Understanding NPV
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Introduction

My name is Raghavendra Rau and I'm a professor at the University of Cambridge. This is the first in a series of Gresham lectures this year on the big ideas of finance. The lectures this year are drawn from my textbook "A Short Introduction to Corporate Finance," published by Cambridge University Press.

There are four major viewpoints in corporate finance: Firms, investors, financial intermediaries, and governments. Firms can range from small local businesses like coffee shops to giants like Microsoft. Despite their sizes, all firms face two major financial decisions: How they will spend their money (investment decision) and how they will raise it (financing decision). Investors seek to maximize returns while minimizing risks. They face a large number of investment options and must figure out which offers the best risk-reward ratio. Financial Intermediaries bridge the gap between investors and firms. They include mutual funds, commercial banks, and investment banks. They can:

- Act as brokers, matching finance providers with seekers.
- Advise on asset pricing and asset allocation.
- Invest on behalf of others, with mutual and hedge funds pooling money to invest in high-return, low-risk assets.
- Provide loans, as commercial banks do by lending deposits to firms.
- Offer advisory services on matters like capital raising and acquisitions, as investment banks do.

Financial intermediaries charge for their services, and there's a critique that many overcomplicate their operations to justify higher charges.

Governments play many roles in corporate finance. They redistribute financial resources. This can be through taxes or subsidies, which can either promote efficiency or cater to vocal sectors. Such policies, like mortgage tax relief or sugar import taxes, play a significant role in corporate finance decisions. They have a multiplier effect. In downturns, governments might boost demand by spending on public projects. This Keynesian approach suggests that government investment can spur economic activity and reduce the recession's impact. Finally, they play a regulatory role. They define the rules of business, influencing firms' and individuals' investing and financing decisions.

How do we address the perspectives of all these players?

It turns out that there are only six major ideas in finance, five of which have won their originators Nobel prizes in economics. What are these ideas?

1. Net Present Value (NPV): This is the idea we are discussing in this lecture.

- NPV is the key principle in investment decision-making, where the objective is to maximize the present value of future payoffs. It involves three steps: computing cash flows, discounting those flows to a single present value using a discount rate and deciding the financing method, which affects taxes.

2. Portfolio Theory and the Capital Asset Pricing Model (CAPM)

- The interest rate or discount rate in NPV is determined by investors, based on available investment opportunities. Markowitz and Sharpe, Nobel laureates, proposed that individual investments are parts of

portfolios. They combined portfolios with risk-free assets to determine the market portfolio. The discount rate is determined using the CAPM formula. We will cover this in lecture 2.

3. Capital Structure Theory:

- Lecture 3 looks at capital structure theory which explains how the discount rate changes based on the firm's financing decision – whether to go with debt or equity. Modigliani and Miller, Nobel winners, posited that in a perfect world, financing form doesn't affect firm value. But with real-world imperfections (like taxes), it does matter.

4. Option Pricing Theory:

- Lecture 4 discusses how to price options, which are contracts that give rights to buy or sell assets. Black, Scholes, and Merton, with the latter two winning a Nobel, provided a solution based on the no-free lunch principle. They matched the cost of a portfolio replicating an option's payoff to the option's cost.

5. Asymmetric Information:

- Lecture 5 deals with information imbalances in transactions, where one party has more information than the other. Akerlof, Spence, and Stiglitz, Nobel laureates, developed key concepts in this area, illustrating how information imbalances affect markets from used cars to financial policies.

6. Market Efficiency:

- The last lecture discusses how markets reflect all available information. The debate lies in the relationship between market prices and NPV. Three Nobel winners, Kahneman, Fama, and Shiller, contributed pioneering ideas on this topic, discussing market behaviour and efficiency.

In essence, corporate finance revolves around six central ideas, with five of them recognized by Nobel Prizes. All these ideas stem from the no-arbitrage or no-free lunch principle.

The basic cycle of finance

Let's start with the basic cycle of finance (Rau, 2017):
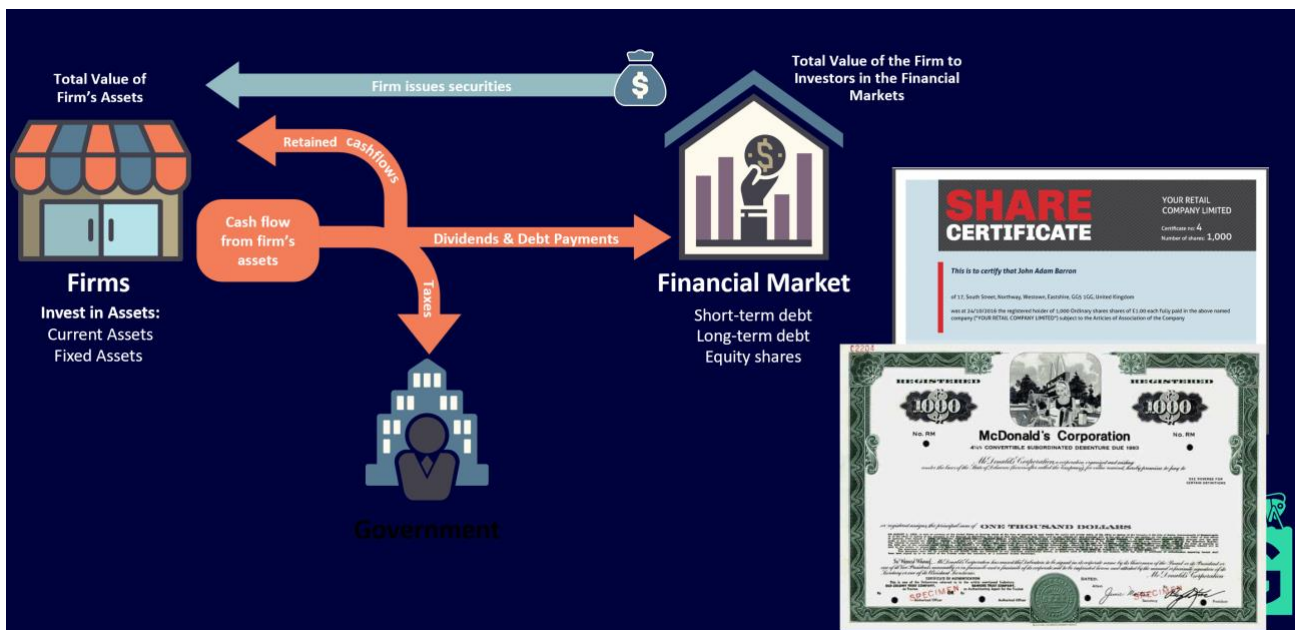

Image 1. Basic Cycle of Finance (Rau, 2017).

On the right-hand side of the figure, lie the investors (the market). They are offered a menu of contracts by the firm on the left-hand side. Some of these contracts involve fixed payments every year or every six months, a promise to return the face value at the end of a fixed term and a promise to pay off the instrument holders first in case of default. These contracts are *debt contracts*. Similarly, another set of contracts offers no guarantee of payments and the possibility of being paid last, if at all, if the firm defaults on its other contracts and goes bankrupt. Why would someone buy such a contract? It offers the possibility of large payments if the firm succeeds. To put this another way, it offers an opportunity to invest in the growth potential of the firm.

We call these contracts *equity*. Other contracts (preferred shares, convertible bonds and so on) may also exist. Investors decide what these contracts are worth. They then buy the share and bond contracts and transfer the money to the firm. The firm then chooses to invest these inflows into either short-term (current) assets or long-term assets. It then retains a portion of these cash flows, pays out some as taxes and returns the rest to the investors as dividends or debt payments.

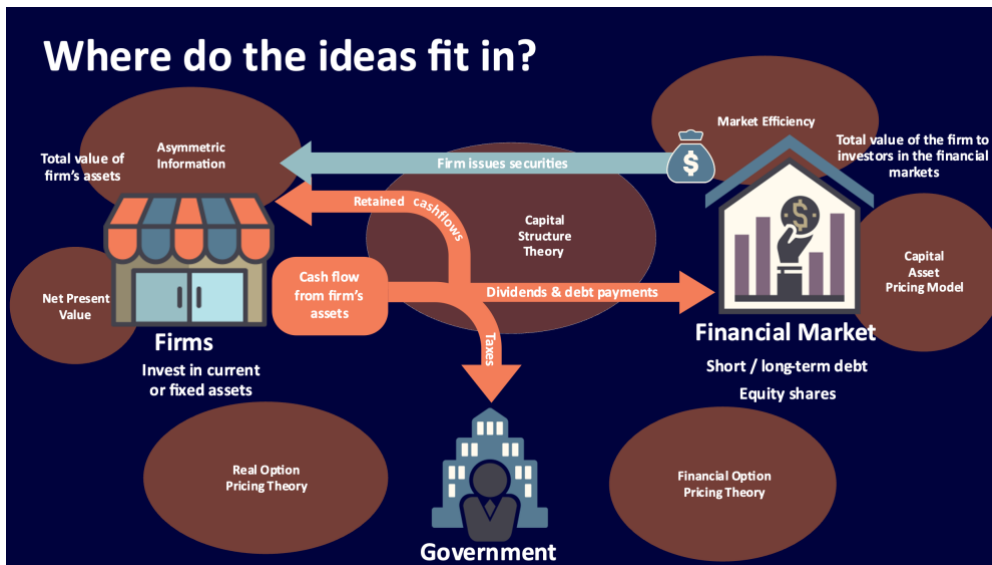So where do the six basic ideas fit into this structure? That is illustrated by the figure below:

Image 2. Basic Cycle of Finance (Rau, 2017) and The Six Basic Ideas of Finance.

So why is NPV the first fundamental idea of finance?

First, let us consider the different stakeholders in a firm, such as workers, managers, shareholders, customers, suppliers, bondholders, regulators, auditors, competitors, and the government, all of whom have vested interests in the company's success. There is an ongoing debate on which stakeholder the firm's managers should prioritize, and the perspective varies globally. While the US and UK primarily prioritize shareholders, countries like France, Germany, and Japan consider all stakeholders important.

However, the conventional belief among American and UK academics is that a firm should operate in the interest of its shareholders. The rationale is that shareholders, providing financial capital, should benefit from the firm's success. However, this viewpoint is challenged by those who argue that other stakeholders also contribute different types of capital (e.g., human capital by workers) to the firm.

Unfortunately, having managers cater to all stakeholders can be counterproductive, as they may prioritize their own interests instead. Hence, focusing on one stakeholder, in this case, the shareholder is considered optimal in financial theory. This choice doesn't imply neglecting other stakeholders, as maximizing shareholder value often indirectly benefits others.

How do we maximize shareholder value when we do not know who our shareholders are?

However, maximizing shareholder value isn't as straightforward as it might seem. This is because shareholders might have varying investment preferences. For instance, consider a firm deciding between a long-term project that pays off in fifty years and a short-term one with returns in two years. If the firm's shareholders are a mix of older pensioners and young MBA graduates, which project should the firm choose? Even if the firm decides to go with the majority, it's challenging for a manager to know the specifics of the shareholder demographics. Furthermore, identifying the importance of certain institutional shareholders over others complicates the decision-making. As another example, consider a Japanese firm with long-term local shareholders and a few short-term activist American shareholders. Who should the manager prioritize?

The concept of NPV solves these issues. Consider two survivors from a shipwreck who are marooned on a desert island, the captain (who did not go down with the ship) and a passenger. The captain is a short-term investor who wants to maximize his consumption today and leave nothing for tomorrow. The passenger is

the reverse, she wants to consume a lot tomorrow and very little today. All they have to eat is a bunch of potatoes. The two survivors have to decide how many of their equally divided potatoes they should plant for the next season and how many they should consume immediately. Due to declining returns to scale, planting more potatoes doesn't result in a proportional yield increase. Graphs represent these choices, with the X-axis showing the current season's potatoes and the Y-axis the next season's yield.
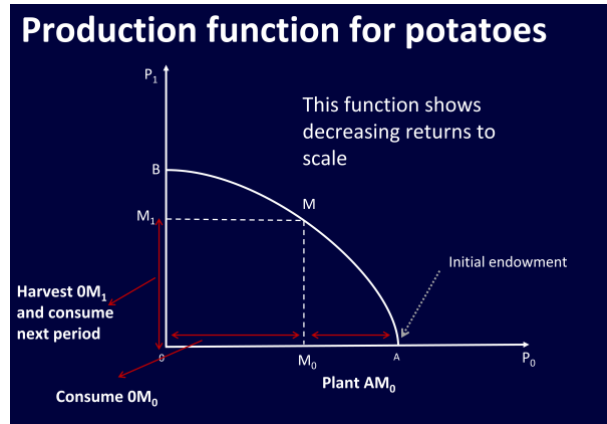

Image 3. The production function for potatoes (Based on the example provided).

Economists use preference (or indifference) curves to model such choices. Just like in a supermarket where one might be indifferent between two baskets with different groceries but of equal value, the preference curves illustrate combinations of current and future consumption between which a consumer is indifferent. The slope of these curves represents a person's patience level. A steeper slope indicates an impatient person who desires immediate gratification, while a shallower slope signifies someone who values future returns more.
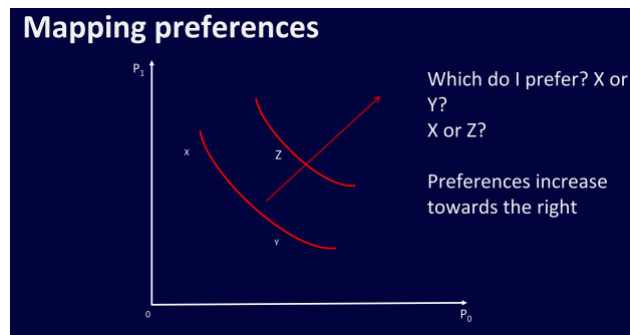

Image 3. Mapping preferences.

The captain, a short-term investor, prioritizes immediate consumption and invests little for the future.
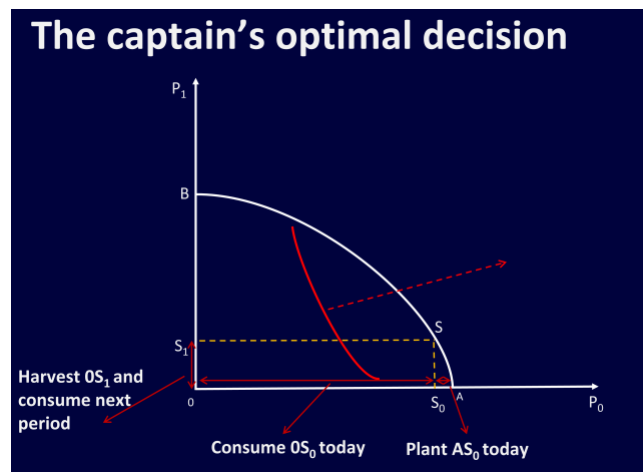

Image 3. The captain's optimal decision (Based on example provided).

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In contrast, the passenger, the long-term investor, prefers to plant more today for a more prosperous future harvest. Each makes decisions based on their individual preference curves which are aligned with the island's potato production capabilities.
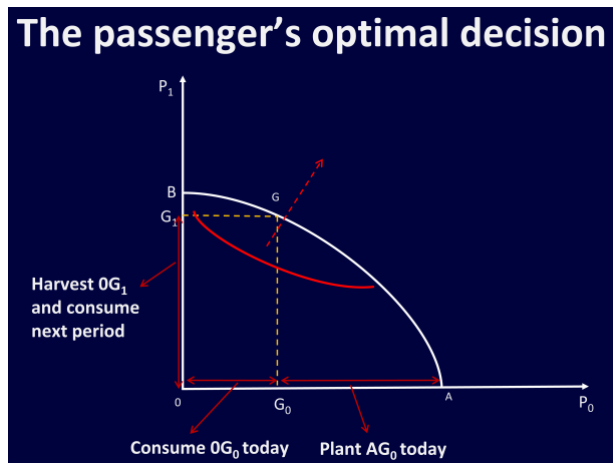

Image 4. The passenger's optimal decision (Based on example provided).

The crux of the problem arises when they attempt to collaborate. Since their preferences starkly contrast, finding a middle ground proves impossible. Any compromise point between their individual choices won't satisfy either of them as much as their individual decisions would. Thus, combining their resources doesn't lead to an optimal solution for both, illustrating the challenges of uniting short-term and long-term investor goals.

Introducing a financial market

Now suppose a third individual, a banker, arrives and introduces a potato exchange system based on a fixed interest rate, r. If one lends him a potato, he promises to return it with an added interest of 'r' in the next season, and similarly, if one borrows a potato, they owe him the principal along with the same interest. For instance, with an interest rate of 10%, lending the banker 10 potatoes would result in a return of 11 potatoes next season. The line representing this interest rate can be graphed, and its slope, derived from basic trigonometry, would equate to 1+r, visually representing the concept of interest.
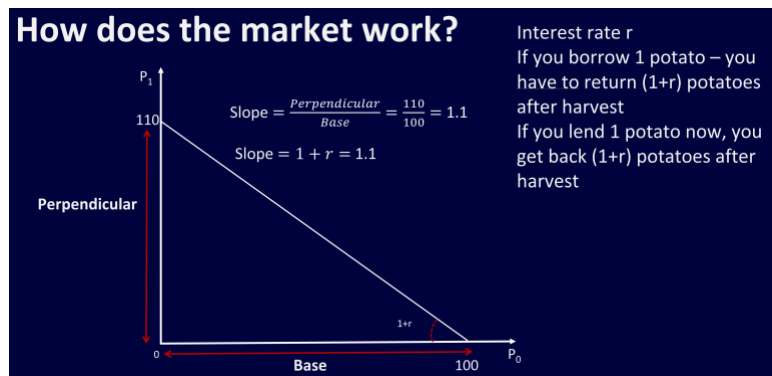

Image 5. How does the market work? (Based on example provided).

The introduction of a potato exchange with a fixed interest rate brings about economic decisions related to borrowing and investing. When we superimpose an interest rate line on a production function, an optimal point 'N' is derived.

For the Captain, who is more short-term oriented, this system allows him to consume more now and slightly less later by borrowing from the banker. He achieves this by:

1. Planting a certain amount (AN0) now.

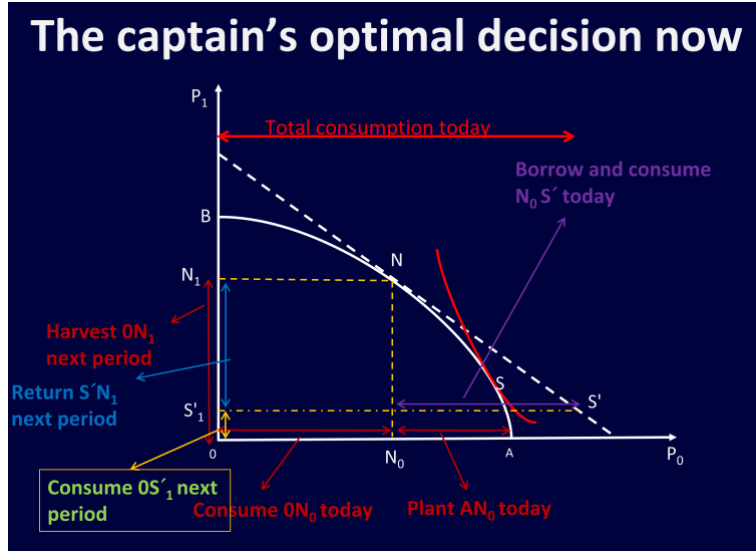2. Consuming more by *borrowing* from the banker, promising to return more next season.

Image 6. The captain's optimal decision now (Based on example provided).

The passenger, with her long-term outlook, can increase her benefits by lending to the banker instead of planting everything. Her steps are:

1. Planting the same amount as the captain (AN0) now.

2. Consuming less and *lending* the remainder to the banker for a return the following season.
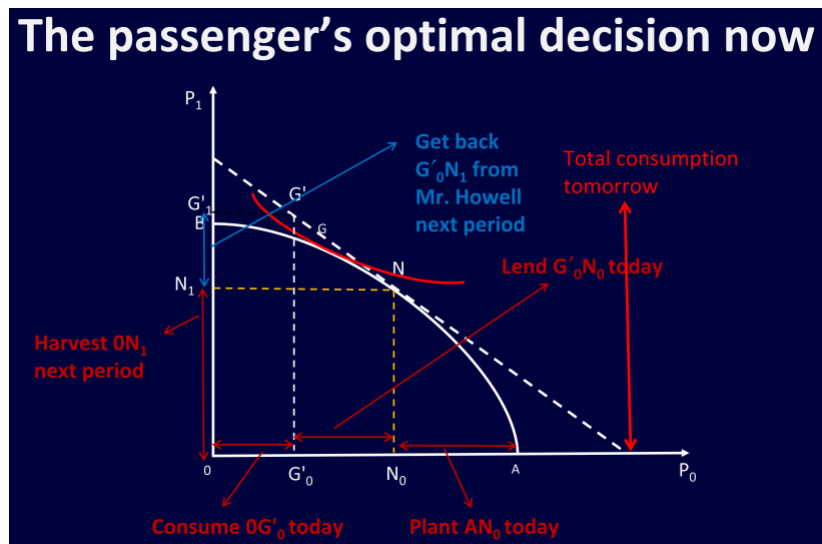

Image 7. The passenger's optimal decision now (Based on example provided).

The crux of their decisions revolves around the slopes of the production function and interest rate line. If borrowing costs (interest rate) are lower than potential gains from planting (production function), the captain borrows. If lending rates are higher than gains from planting, the passenger lends. The fascinating part is that both the captain and the passenger start with the same initial step of planting AN0, regardless of their individual goals.

In an extreme situation where the captain wants absolutely *no* returns in the next season, he borrows maximally from the banker. This highlights the creation of added value (distance AJ) made possible through the potato exchange. Without this system, neither the captain nor the passenger would gain additional benefits.
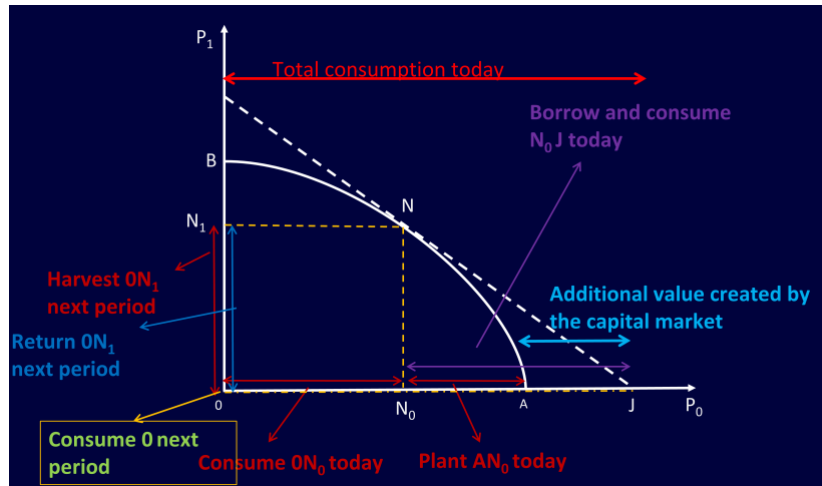
Image 6. The captain's optimal decision now, including the additional value created (Based on example provided).

Mathematically, the optimal point 'N' is derived from high school trigonometry, giving an insight into the relationship between interest rates, production returns, and investments. It culminates in the Net Present Value (NPV) formula which quantifies the value of an investment today based on its future returns, discounted by a specific interest rate.

The NPV formula

In corporate finance, this Net Present Value (NPV) formula plays a pivotal role. Extending the example to the capital markets, the castaways are akin to shareholders, potatoes symbolize money, planting potatoes represents investing, and the potato exchange acts as a financial market. The key concepts from this lecture are:

1. **The Fisherian Separation Theorem:** A crucial concept in finance, named after Irving Fisher who presented it in 1930. This theorem emphasizes that a company's investment decisions should be independent of its owner's consumption preferences. Firms should prioritize maximizing their present value, irrespective of what the owners desire. Subsequently, owners (or shareholders) can achieve their desired financial outcomes through borrowing or lending in capital markets.

2. **Value Addition by Financial Markets:** Financial markets, particularly intermediaries like banks, play a transformative role by converting long-term deposits for short-term needs and vice versa, thus aligning with the interest rate, r. Therefore, the primary function of banks is to morph money over time based on requirements, ensuring they do not accrue profits above the rate r merely for their transformational role.

Then the central question of which shareholders managers should prioritize becomes redundant. Managers should simply concentrate on maximizing the NPV. This requires three components:

- Two explicit elements: cash flows (CF) and the interest rate (r).
- One implicit element: the firm's financial strategy, i.e., its approach to sourcing funds for investment opportunities.

The latter often considers the company's capital structure within the interest rate (discount rate). This rate is determined by investors, with its derivation explored further through portfolio theory and the capital asset pricing model in the next lecture.

However, there's one last twist. In an ideal world, the Fisherian separation theorem, suggests that managers can make decisions without considering investor preferences. But real-world complications like asymmetric information mean that there isn't a one-size-fits-all investment solution. Such intricacies have profound implications on how companies structure their capital and governance.

References and Further Reading

Fisher, Irving, 1930, "The Theory of Interest: As determined by impatience to spend income and opportunity to invest it." MacMillan Co.: New York.

Rau, Raghavendra, 2017, "A short introduction to corporate finance." Cambridge University Press.