COURSE: INVESTMENTS |CHAPTER 7

CAPITAL ASSET PRICING AND ARBITRAGE PRICING THEORY

Dr Abenet Yohannes, Ph.D.

SECTION I

From Diversification to Asset Pricing

Which risk should determine the return investors require?

Dr Abenet Yohannes, Ph.D.

Chapter Purpose

Chapter 6 showed that diversification can reduce firm-specific risk. Now we ask a pricing question.

The central question

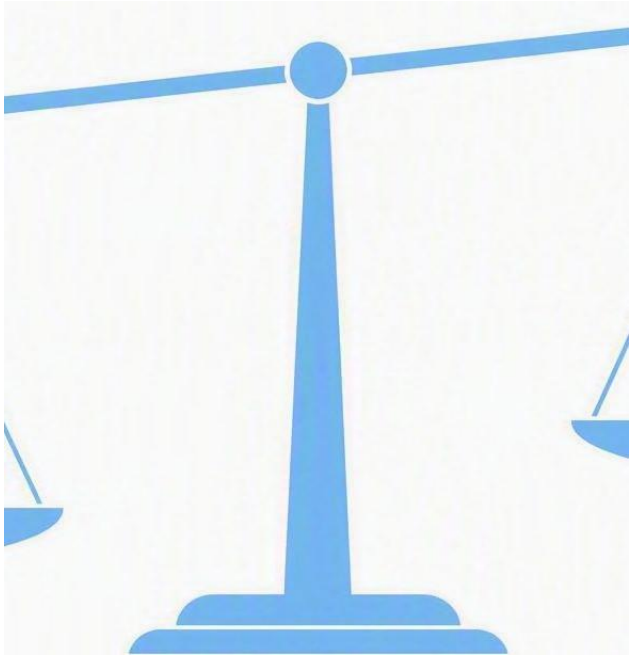
If investors can diversify away some risk, which risk should actually determine the return they require?

CAPM

A single systematic factor: market risk, measured by beta.

APT

Multiple systematic factors, each with its own risk premium.



Learning Objectives

By the end of this chapter, students should be able to:

- Explain CAPM and its logic
- Distinguish systematic from firm-specific risk
- Explain and calculate beta
- Explain the market portfolio
- Calculate required return using CAPM
- Interpret the Security Market Line
- Explain the market risk premium

- Calculate and interpret alpha
- Identify under- and overvalued securities
- Explain CAPM assumptions
- Discuss CAPM limitations
- Explain multifactor models
- Explain Arbitrage Pricing Theory
- Compare CAPM with APT

SECTION II

The Basic Idea

Only risk that cannot be diversified away is rewarded.

Dr Abenet Yohannes, Ph.D.

Remember Diversification

From Chapter 6:

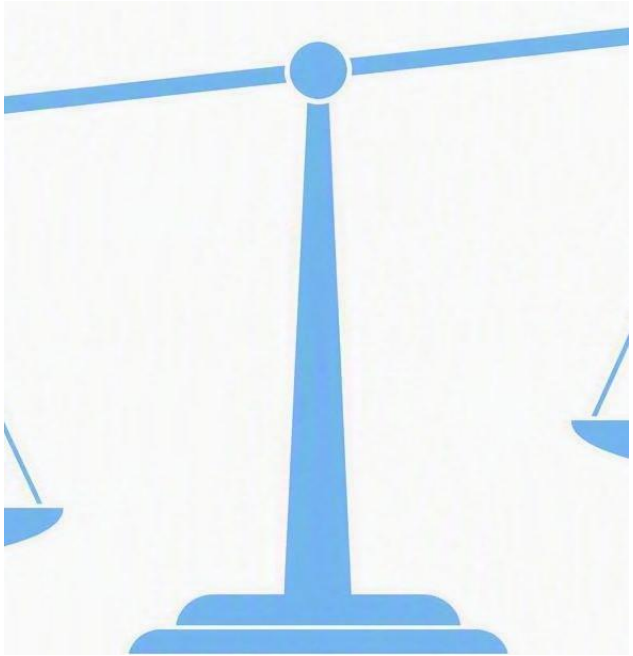
$$\text{Total Risk} = \text{Systematic Risk} + \text{Firm-Specific Risk}$$

Can be reduced

Firm-specific (unsystematic) risk falls sharply as a portfolio is diversified.

Cannot be removed

Systematic (market) risk remains, however many securities are held.



The Big Question

Investor A

Holds only one company's shares — poorly diversified.

Investor B

Holds a broadly diversified portfolio.

Should Investor A automatically receive a higher expected return simply because the portfolio is poorly diversified?

CAPM says: NO.

Investors are not rewarded for taking risk they could have diversified away.

What Risk Matters?

According to CAPM, the relevant risk of an individual security is its contribution to the risk of a diversified market portfolio.

Contribution to market portfolio risk

▼

SYSTEMATIC RISK

▼

Measured by BETA (β)

SECTION III

The Capital Asset Pricing Model

Linking systematic risk to required return.

Dr Abenet Yohannes, Ph.D.

What Is CAPM?

The Capital Asset Pricing Model (CAPM) relates an asset's required expected return to its exposure to systematic market risk.

It answers

Given this asset's market risk, what return should investors require?

Why it matters

It converts a risk measure into a benchmark return for valuation and decision-making.

The CAPM Formula

$$E(R_i) = R_f + \beta_i [E(R_M) - R_f]$$

Symbol	Meaning
$E(R_i)$	Required / expected return on asset i
R_f	Risk-free rate
β_i	Beta of asset i — sensitivity to market movements
$E(R_M)$	Expected return on the market portfolio
$E(R_M) - R_f$	Market risk premium

CAPM in Plain Words

A company asks:

"What return must I offer investors?"

R f

Start with the risk-free return

+

β × MRP

Add compensation for market risk

=

$E(R_i)$

Required return

Required Return = Risk-Free Return + Risk Compensation

SECTION IV

The Risk-Free Rate

Compensation for time, before any risk is taken.

Dr Abenet Yohannes, Ph.D.

What Is the Risk-Free Rate?

The risk-free rate represents the return on an investment assumed to have no uncertainty over the relevant horizon within the theoretical model.

What it compensates

Primarily the time value of money — postponing consumption.

Practical proxy

Short-term, high-quality government securities are commonly used.

Remember

It is the floor of the required return: every risky asset should offer more than R f if investors are to bear systematic risk.

Risk-Free Rate — Example

Suppose:

$$R_f = 5\%$$

An investor could theoretically earn about 5% without taking market risk under the model.

Therefore

A risky investment should generally offer more than 5% expected return to compensate for systematic risk.

5%

Risk-free rate (R_f)

> 5%

Required on risky asset

SECTION V

The Market Risk Premium

The price of one unit of market risk.

Dr Abenet Yohannes, Ph.D.

What Is the Market Risk Premium?

$$\text{Market Risk Premium} = E(R_M) - R_f$$

It is the additional expected return investors require for holding the market portfolio rather than the risk-free asset.

Interpretation

The reward per unit of market risk — the slope of the Security Market Line.

In CAPM

Multiplied by beta, it becomes the risk compensation for a specific security.

Market Risk Premium — Example

13%	−	5%	=	8%
Expected market return E(R M)		Risk-free rate R f		Market risk premium

13% − 5% = 8%

Investors expect 8% more than the risk-free rate for bearing full market risk.

SECTION VI

Beta — Measuring Systematic Risk

How strongly does an asset move with the market?

Dr Abenet Yohannes, Ph.D.

What Is Beta?

Beta measures the sensitivity of a security's returns to movements in the overall market.

In simple terms

How strongly does this investment tend to react when the market moves?

Key point

Beta captures co-movement with the market, not the size of an asset's own swings.

Understanding Beta

$\beta = 1.0$

Moves broadly with the market.

$\beta > 1.0$

More sensitive to market movements — amplifies market swings.

$0 < \beta < 1.0$

Less sensitive to market movements — defensive.

$\beta < 0$

Tends to move opposite the market; negative-beta assets are unusual.

Beta — : Boats on the Ocean

Imagine the market is the ocean; each stock is a boat.

Beta = 1.0

The boat moves roughly with the waves.

Beta = 1.5

The boat reacts more strongly than the waves.

Beta = 0.5

The boat reacts less strongly than the waves.

Beta tells us how sensitive the boat is to the market's waves.

Market Beta

By definition, the market portfolio has a beta of one.

$$\beta_M = 1$$

The benchmark

Beta of 1 is the reference point against which every individual security is compared.

Reading it

β above 1 means more systematic risk than the market; below 1 means less.

Beta — Example

Suppose three stocks have the following betas:

0.50
Stock A — defensive

1.00
Stock B — market-like

1.50
Stock C — aggressive

Conclusion

Stock C has the greatest sensitivity to systematic market movements, and therefore the highest required return under CAPM.

Beta Is Not Total Risk

This distinction is critical.

Standard deviation

Measures total volatility — systematic and firm-specific risk together.

Beta

Measures exposure to systematic market risk only.

Therefore: a security can have high total volatility but a relatively modest beta if much of its risk is company-specific — and CAPM prices only the systematic part.

The Beta Formula

Conceptually, beta is a scaled measure of co-movement:

$$\beta_i = \mathrm{Cov}(R_i, R_M) / \mathrm{Var}(R_M)$$

Numerator

$\mathrm{Cov}(R_i, R_M)$ — how the asset moves together with the market.

Denominator

$\mathrm{Var}(R_M)$ — the market's own variability, used to scale the measure.

SECTION VII

Calculating Required Return

CAPM applied step by step.

Dr Abenet Yohannes, Ph.D.

CAPM — Worked Example

Suppose:

5%	13%	1.50
Risk-free rate	Expected market return	Stock beta

Question

What return should investors require on this stock? We solve it in three steps.

Step 1 — Market Risk Premium

$$E(R_M) - R_f = 13\% - 5\% = 8\%$$

8%

Market risk premium

This is the reward investors require for bearing one full unit of market risk.

Step 2 — Adjust for Beta

The stock's beta of 1.5 scales the market risk premium:

$$1.5 \times 8\% = 12\%$$

12%

Systematic-risk premium for this stock

Because the stock is 1.5 times as sensitive as the market, it earns 1.5 times the market premium.

Step 3 — Required Return

$$E(R_i) = 5\% + 12\% = 17\%$$

17%

Required expected return

Investors should require 17% on this stock given its systematic risk.

Interpretation — Why 17%?

5% · Risk-free rate

Compensation for the time value of money — before any risk is taken.

12% · Systematic risk premium

Beta of 1.5 multiplied by the 8% market risk premium.

17% · Required expected return

The CAPM benchmark: the minimum return that justifies holding this stock.

SECTION VIII

Comparing Different Betas

Higher systematic risk, higher required return.

Dr Abenet Yohannes, Ph.D.

Three Stocks — The Setup

Assume the same market conditions for all three securities:

$$R_f = 5\% \qquad E(R_M) = 13\% \qquad MRP = 8\%$$

Stock	Beta
A	0.50
B	1.00
C	1.50

What changes

Only beta differs. Any difference in required return therefore comes purely from systematic risk.

Required Returns for Each Stock

Stock A

5% + (0.50)(8%)

9%

Required return

Stock B

5% + (1.00)(8%)

13%

Required return

Stock C

5% + (1.50)(8%)

17%

Required return

What Does This Tell Us?

Stock	Beta	Required Return
A	0.50	9%
B	1.00	13%
C	1.50	17%

According to CAPM

Required return rises in a straight line with beta.

Higher Beta

▼

Greater Systematic Risk

▼

Higher Required Return

SECTION IX

The Market Portfolio

The benchmark bundle of all risky assets.

Dr Abenet Yohannes, Ph.D.

What Is the Market Portfolio?

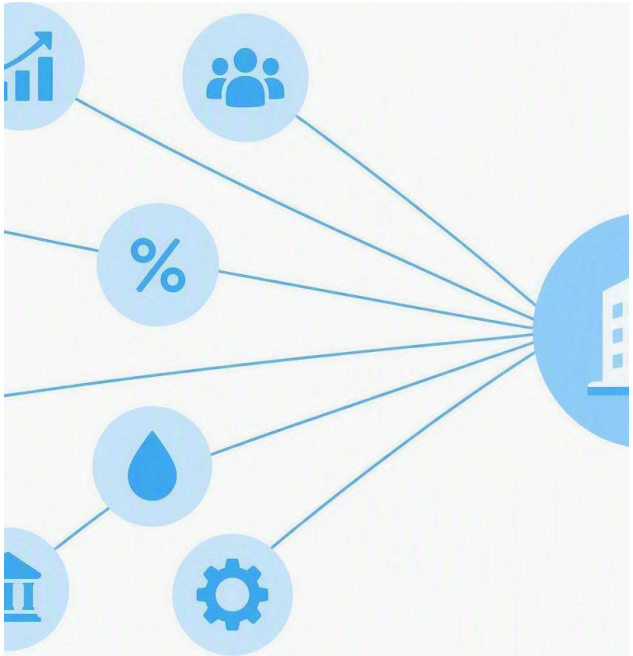
In the theoretical CAPM, the market portfolio contains all risky assets, weighted by market value.

Conceptually

It represents the aggregate portfolio held by all investors together.

In practice

Broad market indexes are commonly used as proxies.



Why Is the Market Portfolio Important?

Under CAPM assumptions:

Investors diversify

Firm-specific risk is assumed away, so only market exposure remains.

Focus on systematic risk

Only non-diversifiable risk is priced in equilibrium.

It is the relevant aggregate

The market portfolio is the risky portfolio all investors effectively share.

Securities are judged by contribution

Each security is evaluated by how much it adds to market risk.

SECTION X

The Security Market Line

CAPM drawn as a straight line.

Dr Abenet Yohannes, Ph.D.

What Is the Security Market Line?

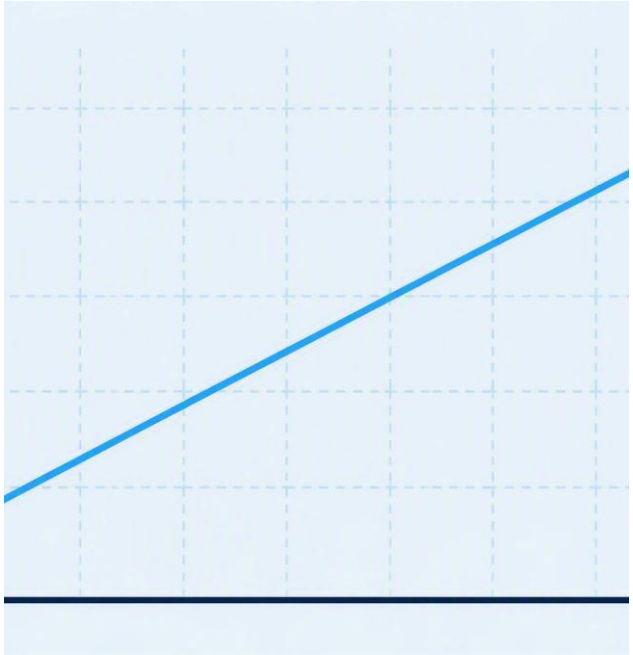
The Security Market Line (SML) shows the CAPM relationship between beta and required expected return.

Horizontal axis

Beta — systematic risk.

Vertical axis

Expected / required return.



The SML Equation

The Security Market Line is simply CAPM represented graphically.

$$E(R_i) = R_f + \beta_i [E(R_M) - R_f]$$

Intercept

R f — the return when beta is zero.

Slope

E(R M) − R f — the market risk premium, the reward per unit of beta.

Important Points on the SML

When β = 0

CAPM return equals the risk-free rate: R = R f.

When β = 1

CAPM return equals the expected market return: R = E(R M).

These two points fix the line: the intercept at R f and the market point at beta 1. Every other security's required return is read off the same line.

Reading the SML

On the line

Securities offer expected returns consistent with their systematic risk — CAPM equilibrium.

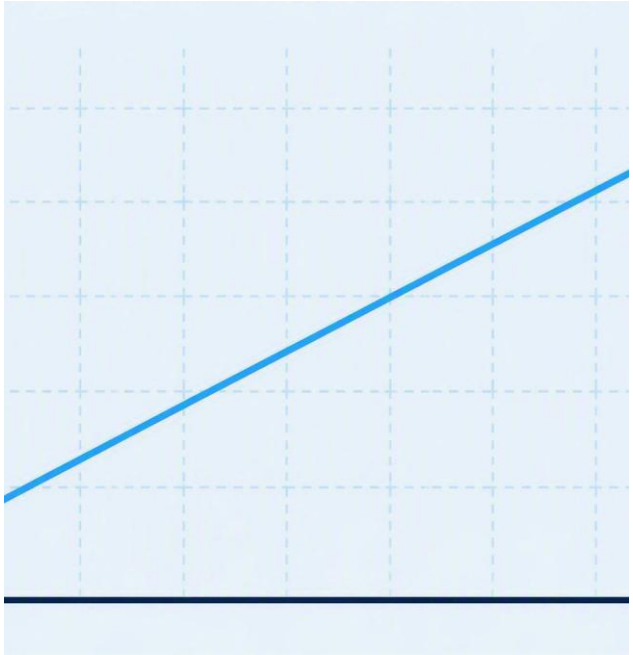
Above the line

Expected return exceeds the CAPM benchmark.

Below the line

Expected return falls short of the benchmark.

That difference is called ALPHA.



SECTION XI

Alpha

Performance measured against the CAPM benchmark.

Dr Abenet Yohannes, Ph.D.

What Is Alpha?

Alpha measures the difference between the return being evaluated and the CAPM benchmark return.

$$\alpha_i = E(R_i)\ \text{forecast} - E(R_i)\ \text{CAPM}$$

Positive alpha

Expected return above what systematic risk requires.

Negative alpha

Expected return below the CAPM benchmark.

Positive Alpha — Example

12%
CAPM required return

→

15%
Analyst's expected return

+3%
Alpha

$$\alpha = 15\% - 12\% = +3\%$$

The security is expected to earn 3% more than its systematic risk requires.

— Positive Alpha

CAPM says

"For this amount of systematic risk, 12% is appropriate."

Your analysis says

"I expect this security to return 15%."

The extra 3% is positive alpha relative to the CAPM benchmark.

Negative Alpha — Example

12%
CAPM required return

→

9%
Expected return

−3%
Alpha

$$\alpha = 9\% - 12\% = -3\%$$

The expected return is below the CAPM-required benchmark for this level of systematic risk.

SECTION XII

Undervalued and Overvalued Securities

Reading mispricing through the CAPM lens.

Dr Abenet Yohannes, Ph.D.

Undervalued Security

Within this simplified CAPM valuation interpretation:

$$\text{Expected Return} > \text{Required Return}$$

Plots above the SML

The security offers more expected return than its systematic risk requires.

May indicate UNDERVALUATION

Positive alpha — a potential buy candidate within the model.

Overvalued Security

$$\text{Expected Return} < \text{Required Return}$$

Plots below the SML

Expected compensation appears inadequate for the security's systematic risk.

May indicate OVERVALUATION

Negative alpha — the security looks expensive relative to the benchmark.

Simple Decision Rule

Positive alpha

Potentially undervalued — plots above the SML.

Zero alpha

Consistent with the CAPM benchmark — fairly priced within the model.

Negative alpha

Potentially overvalued — plots below the SML.

However, the conclusion is only as reliable as the estimates of beta, expected return, risk-free rate and market premium.

SECTION XIII

CAPM Assumptions

Simplification is what makes the model work — and what limits it.

Dr Abenet Yohannes, Ph.D.

CAPM Relies on Simplifying Assumptions

Why assume?

The standard CAPM is built on assumptions designed to simplify the investment environment.

The trade-off

These assumptions make the model analytically powerful, but they also create limitations.

A useful model is not a photograph of reality — it is a simplified map that highlights the relationship that matters.

Major CAPM Assumptions

Traditional CAPM assumptions include simplified conditions such as:

- Investors are rational mean-variance optimizers
- Investors share a common investment horizon
- Investors have homogeneous expectations
- Assets are tradable and divisible
- Markets are competitive

- Information is available to investors
- Taxes and transaction costs are ignored
- Investors can borrow and lend at R f
- Investors can diversify broadly

Why Use Unrealistic Assumptions?

A model does not need to reproduce every feature of reality. It simplifies reality to isolate an important relationship:

Systematic risk should be related to required return.

The real test

Not whether the assumptions are literally true, but whether the simplified model remains useful empirically and practically.

SECTION XIV

Limitations of CAPM

Where the single-factor story runs out.

Dr Abenet Yohannes, Ph.D.

Limitation 1 — Beta Changes Over Time

Historical beta may not remain constant. A company's risk can change because of:

- Leverage
- Business strategy
- Industry conditions
- Economic environment
- Acquisitions
- Regulation

Implication

A beta estimated from past returns may misstate the systematic risk investors face going forward, so estimates must be refreshed and judged in context.

Limitation 2 — Expected Returns Are Unobservable

CAPM concerns expected returns, but expectations cannot be observed directly. Analysts must estimate:

R_f	$E(R_M)$	MRP	β
Risk-free rate	Market return	Market premium	Beta

Consequence

Different assumptions produce different required returns — and therefore different valuation conclusions for the same security.

Limitation 3 — One Factor May Be Too Simple

CAPM explains expected return using a single systematic factor: market risk. But actual returns may also be associated with:

- Company size
- Value characteristics
- Interest rates
- Inflation
- Economic growth
- Other systematic factors

This motivates

Multifactor models — and Arbitrage Pricing Theory — which allow several systematic risks to be priced at once.

SECTION XV

Multifactor Models

More than one systematic force.

Dr Abenet Yohannes, Ph.D.

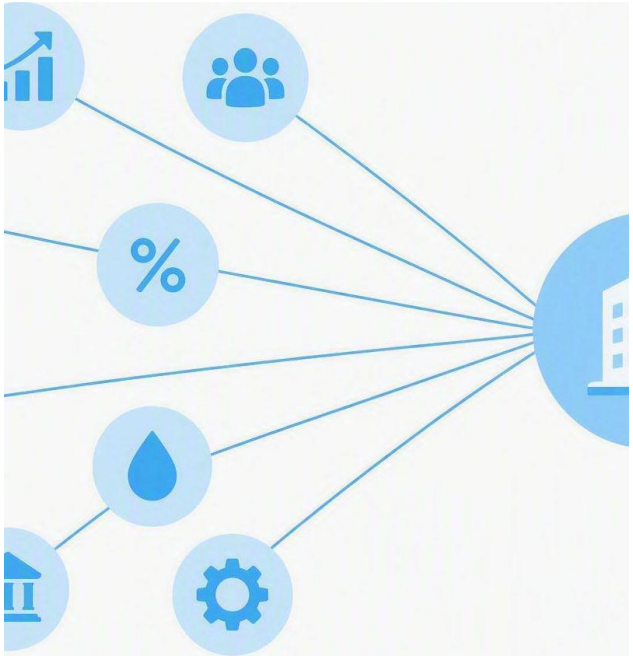
What Is a Multifactor Model?

A multifactor model explains security returns using exposure to several systematic factors.

$$R_i = \text{Expected} + \text{Factor Effects} + \text{Firm-Specific}$$

Key idea

Each factor carries its own sensitivity and its own risk premium.



— Multifactor Thinking

CAPM says

"One major systematic force — the market — explains required return."

Multifactor thinking says

"The market matters, but several economic forces may influence investment returns."

The question shifts from "how much market risk?" to "which risks, and how much of each?"

Possible Factors

Depending on the model, factors may include:

Market movements

Broad equity market returns

Economic growth

Industrial production, GDP surprises

Interest rates

Level and shape of the yield curve

Exchange rates

Currency exposure of cash flows

Inflation

Unexpected changes in price levels

Size & value

Firm characteristics linked to returns

The appropriate factors depend on the specific model being used.

Factor Sensitivity

Different securities react differently to the same factor.

Bank

Highly sensitive to interest rates.

Exporter

Highly sensitive to exchange rates.

Construction firm

Highly sensitive to economic growth.

These sensitivities are called factor betas, or factor loadings.

SECTION XVI

Arbitrage Pricing Theory

Pricing risk without relying on the market portfolio.

Dr Abenet Yohannes, Ph.D.

What Is APT?

Arbitrage Pricing Theory (APT) proposes that expected security returns can be related to exposures to multiple systematic risk factors.

Unlike CAPM

It does not require the market portfolio to be the sole source of priced systematic risk.

Foundation

It rests on no-arbitrage logic rather than strict equilibrium assumptions.

APT — Basic Form

$$E(R_i) = R_f + \beta_{i1}\lambda_1 + \beta_{i2}\lambda_2 + \ldots + \beta_{ik}\lambda_k$$

Symbol	Meaning
R_f	Risk-free rate
β_{ik}	Sensitivity of asset i to factor k
λ_k	Risk premium associated with factor k

CAPM is the special case with a single factor: the market.

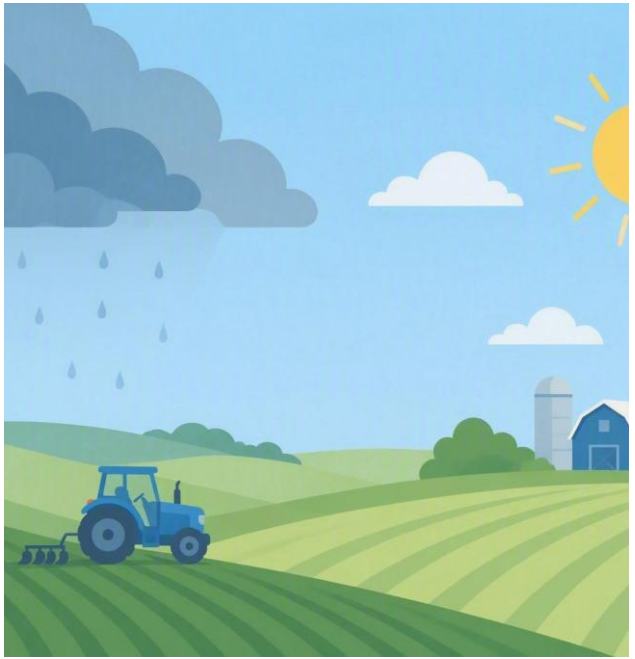
— APT: The Farm

Imagine your investment is a farm. Its performance might depend on:

- Rainfall
- Fertilizer prices
- Fuel prices
- Market prices for produce

One factor is not enough

APT says returns may depend on several systematic economic forces.



SECTION XVII

Factor Sensitivities in Practice

Different exposures, different required returns.

Dr Abenet Yohannes, Ph.D.

Factor Sensitivity — Example

Company A

Strongly affected by economic growth, only slightly by interest rates.

Company B

Shows the opposite pattern — rate-sensitive, growth-insensitive.

The two companies have different factor exposures — and therefore potentially different required returns, even in the same market.

APT — Numerical Example

Assume a risk-free rate of 4% and two priced factors:

Item	Factor premium (λ)	Company sensitivity (β)
Economic growth	5%	1.20
Inflation	3%	0.50

4%
Risk-free rate

1.20
Growth beta

0.50
Inflation beta

Calculating the APT Required Return

$$E(R) = 4\% + (1.2)(5\%) + (0.5)(3\%)$$

$$E(R) = 4\% + 6\% + 1.5\%$$

11.5%

Required expected return

Each factor contributes its own premium, scaled by the company's sensitivity to it.

SECTION XVIII

Arbitrage

The force that keeps prices consistent.

Dr Abenet Yohannes, Ph.D.

What Is Arbitrage?

Arbitrage means exploiting inconsistent prices to obtain a profit with no net investment and no risk, in the idealized theoretical sense.

Simple intuition

If identical economic payoffs have different prices: buy the cheaper, sell the more expensive.

Result

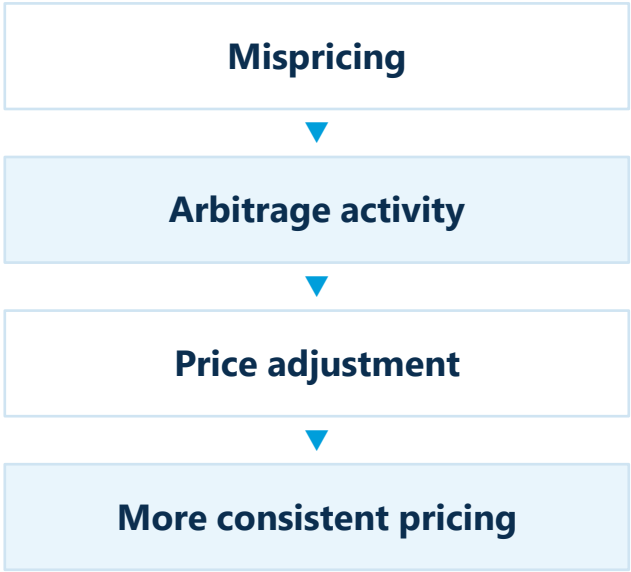
Price pressure should eventually remove the discrepancy.

Why Arbitrage Matters to APT

APT relies on the idea that significant pricing inconsistencies cannot persist indefinitely in sufficiently functioning markets.

The implication

No-arbitrage logic — not equilibrium assumptions about all investors — supports the factor-pricing relationship.



SECTION XIX

CAPM versus APT

Two frameworks, one question.

Dr Abenet Yohannes, Ph.D.

CAPM vs. APT

CAPM	APT
Primarily one systematic factor	Multiple systematic factors
Market beta is central	Multiple factor sensitivities
Requires the market portfolio concept	Does not rely on one market factor alone
Strong equilibrium assumptions	Based strongly on no-arbitrage logic
Simple and intuitive	More flexible
Factors specified by the model	Factors must be identified and estimated

Which Model Is Better?

There is no universal answer for every application.

CAPM is useful because it is

- Simple
- Intuitive
- Widely used in practice
- Easy to communicate
- A clear benchmark for alpha

APT / multifactor is useful when

- Multiple systematic risks matter
- More detailed risk decomposition is required
- Factor exposures differ across assets
- Richer risk attribution is needed

SECTION XX

Practical Applications

Putting CAPM and APT to work.

Dr Abenet Yohannes, Ph.D.

Where Is CAPM Used?

CAPM concepts are commonly applied in:

Cost of equity

Discount rate for equity cash flows

Portfolio analysis

Managing systematic exposure

Business valuation

Input to DCF and WACC

Performance evaluation

Benchmarking returns via alpha

Capital budgeting

Risk-adjusted hurdle rates

Security analysis

Screening for mispricing

Investment Decision — Worked Example

Given

$R_f = 5\%$ · $E(R_M) = 13\%$ · $\beta = 1.25$ · Analyst expects 17%

Step 1 — CAPM return

$5\% + 1.25(13\% - 5\%) = 15\%$

$$\text{Step 2 — Alpha: } \quad 17\% \; - \; 15\% \; = \; +2\%$$

Interpretation

The stock carries a positive expected alpha of 2% relative to the CAPM benchmark.

Practical Exercise

Given R f = 4% and E(R M) = 12%:

Stock	Beta	Expected return
A	0.50	9%
B	1.00	11%
C	1.50	18%

Work in pairs; be ready to justify each conclusion.

Student tasks

- Calculate the market risk premium
- Calculate CAPM required return for each stock
- Calculate alpha for each stock
- Identify which securities plot above or below the SML
- Identify potential under/overvaluation
- Explain why beta — not standard deviation — is the relevant CAPM risk measure

Key Takeaways

- Diversified investors care about systematic risk
- CAPM links required return to systematic risk
- Beta measures sensitivity to market movements
- The market portfolio has beta equal to 1
- Market risk premium = $E(R_M) - R_f$
- Higher beta implies higher required return
- The SML represents the CAPM risk–return relationship

- Alpha compares a return with its CAPM benchmark
- Positive alpha may indicate undervaluation
- Negative alpha may indicate overvaluation
- CAPM depends on simplifying assumptions and estimates
- Multifactor models allow several systematic risks
- APT prices multiple factor sensitivities
- No-arbitrage logic is central to APT

Diversification tells us which risk matters; asset-pricing models tell us how much return investors should require for bearing it.

Next Chapter — The Efficient Market Hypothesis

Chapter 8 will cover:

- Meaning of market efficiency
- Information and security prices
- Random walks
- Weak-form efficiency
- Semi-strong-form efficiency
- Strong-form efficiency
- Technical analysis

- Fundamental analysis
- Event studies
- Market anomalies
- Tests of market efficiency
- Active versus passive investing
- Implications for investment management

THANK YOU

Questions and discussion

Dr Abenet Yohannes, Ph.D.

abenetyohannes@gmail.com · abenetyohannes.com