized by the **minimum-variance frontier**.
- The frontier represents the lowest possible variance for a given portfolio expected return.

Given the input data for expected returns, variances, and covariances, we can calculate the minimum-variance portfolio for any target expected return.

Minimum-Variance Frontier of Risky Assets

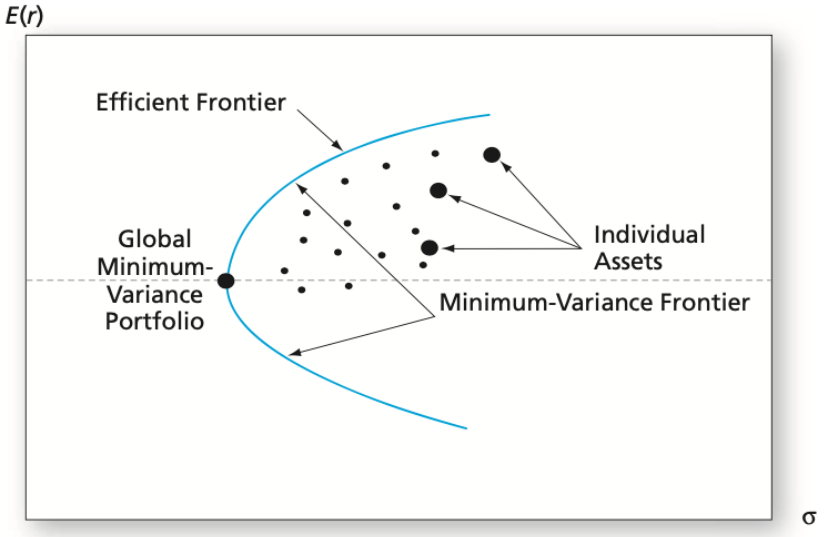
The minimum-variance frontier shows the graph of expected returns vs. standard deviation. Key points:

- Individual assets lie to the right inside the frontier (inefficient).
- Diversification leads to portfolios with higher returns and lower risk.
- Portfolios on the lower portion of the frontier are inefficient.

Efficient Frontier of Risky Assets

- Portfolios on the efficient frontier from the global minimum-variance portfolio and upward offer the best risk-return combinations.
- The lower portion of the minimum-variance frontier is inefficient and can be discarded.

Efficient Frontier



Risk-Return Analysis

The portfolio manager needs inputs for:

- Expected returns of each security, $E(r_i)$.
- Covariance matrix for the securities.

These estimates allow calculation of the expected return and variance of any risky portfolio:

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i)$$

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \text{Cov}(r_i, r_j)$$

Harry Markowitz's Contribution

In 1952, Harry Markowitz formalized the idea of portfolio selection:

- He introduced the efficient frontier of risky assets.
- The efficient frontier minimizes variance for any given expected return, or maximizes expected return for any given risk level.

This work earned him the Nobel Prize in 1990.

Efficient Set of Portfolios

The efficient frontier can be derived through two methods:

- **Variance Minimization:** For a given expected return, find the portfolio with the smallest standard deviation.
- **Return Maximization:** For a given standard deviation, find the portfolio with the highest expected return.

Both methods are equivalent and produce the efficient frontier.

Practical Constraints in Portfolio Selection

Some clients may face additional constraints:

- Prohibition on short positions.
- Constraints on expected dividend yield.
- Socially responsible investing (ethical constraints).

These constraints may result in a lower Sharpe ratio for the optimal portfolio.

Conclusion

The Markowitz portfolio optimization model provides a structured approach for portfolio construction:

- Identify the efficient frontier of risky assets.
- Determine the optimal risky portfolio using the Capital Allocation Line.
- Adjust the mix with a risk-free asset based on individual preferences.

Additional constraints can be added, but they may reduce the portfolio's efficiency.

Case Study: Portfolio Optimization

- Choose any market or/and industry (explain your choice).
- Go to https://smart-lab.ru or any website that present ready-made fundamental ratios and download those you would like to include into your analysis.
- Perform fundamental analysis and choose best representatives (explain your choice as well as the number of stocks you are choosing).
- Download daily close prices and calculate returns (explain your choice of time period).
- Perform portfolio optimization and choose the best option (explain based on theory as well as on your personal preferences and investment goals).
- Message your .xlxs file to me in Telegram.

Problem 1

The portfolio consists of 3 assets. The expected return of the first asset equals to 4.5%, expected return of the second asset = 8.4%, and 5.1% for the third asset. The investments on these assets equal to 0.2 mln, 0.4 mln, 0.3 mln respectively. **Calculate the weights invested in each asset of such portfolio. Identify the expected portfolio return.**

Problem 2

The portfolio consists of 4 assets. The expected return of the first asset equals to 4.7%, expected return of the second asset 3.4%, and 5.6% and 6.5% for the third and the fourth assets respectively. The investments on these assets equal to 0.4 mln, 0.3 mln, 0.2 mln and 0.1 mln respectively. **Calculate the weights invested in each asset of such portfolio. Identify the expected portfolio return.**

Problem 3

The portfolio consists of 2 assets. The standard deviation of returns of the first asset equals to 11%, second asset 15%. Investments on these assets are 0.4 mln and 0.3 mln respectively. The correlation of returns on the assets is 30%. **Calculate the share of funds invested in each asset and determine the riskiness of the portfolio (variance and standard deviation.)**

Problem 4

The portfolio consists of 2 assets. The standard deviation of returns of the first asset equals to 14%, second asset 17%. Investments on these assets are 0.9 mln and 0.5 mln respectively. The covariance between assets is 0.00054. **Calculate the st.deviation of the portfolio.**

Problem 5

1. Get data for stocks META and CPB for dates: 01.03.2020; 01.03.2021; 01.03.2022; 01.03.2023.
   - **Find annual returns, HPR, CAGR, variance and standard deviation for each stock.**
2. Let's assume on 01.03.2023 you have \$100 000 and decide to invest 60% in META and remaining part in CPB.
   - **How many stocks of each company would you buy?**
3. Assume that you expect that the annual return for these two stocks (CAGR) will remain on the same level (later we will learn how to estimate expected return, but for now let us fix it on the historical level).
   - **Find the expected return and expected standard deviation of such portfolio.**

Problem 6

Get qoutes of two real stocks listed on MOEX (2021-2025, up to current date).

1. **Build the efficient frontier for possible portfolios of these two assets.**
2. **Find the Global Minimum Variance portfolio.**

Problem 7

Get qoutes of two real stocks listed on MOEX (2021-2025, up to current date).

1. Build the efficient frontier for possible portfolios of these two assets.
2. Find the Global Minimum Variance portfolio.

Let's improve your portfolio.

1. **Add the risk-free asset.**
2. **Calculate expected return of this new portfolio consisting of 3 assets, using the assumptions on your risk-profile.**