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Sustainable Finance: A Graduate Course

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Dedicated to Louise and her endless

patience. A special thank goes to my

parents,

Jette and Johnie,

without whose support,

this book would not have been.

Preface

NB Have that every channel and lesson at individual, firm, and society level and examples.

Write about having worked in government policy/regulation role, industry as asset management, consulting, and fund reporting, and researched sustainable finance for almost 10 years and taught sustainable finance at university level.

Grand challenges are abound. We have the highest temperatures in recorded history, rising sea levels threatening coastal areas, and unprecedented biodiversity loss. These issues demand immediate and collaborative global action to mitigate their impacts and ensure a sustainable future for upcoming generations.

Sustainable finance growth has been explosive in recent years, with a growing number of investors and companies recognizing the importance of environmental, social, and governance (ESG) factors in their decision-making processes. However, the challenges are immense, and the need for innovative solutions is urgent. At the same time, many jobs related to sustainability has been created, and the field is expected to grow further in the coming years.

This illustrates the current gap between the current need for sustainable finance capital and skills relative to the traditional skill set of the financial industry. At the same time, the financial industry is facing a number of challenges, including the need to adapt to new regulations at a rapid speed, massive reallocation of financial resources, and new the need for new and specialized financial skills. This contrasts with current financial education, which is still focused on traditional finance and does not cover new research in sustainable finance, features little in core courses in finance and investment programmes globally, and does not provide the necessary skills to address the challenges of sustainable finance.

This book aims to bridge this gap by providing a comprehensive overview of sustainable finance, including the latest research, best practices, and case studies. It is designed to be a valuable resource for students, academics, and professionals in the field of finance, investment, and sustainability. At the same time, the book aims to provide a practical guide for investors and companies looking to integrate sustainability into their decision-making processes. It covers a wide range of topics, including the role of finance in addressing sustainability challenges, the impact of sustainability on financial performance, and the latest trends in sustainable finance.

After reading this book, readers will have a solid understanding of the key concepts and issues in sustainable finance, as well as the tools and techniques needed to integrate sustainability into their investment and decision-making processes. They will also be equipped with the knowledge and skills to address the challenges of sustainable finance and contribute to a more sustainable future for all. Specifically, you will be able to:

1. Clarify the sustainability challenges including the central role of externalities

2. Understand the novel concept of internalized value based on the Total Value Framework and relate it to the traditional concepts of private and social value

3. Identify and evaluate the channels of internalization and their implications for sustainability transitioning

4. Explain and analyze the risks arising from externalities and sustainability transitioning and its consequences for corporates including the financial sector in light of internalized value

5. Analyze the effects of transitioning on the equilibrium decisions and returns of corporations and investors

6. Develop and evaluate managerial strategies to address the challenges of sustainable finance
7. Critically review the impact of ESG factors on valuation and pricing for investing and financing
8. Critically review the impact of firms on sustainability and the Sustainable Development Goals (SDGs)
9. Critically review the impact of investors on sustainability and the Sustainable Development Goals (SDGs)
10. Understand the outstanding issues in sustainable finance, including reporting, ratings, and greenwashing

Do a table of the book contents instead?

	Books			
Page content	*VDQI*	*EI*	*VE*	*BE*
Blank half title page	(1)	(1)	(1)	(1)
Frontispiece[1]	(2)	(2)	(2)	(2)
Full title page	(3)	(3)	(3)	(3)
Copyright page	(4)	(4)	(4)	(4)
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Dedication	(6)	(7)	(7)	7
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[1] The contents of this page vary from book to book. In *VDQI* this page is blank; in *EI* and *VE* this page holds a frontispiece; and in *BE* this page contains three epigraphs.

You have learned the foundations of finance, but have not yet explored finance's role in addressing sustainability issues. This book aims to bridge that gap by examining the consequences of financial decisions—both consumption and saving—in the context of sustainability challenges. Through this comprehensive exploration, we will uncover how finance can play a pivotal role in addressing and mitigating these pressing issues.

This will be done over ten chapters grouped into three parts. The first part, *The Framework*, will introduce the Total Value Framework and the channels of internalization. The second part, *Using the Framework*, will explore the transition risks and effects, firm and investor action, and the impact of firms and investors on sustainability. The final part, *Going for Impact*, will explore outstanding issues in sustainable finance.

Each chapter will be structured as follows:

- **Introduction**: A brief overview of the chapter's content and objectives.
- **Key Concepts**: An explanation of the key concepts and theories covered in the chapter.
- **Case Studies**: Real-world examples of how these concepts are applied in practice.
- **Implications**: The implications of these concepts for sustainable finance and the financial industry.
- **Conclusion**: A summary of the chapter's key points and a discussion of future trends and developments.

And will include problems and exercises to help you apply the concepts and theories covered in each chapter.

This sample book discusses the design of Edward Tufte's books[2] and the use of the `tufte-book` and `tufte-handout` document classes.

[2] Edward R. Tufte. *The Visual Display of Quantitative Information*. Cheshire, Connecticut: Graphics Press, 2001. ISBN: 0-9613921-4-2, Edward R. Tufte. *Envisioning Information*. Cheshire, Connecticut: Graphics Press, 1990. ISBN: 0-9613921-1-8, Edward R. Tufte. *Visual Explanations*. Cheshire, Connecticut: Graphics Press, 1997. ISBN: 0-9613921-2-6, Edward R. Tufte. *Beautiful Evidence*. First. Graphics Press, LLC, May 2006. ISBN: 0-9613921-7-7

Chapter 1
Grand Challenges

We live in an interconnected world where economic decisions ripple through environmental and social systems in ways that fundamentally reshape our future. The choices we make today—about energy, production, consumption, and investment—create consequences far beyond immediate financial returns. These consequences, whether intended or not, represent the grand challenges of our time: climate change, biodiversity collapse, resource depletion, and widening inequality.

This course introduces sustainable finance not as a specialized niche, but as the evolution of finance itself. As we will see, financial markets have long struggled with a fundamental problem: prices often fail to reflect true costs. When firms pollute without paying, extract resources without accounting for depletion, or profit from practices that harm communities, they externalize costs onto society. These externalities create market failures that distort capital allocation and undermine long-term value creation.

Understanding and addressing this challenge requires new analytical frameworks, new metrics, and new ways of thinking about value. This opening chapter establishes the intellectual foundation: we explore why sustainability matters for finance, introduce the concept of externalities that lies at the heart of the problem, and preview the tools we'll develop to internalize these externalities into financial decision-making.

The key insight we develop throughout this course: **we are affected by our environment, and our choices affect the environment**. This bidirectional relationship—what economists call general equilibrium thinking—means we must expect others to react to our actions, and these

1.1 The Sustainability Imperative

Planetary Boundaries

The Earth's systems are under unprecedented stress. Consider the evidence:

Climate Change: Global average temperatures have risen approximately 1.1°C above pre-industrial levels, with the warmest years on record concentrated in the past decade. Arctic sea ice has declined by 13% per decade since 1979. Sea levels are rising at an accelerating rate—currently 3.4mm per year—threatening coastal infrastructure worth trillions of dollars. The Intergovernmental Panel on Climate Change (IPCC) projects warming of 1.5-2.0°C by mid-century under current policies, with potentially catastrophic consequences beyond 2°C.

Biodiversity Loss: Species extinction rates are estimated to be 100-1,000 times higher than background rates. The 2019 IPBES Global Assessment found that one million species face extinction, many within decades. This loss extends beyond wildlife: ecosystem services that humans depend on—pollination, water purification, climate regulation—are degrading rapidly. The economic value of these services, estimated at $125-140 trillion annually, dwarfs global GDP.

Resource Depletion: Humanity currently consumes resources at a rate 1.75 times what Earth can regenerate annually. Water stress affects 2.3 billion people, expected to reach 5.7 billion by 2050. Soil degradation threatens 33% of the world's arable land. Critical minerals required for clean energy transitions—lithium, cobalt, rare earths—face supply constraints that could bottleneck decarbonization efforts.

Social Challenges: The richest 1% of humanity now owns 45% of global wealth, while the bottom 50% owns less than 1%. This inequality is not merely a moral concern—it creates political instability, undermines social cohesion, and constrains economic growth. Climate impacts disproportionately affect vulnerable populations, creating feedback loops that exacerbate both environmental and social challenges.

These are not independent crises but interconnected challenges. Climate change accelerates biodiversity loss. Resource scarcity drives conflict and migration. Inequality reduces collective capacity to address environmental problems. This interconnection means solutions must be systemic, not piecemeal.

The UN Sustainable Development Goals

Recognizing these interconnections, the United Nations established 17 Sustainable Development Goals (SDGs) in 2015 as a universal framework for addressing global challenges. These goals span economic development (SDG 8: Decent Work and Economic Growth), social progress (SDG 1: No Poverty; SDG 5: Gender Equality), and environmental protection (SDG 13: Climate Action; SDG 14: Life Below Water; SDG 15: Life on Land).

The SDG framework matters for finance because it:

1. **Quantifies opportunity:** The UN estimates $5-7 trillion in annual investment needed to achieve the SDGs, creating massive market opportunities in renewable energy, sustainable infrastructure, healthcare, education, and clean technology.

2. **Identifies risks:** Companies and investments misaligned with SDG trajectories face growing regulatory, reputational, and physical risks.

3. **Provides common language:** The SDGs create a standardized framework for measuring and reporting sustainability impacts, facilitating capital allocation toward positive outcomes.

The SDGs represent the international consensus on development priorities through 2030. Unlike earlier frameworks that treated economic, social, and environmental goals separately, the SDGs emphasize their interdependence. Progress on climate (SDG 13) enables progress on poverty reduction (SDG 1), just as gender equality (SDG 5) supports economic growth (SDG 8).

For financial professionals, the SDGs translate abstract sustainability concepts into concrete investment themes and measurable targets. They make sustainability investable.

1.2 *Climate Change: The Defining Challenge*

The Science and Economics of Climate Risk

Among the sustainability challenges confronting our world, climate change stands as the most urgent and far-reaching. The mechanism is well understood: atmospheric CO_2 concentrations have risen from 280 parts per million (ppm) in pre-industrial times to over 420 ppm today, primarily from burning fossil fuels. This greenhouse gas accumulation traps heat, raising global temperatures with cascading consequences.

The physical impacts are accelerating:

The frequency of billion-dollar weather disasters in the United States has increased from 3 per year in the 1980s to over 20 per year in the 2020s, with total annual damages exceeding $100 billion in multiple recent years.

- **Extreme weather:** Hurricane intensity has increased, with Category 4-5 storms becoming more frequent. Droughts of unprecedented duration affect major agricultural regions. Wildfires burn with greater severity across multiple continents.

- **Sea level rise:** Coastal flooding threatens $1 trillion in U.S. assets by 2050. Cities like Miami, Jakarta, and Shanghai face existential infrastructure challenges. Small island nations confront displacement of entire populations.

- **Ecosystem disruption:** Coral reefs—which support 25% of marine biodiversity—face near-total collapse above 2°C warming. Agricultural yields decline in many regions as temperature and precipitation patterns shift.

For finance, climate change creates three distinct risk categories identified by Mark Carney, former Bank of England Governor:

Physical Risks Direct damage to assets and operations from climate impacts. Real estate in flood zones faces declining valuations. Agricultural companies see crop yields fall. Utilities experience infrastructure damage from extreme weather. Insurance companies face mounting claims that exceed historical actuarial models.

Transition Risks Financial losses as economies shift away from fossil fuels. Coal companies face stranded assets as plants close prematurely. Automotive manufacturers must retool for electric vehicles or lose market share. Oil and gas reserves may become unburnable under climate constraints, destroying shareholder value.

Liability Risks Legal exposure as climate damages mount and causation becomes clearer. Energy companies face lawsuits seeking damages for climate impacts. Directors face fiduciary duty claims for failing to address climate risks. Insurers may challenge coverage for climate-related losses.

Yet within this challenge lies extraordinary opportunity. The International Energy Agency estimates $4 trillion in annual clean energy investment needed to reach net-zero by 2050. This capital reallocation represents the largest investment opportunity of the 21st century—renewable energy, grid modernization, electric transportation, carbon capture, climate adaptation infrastructure, and sustainable agriculture.

Nordhaus and the Economics of Climate Action

The 2018 Nobel Prize in Economics, awarded to William Nordhaus, recognized the integration of climate change into economic growth models. Nordhaus's Dynamic Integrated Climate-Economy (DICE) model established the framework we still use today for analyzing climate policy.

Nordhaus shared the 2018 Prize with Paul Romer, who developed theories of endogenous technological change—equally relevant for understanding clean energy innovation.

The DICE model captures key relationships:

1. **Emissions → Temperature:** Economic activity generates CO_2 emissions, which accumulate in the atmosphere and raise global temperatures according to well-established climate physics.

2. **Temperature → Damages:** Higher temperatures reduce economic output through agricultural losses, health impacts, infrastructure damage, and ecosystem degradation.

3. **Abatement Costs:** Reducing emissions requires costly investments in clean energy, efficiency, and carbon capture.

Nordhaus's key insight: the optimal policy balances marginal abatement costs against marginal climate damages, implemented through a carbon tax that rises over time. His original estimate suggested an optimal carbon price of $40 per tonne CO_2, significantly higher than actual prices in most jurisdictions.

However, Nordhaus's framework has important limitations:

- **Damage functions:** The model may underestimate catastrophic tail risks like ice sheet collapse or ecosystem tipping points.
- **Discount rates:** Using standard rates (3-5%) to discount far-future climate damages is ethically controversial—why should we value our grandchildren's welfare so much less than our own?
- **Distribution:** Climate damages fall disproportionately on poor nations and future generations who contributed least to the problem.

More recent estimates, incorporating climate tipping points and lower discount rates, suggest social costs of carbon in the $150-200 per tonne range—far above current carbon prices. This gap between social cost and market price represents the core externality problem we address in this course.

1.3 Externalities: The Core Market Failure

Defining Externalities

An **externality** occurs when an economic transaction affects third parties who did not choose to be involved in that transaction. The cost or benefit is "external" to the market price—neither the buyer nor the seller accounts for it in their decision-making, yet society bears the consequence.

Classic examples: A factory emits pollution that causes respiratory illness in nearby residents. A beekeeper's bees pollinate neighboring orchards without compensation. A vaccination protects not just the recipient but everyone through herd immunity.

Externalities are *the* central concept in sustainable finance because they represent the mechanism through which private financial decisions create social and environmental consequences. When externalities are large and pervasive—as with climate change, biodiversity loss, or inequality—they create systematic market failures that distort capital allocation.

Externalities can be:

- **Negative:** Costs imposed on third parties (pollution, resource depletion, noise, congestion)
- **Positive:** Benefits enjoyed by third parties (education, R&D spillovers, ecosystem restoration)

The key insight: when externalities exist, market outcomes are inefficient. Firms that generate negative externalities overproduce (pollution is too high) because they don't bear the full cost. Firms that generate positive externalities underproduce (too little innovation) because they can't capture the full benefit.

The Coase Theorem and Its Limits

Ronald Coase's 1960 insight revolutionized how economists think about externalities. The **Coase Theorem** states that if property rights are well-defined and transaction costs are zero, private parties can negotiate to internalize externalities without government intervention.

Example: If a factory pollutes a river harming downstream fisheries, and property rights are clear, the factory and fishery could negotiate. Either the fishery pays the factory to reduce pollution, or the factory compensates the fishery for damages. Either way, the outcome is efficient.

In practice, however, Coase's conditions rarely hold for environmental and social externalities:

Ill-Defined Property Rights Who owns the atmosphere? Who has rights to biodiversity? For diffuse resources like air quality or climate stability, property rights cannot be meaningfully assigned.

High Transaction Costs Climate change affects billions of people across generations. Negotiating compensation between all affected parties is impossible. Even localized pollution often involves thousands of affected individuals, making direct negotiation infeasible.

Information Asymmetries Polluters often know more about their emissions than affected parties. Long time lags between action and impact (as with climate change) obscure causation.

These failures mean that for large-scale externalities, government intervention or collective action mechanisms are necessary. This brings us to policy tools.

1.4 *Analytical Toolkit for Sustainable Finance*

Before we develop the comprehensive Total Value Framework in later chapters, we introduce two foundational tools that appear throughout the course: the Gordon Growth Model for valuation and game theory for strategic interactions. Understanding these tools now will facilitate deeper analysis later.

The Gordon Growth Model

Firm valuation lies at the heart of financial decision-making. The Gordon Growth Model (also called the dividend discount model or perpetuity growth model) provides the simplest framework for understanding how cash flows translate into firm value.

The model values a firm as the present value of its future dividend stream, assuming constant growth:

$$P_0 = \frac{D_1}{r - g} \tag{1.1}$$

where:

- P_0 is the current stock price (firm value per share)
- D_1 is next year's expected dividend per share
- r is the required rate of return (cost of equity)
- g is the perpetual dividend growth rate

The intuition is straightforward: a firm's value equals what it will pay shareholders over time, discounted to present. The model assumes $g < r$ (otherwise value would be infinite) and constant growth (a strong simplification).

Example: A firm pays \$2 dividend per share next year, expected to grow at 3% annually forever. If investors require 8% return, the stock is worth: $P_0 = \frac{\$2}{0.08-0.03} = \$40$ per share.

Connection to Sustainable Finance Why does this matter for sustainability? Because externalities affect all three parameters:

1. **Dividends (D_1):** As regulations internalize externalities (e.g., carbon taxes), polluting firms see cash flows decline. Clean firms may see cash flows increase through market share gains or regulatory advantages.

2. **Growth rate (g):** Firms misaligned with sustainability transitions face shrinking markets (declining g). Firms enabling the transition capture expanding markets (rising g).

3. **Required return (r):** Firms with large unpriced externalities face higher risk premiums as markets price in regulatory, physical, and reputational risks.

Later in this course, we'll extend the Gordon model to explicitly incorporate externalities through the internalization parameter ι, creating a bridge between sustainability impacts and financial valuation.

Game Theory and Strategic Sustainability

Sustainability challenges are fundamentally strategic. When one firm reduces emissions, it bears costs but shares benefits with all of society. When one country implements carbon taxes, it may lose competitiveness to countries that don't. These situations—where outcomes depend on what multiple actors choose simultaneously—require game-theoretic thinking.

Nash Equilibrium A **Nash equilibrium** is a situation where no player can improve their outcome by unilaterally changing strategy, given what others are doing. It represents a stable outcome of strategic interaction.

Named for John Nash (1928-2015), whose doctoral thesis revolutionized economics. His life was depicted in the film *A Beautiful Mind*.

The concept is crucial for understanding why individual rationality can lead to collective failure—the essence of many sustainability problems.

The Climate Prisoner's Dilemma Consider two countries deciding whether to reduce emissions:

	Country B Reduces	**Country B Pollutes**
Country A Reduces	(-2, -2)	(-5, 0)
Country A Pollutes	(0, -5)	(-10, -10)

Table 1.1: Climate policy as a prisoner's dilemma. Numbers represent welfare (higher is better). Both countries prefer to pollute individually, but both are better off if both reduce emissions.

The payoffs reflect:

- **Mutual cooperation** (both reduce): Climate damages are moderate (-2, -2)

- **Unilateral reduction**: The reducing country bears costs without sufficient climate benefit (-5), while the free-rider enjoys climate benefits without costs (0)
- **Mutual defection** (both pollute): Severe climate damages (-10, -10)

The Nash equilibrium is for both to pollute: given that Country B pollutes, Country A is better off polluting (payoff -10 vs -5). The same logic applies to Country B. Yet both countries would prefer the outcome where both reduce emissions (-2) to the Nash equilibrium where both pollute (-10).

This is the tragedy at the heart of climate policy: individual rationality leads to collective catastrophe.

Implications for Sustainable Finance Game theory teaches us three critical lessons:

1. **Collective action problems require coordination:** Market mechanisms alone won't solve sustainability challenges. International agreements (Paris Accord), regulations, and standards help coordinate toward better equilibria.
2. **First-mover disadvantages:** Early adopters of sustainability practices may face competitive disadvantages unless policy creates level playing fields. This explains industry lobbying for regulation—incumbents sometimes prefer clear rules to uncertain competitive dynamics.
3. **Strategic complementarities:** In some settings, sustainability actions are mutually reinforcing. If many firms invest in clean tech, innovation accelerates and costs fall, making others' investments more attractive. This creates positive feedback loops that can tip markets toward sustainable equilibria.

Understanding these strategic dynamics is essential for investors. Firms and sectors where sustainability actions exhibit strong strategic complementarities may see rapid transitions. Those stuck in prisoner's dilemmas may resist change absent regulatory forcing.

1.5 Policy Tools for Internalization

Game theory reveals why markets fail to address externalities spontaneously. This brings us to policy: the mechanisms governments and regulators use to internalize externalities and move toward efficient outcomes.

The Policy Toolkit

Economists have developed a standard taxonomy of interventions:

Pigouvian Taxes Named for economist Arthur Pigou, these taxes equal the marginal social cost of an externality. A carbon tax of $150/tonne, if it equals the social cost of carbon, makes firms face the true cost of their emissions. This internalizes the externality: firms reduce pollution until their marginal abatement cost equals the tax.

Sweden introduced a carbon tax in 1991 at approximately $30/tonne, rising to over $130/tonne today. Emissions have fallen 29% since 1990 while GDP has grown 80%, demonstrating that carbon pricing and economic growth can coexist.

Cap-and-Trade Government sets a total emissions limit (cap) and issues tradable permits. Firms that can reduce emissions cheaply do so and sell permits; firms facing high abatement costs buy permits. This achieves the emissions target at minimum cost. The EU Emissions Trading System (EU ETS), covering 40% of European emissions, is the world's largest carbon market.

Regulation Direct limits on emissions, technology mandates, or performance standards. Examples include vehicle fuel efficiency standards, coal plant phase-outs, and renewable portfolio standards requiring utilities to source electricity from clean energy. Regulations provide certainty but may not achieve cost-effective abatement.

Subsidies Payments for positive externalities or clean alternatives. Examples include solar investment tax credits, R&D grants for clean technology, and subsidies for electric vehicle purchases. Subsidies can accelerate adoption but require government funding and may be inefficiently targeted.

Carbon Pricing in Practice

As of 2024, 73 carbon pricing instruments operate globally, covering approximately 23% of global emissions. But prices vary enormously:

- **EU ETS:** €80-90 per tonne CO_2 (fluctuates with market conditions)
- **UK Carbon Price Floor:** £18 per tonne minimum
- **California Cap-and-Trade:** $30-35 per tonne
- **China National ETS:** $8-10 per tonne (launched 2021, covers power sector)
- **Voluntary carbon markets:** $5-50 per tonne (wide quality variation)

This price dispersion represents a violation of the Law of One Price—the same externality (a tonne of CO_2) has different prices in different markets. This creates several implications:

Carbon Leakage Industries facing high carbon prices may relocate to jurisdictions with low or no carbon pricing, shifting emissions rather than reducing them. This "leakage" problem motivates border carbon adjustments, where importers pay tariffs based on embedded emissions.

The EU's Carbon Border Adjustment Mechanism (CBAM), phased in from 2023-2026, imposes tariffs on imports (steel, cement, aluminum, fertilizers, electricity) based on carbon content. This aims to prevent leakage and incentivize trading partners to implement carbon pricing.

Competitive Dynamics Firms operating across multiple jurisdictions face different carbon costs, affecting competitiveness. This creates strategic considerations for where to locate production and how to structure supply chains.

Arbitrage Opportunities? Standard financial arbitrage doesn't work—you can't buy cheap carbon credits in China and sell them in the EU. But the price dispersion creates opportunities for firms to source low-carbon inputs from high-price jurisdictions (where carbon avoidance is expensive) and sell into those markets at premium valuations.

The Role of Sustainable Finance

This brings us to the central question of this course: *How does finance interact with policy to drive sustainability transitions?*

Sustainable finance complements carbon pricing through several channels:

1. **Price discovery:** ESG-integrated investors incorporate expected future carbon prices into valuations today, creating forward-looking price signals that can precede regulation.

2. **Capital reallocation:** By overweighting low-carbon firms and underweighting high-carbon firms, sustainable investors accelerate the cost-of-capital wedge that drives transition.

3. **Engagement and governance:** Investors pressure management to reduce emissions, develop transition plans, and improve disclosure—mechanisms beyond policy.

4. **Innovation funding:** Venture capital, growth equity, and green bonds channel capital to clean technologies, infrastructure, and business models that enable decarbonization.

The **carbon tax-premium equivalence** is the key conceptual link: a carbon tax of $T per tonne has the same effect on firm value as investors imposing a risk premium of Δr on high-carbon firms, where the premium reflects the present value of expected future carbon costs. If investors perfectly anticipate policy, sustainable finance can substitute for or complement regulation.

Later chapters formalize this relationship and explore when finance-driven internalization is most effective versus when policy is required.

1.6 Conclusion: The Path Forward

This chapter has established the foundations for sustainable finance:

The Challenge: Environmental and social externalities—climate change, biodiversity loss, resource depletion, inequality—create market failures that distort capital allocation and threaten long-term value creation.

The Mechanism: When firms externalize costs, market prices fail to reflect true costs. This leads to overproduction of harmful activities and underinvestment in solutions.

The Response: Policy tools (carbon taxes, cap-and-trade, regulation, subsidies) aim to internalize externalities. Sustainable finance complements policy by incorporating externalities into investment decisions, reallocating capital, and engaging with companies.

The remainder of this course develops a unified framework—the Total Value Framework—that formalizes these relationships. We introduce the internalization parameter ι to measure the extent to which externalities are priced into firm value, then explore how firms, investors, and policy interact to drive ι from its current low levels toward fuller internalization.

Understanding these dynamics is not merely academic. It represents the essential skill set for 21st-century finance professionals. As climate risks materialize, regulations tighten, and investor preferences shift toward sustainability, the ability to assess and price externalities will separate successful investors from those left holding stranded assets.

Exercises

Conceptual Questions

1. **Planetary Boundaries:** Identify three major sustainability challenges beyond climate change and explain how each creates financial risks. For one challenge, describe both physical risks (direct impacts) and transition risks (policy/market shifts).

2. **SDG Investment Opportunity:** The UN estimates $5-7 trillion in annual investment needed to achieve the Sustainable Development Goals. Choose one SDG and identify three specific investment opportunities (with company or sector examples) that address that goal. What are the risks and returns?

3. **Externality Examples:** For each of the following, identify whether the externality is positive or negative, explain the

market failure, and propose one policy intervention:

- A coal power plant operating in an industrial zone
- A company developing open-source climate adaptation technology
- Industrial agriculture using antibiotics in livestock
- A corporate training program that improves general workforce skills

4. **Coase Theorem Limitations:** Explain why the Coase Theorem fails to resolve climate externalities. Specifically address: (a) property rights definition, (b) transaction costs, and (c) information asymmetries. Would Coase's conditions hold better for local pollution (e.g., a factory polluting a nearby river)? Why or why not?

Quantitative Problems

5. **Gordon Growth Model with Carbon Tax:**

   A coal-fired utility currently pays $2 per share in annual dividends, expected to grow at 2% annually. Investors require a 9% return.

   (a) Calculate the current stock price using the Gordon Growth Model.

   (b) The government introduces a carbon tax of $50/tonne CO_2. The utility emits 10 million tonnes annually and has 100 million shares outstanding. Assume the tax fully reduces dividends (no pass-through to customers or abatement). What is the new dividend per share?

   (c) Recalculate the stock price with the carbon tax. What percentage of firm value is destroyed?

   (d) Now assume the firm can reduce emissions 40% at a cost of $0.50 per share annually. Should it abate or pay the tax? Calculate the stock price under optimal abatement.

6. **Nash Equilibrium in Emission Reduction:**

Two competing firms must decide whether to invest in emissions reduction. The payoff matrix (in millions of dollars of NPV) is:

	Firm B Reduces	**Firm B Pollutes**
Firm A Reduces	(100, 100)	(60, 130)
Firm A Pollutes	(130, 60)	(80, 80)

(a) Identify all Nash equilibria.

(b) Is this a prisoner's dilemma? Explain.

(c) What policy intervention could move firms from the Nash equilibrium to the socially optimal outcome?

(d) Suppose the game is played repeatedly (10 times). Describe a strategy that could sustain cooperation.

7. **Social Cost of Carbon Calculation:**

   Using Nordhaus's framework, assume:

   - Marginal damage from 1 tonne CO_2: \$150 today, growing at 2%/year
   - Discount rate: 4%
   - Time horizon: 100 years

(a) Calculate the present value of damages from emitting 1 tonne CO_2 today (the social cost of carbon).

(b) Recalculate using a 2% discount rate. How much does the social cost change?

(c) What ethical arguments support using a lower discount rate for climate damages?

8. **Carbon Price Dispersion and Leakage:**

   A steel producer operates plants in the EU (carbon price: €80/tonne) and Poland (no carbon price). Each plant produces 1 million tonnes of steel annually, emitting 2 tonnes CO_2 per tonne of steel. Production cost (excluding carbon) is €400/tonne in both locations.

(a) Calculate the all-in production cost per tonne in each location.

(b) If steel sells for €600/tonne globally, calculate profit per plant.

(c) If the firm shifts production from EU to Poland, what happens to: (i) global emissions, (ii) firm profits, (iii) effective carbon price?

(d) The EU introduces a carbon border adjustment charging importers €80/tonne embedded CO_2. How does this change the production decision?

Case Study

9. **Analyzing a Real-World Sustainability Challenge:**

   Choose a publicly traded company in a high-externality sector (energy, heavy industry, agriculture, fast fashion). Using publicly available data:

(a) Identify the company's major environmental and social externalities (with quantification where possible).

(b) Estimate the current extent of internalization (what percentage of externalities does the company currently pay for through taxes, regulations, or voluntary commitments?).

(c) Analyze how the company's stock price might change under three scenarios: (i) business-as-usual internalization, (ii) Paris-aligned climate policy, (iii) delayed but abrupt transition.

(d) Compare the company's externality profile to a competitor. Which firm is better positioned for increasing internalization?

Notes

On Climate Science: The IPCC Sixth Assessment Report (2021-2023) provides the definitive scientific consensus on climate change. Key findings include: human influence has unequivocally warmed the climate (+1.1°C since pre-industrial), the rate of warming is unprecedented in at least 2,000 years, and many changes (sea level rise, ocean acidification) are irreversible on century-to-millennium timescales.

On the Social Cost of Carbon: The U.S. government's Interagency Working Group estimated a social cost of carbon of $51/tonne CO_2 in 2020 (updated to $190/tonne in 2023 draft guidance). However, estimates vary widely based on damage functions, discount rates, and equity weights. Stern (2007) suggested $85/tonne, while Nordhaus (2017) estimated $31/tonne. More recent work incorporating climate tipping points and lower discount rates suggests $150-250/tonne.

On Economic Models of Climate: Integrated Assessment Models (IAMs) like Nordhaus's DICE, the FUND model, and the PAGE model underpin most climate policy analysis. Critics argue these models underestimate tail risks, use inappropriate discount rates, and rely on damage functions calibrated from limited data. The "climate-economy" literature continues to evolve, with recent work on growth effects, tipping points, and fat-tailed risk distributions suggesting higher optimal carbon prices.

On Game Theory and Climate: The climate prisoner's dilemma is a standard framing, but alternative game structures matter. If climate action exhibits "strategic complementarities"—where one country's mitigation increases others' incentives to act—the game becomes a coordination problem with multiple equilibria. Small policy changes can then tip the system from a high-emission to low-emission equilibrium. See Barrett (2003) and Heal (2016) for surveys.

On Carbon Pricing Coverage: The World Bank's "State and Trends of Carbon Pricing" report (published annually) tracks carbon pricing instruments globally. As of 2024, coverage has grown from 7

On Law of One Price Violations: Carbon price dispersion is economically inefficient—global abatement costs could be minimized by equalizing marginal abatement costs across jurisdictions through uniform pricing. Efforts toward international carbon price coordination (e.g., the Carbon Pricing Leadership Coalition) have made limited progress due to sovereignty concerns and distributional conflicts between developed and developing nations.

On Sustainable Finance Scale: Global sustainable investment reached $35 trillion in 2020 (36% of professionally managed assets), up from $13 trillion in 2012, though definitions and methodologies vary across regions. The EU's Sustainable Finance Disclosure Regulation (SFDR) and Taxonomy Regulation aim to standardize definitions and reduce greenwashing. See the Global Sustainable Investment Alliance (GSIA) for biennial surveys of sustainable investment trends.

Part I

The Framework

Chapter 2
Unifying Framework of Total Value

What is missing? Despite the explosive growth in sustainable finance—with ESG investing adoption rising from less than 10% of global assets in 2006 to over 50% by 2022, and sustainable finance regulation expanding to cover 90% of major economies[1]—a fundamental gap remains in how we analyze these investment decisions.

Consider the magnitude of the challenge ahead. McKinsey estimates that capital spending on physical assets for energy and land-use systems will need to rise by $3.5 trillion per year for the next 30 years to achieve net-zero emissions by 2050.[2] This reallocation of nearly $10 trillion annually represents one of the largest capital deployment challenges in history.

Yet the traditional financial toolkit—taught to generations of finance professionals and still dominating curricula worldwide—provides no framework for analyzing how sustainability factors affect firm value, investor returns, or societal outcomes. This chapter introduces a unifying framework that bridges this gap by explicitly incorporating externalities into financial valuation.

[1] Amir Amel-Zadeh and George Serafeim. "Why and how investors use ESG information: Evidence from a global survey". In: *Financial Analysts Journal* 74.3 (2018), pp. 87–103

[2] McKinsey Global Institute, "The net-zero transition: What it would cost, what it could bring" (2022). This represents an increase from current spending of approximately $1 trillion annually on low-emissions assets.

2.1 The Need for a New Framework

When Externalities Become Material

On April 20, 2010, the Deepwater Horizon oil rig, operated by BP, exploded in the Gulf of Mexico. The disaster killed 11 workers and triggered the largest marine oil spill in history, releasing an estimated 4.9 million barrels of crude oil over 87 days.[3]

The environmental devastation was severe: extensive damage to marine and coastal ecosystems, wildlife deaths, and habitat destruction affecting the Gulf region for years. But what makes this case particularly instructive for sustainable finance is how markets internalized these external costs.

From April 19 to June 25, 2010, BP's share price collapsed by 55%—from $59.48 to $27 per share. This represented a market capitalization loss of over $100 billion. The stock market, in effect, priced in the future costs that BP would bear: cleanup expenses, legal settlements, fines for Clean Water Act violations, and permanent reputational damage.

This episode illustrates a crucial point: externalities that were previously ignored by financial markets can suddenly become internalized—transferred from society back to the firm creating them—through regulation, litigation, consumer backlash, or investor pressure. Traditional valuation models, which focus solely on cash flows to shareholders, fail to capture this dynamic.

[3] W. McGuire, E. A. Holtmaat, and A. Prakash. "Penalties for industrial accidents: The impact of the Deepwater Horizon accident on BP's reputation and stock market returns". In: *PLoS One* 17.6 (2022), e0268743. DOI: 10.1371/journal.pone.0268743

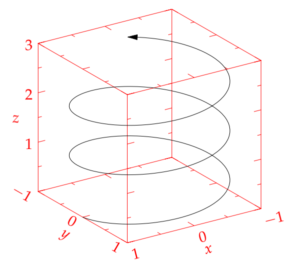

Figure 2.1: BP's stock price during the Deepwater Horizon crisis. The dramatic decline reflects the market's assessment of both direct costs and long-term liability from environmental damage.

The Gap Between Finance and Impact

Traditional finance education equips students with powerful tools: discounted cash flow analysis, the Capital Asset Pricing Model, option pricing theory, and market efficiency concepts. These tools excel at valuing private cash flows—the money that flows to and from investors.

But sustainable finance requires us to track two parallel value streams:

1. **Internal Value** (V^I): The traditional private value captured by shareholders through dividends, share buybacks, and capital gains. This is what standard DCF models measure.

2. **External Value** (V^E): The value (positive or negative) created for society but not captured in market prices. This includes environmental externalities like carbon emissions, social impacts like labor conditions, and governance effects like corruption or tax avoidance.

The key insight of the Total Value Framework is recognizing that these two value streams are not independent. As we saw with BP, external costs can become internalized—transformed into financial costs borne by the firm—through various channels we will explore in the next chapter.

2.2 *Private, Social, and Total Value*

LET US FORMALIZE the distinction between different notions of value. These concepts, while rooted in welfare economics, take on new practical importance in the context of sustainable finance.[4]

[4] Dirk Schoenmaker and Willem Schramade. *Principles of Sustainable Finance*. Second. Oxford University Press, 2020. ISBN: 978-0-19-884460-6

Definitions

Private Internal Value ($V_{i,t}^{I,0}$) is the present value of all cash flows accruing to the shareholders of firm i at time t, evaluated using standard financial models:

$$V_{i,t}^{I,0} = \sum_{n=0}^{\infty} \frac{D_{i,t,n}^{c}}{\exp(n\mu_{i,t,n}^{c})} \tag{2.1}$$

where $D_{i,t,n}^{c}$ represents the expected dividends (or free cash flows) n periods ahead, and $\mu_{i,t,n}^{c}$ is the appropriate discount rate.[5]

[5] The superscript 0 indicates this is the *original* value before any internalization has occurred. The superscript c denotes cash flows, distinguishing them from externality flows we introduce shortly.

This is the familiar dividend discount model, which we can specialize to the Gordon Growth Model under the assumption of constant growth g and discount rate r:

$$V_{i,t}^{I,0} = \frac{D_{i,t}}{r-g} \tag{2.2}$$

Myron Gordon, who developed this formula in the 1950s, provided one of the most elegant and widely-used valuation tools in finance. Its simplicity belies its power: under fairly general conditions, the value of any asset equals the present value of the cash it generates.

External Value ($V^{E,0}_{i,t}$) is the present value of all externalities—costs or benefits imposed on society but not reflected in market prices:

$$V^{E,0}_{i,t} = \sum_{n=0}^{\infty} \frac{D^e_{i,t,n}}{\exp(n\mu^e_{i,t,n})} \tag{2.3}$$

where $D^e_{i,t,n}$ represents the expected externality flows n periods ahead.[6] The discount rate $\mu^e_{i,t,n}$ may differ from the financial discount rate if externalities have different risk characteristics than cash flows.

[6] Note that D^e can be negative (costs imposed on society, like pollution) or positive (benefits provided to society, like education spillovers or technology diffusion).

Total Value ($V_{i,t}$) is simply the sum of internal and external value:

$$V_{i,t} = V^{I,0}_{i,t} - V^{E,0}_{i,t} \tag{2.4}$$

The negative sign appears because, by convention, we measure negative externalities (like pollution) as positive numbers. Thus, a polluting firm has positive $V^{E,0}$ (it creates costs for society), which reduces its total value to society.

A Simple Example: The Polluting Firm

Consider two firms deciding whether to pollute in the course of their operations. Each firm can earn a private benefit of \$100 from polluting, but pollution imposes costs of \$62.50 on each firm (for example, through health impacts, environmental degradation, or climate change effects).[7]

[7] These numbers are chosen for pedagogical clarity. In reality, the social cost of carbon is estimated between \$50-\$200 per ton of CO_2, depending on the discount rate and damage function assumptions used.

Table 2.1 shows the payoffs in a game-theoretic framework.

	Firm 2: Not pollute	Firm 2: Pollute
Firm 1: Not pollute	0, 0 *Sum: 0*	-62.5, 37.5 *Sum: -25*
Firm 1: Pollute	37.5, -62.5 *Sum: -25*	-25, -25 *Sum: -50*

Table 2.1: Payoff matrix before internalization. First number in each cell is Firm 1's payoff, second is Firm 2's payoff. Italics show total social value (sum of both firms' payoffs).

In this game, each firm has a dominant strategy to pollute: regardless of what the other firm does, polluting yields a higher private payoff (37.5 vs 0 if the other firm doesn't pollute; -25 vs -62.5 if the other firm does pollute). This is a classic prisoner's dilemma, and the Nash equilibrium is for both firms to pollute, resulting in total social value of -50.

Yet notice: if both firms could commit to not polluting, total value would be 0—a gain of 50 relative to the equilibrium. This demonstrates the fundamental market failure: private incentives lead to outcomes that are collectively suboptimal.

2.3 *The Internalization Framework*

INTERNALIZATION is the process by which external costs or benefits become internal to the decision-maker who creates them. This can occur through various channels—regulation, carbon taxation, consumer boycotts, investor pressure, or litigation—which we will examine in detail in Chapter 3.

Mathematical Representation

Let ι (iota) represent the degree of internalization, where $\iota \in [0,1]$. When $\iota = 0$, there is no internalization (pure externality); when $\iota = 1$, externalities are fully internalized (become fully priced into financial value).

The firm's **internalized private value** becomes:[8]

$$V_{i,t}^{I} = V_{i,t}^{I,0} + \iota V_{i,t}^{E,0} \tag{2.5}$$

The firm now bears a fraction ι of the external costs it creates. These appear as actual financial costs: carbon taxes paid, cleanup expenses, fines, or reduced revenues from consumer boycotts.

The **remaining external value** is:

$$V_{i,t}^{E} = V_{i,t}^{E,0} - \iota V_{i,t}^{E,0} = (1-\iota)V_{i,t}^{E,0} \tag{2.6}$$

Only the portion $(1-\iota)$ remains as an externality imposed on society. The portion ι has been transferred to the firm's financial statements.

[8] Jules H. van Binsbergen and Andreas Brøgger. "The Future of Emissions". In: *Available at SSRN 4241164* (2023). URL: `https://ssrn.com/abstract=4241164`

Total value remains unchanged:

$$V_{i,t} = V^{I}_{i,t} - V^{E}_{i,t} = [V^{I,0}_{i,t} + \iota V^{E,0}_{i,t}] - [(1-\iota)V^{E,0}_{i,t}] = V^{I,0}_{i,t} - V^{E,0}_{i,t} \quad (2.7)$$

This is a crucial insight: *internalization does not create or destroy value; it merely transfers it from society to the firm (or vice versa for positive externalities).*

The Socially Optimal Internalization Level

What level of internalization ι maximizes social welfare? If we assume that social welfare is simply total value $V_{i,t}$, then any level of ι achieves the same total value. However, ι affects the firm's incentives and thus its future decisions about whether to reduce externalities.

In our pollution example, suppose firms can choose their externality level $e \geq 0$ at a cost $c(e)$. The firm chooses e to maximize:

$$\max_{e} \quad V^{I,0} + R(e) + \iota \cdot e - c(e) \quad (2.8)$$

where $R(e)$ represents the private revenues from the activity generating externality e. Taking the first-order condition:

$$R'(e) + \iota = c'(e) \quad (2.9)$$

The firm balances the marginal private benefit of the externality-generating activity (R') plus the marginal internalized cost (ι) against the marginal cost of reducing externalities (c').

Social optimality requires that the firm faces the full social cost, meaning $\iota^* = 1$. At this level, the firm's private optimization problem aligns with social optimization.[9]

Returning to our pollution example with $\iota = 1$ (full internalization through, say, a Pigouvian tax), the payoff matrix becomes Table 2.2.

With full internalization, neither firm wants to pollute regardless of the other's action. The Nash equilibrium coincides with the social optimum: total value rises from -50 to 0, an increase of 50. Notice that while total value increases, no firm is better

[9] This result relies on the assumption that the firm has perfect information about damages and can costlessly adjust its externality level. In practice, informational frictions and adjustment costs complicate the optimal policy design. We return to these issues in Chapter 10.

	Firm 2: Not pollute	Firm 2: Pollute
Firm 1: Not pollute	0, 0 *Sum: 0*	0, -25 *Sum: -25*
Firm 1: Pollute	-25, 0 *Sum: -25*	-25, -25 *Sum: -50*

Table 2.2: Payoff matrix after full internalization ($\iota = 1$). Each firm now bears the full cost of pollution it creates. The Nash equilibrium shifts to (Not pollute, Not pollute) with total value of 0.

off individually (both earn 0 instead of -25). This is the challenge of implementing internalization: it requires coordination or enforcement to overcome individual incentives.

2.4 *Financial Value and Market Prices*

A FUNDAMENTAL QUESTION for investors is: how does internalization affect market prices? Traditional finance assumes:

$$P_{i,t} = V_{i,t}^{I,0} \tag{2.10}$$

The stock price equals the present value of future cash flows to shareholders, with no adjustment for externalities.

But if investors expect future internalization—through regulation, consumer pressure, or other channels—they should price this into the stock today. The **financial value** (the rational market price) becomes:[10]

$$P_{i,t} = V_{i,t}^{I} = V_{i,t}^{I,0} + \mathbb{E}[\iota_{i,t}]V_{i,t}^{E,0} \tag{2.11}$$

where $\mathbb{E}[\iota_{i,t}]$ represents investors' expectation of the degree of future internalization.

This equation has profound implications:

1. **Companies with negative externalities** ($V^{E,0} > 0$) should trade at a discount when investors expect internalization ($\mathbb{E}[\iota] > 0$). The market prices in future carbon taxes, cleanup costs, or regulatory expenses.

2. **Companies with positive externalities** ($V^{E,0} < 0$) should trade at a premium when these benefits will be captured

[10] R. de Adelhart Toorop, D. Schoenmaker, and W. Schramade. "Decision rules for corporate investment". In: *International Journal of Financial Studies* 12.1 (2024), p. 24

financially (through subsidies, preferential regulation, or consumer willingness-to-pay).

3. **Changes in expected internalization** drive stock returns. If investors revise upward their expectation of future carbon taxes, brown stocks fall even before the tax is implemented.

4. **Impact investing strategies** that seek to increase ι will affect stock prices. Exclusion, divestment, and engagement all work by changing the expected path of internalization.

The Value Frontier

de Adelhart Toorop, Schoenmaker, and Schramade (2024) visualize this relationship using a *value frontier*: the trade-off between financial value (FV) and social-environmental value (SEV) available to firms and investors.[11]

[11] R. de Adelhart Toorop, D. Schoenmaker, and W. Schramade. "Decision rules for corporate investment". In: *International Journal of Financial Studies* 12.1 (2024), p. 24

For a given firm, there exists a frontier of feasible combinations of FV and SEV. A coal power plant might maximize FV by running at full capacity (high emissions, high cash flow) or maximize SEV by shutting down (zero emissions, zero cash flow). Intermediate positions involve partial operation or investments in abatement technology.

As internalization increases, this frontier shifts. Activities that once maximized FV (running the dirty plant) now destroy FV because the firm bears the externality costs. The new FV-maximizing position moves toward lower emissions.

Critically, the *total value* frontier—the sum FV + SEV—remains unchanged, validating our earlier claim that internalization redistributes value rather than creating it. But the shifting frontier gives firms an incentive to reduce externalities as ι rises.

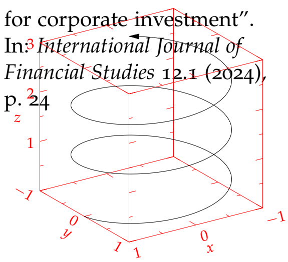

Figure 2.2: Dynamic company value frontiers. As internalization increases from $\iota = 0$ to $\iota = 1$, the value frontier shifts from the blue (original) to green (internalized) curve. The orange dots show the optimal financial-value maximizing positions for different internalization levels. Source: adapted from de Adelhart Toorop et al. (2024).

2.5 *Returns, Valuations, and Impact*

Expected Returns

The framework has implications for expected returns. Define the log expected return as:

$$r_{i,t} = \mathbb{E}_t[\ln P_{i,t+1} + \ln(1 + d_{i,t+1})] - \ln P_{i,t} \tag{2.12}$$

where d is the dividend yield. For small returns, this approximates the geometric return $(P_{t+1} + D_{t+1})/P_t - 1$.

Under equation 2.11, the expected return can be decomposed:

$$r_{i,t} \approx \bar{\mu}^c_{i,t} + \frac{\partial \mathbb{E}[\iota_{i,t}]}{\partial t} \cdot \frac{V^{E,0}_{i,t}}{P_{i,t}} \tag{2.13}$$

where $\bar{\mu}^c_{i,t}$ is the dividend-weighted average discount rate (the "fundamental" expected return), and the second term captures the impact of changing internalization expectations.

This decomposition clarifies recent empirical findings on ESG and returns:[12]

- If $\mathbb{E}[\iota]$ increases over time (growing expectations of carbon taxes, stricter regulation), then $\frac{\partial \mathbb{E}[\iota]}{\partial t} > 0$. For firms with negative externalities ($V^{E,0} > 0$), this creates a negative return contribution. Brown stocks underperform not because they have lower cash flows, but because investors are pricing in rising future internalization.
- Conversely, green firms with positive net externalities ($V^{E,0} < 0$) earn positive abnormal returns during periods of rising internalization expectations.
- In steady state, if $\mathbb{E}[\iota]$ stops changing, this return differential disappears. Green and brown stocks earn the same risk-adjusted return, but brown stocks trade at permanently lower valuations (higher $\mathbb{E}[\iota]V^{E,0}$ discount).

This framework reconciles conflicting empirical evidence: green stocks have outperformed in recent years as ESG concern surged, but there is no reason to expect permanent outperformance once internalization expectations stabilize.

[12] Ľuboš Pástor, Robert F. Stambaugh, and Lucian A. Taylor. "Sustainable investing in equilibrium". In: *Journal of Financial Economics* 142.2 (2021), pp. 550–571, Lasse Heje Pedersen, Shaun Fitzgibbons, and Lukasz Pomorski. "Responsible investing: The ESG-efficient frontier". In: *Journal of Financial Economics* 142.2 (2021), pp. 572–597

Impact Measurement

The framework also provides a rigorous definition of **impact**. Define the impact created by firm i between periods $t-1$ and t as:

$$\text{Impact}_{i,t} = V^E_{i,t-1} - V^E_{i,t} \tag{2.14}$$

A positive impact means the firm has reduced negative externalities (or increased positive ones). Using equation 2.6:

$$\text{Impact}_{i,t} = (1 - \iota_{t-1})V^{E,0}_{i,t-1} - (1 - \iota_t)V^{E,0}_{i,t} \tag{2.15}$$

Impact can be created in two ways:

1. **Operational improvement**: reducing $V^{E,0}$ by changing the firm's activities (installing scrubbers, improving labor practices, etc.).

2. **Internalization**: increasing ι through advocacy, engagement, or policy change.

For investors, we can normalize by the capital invested to get **impact per dollar**:

$$\text{Impact per dollar}_{i,t} = \frac{V^E_{i,t-1} - V^E_{i,t}}{P_{i,t-1}} \tag{2.16}$$

This metric is crucial for impact investors who want to maximize environmental or social benefits per dollar invested. As we will explore in Chapters 8 and 9, maximizing impact per dollar often involves investing in brown firms in transition (high $V^{E,0}$, potential for large ΔV^E) rather than green firms (low $V^{E,0}$, limited room for improvement).[13]

[13] This counterintuitive result—that impact investors should sometimes invest in polluters rather than clean firms—is one of the most important implications of the framework. We develop it fully in Chapter 9.

2.6 Conclusion

The Total Value Framework provides a unified language for sustainable finance. By explicitly tracking both internal value (cash flows to shareholders) and external value (costs or benefits to society), and modeling the process of internalization that transfers one to the other, we can analyze:

- How sustainability factors affect firm valuation and stock returns
- Why ESG investing has grown and what returns to expect going forward
- How firms should respond to rising internalization pressures

- What investment strategies maximize environmental and social impact
- When impact and financial return align, and when they trade off

Three key equations summarize the framework:

$$V_{i,t} = V_{i,t}^{I,0} - V_{i,t}^{E,0} \quad \text{(Total Value)} \tag{2.17}$$

$$P_{i,t} = V_{i,t}^{I,0} + \iota V_{i,t}^{E,0} \quad \text{(Financial Value)} \tag{2.18}$$

$$V_{i,t}^{E} = (1 - \iota) V_{i,t}^{E,0} \quad \text{(Remaining Externality)} \tag{2.19}$$

In the next chapter, we examine the channels through which internalization occurs: the mechanisms by which external costs become internal. Understanding these channels is essential for both predicting how internalization will evolve and for designing strategies to accelerate it.

Exercises

1. **Conceptual: Internalization and Value**

   (a) Explain in your own words what it means for an externality to be "internalized."

   (b) A coal power plant emits CO_2 with a social cost (at the appropriate discount rate) of $1 billion. The plant is worth $500 million to shareholders based on its expected future cash flows. What is the total value of the plant? Should it continue operating from society's perspective?

   (c) Suppose a carbon tax with $\iota = 0.5$ is implemented (the firm pays half the social cost of carbon). What happens to (i) the financial value of the plant, (ii) the remaining external value, and (iii) the total value?

2. **Quantitative: Gordon Growth with Externalities**

   A firm currently pays dividends of $2 per share and is expected to grow at 3% annually. The appropriate discount rate is 8%. The firm also generates negative externalities worth $10 per share (present value) primarily through carbon emissions.

(a) Calculate the firm's traditional financial value $V^{I,0}$ using the Gordon Growth Model.

(b) Suppose investors expect carbon pricing legislation that will internalize 60% of emissions costs within 5 years. How should this affect the current stock price?

(c) If the firm could eliminate all emissions at a one-time cost of $8 per share, should it do so? Consider both the financial and total value perspectives.

3. **Impact Measurement**

   Consider four investment strategies for a $100,000 portfolio:

   (a) Invest in a green technology firm with $V^{E,0} = -\$10,000$ (positive externalities) and $P = \$100,000$

   (b) Invest in a brown industrial firm with $V^{E,0} = \$50,000$ (negative externalities) and $P = \$100,000$

   (c) Invest in the brown firm from (b) and engage with management to reduce emissions by 20% over one year

   (d) Divest from the brown firm in (b), causing its expected internalization $\mathbb{E}[\iota]$ to increase by 0.1

   For each strategy, calculate the impact created (in dollars) and the impact per dollar invested. Which strategy maximizes impact? What assumptions are needed for your answer?

4. **Game Theory: Internalization and Equilibrium**

   Two competing ride-sharing companies (Firm A and Firm B) can choose to operate fleets of gasoline vehicles (Pollute) or electric vehicles (Not Pollute). Electric vehicles cost an extra $30,000 per year to operate but create no pollution. Gasoline vehicles impose pollution costs of $40,000 annually on society.

   (a) Construct the payoff matrix for this game, showing both private payoffs and total value (sum of payoffs) in each cell.

   (b) Find the Nash equilibrium without internalization ($\iota = 0$). Is it socially optimal?

(c) Now suppose a gasoline tax internalizes 80% of pollution costs ($\iota = 0.8$). Reconstruct the payoff matrix. What is the new Nash equilibrium?

(d) What is the minimum internalization level ι^{min} needed to make (Not Pollute, Not Pollute) the Nash equilibrium?

5. **Application: Impact per Dollar**

   You are an impact investor trying to decide where to allocate capital to maximize carbon emissions reduction per dollar invested. Consider these options:

(a) Invest in a solar panel manufacturer (currently green)

(b) Invest in a coal mining company to push for managed decline

(c) Invest in a company transitioning from coal to natural gas

(d) Invest in a company developing carbon capture technology

   Using the Total Value Framework, what factors should determine your choice? Under what conditions would investing in the coal company (option b) create more impact per dollar than the solar company (option a)? Write a brief memo (300 words) explaining your reasoning.

Notes

Chapter 3
Channels of Internalization

How do externalities become internalized in practice? In Chapter 2, we introduced the Total Value Framework and the internalization parameter ι. But we left unanswered the crucial question: through what mechanisms does ι actually increase? How do negative externalities become reflected in market prices and corporate decision-making?

This chapter explores the five primary channels through which externalities become internalized: government regulation, civil society pressure, consumer choices, corporate voluntary action, and financial markets. Understanding these channels is essential for predicting when and how sustainability considerations will affect asset prices and corporate behavior.

3.1 *Modigliani-Miller Revisited*

Before examining internalization channels, we must first recognize that externalities are not a new phenomenon in finance—we have simply failed to recognize them as such. Consider one of the most celebrated results in corporate finance: the Modigliani-Miller theorem on capital structure.

The classic Modigliani-Miller result with taxes suggests that debt creates value through the tax shield. The present value of the tax shield is given by:

$$PV(\text{Tax Shield}) = \tau_c \times D \tag{3.1}$$

The Modigliani-Miller theorem states that in a perfect market without taxes, a firm's value is independent of its capital structure. However, introducing corporate taxes creates a tax shield that appears to increase firm value.

where τ_c is the corporate tax rate and D is the amount of debt.

But does debt truly *create* value? Or does it merely *transfer* value from one stakeholder to another? The tax shield represents a reduction in tax payments to the government—it is a transfer from taxpayers to shareholders. No new value is created; existing value is simply redistributed.[1]

[1] Dirk Schoenmaker and Willem Schramade. *Principles of Sustainable Finance*. Second. Oxford University Press, 2020. ISBN: 978-0-19-884460-6

This insight is profound: the tax benefit of debt is an *externality*. Shareholders capture the benefit (reduced tax payments) while the cost is borne by society (reduced government revenue, which must be made up through higher taxes elsewhere or reduced public services). When we measure firm value using only the internal value $V^{I,0}$, we see the tax shield as value creation. When we measure Total Value $V = V^{I,0} - V^{E,0}$, we recognize it as a value transfer.

This realization suggests that many traditional financial mechanisms involve externalities that we have historically ignored. Internalization channels work to reduce these blind spots.

3.2 *The Five Channels of Internalization*

Externalities become internalized through five primary channels, each operating through different mechanisms and with varying degrees of effectiveness.

Government Regulation and Taxation

The most direct mechanism for internalization is government intervention through regulation and taxation. By imposing costs on activities that generate negative externalities, governments can force these costs to be reflected in private decision-making.

Pigouvian taxes are designed to make economic actors pay the full social cost of their activities by taxing them an amount equal to the external cost they impose.

Carbon taxes provide a clear example. Sweden introduced a carbon tax in 1991 at SEK 250 (approximately €25) per tonne of CO_2. By 2023, this had risen to over SEK 1,200 (approximately €110) per tonne—one of the highest carbon taxes in the world. This tax directly increases the cost of carbon-intensive activities, making cleaner alternatives relatively more attractive.

The European Union's Emissions Trading System (EU ETS) takes a different approach, creating a market for carbon emissions. By capping total emissions and allowing firms to trade emission permits, the system creates a price for carbon that reflects its scarcity. In 2023, EU carbon prices exceeded €100 per tonne, making carbon emissions a significant consideration in business decisions.

Regulation can also take non-price forms. Denmark's "green business action" initiative, championed by King Frederik X, requires large companies to report on climate risks and set science-based targets for emission reductions. Such disclosure requirements create pressure for action even without direct financial penalties.

However, government intervention faces significant challenges. Carbon prices remain far below the estimated social cost of carbon (approximately $185 per tonne according to recent estimates).[2] Political resistance, competitiveness concerns, and lobbying by affected industries often limit the scope and stringency of environmental regulation.

[2] Jules H. van Binsbergen and Andreas Brøgger. "The Future of Emissions". In: *Available at SSRN 4241164* (2023). URL: https://ssrn.com/abstract=4241164

Civil Society Pressure

Non-governmental organizations, activist groups, media campaigns, and social movements can create powerful pressure for companies to internalize externalities. This pressure operates through multiple mechanisms: reputational damage, consumer boycotts, shareholder activism, and legal action.

Civil society refers to the space of collective action around shared interests, purposes, and values, distinct from government and commercial actors.

The campaign against BP following the Deepwater Horizon disaster (discussed in Chapter 2) illustrates civil society's power. Environmental groups organized protests at BP stations, media coverage highlighted the company's safety record, and public outrage translated into reputational damage and lost customers.

Climate activist groups like Extinction Rebellion and Fridays for Future have successfully shifted public discourse on climate change, creating social pressure that influences both corporate behavior and government policy. The "divestment movement" has convinced universities, pension funds, and other institutional investors to divest from fossil fuel companies, reducing their access to capital and stigmatizing the industry.

However, civil society pressure is often diffuse and unpredictable. It depends on media attention, public awareness, and organizational capacity. Some externalities (like biodiversity loss) struggle to generate the same public mobilization as climate change.

Consumer Choices

When consumers are willing to pay more for sustainable products or boycott unsustainable ones, market prices can reflect environmental and social costs. This creates a business case for internalization without requiring government intervention.

The "willingness to pay" for sustainability represents consumers' revealed preference for products with lower negative externalities, even at higher prices.

The organic food market demonstrates consumer-driven internalization. Consumers pay premiums of 20–100% for organic products, which reflect some (though not all) of the environmental costs of conventional agriculture. The global organic food market reached $220 billion in 2022, showing substantial consumer demand for more sustainable alternatives.

Fair trade certification provides another example. Consumers pay premiums to ensure that producers in developing countries receive fair wages and work in acceptable conditions. This internalizes social externalities (poverty, exploitation) that would otherwise be invisible in market prices.

Yet consumer-driven internalization faces significant limitations. Many consumers express sustainability preferences in surveys but do not follow through in purchasing decisions—the so-called "attitude-behavior gap." Price sensitivity, information asymmetries, and the difficulty of verifying sustainability claims all limit the effectiveness of this channel.

Corporate Voluntary Action

Some companies voluntarily internalize externalities even without external pressure. This seemingly puzzling behavior can be explained by five primary motivations:

1. **Risk management**: Companies recognize that unmanaged externalities create long-term risks. Climate change threatens supply chains, water scarcity affects operations, and social unrest disrupts business continuity.

2. **Innovation and efficiency**: Addressing externalities often requires innovation that reduces costs or opens new markets. Energy efficiency investments simultaneously reduce emissions and operating costs.

3. **License to operate**: Companies depend on social and regulatory permission to operate. Proactively addressing externalities helps maintain this license and prevent stricter regulation.

4. **Employee attraction and retention**: Particularly in knowledge-intensive industries, sustainability performance affects companies' ability to recruit and retain talented employees who increasingly seek purposeful work.

5. **Competitive advantage**: Early movers on sustainability can gain first-mover advantages, differentiate their products, and shape emerging regulations to favor their approach.

Evidence suggests that these motivations are real. A 2021 survey of pension fund participants by Bauer, Ruof, and Smeets found that two-thirds would support their fund engaging with companies on UN Sustainable Development Goals even if it reduced financial returns.[3] This creates a business case for voluntary internalization.

The business case for sustainability suggests that addressing externalities can create shareholder value through risk reduction, cost savings, revenue growth, and intangible benefits.

[3] Rob Bauer, Tobias Ruof, and Paul Smeets. "Get real! Individuals prefer more sustainable investments". In: *The Review of Financial Studies* 34.8 (2021), pp. 3976–4043

Financial Markets

Finally, financial markets themselves can become a channel for internalization. When investors incorporate ESG factors into their investment decisions, companies with high externalities face higher costs of capital or lower valuations.

This channel operates through multiple mechanisms:

ESG integration refers to the systematic and explicit inclusion of environmental, social, and governance factors in investment analysis and decisions.

- **Exclusion screening**: Investors exclude companies with high negative externalities from their portfolios, reducing demand for their securities.

- **ESG integration**: Investors adjust valuations or required returns based on ESG performance, creating a sustainability premium or discount.

- **Active ownership**: Investors engage with companies and vote on sustainability-related shareholder proposals, pressing for better ESG performance.

- **Impact investing**: Investors explicitly seek to generate positive environmental or social impact alongside financial returns.

Research by Pástor, Stambaugh, and Taylor [7] suggests that sustainable investing can affect real outcomes by increasing the cost of capital for "brown" (high-externality) firms relative to "green" (low-externality) firms. This tilts investment and innovation toward more sustainable activities.

However, the effectiveness of this channel remains debated. Critics argue that much ESG investing is merely "greenwashing" that does not affect real corporate behavior. The evidence on whether ESG integration actually reduces corporate externalities remains mixed.

3.3 *Social Versus Environmental Externalities*

The five channels operate differently for social versus environmental externalities. Social externalities—labor exploitation, unsafe working conditions, poverty wages—tend to be more visible and generate stronger emotional responses. The collapse of the Rana Plaza factory in Bangladesh (2013), which killed over 1,100 garment workers, sparked immediate and intense consumer and investor pressure.

Environmental externalities, particularly climate change, are often more diffuse and distant in time and space. The connection between individual actions and consequences is less direct, making mobilization more difficult. A garment worker's suffering is visible and immediate; the impact of carbon emissions is global and delayed.

This difference affects which channels are most effective. Social externalities often respond well to civil society pressure and consumer boycotts. Environmental externalities may require government intervention due to their collective action nature and long time horizons.

3.4 *Case Study: The True Price of Roses from Kenya*

The concept of "true pricing" illustrates how internalization works in practice. Consider roses grown in Kenya and sold in European flower markets.

True pricing attempts to measure and incorporate the full environmental and social costs of production into market prices, making externalities visible and actionable.

The conventional market price for Kenyan roses is approximately €0.70 per stem. This price reflects private costs (labor, inputs, transportation) but ignores significant externalities:

- Water depletion in Lake Naivasha region
- Pesticide pollution affecting local ecosystems and health
- Carbon emissions from air freight to Europe
- Social costs related to labor conditions

Researchers calculated the "true price" that would fully internalize these externalities: €0.92 per stem—a 31% premium over the market price.

However, the story does not end there. By optimizing production methods—using drip irrigation, reducing pesticide use, switching to sea freight where possible, and improving labor conditions—producers could reduce externalities while maintaining profitability. The optimized true price fell to €0.74 per stem—only a 6% premium over the conventional price.

This case study reveals three important insights:

1. Current market prices significantly underestimate true costs, with externalities representing 31% of the total cost in this case.
2. Full internalization would require substantial price increases if production methods remained unchanged.
3. Innovation and optimization can dramatically reduce the cost of internalization, making sustainability more economically feasible.

The question becomes: which of the five channels can drive this transition? Consumer willingness to pay premiums is limited. Government regulation could mandate sustainable practices or tax externalities. Civil society could pressure retailers to source responsibly. Companies could voluntarily adopt better practices. Financial markets could reward sustainable flower producers with better access to capital.

In practice, all five channels are beginning to operate in the flower industry, though with varying degrees of effectiveness.

3.5 Evidence of Current Internalization Levels

How much internalization is currently occurring through these five channels? While comprehensive measurement is challenging, several studies provide insights.

Research by Bauer, Ruof, and Smeets [3] surveyed Dutch pension fund participants about their preferences for sustainable investing. The results are striking:

- 67% would support their pension fund engaging with companies on UN Sustainable Development Goals
- This support persisted *even when told it might reduce financial returns*
- Support was higher among younger participants and women
- Environmental issues (climate change) and social issues (human rights) received similar support

This suggests substantial latent demand for internalization through the financial channel. However, whether this stated preference translates into actual investment behavior remains uncertain—the attitude-behavior gap may be substantial.

Carbon pricing provides more concrete evidence. As of 2023:

- 73 carbon pricing initiatives operate worldwide (taxes and emissions trading systems)
- These cover approximately 23% of global greenhouse gas emissions
- Prices range from under $1 per tonne to over $100 per tonne
- The weighted average carbon price is approximately $30 per tonne

Compared to estimated social costs of carbon ($185 per tonne), current internalization through carbon pricing is approximately 16% of the optimal level. The internalization parameter ι for carbon emissions is thus roughly 0.16—far from complete internalization, but no longer zero.

3.6 The Dynamics of Internalization

Internalization is not static—the parameter ι changes over time as political, social, and economic conditions evolve. Understanding these dynamics is crucial for predicting how sustainability will affect future asset prices.

Several forces are driving ι upward:

- **Climate change intensification**: As physical climate impacts become more severe and visible, political pressure for action increases.
- **Generational change**: Younger cohorts express stronger sustainability preferences and are beginning to accumulate wealth and political power.
- **Technological progress**: Renewable energy, electric vehicles, and other clean technologies are becoming cost-competitive, reducing the economic pain of internalization.
- **Information availability**: Better measurement and disclosure of externalities makes them more visible and actionable.

However, countervailing forces also exist:

- **Political backlash**: High energy prices and economic uncertainty can generate resistance to climate policies.
- **International coordination problems**: Unilateral action creates competitiveness concerns, requiring international cooperation that is difficult to achieve.
- **Lobbying and resistance**: Industries threatened by internalization invest heavily in political influence to slow or prevent regulation.

The net effect of these forces determines the trajectory of ι. Most scenarios suggest continued gradual increase, but the pace and endpoint remain highly uncertain—creating significant transition risks that we explore in Chapter 4.

3.7 Conclusion

Internalization occurs through five primary channels: government regulation, civil society pressure, consumer choices, corporate voluntary action, and financial markets. Each operates through different mechanisms and faces different limitations. Effective internalization typically requires multiple channels operating in concert.

Current levels of internalization remain far from complete. For carbon emissions, we estimate $\iota \approx 0.16$—meaning that approximately 16% of climate externalities are currently reflected in prices and corporate decisions. For many other externalities (biodiversity, water, social impacts), internalization may be even lower.

Yet the direction of change is clear: ι is increasing over time, driven by climate urgency, generational shifts, and technological progress. This creates both risks (for high-externality companies and assets) and opportunities (for sustainable alternatives). Understanding these dynamics is essential for predicting how sustainability will affect the financial markets and corporate behavior in the coming decades.

The Kenya roses case study illustrates that internalization need not be economically devastating. Innovation and optimization can dramatically reduce the cost of sustainability, making the transition more feasible. The question is not whether externalities will become internalized, but how quickly and through which channels.

Exercises

1. **The Tax Shield Externality**

   Consider the Modigliani-Miller analysis with taxes discussed in Section 3.1. Suppose a corporation increases its debt level from \$0 to \$100 million. The corporate tax rate is $\tau_c = 25\%$.

(a) Calculate the present value of the tax shield created by this debt issuance.

(b) Who benefits from this tax shield? Who bears the cost?

(c) Using the Total Value Framework from Chapter 2, explain whether this debt issuance creates value or merely transfers it.

(d) If you were measuring the firm's Total Value $V = V^{I,0} - V^{E,0}$, how would this debt issuance affect each component?

2. **Carbon Pricing and Internalization**

Section 3.5 reports that the weighted average carbon price globally is approximately \$30 per tonne, while the estimated social cost of carbon is \$185 per tonne.

(a) Calculate the current internalization parameter ι for carbon emissions based on these figures.

(b) A coal-fired power plant emits 10 million tonnes of CO_2 annually. How much does it currently pay in carbon costs (using the \$30 price)? How much would it pay if carbon were fully internalized (\$185 price)?

(c) Suppose political pressure causes the carbon price to increase by 10% per year. How many years will it take for ι to reach 0.50 (half internalization)? What does this imply about transition risks for fossil fuel companies?

(d) Which of the five channels (government, civil society, consumers, corporates, financials) do you think will be most important in driving carbon prices higher? Explain your reasoning.

3. **The Kenya Roses Case Study**

The Kenya roses case in Section 3.4 showed three price points: conventional (€0.70), true price (€0.92), and optimized true price (€0.74).

(a) Calculate the externality per rose stem under conventional production methods. What percentage of the true cost is externalized?

(b) Calculate the externality per rose stem under optimized production methods. By what percentage does optimization reduce the externality?

(c) Suppose a European retailer sells 100 million rose stems annually. If consumers are willing to pay a 10% premium for sustainably grown roses (but not the full 31% premium for conventional true pricing), which production method—conventional or optimized sustainable—would maximize the retailer's profit? State your assumptions clearly.

(d) Which of the five internalization channels could drive the transition from conventional to optimized production? Rank them from most to least effective and justify your ranking.

4. **Pension Fund Preferences and the Attitude-Behavior Gap**

Section 3.5 reports that 67% of Dutch pension fund participants would support SDG engagement even if it reduced financial returns.

(a) Suppose a pension fund has €10 billion in assets. If it implements SDG engagement and this reduces returns by 0.1% per year (10 basis points), what is the annual cost to fund participants? Do you think most participants understand this cost when expressing support for SDG engagement?

(b) Research suggests that stated preferences often exceed revealed preferences—the "attitude-behavior gap." Propose two mechanisms that pension funds could use to test whether participants' stated support for SDG engagement translates into actual willingness to accept lower returns.

(c) If the attitude-behavior gap is large, what does this imply about the effectiveness of the financial markets channel for internalization? Would mandatory regulation (government channel) be more effective? Explain the trade-offs.

(d) Design a pension fund structure that would allow heterogeneous preferences: some participants get high financial returns with low sustainability, others get lower returns with high sustainability. What are the advantages and challenges of this approach?

5. **Comparing Channels Across Externality Types**

   Section 3.3 argues that social and environmental externalities differ in visibility and emotional resonance, affecting which channels work best.

   (a) Consider two externalities: (i) child labor in textile supply chains, and (ii) biodiversity loss from agricultural expansion. For each externality, rank the five channels from most to least effective. Explain your reasoning.

   (b) Some companies voluntarily adopt sustainability practices that go beyond legal requirements (Section 3.2). For which types of externalities is voluntary corporate action most likely? Least likely? Why?

   (c) Climate change is a global externality with diffuse impacts decades in the future. Labor exploitation is a local externality with immediate visible impacts. Given these differences, explain why international coordination on climate policy is more difficult than regulation of labor standards.

   (d) Propose a mechanism that could make environmental externalities as salient and emotionally resonant as social externalities. Would this increase the effectiveness of the civil society and consumer channels?

Notes

Part II

Using the Framework

Chapter 4
Transition Risks

THE SUSTAINABILITY TRANSITION is not a distant theoretical possibility—it is happening now, with dramatic consequences for companies, investors, and economies. Some companies thrive in this transition while others fail catastrophically. Understanding transition risks is essential for predicting which companies will survive and prosper as internalization accelerates.

This chapter examines how increasing internalization (rising ι) creates both risks and opportunities for companies. We explore real-world examples of companies that have succeeded (Patagonia, Ørsted) and failed (Forever 21, coal companies) during the sustainability transition, analyze why certain firms are better positioned to navigate transition risks, and examine how sustainability affects creditworthiness and access to capital.

4.1 The Nature of Transition Risks

Transition risks arise when the internalization parameter ι changes over time. Recall from Chapter 2 that internalized value is given by:

$$V_{i,t}^{I} = V_{i,t}^{I,0} + \iota V_{i,t}^{E,0} \tag{4.1}$$

Transition risks emerge from changes in ι over time, creating winners and losers as externalities become internalized.

When ι increases—through new regulation, changing consumer preferences, civil society pressure, or financial market shifts—companies with large negative externalities ($V_{i,t}^{E,0} < 0$) see their value fall. Companies with positive externalities or low negative externalities see relative gains.

But transition risks go beyond simple valuation changes. They include:

- **Policy risk**: Governments may impose carbon taxes, emissions regulations, or sustainability disclosure requirements that disadvantage high-externality companies.
- **Technology risk**: Clean alternatives may become cost-competitive, rendering existing business models obsolete.
- **Market risk**: Consumer preferences may shift toward sustainable products, reducing demand for conventional offerings.
- **Reputation risk**: Companies with poor sustainability performance may face boycotts, protests, or social media campaigns that damage their brand.
- **Legal risk**: Litigation related to environmental or social harms may impose unexpected costs.
- **Financing risk**: Access to capital may become constrained as lenders and investors integrate ESG factors into their decisions.

These risks interact and compound. A company facing carbon regulation may simultaneously experience technology disruption, reputational damage, and difficulty accessing capital—creating a spiral that can lead to bankruptcy.

4.2 Tale of Two Retailers: Forever 21 and Patagonia

The contrast between Forever 21 and Patagonia illustrates how different approaches to sustainability create vastly different outcomes during the transition.

Forever 21's fast-fashion model collapsed under pressure from labor rights groups, environmentalists, and changing consumer preferences, leading to bankruptcy in 2019.

Forever 21: A Cautionary Tale

Forever 21 was an American fast-fashion retailer founded in 1984 with just $11,000 in savings. By 2015, it had reached peak success with $4.4 billion in global sales and over 900 stores worldwide.

The company's business model relied on rapid production cycles, low prices, and designs mimicking South Korean fashion trends.

However, Forever 21's model generated massive negative externalities:

- Environmental: Fast fashion creates textile waste, uses water-intensive production, and generates emissions from global supply chains.
- Social: The company faced repeated accusations of labor exploitation, unsafe working conditions, and poverty wages in supply chains.
- Ethical: Copyright infringement lawsuits and the 2019 "fat-shaming" controversy (weight-loss bars included with plus-size orders) damaged its reputation.

As internalization accelerated in the late 2010s, Forever 21 faced mounting pressure:

- Civil society campaigns highlighted labor and environmental issues
- Consumer preferences shifted, particularly among younger buyers who increasingly valued sustainability
- Competition from online retailers (SHEIN, ASOS) with better sustainability positioning intensified
- Brand preference among teens collapsed from 10% (2010) to 5% (2019)

The company experienced a 32% drop in global sales in 2019. On September 29, 2019, Forever 21 filed for Chapter 11 bankruptcy protection. The internalization of its social and environmental externalities—combined with failure to adapt—destroyed the company.

Patagonia: Thriving Through Sustainability

Patagonia presents a stark contrast. Founded in 1957 by rock climber Yvon Chouinard, the company built its brand around environmental responsibility from the beginning. Key strategic decisions demonstrate voluntary internalization:

- 2011: Ran the advertisement "Don't Buy This Jacket," urging consumers to reduce consumption and repair existing gear
- 2019: Restricted branded product distribution to firms committed to ESG initiatives
- 2022: Chouinard transferred ownership to the Patagonia Purpose Trust, dedicating all profits to addressing climate change and protecting land

Rather than destroying value, these sustainability commitments created value. Patagonia's revenue grew from $300 million (2009) to over $1.5 billion (2022)—a 400% increase. The "Don't Buy This Jacket" campaign, counterintuitive though it seemed, actually boosted sales by strengthening brand loyalty among sustainability-conscious consumers.

Patagonia succeeded by proactively increasing its own ι before external pressure forced it to do so. By voluntarily internalizing externalities, the company:

Patagonia's voluntary internalization strategy created competitive advantages: brand differentiation, customer loyalty, and resilience to regulatory changes.

1. Built strong brand differentiation in a crowded outdoor apparel market
2. Attracted customers willing to pay premium prices for sustainable products
3. Avoided the regulatory and reputational risks that damaged competitors
4. Positioned itself to benefit as consumer preferences shifted toward sustainability

The contrast is striking: Forever 21's resistance to internalization led to bankruptcy; Patagonia's embrace of internalization drove extraordinary growth.

4.3 *Energy Transition: BP Versus Ørsted*

The energy sector provides even more dramatic examples of transition risks and opportunities. Compare two companies: BP and Ørsted.

BP: Caught in the Crosscurrents

BP (British Petroleum) has oscillated on climate strategy, creating uncertainty and missed opportunities. In the early 2000s, BP rebranded as "Beyond Petroleum," emphasizing renewable investments. However, this commitment proved superficial.

The 2010 Deepwater Horizon disaster—discussed in Chapter 2—demonstrated the catastrophic costs of environmental externalities. BP's share price fell 55% (from $59.48 to $27 per share) between April and June 2010.

More recently, BP has struggled to navigate the energy transition:

- Initially set ambitious targets for renewable energy investment and emissions reduction
- In February 2025, reversed course, announcing plans to cut renewable investments and increase oil and gas production
- Share price fell 2% immediately following the announcement
- Greenpeace UK stated BP's decision was "proof that fossil fuel companies can't or won't be part of climate crisis solutions"

BP's net income has been highly volatile, with major losses in recent years as it struggles to position itself in the transition. The company faces a fundamental dilemma: its core business (fossil fuels) generates large negative externalities that are increasingly internalized, but pivoting to renewables requires massive investment and acceptance of lower short-term profits.

Ørsted: The Transformation Success Story

Ørsted (formerly DONG Energy—Danish Oil and Natural Gas) demonstrates the opposite approach: bold transformation rather than hesitant oscillation.

In 2006, DONG Energy was Denmark's largest oil and gas company, with 85% of revenue from fossil fuels. Management

Ørsted transformed from Denmark's largest oil and gas company to the world's leading offshore wind developer in less than a decade, creating substantial shareholder value in the process.

recognized that rising ι would make this business model unsustainable. Between 2006 and 2017, the company executed a radical transformation:

- Divested all oil and gas assets, selling them to Ineos for $1.05 billion
- Invested heavily in offshore wind energy, becoming the global market leader
- Changed the company name to Ørsted (after Danish physicist Hans Christian Ørsted) to signal its new identity
- Achieved carbon neutrality in power generation

The transformation was not smooth—Ørsted experienced losses and negative net income in several years during the transition. But by 2023, the company had emerged as the world's most valuable pure-play renewable energy company.

Unlike BP, which tried to straddle both worlds (fossil fuels and renewables), Ørsted made a complete break. This decisiveness created several advantages:

1. Clear strategic direction that aligned all parts of the organization
2. Credibility with environmentally conscious customers and investors
3. First-mover advantages in offshore wind technology and project development
4. Resilience to future carbon pricing and regulatory changes

The Ørsted transformation illustrates that companies can successfully navigate transition risks—but it requires bold leadership, significant investment, and acceptance of short-term pain for long-term gain.

4.4 *Understanding Company Value During Transition*

Why do some companies thrive during transition while others fail? The dynamic company value frontier framework from Adelhart Toorop, Schoenmaker, and Schramade [1] provides insight.

Recall that companies face a tradeoff between financial value (FV) and social/environmental value (SEV). Figure 2.2 shows how this frontier shifts as internalization increases. The original blue curve represents the company's opportunities when $\iota = 0$ (no internalization). The green curve shows opportunities when $\iota = 1$ (full internalization).

Several insights emerge:

The 45-degree line represents combinations where Total Value $V = V^I - V^E$ is positive. Companies must be above this line to create net positive value for society.

1. **The positive total value line**: The 45-degree line represents the boundary where $V^I = V^E$, so Total Value $V = V^I - V^E = 0$. Companies below this line destroy net value for society, even if they create financial value. As ι increases, markets and regulators increasingly penalize companies below this line.

2. **Maximum total value at $\iota = 1$**: The point of tangency between the company value frontier and the maximum total value line occurs at $\iota = 1$. This means companies maximize their total contribution to society when they fully internalize externalities. Partial internalization is suboptimal.

3. **Transition paths matter**: Companies starting on the left side of the frontier (high financial value, low sustainability) must traverse a difficult path to reach high-sustainability positions. This transition is costly and risky—many companies fail en route.

4. **First-movers gain**: Companies that voluntarily shift to higher sustainability before ι increases capture "option value"—they are positioned to benefit when the market shifts rather than scrambling to catch up.

This framework helps explain our case studies:

- Forever 21 operated far from the positive total value line, generating large negative externalities. As ι increased, its financial value collapsed.

- Patagonia positioned itself on the right side of the frontier early, creating both financial value and positive social/environmental value. Rising ι enhanced rather than threatened its position.

- BP remains stuck in the middle, trying to maintain positions on both the old (blue) and new (green) frontiers, creating strategic confusion.
- Ørsted made a decisive jump from the left to the right side of the frontier, accepting short-term value destruction to reach a sustainable long-term position.

4.5 *Transition Risks and Creditworthiness*

Transition risks directly affect companies' ability to borrow and their cost of capital. ESG factors increasingly influence creditworthiness through a clear channel:

ESG factors affect creditworthiness by signaling exposure to policy risks, technology disruption, reputation damage, and changing consumer preferences.

Environmental, Social, and Governance Factors

$\downarrow$

Factors Influencing Creditworthiness

$\downarrow$

Credit Risk Indicators

Evidence supports this linkage. Country-level data shows a strong correlation (0.77) between ESG scores and credit ratings. Countries with high ESG performance (Norway, Switzerland, Netherlands) have AAA credit ratings. Countries with low ESG performance (Pakistan, Nigeria, Venezuela) have much lower ratings.

Why does sustainability matter for borrowing? Several mechanisms operate:

1. **Direct financial impact**: Companies facing carbon taxes, cleanup costs, or litigation pay these expenses from the same cash flows that service debt. Higher sustainability costs reduce the margin of safety for creditors.
2. **Stranded assets**: Fossil fuel companies face the risk that reserves become unburnable if climate policy tightens, destroying collateral value.
3. **Revenue volatility**: Companies exposed to changing consumer preferences or technology disruption face more uncertain cash flows, increasing default risk.

4. **Regulatory risk**: Sudden policy changes can dramatically alter company economics, as coal companies discovered when many countries announced coal phase-outs.

5. **Refinancing risk**: As ESG integration spreads among lenders, companies with poor sustainability performance may struggle to refinance maturing debt.

The importance of bank credit varies by geography. In China, bank credit represents approximately 160% of GDP—versus only 50% for the United States. In Europe, the ratio is about 90%. This means Chinese and European companies are particularly exposed to banks' ESG lending criteria.

Banks integrate sustainability through three stages:

Sustainable finance evolution: 1.0 (Exclusion), 2.0 (ESG integration), 3.0 (Impact lending)

- **Sustainable Finance 1.0**: Simple exclusion policies that prohibit lending to certain sectors (e.g., coal mining, weapons).
- **Sustainable Finance 2.0**: ESG integration, where sustainability factors adjust credit terms, pricing, and limits.
- **Sustainable Finance 3.0**: Impact lending and microfinance, where loans explicitly target positive social or environmental outcomes.

As more banks move from 1.0 to 2.0 and 3.0, companies with poor sustainability performance will face higher borrowing costs or credit rationing. This creates a self-reinforcing cycle: companies with high transition risk face higher capital costs, reducing their ability to invest in sustainability improvements, further increasing their risk.

4.6 Three Keys to Transition Success

Comparing successful and unsuccessful companies reveals three critical factors:

Companies that navigate transition risks successfully tend to share three characteristics: public responsibility, adaptability, and first-mover positioning.

Taking Public Responsibility

Successful companies take public responsibility for their externalities rather than denying or minimizing them. Patagonia openly acknowledges the environmental impact of outdoor apparel and commits to addressing it. Ørsted acknowledged that fossil fuels were incompatible with climate goals and divested accordingly.

Companies that deny responsibility (like BP's repeated greenwashing) lose credibility and struggle to build trust with stakeholders. This matters because transition requires support from employees, customers, investors, and regulators—all of whom are more willing to support companies that demonstrate genuine commitment.

Adaptability

The transition creates rapid, unpredictable changes. Successful companies demonstrate organizational adaptability:

- Willingness to abandon legacy business models
- Ability to acquire new capabilities quickly
- Openness to experimentation and learning
- Cultural flexibility that embraces change rather than resisting it

Ørsted's transformation required developing entirely new engineering capabilities, project finance expertise, and regulatory relationships. The company succeeded because it attracted talent from renewable energy, retrained existing employees, and maintained flexibility as the offshore wind industry evolved.

Forever 21, in contrast, doubled down on fast fashion even as the model's externalities became increasingly visible and criticized. Its failure to adapt ultimately proved fatal.

First-Mover Positioning

Companies that move early capture advantages:

- Learning curves: Early experience reduces costs and builds expertise
- Reputation: First-movers are perceived as leaders rather than reluctant followers

- Regulatory influence: Early movers help shape regulations in their favor
- Talent attraction: Purpose-driven employees prefer companies leading rather than lagging
- Option value: Early positioning creates flexibility to adjust as markets evolve

Patagonia's early sustainability commitment created brand equity that now protects it from competitors. Ørsted's early offshore wind investments created technological and project development expertise that competitors struggle to match.

BP's oscillation between fossil fuels and renewables meant it captured neither the advantages of leading the transition nor the (diminishing) profits from staying in oil and gas. This middle position proved worst of all.

4.7 *The Broader Pattern*

Beyond our four main examples, the pattern holds across industries:

Coal companies: Peabody Energy and Murray Energy both filed for bankruptcy as coal became increasingly uneconomic due to cheap natural gas and renewable energy, plus rising carbon costs and air quality regulations. Companies that denied climate change and lobbied against regulation performed worst.

Automotive: Tesla's pure-electric focus allowed it to become the world's most valuable car company, while traditional automakers struggle with the costly transition from internal combustion engines. Volkswagen's "Dieselgate" scandal demonstrated the catastrophic costs of trying to appear sustainable while actually cheating on emissions.

Fast fashion: H&M and Zara have invested heavily in recycling programs and sustainable materials, while ultra-fast fashion (SHEIN) faces mounting regulatory and reputational pressure. The industry is bifurcating between sustainability leaders and laggards.

Agriculture: Impossible Foods and Beyond Meat captured substantial investment and consumer interest by offering plant-based alternatives that internalize the climate and land-use externalities of conventional meat. Traditional meat producers face increasing pressure.

The common thread: companies with large negative externalities face mounting transition risks as ι increases, while companies that proactively internalize externalities position themselves to thrive.

4.8 Conclusion

Transition risks are not hypothetical future possibilities—they are destroying and creating value right now. Forever 21's bankruptcy, BP's struggles, and the coal industry's collapse demonstrate the catastrophic consequences of failing to adapt. Patagonia's growth and Ørsted's transformation demonstrate the opportunities available to companies that embrace the transition.

Three insights are critical:

1. **Higher sustainability means lower risk**: Companies with strong ESG performance face lower transition risks, better credit ratings, and more stable access to capital. The correlation between sustainability and creditworthiness will only strengthen as ι continues to rise.

2. **Adaptation is mandatory, not optional**: Companies cannot avoid the transition by ignoring it. As Chapter 3 explained, multiple channels (government, civil society, consumers, corporates, financials) are driving internalization forward. Companies must adapt or be replaced.

3. **First-movers capture disproportionate advantages**: Early action on sustainability creates learning curves, reputational benefits, regulatory influence, and strategic positioning that are difficult for late-movers to replicate.

For investors, the implications are clear: assess companies' exposure to transition risks, evaluate their readiness to navigate increasing ι, and favor companies that demonstrate public responsibility, adaptability, and first-mover positioning. The companies that will thrive in the next decades are those already preparing for a world where ι approaches 1.

The transition is not smooth or predictable. Some companies will successfully pivot (like Ørsted), others will struggle along (like BP), and many will fail entirely (like Forever 21 and coal companies). Understanding which path a company is on—and why—is essential for predicting winners and losers in the sustainable economy that is rapidly emerging.

Exercises

1. **Transition Risk Typology**

   Section 4.1 identified six types of transition risks: policy, technology, market, reputation, legal, and financing.

   (a) For Forever 21, which of these six risk types were most significant in causing its bankruptcy? Rank them from most to least impactful and explain your reasoning.

   (b) BP faces all six types of transition risks. Explain how each risk type manifests for BP, providing specific examples (e.g., carbon pricing for policy risk, electric vehicles for technology risk).

   (c) Consider a coal-fired power plant operator. The company faces a carbon tax of \$50 per tonne of CO_2, while its emissions are 2 million tonnes annually. Simultaneously, renewable energy costs have fallen to the point where new solar is cheaper than operating existing coal plants. Which transition risk (policy or technology) poses the greater threat? How would you quantify the magnitude of each risk?

   (d) Propose two strategies the coal plant operator could use to mitigate these transition risks. Evaluate the feasibility and effectiveness of each strategy.

2. **Company Value Frontiers and Transition Paths**

   Section 4.4 discusses how company value frontiers shift as ι increases from 0 to 1.

(a) On a graph with Financial Value (FV) on the vertical axis and Social/Environmental Value (SEV) on the horizontal axis, sketch the original frontier (blue, $\iota = 0$) and shifted frontier (green, $\iota = 1$). Add the 45-degree line representing positive total value.

(b) Explain in your own words why the point of maximum total value occurs at $\iota = 1$. Why is partial internalization ($0 < \iota < 1$) suboptimal from a total value perspective?

(c) Plot approximate positions for Forever 21, Patagonia, BP, and Ørsted on your graph. For each company, show: (i) where they started, (ii) the direction they moved (if any), and (iii) where they ended up.

(d) Ørsted's transformation involved several years of losses (negative net income). Using the value frontier framework, explain why accepting short-term financial value destruction can be rational if it enables movement to a better long-term position. What determines whether such a strategy succeeds or fails?

3. **The Three Keys to Transition Success**

Section 4.6 identifies public responsibility, adaptability, and first-mover positioning as critical success factors.

(a) Assess Patagonia on each of the three dimensions (public responsibility, adaptability, first-mover positioning) using a scale of 1-10. Justify your scores with specific examples from the chapter.

(b) Do the same assessment for BP. Where does BP score highest and lowest? What would BP need to do to improve its transition readiness on each dimension?

(c) Some argue that first-mover positioning is too risky because technology and regulation remain uncertain. Others argue that waiting is riskier because late-movers face steeper transition paths. Using real-world examples, evaluate both perspectives. Under what conditions is first-moving advantageous versus risky?

(d) Design a "transition readiness scorecard" that a board of directors could use to evaluate their company's preparedness. The scorecard should incorporate the three success factors but may also include additional dimensions you consider important. Explain how each dimension would be measured and weighted.

4. **ESG and Creditworthiness**

   Section 4.5 explains how ESG factors influence credit ratings and borrowing costs.

   (a) The correlation between country-level ESG scores and credit ratings is 0.77. Is this a causal relationship (ESG performance causes better credit ratings) or merely correlation (both are driven by underlying factors like institutional quality and economic development)? Defend your position with economic reasoning.

   (b) A company with poor ESG performance faces a 50 basis point (0.5%) premium on its borrowing costs compared to industry peers. If the company has $1 billion in debt and rolls over 20% annually, what is the annual cost of this ESG premium? Over 10 years, how much value is destroyed by the premium (assuming debt levels remain constant and the premium persists)?

   (c) Banks are evolving from Sustainable Finance 1.0 (exclusion) to 2.0 (ESG integration) to 3.0 (impact lending). For each stage, explain: (i) how it affects high-externality companies, (ii) how it affects low-externality companies, and (iii) what behavioral changes it incentivizes.

   (d) In China, bank credit represents 160% of GDP versus 50% in the United States. How does this difference affect the magnitude of transition risks for Chinese versus American companies? Which financial system will drive faster internalization, and why?

5. **Strategic Responses to Transition Risk**

   Considering all the material in this chapter, analyze strategic options for companies facing transition risks.

(a) A traditional automotive manufacturer faces transition risks from electric vehicles. Compare three possible strategies: (i) gradual transition (maintain combustion engines while slowly building EV capacity), (ii) rapid transformation (exit combustion engines entirely and go all-electric like Tesla), (iii) diversification (expand into mobility services, autonomous vehicles, etc.). For each strategy, identify the risks, benefits, and conditions under which it would be optimal.

(b) BP tried strategy (i)—gradual transition—and struggled. Ørsted pursued strategy (ii)—rapid transformation—and succeeded. Does this mean rapid transformation is always superior? What company characteristics and market conditions determine which strategy works best?

(c) Some fast-fashion retailers are responding to transition risks by launching "conscious" or "sustainable" product lines alongside conventional offerings. Others, like Patagonia, build their entire brand around sustainability. Compare these approaches. When is a hybrid approach viable, and when does it risk accusations of greenwashing?

(d) Imagine you are a board member of a fossil fuel company in 2025. The CEO proposes a bold transformation similar to Ørsted's: divest all oil and gas assets and pivot entirely to renewables. What questions would you ask? What analysis would you require before approving this strategy? What could go wrong, and how would you mitigate those risks?

Notes

Chapter 5
Transition Opportunities

Does sustainable investing generate superior returns? This question sits at the heart of debates about whether financial markets can drive the sustainability transition. If ESG-focused investments outperform conventional portfolios, market forces alone could allocate capital toward sustainable companies. If not, achieving sustainability goals may require policy intervention that accepts financial trade-offs.

This chapter critically assesses the evidence on ESG investment performance. We examine theoretical arguments for why ESG factors might affect returns, review empirical evidence from academic research and industry practice, and evaluate competing explanations for observed patterns. The central question is whether transition opportunities create financial value for investors, or whether sustainable investing requires accepting below-market returns to achieve impact objectives.

5.1 *Theoretical Perspectives on ESG and Returns*

Why might ESG factors affect investment returns? Three theoretical perspectives offer different predictions.

ESG as Risk Management

The risk-based view argues that companies with strong ESG practices face lower downside risks. Environmental disasters, social conflicts, and governance failures create tail risks—low-probability but high-impact events that destroy value. Companies with robust ESG management systems identify and mitigate these risks before they materialize.

Examples include BP's Deepwater Horizon oil spill ($65B in losses), Volkswagen's emissions scandal ($30B+ in fines and settlements), and numerous supply chain labor controversies.

Under this view, ESG screening reduces portfolio risk. High-ESG companies should exhibit:

- Lower volatility (fewer extreme negative events)
- Lower maximum drawdown (smaller worst-case losses)
- Better crisis performance (resilience during market stress)
- Lower bankruptcy probability

If ESG reduces risk without reducing expected returns, ESG portfolios should achieve higher Sharpe ratios—better risk-adjusted performance. However, if markets efficiently price risk reduction, ESG stocks should trade at higher valuations, generating lower expected returns through the standard risk-return trade-off.

ESG as Competitive Advantage

The competitive advantage view argues that strong ESG practices create operational efficiencies and strategic benefits:

Operational efficiency Energy efficiency, waste reduction, and resource conservation directly reduce costs. These "win-win" opportunities improve both environmental and financial performance.

Human capital Companies with strong employee relations, diversity, and workplace quality attract and retain better talent. In knowledge-intensive industries, human capital advantages translate to innovation and productivity gains.

Customer loyalty Consumers increasingly prefer sustainable products and brands. Companies with authentic environmental and social commitments build customer loyalty and command price premiums.

Regulatory positioning Firms that proactively address ESG issues shape emerging regulations to favor their approaches, gaining first-mover advantages as regulatory requirements tighten.

License to operate Companies maintaining strong community and stakeholder relationships secure permissions for expansion and avoid costly conflicts.

If these mechanisms create real competitive advantages, high-ESG companies should generate superior cash flows, producing higher returns even at higher valuations. This perspective predicts ESG stocks should outperform on fundamental metrics (profit margins, ROE, sales growth) and generate positive alpha.

ESG as Investor Preference

The investor preference view emphasizes demand-side effects. Some investors value ESG characteristics beyond financial returns—either for ethical reasons or because they care about portfolio social impact. This preference shifts demand toward high-ESG stocks.[1]

[1] Pedersen, L. H., S. Fitzgibbons, and L. Pomorski (2021), "Responsible Investing: The ESG-Efficient Frontier," *Journal of Financial Economics* 142, 572-597.

When ESG-motivated investors enter the market, they bid up prices of high-ESG stocks and depress prices of low-ESG stocks. This creates a valuation wedge: high-ESG stocks trade at lower expected returns (higher prices) while low-ESG stocks offer higher expected returns (lower prices).

Critically, this effect is one-time. During the transition period as ESG investing grows, high-ESG stocks outperform (capital gains from rising valuations). But once ESG investor demand stabilizes, expected returns normalize to reflect the new equilibrium valuations. Going forward, high-ESG stocks earn lower returns to compensate ESG-motivated investors for the non-financial benefits they receive.

This view predicts:

- **Transition period outperformance**: High-ESG stocks outperform during periods of rising ESG capital flows
- **Long-run underperformance**: High-ESG stocks earn lower returns in equilibrium to reflect investor willingness to accept financial sacrifice

- **No alpha**: After controlling for the ESG factor, no systematic outperformance remains

Reconciling the Views

These perspectives are not mutually exclusive. ESG could reduce risk, create competitive advantages, *and* attract investor preference simultaneously. The key empirical questions become:

1. Do ESG stocks generate alpha (risk-adjusted outperformance)?
2. Are ESG-related returns compensation for risk or a return discount reflecting investor preferences?
3. Has recent ESG outperformance been driven by fundamentals (improving cash flows) or valuations (increasing investor demand)?
4. Are observed patterns persistent or transitional?

5.2 Empirical Evidence: Academic Research

Meta-Analyses and Historical Performance

Early research yielded mixed results. Friede, Busch, and Bassen (2015) conduct a meta-analysis of over 2,000 empirical studies on ESG and financial performance.[2] Their findings:

[2] **friede2015esg**

- Roughly 90% of studies find non-negative ESG-return relationships
- Approximately 50% find positive relationships
- The relationship appears stronger in emerging markets and for certain ESG dimensions (particularly governance)
- Effects are more consistent for accounting measures (ROE, ROA) than stock returns

However, meta-analyses face challenges. Publication bias favors positive findings. Methodological variations across studies make synthesis difficult. And most studies examine relatively short time periods during which broader market conditions may drive results.

Factor-Based Analysis

Modern research applies factor models to isolate ESG effects from other return drivers. The key insight: simply comparing high-ESG versus low-ESG portfolio returns confounds ESG effects with exposure to market, size, value, and momentum factors.

Pastor, Stambaugh, and Taylor (2021) construct an ESG factor as the return difference between high- and low-ESG stocks, controlling for traditional factors.[3] Key findings:

[3] **pastor2021esg**

Negative ESG premium In their sample (MSCI USA, 2012-2018), the ESG factor earns significantly negative returns of approximately -2.5% annually. High-ESG stocks underperform low-ESG stocks after controlling for other factors.

Interpretation This negative premium is consistent with ESG investor preferences. As ESG capital flows increased during their sample period, high-ESG stock prices rose (generating the positive returns investors experienced), but this price appreciation left future expected returns lower. Investors essentially paid a premium to hold ESG portfolios.

Out-of-sample performance When ESG capital flows reverse or slow, the pattern could invert. High-ESG stocks might underperform if investor preferences weaken.

The ESG-Return Relationship Over Time

Recent evidence suggests the ESG-return relationship varies substantially across periods:

2010-2020: Outperformance period Many ESG indices and funds outperformed broad market benchmarks during this decade. MSCI USA ESG Leaders Index beat MSCI USA by roughly 30 basis points annually from 2013-2020.

2022-2023: Reversal period ESG funds significantly underperformed in 2022 as energy stocks (typically low ESG scores) surged and technology stocks (often high ESG scores) declined. This reversal highlights the time-varying nature of ESG returns.

Sector concentration explains much of the pattern ESG portfolios systematically underweight fossil fuel companies and overweight technology. Technology's exceptional performance from 2010-2020 drove much of ESG outperformance. Energy's 2022 surge drove underperformance. After controlling for sector tilts, ESG effects diminish substantially.

ESG and Risk

Does ESG reduce risk as the risk management view predicts? Evidence is mixed:

Lower tail risk Several studies find high-ESG portfolios exhibit smaller maximum drawdowns and better downside protection during market crises. Albuquerque et al. (2020) show high-ESG stocks outperformed during the COVID-19 crash.[4]

[4] **albuquerque2020corporate**

Similar or higher volatility Overall volatility measures (standard deviation) show no consistent pattern. Some studies find slightly higher volatility for ESG portfolios, possibly due to sector and growth stock tilts.

Systematic versus idiosyncratic risk ESG may reduce company-specific risks (disasters, scandals) without necessarily reducing market beta. This would improve diversified portfolio outcomes without changing expected returns in a CAPM framework.

5.3 Industry Evidence and Practice

ESG Fund Performance

How have ESG-labeled mutual funds and ETFs actually performed? Recent data from Morningstar provides insights:

Survivor bias matters Many ESG funds that underperformed closed or dropped ESG labels. Performance studies of surviving funds overstate returns relative to the full cohort of funds that attempted ESG strategies.

Fee drag ESG funds often charge higher expense ratios than comparable passive funds. A 0.2-0.5% annual fee difference compounds significantly over time, creating a headwind for ESG fund performance regardless of underlying stock performance.

Active management alpha Some ESG funds outperformed through skillful active management rather than ESG effects per se. Separating ESG-driven returns from manager skill requires careful analysis.

Index tracking Passive ESG index funds largely track their ESG index benchmarks. Their performance versus broad market indices reflects the ESG index construction methodology, not active ESG integration insights.

Shareholder Engagement

An alternative ESG implementation strategy is shareholder engagement—actively working with companies to improve ESG practices rather than simply screening portfolios. Evidence on engagement effectiveness:

Some successes Dimson, Karakas, and Li (2015) find successful engagements (where companies implement requested changes) associate with 7% abnormal returns over the following year.[5]

[5] **dimson2015engagement**

Low success rates Most engagement attempts fail to achieve their objectives. Success rates range from 10-30% depending on the issue and engagement approach.

Selection effects Engaged companies may differ systematically from non-engaged companies in ways that affect returns independent of the engagement itself.

Free rider problems Engagement creates public good benefits (improved corporate practices) that accrue to all shareholders, not just the engaging investor. This creates incentives to free-ride rather than bear engagement costs.

5.4 Reconciling Conflicting Evidence

How can we reconcile studies finding ESG outperformance with those finding underperformance? Several factors explain apparent contradictions:

Time Period Effects

ESG return patterns vary dramatically across time periods:

- **Rising ι periods**: When internalization increases (regulatory action, growing climate concern, expanding ESG capital flows), high-ESG stocks benefit from both fundamental improvements and valuation expansion
- **Stable ι periods**: Returns reflect steady-state factor premiums, which may be negative if ESG investors accept lower returns
- **Falling ι periods**: If ESG concern or capital flows reverse, high-ESG stocks could underperform

Most ESG outperformance occurred during 2010-2020, a period of rapidly rising ι. As ι stabilizes or the rate of increase slows, return patterns may shift.

Measurement Challenges

ESG measurement quality affects results:

Rating disagreement As discussed in Chapter **??**, ESG ratings correlate only 0.54 across providers. Studies using different ESG measures reach different conclusions.

Backward-looking ratings Most ESG ratings reflect past performance. Investors care about future ESG trajectories. Companies improving ESG may outperform those with high but stagnant scores.

Materiality variation ESG factors that matter for returns vary by industry. Broad ESG scores may obscure value-relevant ESG dimensions.

Implementation Differences

How ESG strategies are implemented matters enormously:

Best-in-class Selecting high-ESG companies within each sector maintains sector diversification, potentially reducing factor tilts that drive performance

.

Exclusionary screening Eliminating entire sectors (fossil fuels, tobacco, weapons) creates concentrated sector bets that dominate ESG effects.

Integration depth Sophisticated ESG integration considering materiality and forward-looking analysis differs from simple high-ESG screening.

Active versus passive Active ESG managers can time factor exposures and exploit mispricing. Passive ESG simply holds index-constructed portfolios.

5.5 *ESG in the Total Value Framework*

How do ESG investment returns fit within the Total Value Framework? Consider the evolution as ι increases:

Low ι (Traditional Finance)

When externalities are not internalized:

- ESG factors don't affect company cash flows (no regulatory costs, no consumer preferences)

- ESG investors are rare; no demand-driven valuation effects
- No ESG factor premium (positive or negative)
- ESG strategies underperform if they impose any costs (screening, research, engagement)

Rising ι (Transition Phase)

As internalization increases:

- High-ESG companies benefit from:
  - Regulatory advantages (prepared for tightening standards)
  - Market share gains (consumer preferences shift)
  - Lower cost of capital (growing ESG investor base)
- Low-ESG companies face:
  - Regulatory costs (carbon pricing, environmental standards)
  - Market share losses (consumer backlash)
  - Higher financing costs (ESG investors divest)
- During transition, high-ESG stocks outperform through both:
  - Fundamental improvements (higher cash flows)
  - Valuation expansion (higher multiples as demand increases)

This explains ESG outperformance from 2010-2020: the period coincided with rapidly rising ι driven by Paris Agreement, growing climate awareness, ESG capital flow acceleration, and increasing regulation.

High ι (New Equilibrium)

Once internalization stabilizes at a higher level:

- High-ESG companies have higher fundamental value (better positioned for internalized world)
- But these advantages are reflected in current prices

- High-ESG stocks trade at premium valuations
- Expected returns are lower to reflect the risk-adjusted valuation premium
- ESG factor premium becomes negative: high-ESG stocks earn lower returns than low-ESG stocks with similar risk profiles

Investors willing to accept lower returns for ESG alignment hold high-ESG portfolios. Investors purely maximizing risk-adjusted returns may tilt toward low-ESG stocks offering higher expected returns (analogous to holding value stocks).

Implications for Sustainable Investing

This framework implies:

Timing matters ESG investors who positioned early (before ι increased substantially) captured transition gains. Late entrants buy at premium valuations with lower prospective returns.

Alpha is transitional ESG "alpha" during the 2010s reflected rising ι, not a persistent return source. As ι stabilizes, alpha disappears.

Impact investing trade-offs In equilibrium, investors face a trade-off: accept lower returns to hold high-ESG portfolios, or pursue returns by tilting to low-ESG stocks. There is no free lunch.

Catalytic capital role If some investors accept below-market returns to support the transition (impact investors, mission-driven institutions), they effectively subsidize high-ESG company cost of capital, accelerating transition dynamics.

5.6 Practical Implications

What should investors conclude about ESG and returns?

For Individual Investors

Clarify objectives Distinguish between:

- Pure financial optimization (maximize risk-adjusted returns)
- Values alignment (hold companies consistent with beliefs)
- Impact seeking (allocate capital to accelerate transition)

Different objectives warrant different strategies. Confusing them leads to poor outcomes.

Understand costs ESG portfolios may underperform in equilibrium. This isn't necessarily a failure—it reflects investor willingness to accept financial sacrifice for non-financial benefits. But the trade-off should be transparent.

Avoid greenwashing Many "ESG" funds hold portfolios barely distinguishable from conventional indices, charging premium fees for minimal ESG tilt. Examine holdings and methodology carefully.

For Institutional Investors

Fiduciary considerations Trustees must clarify whether fiduciary duty permits or requires considering beneficiary values beyond pure return maximization. Legal frameworks vary across jurisdictions.

Engagement versus screening For large institutions, shareholder engagement may create more impact than portfolio screening. Engagement affects corporate behavior; screening primarily affects portfolio composition without necessarily changing company practices.

Systematic integration Rather than binary ESG/non-ESG classification, integrate material ESG factors into fundamental analysis across all holdings. Material ESG issues affect long-term value in ways traditional financial analysis may miss.

For Asset Managers

Transparency Clearly communicate:

- ESG methodology and its limitations
- Historical performance attribution (ESG effects versus sector/factor tilts)
- Expected return implications of ESG constraints
- Actual ESG characteristics of the portfolio

Materiality focus Not all ESG factors matter equally for all companies. Effective ESG investing focuses on material factors that actually affect business performance, varying by sector and company.

Forward-looking analysis Backward-looking ESG ratings miss trajectory. Companies improving ESG practices may offer better risk-adjusted returns than high-but-static ESG scorers.

Exercises

1. **ESG Factor Returns and Market Conditions**

   Analyze how ESG factor performance varies with the internalization parameter ι.

   (a) Pastor, Stambaugh, and Taylor (2021) find the ESG factor earned -2.5% annually during 2012-2018. MSCI data shows ESG indices outperformed from 2010-2020 but underperformed in 2022. Reconcile these apparently contradictory findings using the rising ι framework.

   (b) Suppose ι increases linearly from 0.2 to 0.6 over a 10-year period, then stabilizes. Sketch the expected cumulative return difference between high-ESG and low-ESG portfolios over 20 years (10-year transition + 10-year stability). Explain the shape of your curve.

(c) A pension fund invested in an ESG index fund in 2015 and outperformed the broad market by 100 basis points annually through 2020. The trustee concludes: "ESG investing generates alpha." Evaluate this conclusion. What alternative explanations should the trustee consider?

(d) If ι were to decline (e.g., due to political backlash against ESG), what would happen to high-ESG stock prices and returns? How should ESG investors respond to this risk?

2. **Decomposing ESG Performance**

   Separate fundamental, valuation, and factor effects in ESG returns.

   Data: From 2015-2020, an ESG portfolio returned 12% annually versus 10% for the broad market. The ESG portfolio had:

   - 30% technology weight versus 20% market weight
   - Technology returned 18% annually
   - Average P/E ratio increased from 18 to 22 (vs. market 16 to 18)
   - ROE increased from 15% to 17% (vs. market stable at 14%)

   (a) Calculate the return contribution from:
      - Technology sector overweight
      - Valuation multiple expansion
      - Fundamental improvement (ROE growth)

   (b) After removing sector and valuation effects, how much "pure ESG alpha" remains?

   (c) The portfolio manager claims the 200 basis point outperformance proves ESG adds value. Assess this claim based on your decomposition.

   (d) Looking forward, which components (sector, valuation, fundamentals) are most likely to persist? What does this imply for future ESG portfolio returns?

3. **ESG and Risk Management**

   Evaluate the risk-reduction argument for ESG investing.

(a) Two portfolios have identical expected returns of 10% and standard deviations of 15%. Portfolio A (high-ESG) has maximum drawdown of -25%; Portfolio B (low-ESG) has maximum drawdown of -35%. Calculate and compare Sharpe ratios and Sortino ratios. Which portfolio is "better"?

(b) Explain why ESG might reduce maximum drawdown without reducing standard deviation. What types of risks does ESG primarily mitigate?

(c) During the COVID-19 crash (Feb-March 2020), many ESG indices outperformed broad markets. Does this one observation prove ESG reduces risk? What alternative explanations should we consider?

(d) A CFO argues: "ESG risk management is redundant. We already have enterprise risk management, insurance, and hedging strategies that address these risks more efficiently." Evaluate this argument. What risks might ESG practices address that traditional risk management misses?

4. **Investor Preferences and Equilibrium Returns**

Model how ESG investor preferences affect equilibrium prices and returns.

Setup: Consider a simple market with:

- Company G (green): Expected cash flow $100, zero growth
- Company B (brown): Expected cash flow $100, zero growth
- Two investor types:
  - Traditional investors: Value both companies at $\frac{100}{r}$ using discount rate $r = 10\%$
  - ESG investors: Value G at $\frac{100}{r}$ but value B at $\frac{100}{r+\delta}$ where $\delta = 2\%$ (ESG penalty)
- ESG investors hold share θ of total wealth

(a) When $\theta = 0$ (no ESG investors), what are equilibrium prices and expected returns for G and B?

(b) When $\theta = 0.3$ (30% ESG investors), which stock's price is bid up? Solve for new equilibrium prices and expected returns.

(c) Calculate the "ESG factor premium" (return difference between B and G) as a function of θ.

(d) Suppose θ increases from 0.2 to 0.4 over 5 years. What cumulative return difference would G earn relative to B during this transition? What happens to returns after θ stabilizes?

(e) Use this model to explain why ESG funds outperformed in the 2010s but may underperform going forward.

5. **Integration: ESG Opportunities and Total Value**

Connect ESG investment returns to the Total Value Framework.

(a) In the Total Value Framework, how does rising ι affect:
- High-ESG company cash flows
- High-ESG company valuations
- High-ESG company stock returns during transition
- High-ESG company expected returns in new equilibrium

(b) An impact investor accepts 1% lower returns to hold a 100% high-ESG portfolio rather than the market portfolio. Over 30 years with $100 million initial investment, how much wealth does the investor sacrifice for impact? (Assume market returns 8%, ESG portfolio returns 7%.) Is this "cost" worth it from a total value perspective?

(c) Chapters 4 and 6 show companies underinvest in adaptation and transition (23% adaptation rate, slow green bond growth). How might ESG investing affect these corporate behaviors? Through what mechanisms could lower cost of capital for high-ESG firms accelerate corporate transition action?

(d) Synthesize: ESG funds held $2.5 trillion in 2020. Green bonds issued $500B in 2021. Which capital allocation channel (equity or debt) likely has more impact on accelerating corporate sustainability? Why?

(e) Return to Chapter 2's fundamental question: Can financial markets alone achieve socially optimal levels of internalization? Based on ESG return evidence, will profit-maximizing investors allocate sufficient capital to sustainability transition? Or does achieving transition goals require some investors to accept financial sacrifice?

Notes

Chapter 6
Firm Action

Corporate action stands at the heart of the sustainability transition. While investors allocate capital and governments set policy, companies ultimately determine whether sustainability goals translate into real-world impact. Firms can respond to sustainability pressures in multiple ways—from adapting operations to manage climate risks, to proactively financing green projects, to fundamentally restructuring business models for a low-carbon economy.

This chapter examines how companies take action on sustainability. We analyze empirical evidence on corporate adaptation to climate risks, explore green bonds as an increasingly important financing tool, and assess whether these actions create value for firms while advancing environmental goals. The central question is whether market forces alone can drive adequate firm action, or whether companies systematically under-invest in sustainability relative to social optimum.

6.1 Corporate Adaptation to Climate Risk

Climate change affects every company, but the nature and magnitude of exposure varies dramatically across firms and sectors. Some companies face immediate physical risks—coastal real estate threatened by sea-level rise, agricultural operations vulnerable to drought, supply chains disrupted by extreme weather. Others confront transition risks as carbon pricing, regulation, and shifting consumer preferences reshape competitive dynamics.

How are firms responding to these risks? The critical challenge for researchers is measuring both climate exposure and corporate adaptation strategies across diverse companies and geographies.

Measuring Climate Exposure

Traditional risk assessment relies on historical data. But climate change is forward-looking—companies face risks that have not yet fully materialized. This requires combining geospatial analysis of company operations with climate model projections.

Li (2024) develops novel measures of forward-looking climate exposure using data from Four Twenty Seven (now part of Moody's), which quantifies corporate exposure to five physical climate risks:[1]

- **Heat stress**: Extreme temperature events affecting worker productivity, equipment, and operations
- **Water stress**: Scarcity of freshwater resources for industrial processes and agriculture
- **Sea-level rise**: Gradual inundation of coastal facilities and infrastructure
- **Floods**: Acute flooding events damaging property and disrupting operations
- **Hurricanes/typhoons**: Severe storm events with widespread destruction

The exposure scores combine geospatial data on facility locations with climate model projections (not just historical weather patterns). This forward-looking approach better captures emerging risks than backward-looking historical analysis.

Measuring Corporate Adaptation

Quantifying corporate adaptation presents even greater challenges. Companies pursue diverse strategies in response to

[1] Li, J. (2024), "How Do Firms Adapt to Physical Climate Risks?" Working paper.

different climate exposures. Some actions are routine—risk assessment, insurance, business continuity planning. Others are non-routine—technology adoption, product diversification, facility relocation.

Li (2024) hand-codes climate adaptation strategies from corporate disclosures to the CDP (Carbon Disclosure Project). The coding distinguishes between routine and non-routine adaptation:

The distinction between routine and non-routine adaptation mirrors the strategic management literature's differentiation between ordinary and dynamic capabilities.

Routine Adaptation:

- **Risk assessment**: Risk identification, monitoring, modeling, and profiling
- **Risk management**: Safety plans, crisis management, disaster recovery, business continuity planning
- **Risk transfer**: Insurance and financial derivatives
- **Supplier management**: Supplier diversification and procurement adjustments
- **Enterprise risk management**: Firm-wide strategies to identify and prepare for hazards
- **Buffer building**: Stockpiling inventory and building redundant capacity

Non-routine Adaptation:

- **Hard technology**: Adopting physically tangible new designs and technologies (e.g., sea walls, cooling systems, climate-resistant infrastructure)
- **Soft technology**: Implementing non-tangible technologies like IT systems and digital platforms
- **Resilient inputs**: Adopting more climate-resilient materials and inputs
- **Market diversification**: Targeting alternative markets
- **Product diversification**: Developing different product lines

- **Location diversification**: Building facilities in alternative locations
- **Corporate strategy**: Considering climate in M&A, joint ventures, and spin-off decisions
- **Substitution**: Self-production versus outsourcing decisions
- **Relocation**: Moving facilities or headquarters
- **R&D**: Research and new product/technology development

Key Findings

The analysis of 1,068 public companies across 43 countries from 2011–2017 reveals striking patterns:

Low Overall Adaptation The average adaptation rate across firms and climate exposures is only 23%. Even firms facing substantial projected climate risks show limited adaptation. This suggests significant under-investment in climate resilience.

Routine Dominates Non-routine Firms overwhelmingly favor routine adaptation strategies over non-routine ones. Routine measures (risk assessment, insurance, business continuity planning) are easier to implement and require fewer resources than transformative non-routine strategies (technology adoption, facility relocation, product diversification).

Acute versus Chronic Risks Adaptation patterns vary by risk type. Routine adaptation is more common for acute climate events (floods, hurricanes) that resemble traditional disaster scenarios. Responses to gradual chronic shifts (heat stress, water stress) are less routine, possibly because these novel risks lack established management templates.

Perception Drives Action The study uncovers a critical mechanism: *perceived impact of climate change* mediates the relationship between actual climate exposure and adaptation. Higher exposure increases perceived impact (measured by management's climate risk ratings in CDP reports), which in turn drives adaptation.

This finding has profound implications. Even firms facing identical objective climate exposure adapt differently based on management perceptions. Perceived impact explains more variation in adaptation than objective exposure metrics alone.

Implications for Policy and Practice

The low adaptation rate (23%) and the importance of perception suggest several policy interventions could accelerate corporate climate resilience:

Mandatory Climate Risk Disclosure Regulations requiring companies to assess and report climate exposure (like the TCFD framework) may increase adaptation not through direct mandates but by raising management awareness. The act of measuring and disclosing climate risks appears to increase perceived impact, which drives action.

Climate Scenario Analysis Encouraging companies to conduct forward-looking scenario analysis (as TCFD recommends) may help management internalize long-term climate risks that are not yet visible in historical data.

Information Campaigns Industry associations, investors, and regulators can disseminate information about climate impacts specific to sectors and geographies. Better information may shift perceptions more effectively than regulatory mandates.

Addressing the Routine Bias The predominance of routine adaptation suggests companies may be preparing for climate change as if it were merely an extension of existing risk categories (like hurricane insurance). Policy should encourage non-routine adaptation—technology change, business model transformation—that better addresses the fundamental nature of climate risks.

The gap between adaptation rates and exposure levels points to market failures. Companies may under-adapt because:

- Climate impacts are uncertain and long-term, while managers face short-term pressures
- Adaptation costs are borne privately while benefits (avoided damages) are diffuse
- Capital markets may not fully price climate risks, reducing incentives to adapt
- Coordination failures: adaptation by one firm creates spillover benefits for others (e.g., supplier diversification)

6.2 Green Bonds: Financing the Transition

While climate adaptation helps firms manage sustainability risks, green bonds represent proactive firm action to finance environmental projects. Green bonds have emerged as one of the most visible and fastest-growing instruments in sustainable finance.

What Are Green Bonds?

Green bonds are fixed-income securities whose proceeds are committed to financing environmental and climate-friendly projects. Unlike conventional bonds, green bond issuers commit to use the capital raised exclusively for specified green purposes:

- Renewable energy (solar, wind, hydroelectric power generation)
- Energy efficiency (building retrofits, efficient equipment, smart grids)
- Pollution prevention and control (waste management, recycling, emissions reduction)
- Clean transportation (electric vehicles, public transit, rail infrastructure)
- Sustainable water and wastewater management
- Climate change adaptation (resilient infrastructure, flood defenses)

- Biodiversity conservation and sustainable land use

Green bonds typically follow voluntary guidelines like the Green Bond Principles, which recommend transparency about use of proceeds, project evaluation and selection processes, management of proceeds, and regular reporting.[2]

[2] The Green Bond Principles are administered by the International Capital Market Association (ICMA) and represent the most widely adopted standards for green bond issuance.

Market Growth

The green bond market has experienced explosive growth since its inception. The first modern green bond was issued in 2007 by the European Investment Bank (EIB), raising funds to finance renewable energy and energy efficiency projects.

Market evolution:

- **2007**: $0.8 billion (first EIB green bond)
- **2013**: $13 billion
- **2016**: $95 billion
- **2019**: $260 billion
- **2021**: $500+ billion

Data from Climate Bonds Initiative. The 2021 figure represents a 600-fold increase over 14 years—one of the fastest growth rates in financial market history.

By 2018, green bonds represented 0.44% of global bond issuance by value and 0.27% by number. While still a small fraction of total bond markets ($356 trillion in conventional bonds versus $490 billion in green bonds through 2018), the growth trajectory is remarkable.

Notable corporate green bond issuances include:

- **Unilever (2014)**: £250 million green bond to "cut in half the amount of waste, water usage and greenhouse gas emissions of existing factories"
- **Apple (2016)**: $1.5 billion green bond to finance "installation of more energy efficient heating and cooling systems, and an increase in the company's use of biodegradable materials"
- **ICBC (China, 2016)**: $3 billion green bond, one of the largest single issuances

Geographic Distribution

Green bond issuance is globally distributed but concentrated in developed markets and China:

Europe led early issuance due to strong environmental regulations and investor demand. China's rapid growth reflects government policies supporting green finance and the country's renewable energy expansion.

- **Europe**: Early leader, peaked at $77 billion in 2017; strong issuance from France, Germany, Netherlands, and Scandinavian countries
- **China**: Explosive growth from near-zero in 2015 to $40 billion by 2018; now the largest single-country issuer
- **North America**: Steady growth to $21 billion by 2018; dominated by U.S. issuers including municipal bonds
- **Asia (ex-China)**: Growing market reaching $13 billion by 2018; Japan, South Korea, and India as major issuers
- **South America**: Modest but growing, $1-2 billion annually; Brazil leading
- **Africa and Oceania**: Limited issuance below $1 billion

Industry Distribution

Green bond issuance varies significantly by sector, reflecting both financing needs and credibility of environmental claims:

Utilities and energy companies issue more green bonds by number but government and financial sector bonds dominate by value, as these entities issue larger individual bonds.

Top issuers by value (2007-2018):

1. **Government**: $182.6 billion (sovereign, municipal, development banks)
2. **Financials**: $150.9 billion (commercial banks issuing to finance green lending)
3. **Utilities**: $86.8 billion (renewable energy infrastructure, grid modernization)
4. **Industrials**: $31.4 billion (energy efficiency, emissions reduction)
5. **Energy**: $15.4 billion (renewable energy projects)

The high share of government and financial issuers reflects the role of development banks (like EIB) and commercial banks using green bonds to fund green lending portfolios. Corporate issuers are led by utilities (2.07% of sector bonds are green by value), followed by energy companies (0.33%) and industrials (0.55%).

Do Green Bonds Create Value?

The central question for corporate finance is whether green bond issuance affects firm value. Several mechanisms could drive value creation or destruction:

Potential value creation:

- **Lower cost of capital**: If green investors accept lower yields ("greenium"), firms reduce financing costs
- **Expanded investor base**: Access to ESG-focused funds and mandated investors increases demand
- **Reputational benefits**: Green bond issuance signals environmental commitment, enhancing brand value
- **Operational improvements**: Discipline of green bond frameworks may improve project selection and execution
- **Real environmental impact**: If proceeds fund value-creating green projects

Potential value destruction:

- **Certification and monitoring costs**: Green bonds require verification, reporting, and compliance with frameworks
- **Use-of-proceeds restrictions**: Constraining capital allocation may force sub-optimal investments
- **Greenwashing risk**: If environmental claims prove unsubstantiated, reputational damage may exceed benefits
- **Opportunity costs**: Management time and resources devoted to green bond process

Flammer (2021) provides the most comprehensive empirical evidence, finding:[3]

- **Positive stock price reaction**: Green bond announcements generate significant positive abnormal returns
- **Improved long-term performance**: Issuers show better environmental ratings and operational performance
- **Lower cost of capital**: Institutional ownership increases and subsequent bond yields decline for issuers
- **Certification matters**: External verification and third-party certification strengthen positive effects
- **Greenness quality matters**: Stock price reactions are stronger when proceeds finance genuinely novel green projects versus routine environmental expenditures

[3] Flammer, C. (2021), "Corporate Green Bonds," *Journal of Financial Economics* 142, 499-516.

These findings suggest green bonds create value through multiple channels—signaling credible environmental commitment, attracting long-term investors, and potentially selecting value-creating projects.

Green Bonds and the Total Value Framework

How do green bonds fit within our Total Value Framework? Consider a firm issuing a green bond to finance renewable energy capacity.

The firm's value frontier shifts as internalization (ι) increases:

1. **Low ι regime** (traditional finance): Firm optimizes purely on financial value. Green bonds impose costs (certification, restrictions) without financial benefit. No green bond issuance in equilibrium.
2. **Rising ι** (partial internalization): As some investors and consumers begin valuing emissions reductions:
    - Green bonds attract ESG investors, lowering cost of capital
    - Brand value increases from environmental reputation

- Firm experiences positive financial value from green bond issuance
- Green bonds become financially optimal even absent full social cost internalization

3. **High ι** (full internalization): Firm internalizes social costs of emissions:

   - Green projects generate both private and social value
   - Green bonds become the optimal financing vehicle for expansion
   - Financial value and total value alignment improves

The explosive growth of green bonds from 2007 to 2021 directly reflects rising ι over this period. The Paris Agreement (2015), growing climate awareness, expansion of ESG investing, and increasing climate policy all raised investor and consumer sensitivity to corporate environmental impact. Green bond growth tracks this internalization increase.

However, green bond issuance still represents less than 0.5% of total bond issuance, suggesting significant room for expansion as ι continues to rise.

Challenges and Limitations

Despite growth, green bonds face several challenges:

Greenwashing risk Without mandatory standards and verification, some issuers may label bonds "green" without meaningful environmental impact. This undermines market credibility and may drive a "race to the bottom" in green bond quality.

Additionality question Critics question whether green bond proceeds fund truly *additional* green projects—projects that would not occur otherwise—or simply relabel existing environmental expenditures. If bonds merely refinance existing projects, environmental impact is limited.

Limited accountability Most green bonds lack enforceable consequences if issuers fail to use proceeds as promised or if projects underperform environmentally. Post-issuance monitoring remains voluntary.

Difficulty measuring impact Unlike financial returns (easily measured), environmental impact is hard to quantify. How much emission reduction does a $1 billion renewable energy green bond deliver? Different methodologies yield different answers, making cross-bond comparisons difficult.

Fragmented standards Multiple competing frameworks (Green Bond Principles, Climate Bonds Standard, EU Green Bond Standard) create complexity. Lack of universal standards increases costs and reduces market efficiency.

Concentration in large issuers Most green bonds are issued by large corporations, governments, and banks. Small and medium enterprises largely lack access to green bond markets, potentially limiting overall environmental impact.

6.3 Other Firm Actions

Beyond climate adaptation and green bonds, firms take numerous other sustainability-related actions:

Sustainability-linked executive compensation Tying CEO and executive pay to ESG targets (emissions reductions, diversity metrics, safety records) can align incentives. However, effectiveness depends on target rigor and measurement quality.

Voluntary emissions commitments Science-based targets, net-zero pledges, and sectoral decarbonization commitments. Credibility requires clear interim targets, transparent reporting, and third-party verification.

Supply chain management Requiring suppliers to meet environmental and social standards. May reduce Scope 3 emissions and social risks, but enforcement is challenging across global supply chains.

Product innovation Developing environmentally superior products (electric vehicles, plant-based meat, sustainable materials). Can create competitive advantage if consumers value sustainability.

Operational improvements Energy efficiency, waste reduction, water conservation. Often generate both environmental and financial benefits ("win-win" opportunities).

The Total Value Framework helps predict which actions firms will take as ι increases. Actions that require minimal financial sacrifice (operational efficiency) occur first. Actions requiring substantial upfront investment (product innovation, facility relocation) occur only as ι rises sufficiently to justify costs.

Exercises

1. **Climate Adaptation and Exposure**

   The Li (2024) study finds average corporate adaptation rates of only 23% despite significant climate exposure.

   (a) Two manufacturing companies have identical climate exposure scores for water stress (both operate facilities in drought-prone regions). Company A has adapted by investing in water recycling technology and alternative water sources. Company B has done nothing. Using the Total Value Framework, explain why both companies' behavior could be rational from a financial value perspective even though they face identical risks.

   (b) The study finds that perceived impact of climate change is more predictive of adaptation than objective exposure measures. A CFO argues: "We should ignore these subjective perceptions and focus only on hard data from climate models." Evaluate this argument. What role should management perception play in climate risk management?

(c) Routine adaptation (risk assessment, insurance) dominates non-routine adaptation (technology change, relocation) by a ratio of approximately 2:1. As ι increases from 0.3 to 0.8, predict how this ratio should change. Will routine or non-routine adaptation grow faster? Why?

(d) Calculate the social cost of under-adaptation. If firms with high climate exposure should adapt at 60% to maximize total value but actually adapt at 23%, and the average firm faces $50 million in expected climate damages over 20 years, what is the deadweight loss from insufficient adaptation per firm? What does this imply for policy intervention?

(e) The study uses forward-looking climate model projections rather than historical weather data. Explain why this matters for measuring corporate climate exposure. Give an example of a company where historical and projected exposure differ substantially.

2. **Green Bond Market Dynamics**

Green bond issuance grew from $0.8 billion in 2007 to over $500 billion in 2021—a 600-fold increase.

(a) Plot this growth on a graph with ι on the x-axis. What events between 2007 and 2021 increased ι? (Consider: Paris Agreement 2015, growth of ESG funds, increasing climate policy, rising climate awareness.) Does the timing of green bond acceleration match major ι shifts?

(b) Utilities issue 2.07% of their bonds as green bonds (by value), while technology companies issue only 0.17%. Using the Total Value Framework, explain this difference. Which sector should issue more green bonds as ι increases from 0.4 to 0.7?

(c) A CFO considers issuing a $500 million green bond versus a conventional bond. The green bond requires $2 million in certification and reporting costs and restricts use of proceeds to renewable energy projects. The firm estimates the green bond will attract additional ESG-focused investors, lowering the yield by 15 basis points. Should the firm issue the green bond? At what ι level does this become optimal?

(d) Flammer (2021) finds positive stock price reactions to green bond announcements, but the effect is stronger for externally verified bonds. A company wants to minimize issuance costs by avoiding third-party verification. Use signaling theory to explain why this may be counterproductive. What is the equilibrium verification strategy?

(e) Green bonds represent only 0.44% of global bond issuance ($490 billion green versus $356 trillion conventional through 2018). If ι increases from its current level to full internalization, what share of bond issuance should become green? What industries should approach 100% green bond issuance?

3. **Firm Action Trade-offs**

Companies face choices between different sustainability actions.

(a) A manufacturing firm can either: (A) invest $100 million in energy efficiency improvements that reduce emissions by 20% and save $8 million annually in energy costs, or (B) issue a $100 million green bond to finance a solar farm that reduces emissions by 25% but generates no direct cost savings. Using NPV analysis with a 10% discount rate, which action creates more financial value? Which creates more total value assuming external climate damages are $50 per ton CO_2?

(b) The firm chooses option A (energy efficiency) when $\iota = 0.3$ and option B (solar farm) when $\iota = 0.7$. What does this reveal about the projects' relative financial and environmental value? Sketch the two projects' positions on a financial value (FV) versus social-environmental value (SEV) graph.

(c) Suppose the firm announces option B (green bond for solar farm) and the stock price increases by 2%. Does this prove the decision created value? What alternative explanations could account for the positive stock price reaction?

(d) A competitor issues a green bond and receives positive media coverage. Your firm faces pressure to do the same. How should the decision-maker evaluate whether to issue a green bond? What questions should they ask before proceeding?

(e) Discuss the "additionality" problem for green bonds. If a firm was already planning to build a solar farm and simply finances it with a green bond instead of conventional debt, has any environmental impact been created? Does the green bond add value in this case?

4. **Adaptation Mechanisms**

Li (2024) finds that perceived climate impact mediates the relationship between exposure and adaptation.

(a) Draw a mediation diagram showing: Climate Exposure $\to$ Perceived Impact $\to$ Adaptation. A one-standard-deviation increase in exposure increases perceived impact by 0.05 standard deviations. A one-standard-deviation increase in perceived impact increases adaptation by 0.31 standard deviations. Calculate the total effect of exposure on adaptation through the perception channel.

(b) Two companies have identical water stress exposure scores of 0.8 (high). Company A's management rates climate impact as 4/5. Company B's management rates it as 2/5. Predict: which company adapts more? By approximately how much? What could explain the perception difference despite identical exposure?

(c) Regulators are considering mandatory climate risk disclosure (similar to TCFD). Using the perceived impact mechanism, explain how this regulation might increase adaptation even without directly mandating specific actions. What is the key assumption required for this to work?

(d) Some argue that improving climate science and making exposure data more accessible to companies would increase adaptation more effectively than regulations. Evaluate this claim using the perceived impact evidence. Is better information sufficient?

(e) The perceived impact effect suggests management psychology matters for climate action. What specific interventions might shift management perceptions? Consider: executive education, industry conferences, climate scenario exercises, board diversity, investor engagement.

5. **Integration: Firm Actions in the Total Value Framework**

   Connect firm action (climate adaptation, green bonds) to the broader course framework.

   (a) A coal-fired power utility faces rising ι from 0.3 to 0.7. Map out the sequence of firm actions you expect: when does it begin routine climate adaptation? When does it invest in renewable energy? When does it issue green bonds? When does it phase out coal assets? Use the company value frontiers (Figure 2.2) to illustrate.

   (b) Compare two firms: Firm Green adapts to climate risks and issues green bonds early (at $\iota = 0.4$). Firm Brown waits until forced by regulation (at $\iota = 0.8$). Sketch their value frontier trajectories. Which firm creates more total value? Which creates more financial value for shareholders? Does the answer depend on when we measure?

   (c) Chapter 4 identified firms that thrive versus fail during transition. Synthesize: Do firms that adapt early and issue green bonds face lower transition risk? Use the Li (2024) finding that only 23% of firms adapt despite exposure to argue whether market forces alone can manage transition risks.

   (d) Green bonds grew 600-fold from 2007 to 2021, tracking rising ι. Climate adaptation rates remain at 23%. Why the difference? Why has one firm action (green bonds) grown explosively while another (climate adaptation) remains limited? What does this reveal about what drives corporate sustainability action?

   (e) Suppose we achieve full internalization ($\iota = 1$). Describe the equilibrium state for corporate climate action. What share of bonds are green? What share of firms have adapted to climate risks? What actions do firms take that they don't take today? Is this equilibrium achievable through market forces alone or does it require policy intervention?

Notes

Chapter 7 *Investor Action*

7.1 Introduction

Sustainable investing has exploded over the past two decades. Investment funds that integrate environmental, social, and governance (ESG) factors into their portfolio decisions have grown from a niche market to a dominant force in global finance. By 2022, roughly 90% of the market capitalization of publicly traded companies was covered by at least one ESG fund—up from just 5% in 2006.

This growth reflects both institutional mandates and individual preferences. Major pension funds like Norway's Government Pension Fund Global ($1.62 trillion in assets) and the Dutch ABP (€502 billion) have adopted explicit sustainability mandates. Asset managers like BlackRock ($10.5 trillion under management) have made ESG integration central to their investment philosophy.

Yet this phenomenon presents a puzzle. If sustainable companies generate higher earnings (as argued in Chapter 6), why would their expected returns differ from conventional investments? And if sustainable investments offer lower expected returns, why do rational investors choose them?

This chapter develops a theoretical framework—*CAPM with mandates*—that resolves this puzzle. We show how investor preferences and mandates affect asset prices, expected returns, and portfolio composition. The framework yields several important insights:

1. Assets with higher ESG scores can have *lower* expected returns in equilibrium, even though the underlying companies may be more profitable

2. Investors may rationally hold green assets despite lower expected returns if they face mandates or derive utility from sustainability

3. Unexpected changes in ESG preferences can generate substantial returns

4. Investors with skill in predicting ESG improvements can earn excess returns

The CAPM with mandates extends traditional asset pricing theory to incorporate investor preferences for sustainability characteristics.

Understanding these dynamics is crucial for both investors designing sustainable portfolios and companies considering ESG improvements.

7.2 *The Growth of Sustainable Investing*

The rise of sustainable investing represents one of the most significant shifts in capital markets over the past generation. ESG fund coverage of global market capitalization grew from approximately 5% in 2006 to nearly 90% by 2022—a dramatic transformation in just over fifteen years.[1]

[1] Data from Global Sustainable Investment Alliance and MSCI ESG coverage statistics.

Multiple channels have accelerated sustainable investing growth: regulatory pressure, generational wealth transfer, and evidence of financial materiality.

This growth has been driven by several factors:

Institutional mandates. Large pension funds and sovereign wealth funds have adopted explicit sustainability criteria. Norway's Government Pension Fund Global, the world's largest sovereign wealth fund with $1.62 trillion in assets, excludes companies based on ethical criteria including environmental damage, human rights violations, and weapons production. The fund has divested from coal companies and is actively engaging with portfolio companies on climate risks.

The Dutch ABP, Europe's largest pension fund with €502 billion in assets, announced in 2021 that it would fully divest from fossil fuel companies by 2023. This decision affected investments worth €15 billion and sent shockwaves through energy markets.

Asset manager commitments. BlackRock, the world's largest asset manager with $10.5 trillion under management, made ESG integration central to its investment process. In his 2020 letter to CEOs, Chairman Larry Fink wrote: "Climate risk is investment risk." The firm announced it would make sustainability its new standard for investing, including:

- Placing sustainability at the center of its investment approach
- Exiting investments with high sustainability risk
- Launching new investment products with sustainability at their core
- Strengthening commitment to sustainability and transparency in index-based strategies

Regulatory developments. The European Union's Sustainable Finance Disclosure Regulation (SFDR), implemented in 2021, requires financial market participants to disclose how they integrate sustainability risks into investment decisions. Similar regulations have emerged in other jurisdictions, creating demand for ESG data and analysis.

Generational wealth transfer. Younger investors demonstrate stronger preferences for sustainable investments. As millennials and Generation Z accumulate wealth, these preferences increasingly shape capital allocation decisions.

7.3 *Why Do Investors Buy Green Assets?*

The growth of sustainable investing presents a theoretical puzzle that requires careful analysis. Consider the following logic:

1. Companies with higher ESG scores may generate higher earnings (as discussed in Chapter 6, through better risk management, innovation, and stakeholder relations)
2. In standard asset pricing theory, assets with higher expected cash flows should have higher prices
3. Higher prices imply lower expected returns (holding cash flows constant)

4. Therefore, sustainable investments might offer *lower* expected returns

This raises an obvious question: why would rational investors choose assets with lower expected returns?

There are two primary answers:

Investors may accept lower returns on green assets either because they face mandates requiring such holdings, or because they possess skill in identifying ESG improvements before they are priced in.

Answer 1: Mandates and preferences. Investors may face constraints or derive utility from holding sustainable assets. Pension funds may have fiduciary duties that incorporate beneficiary preferences for sustainability. Endowments may face donor restrictions requiring ethical investment. Individual investors may simply prefer portfolios aligned with their values, accepting lower financial returns in exchange for this alignment.

This is analogous to other consumption choices: people pay premium prices for organic food, fair-trade coffee, or electric vehicles not because these products offer superior financial returns, but because they value their characteristics. Similarly, investors may pay a premium for (accept lower returns on) sustainable investments.

Answer 2: Skill and private information. Some investors may possess superior ability to identify companies whose ESG characteristics will improve. If ESG improvements are not fully priced in, investors with this skill can earn excess returns. This is similar to traditional security selection: investors with skill in identifying undervalued companies can outperform, even if the average investor cannot.

The distinction between these two explanations is crucial:

- Under the *mandates* explanation, sustainable investing involves accepting lower returns to satisfy constraints or preferences

- Under the *skill* explanation, sustainable investing can generate higher returns for investors with superior ESG analysis capabilities

Both channels likely operate in practice. The CAPM with mandates framework developed in the next section formalizes the first channel, then extends to incorporate skill.

7.4 CAPM with Mandates

We now develop a formal model of asset pricing when investors face ESG mandates. The framework extends the traditional Capital Asset Pricing Model (CAPM) to incorporate investor preferences for portfolio ESG characteristics.

Setup and Assumptions

Consider a market with multiple risky assets and a continuum of investors indexed by i. Each asset j has:

- Random return $\tilde{r}_j$ (assumed normally distributed)
- ESG score g_j (deterministic, known to all investors)

Let μ denote the vector of expected returns and Σ the covariance matrix of returns. Define g as the vector of ESG scores.

Investors have three key characteristics:

The model incorporates three dimensions of investor heterogeneity: risk aversion, wealth, and ESG mandates.

1. Wealth ω_i (with $\int_i \omega_i di = 1$, normalizing total wealth to one)
2. Risk aversion parameter γ (assumed identical across investors for simplicity)
3. ESG mandate $\bar{g}_i$ (the target ESG score for investor i's portfolio)

Investors choose portfolios to maximize a utility function that combines standard mean-variance preferences with a penalty for deviating from their ESG mandate:

$$\max_{X_i} \quad \mu' X_i - \frac{\gamma}{2} X_i' \Sigma X_i - \frac{c}{2}(g' X_i - \bar{g}_i)^2 \tag{7.1}$$

where:

- X_i is investor i's portfolio (vector of holdings)
- $\mu' X_i$ is expected return
- $X_i' \Sigma X_i$ is portfolio variance (risk)
- $g' X_i$ is the ESG score of investor i's portfolio

- $c \geq 0$ measures the importance of meeting the ESG mandate

The parameter c captures how strongly the investor cares about meeting the mandate $\bar{g}_i$. When $c = 0$, we recover standard mean-variance optimization. As c increases, investors become more willing to sacrifice risk-adjusted returns to achieve their target ESG score.

Optimal Portfolio Choice

Taking the first-order condition of equation (7.1) with respect to X_i yields:

$$\mu - \gamma \Sigma X_i - c(g' X_i - \bar{g}_i) g = 0 \tag{7.2}$$

Rearranging:

$$X_i = \frac{1}{\gamma} \Sigma^{-1} [\mu + c(g - \bar{g}_i)] \tag{7.3}$$

Each investor's optimal portfolio depends on expected returns, the covariance matrix, and the deviation between the asset's ESG score and the investor's mandate.

This equation reveals several important insights:

1. When $c = 0$ (no ESG mandate), we recover the standard mean-variance portfolio: $X_i = \frac{1}{\gamma} \Sigma^{-1} \mu$
2. The term $c(g - \bar{g}_i)$ acts as an adjustment to expected returns based on each asset's ESG score relative to the investor's mandate
3. Investors with high mandates ($\bar{g}_i$ large) will overweight assets with high ESG scores (g large) relative to their expected returns
4. Conversely, investors with low mandates will overweight low-ESG assets

Market Equilibrium

In equilibrium, the market must clear: the total demand for each asset must equal its supply. Let X_m denote the market portfolio (the supply of risky assets). Market clearing requires:

$$X_m = \int_i \omega_i X_i \, di \tag{7.4}$$

Substituting the optimal portfolio choice from equation (7.3) and using $\int_i \omega_i di = 1$:

$$X_m = \frac{1}{\gamma}\Sigma^{-1}\left[\mu + c\left(g - \int_i \omega_i \bar{g}_i \, di\right)\right] \tag{7.5}$$

Define $\bar{g}_m \equiv \int_i \omega_i \bar{g}_i \, di$ as the wealth-weighted average mandate across all investors. Rearranging:

$$\gamma \Sigma X_m = \mu + c(g - \bar{g}_m) \tag{7.6}$$

This yields the key pricing equation:

In equilibrium, expected returns equal the standard CAPM prediction minus a term that decreases in the asset's ESG score. Green assets have lower expected returns.

$$\mu = \gamma \Sigma X_m - c(g - \bar{g}_m) \tag{7.7}$$

Using the definition of beta ($\beta = \frac{\mathrm{Cov}(r, r_m)}{\mathrm{Var}(r_m)} = \frac{\Sigma X_m}{\sigma_m^2}$) and the market expected return ($\mu_m = \gamma \sigma_m^2$), we can rewrite equation (7.7) as:

$$\mu = \mu_m \beta_m - c(g - g_m) \tag{7.8}$$

where $g_m = g' X_m$ is the ESG score of the market portfolio.

Implications

Equation (7.8) has profound implications for understanding sustainable investing:

The CAPM with mandates predicts that green assets trade at a premium (higher prices, lower expected returns) when investors have positive ESG mandates on average.

1. **Green assets have lower expected returns.** Assets with ESG scores above the market average ($g > g_m$) have expected returns below what standard CAPM would predict. The discount is proportional to $(g - g_m)$.

2. **The discount depends on mandate strength.** The parameter c measures how much investors care about ESG mandates. As c increases (mandates become more important), the return discount for green assets increases.

3. **Market-wide shifts in mandates change prices.** If the average mandate $\bar{g}_m$ increases (more investors adopt sustainability mandates), the parameter c effectively increases, causing green asset prices to rise and expected returns to fall.

4. **This is consistent with higher green company earnings.** Green companies may have higher expected cash flows (as discussed in Chapter 6), but also higher prices due to investor demand. The net effect is lower expected returns despite higher expected earnings.

The framework resolves our initial puzzle: investors rationally hold green assets with lower expected returns because they derive utility from meeting ESG mandates, either due to institutional constraints or personal preferences.

7.5 Extension 1: Unexpected Changes in Mandates

The basic CAPM with mandates assumes that the strength of ESG preferences (c) is constant and known. In reality, societal preferences for sustainability change over time. Public concern about climate change has intensified, regulatory frameworks have evolved, and institutional mandates have strengthened. These changes in c have important implications for realized returns.

The Impact of Unexpected Mandate Strengthening

Suppose at time t, investors unexpectedly increase the weight they place on ESG mandates. Formally, let c increase from c_0 to c_1, with $\Delta c = c_1 - c_0 > 0$.

From equation (7.8), the expected return on an asset changes from:

$$\mu_0 = \mu_m \beta_m - c_0(g - g_m) \tag{7.9}$$

to:

$$\mu_1 = \mu_m \beta_m - c_1(g - g_m) \tag{7.10}$$

The change in expected return is:

$$\Delta\mu = \mu_1 - \mu_0 = -\Delta c(g - g_m) \tag{7.11}$$

An unexpected increase in ESG mandate strength causes green assets to have lower expected future returns but generates immediate positive realized returns through price appreciation.

For assets with $g > g_m$ (green assets), expected returns *decrease*. This might seem counterintuitive, but it reflects the fact that green asset prices have *increased* in response to stronger ESG mandates.

Using the Gordon growth model logic (see Chapter 2), if expected returns decrease while cash flows remain constant, prices must increase. The immediate realized return at time t when the mandate strengthens includes this price appreciation:

$$\text{Realized return} = \mu_m \beta_m - c_0(g - g_m) + \Delta c \cdot g \tag{7.12}$$

The last term, $\Delta c \cdot g$, represents the capital gain from the strengthening mandate. Notice that this gain is proportional to the asset's ESG score g, not to its deviation from the market $(g - g_m)$. Higher ESG assets experience larger price appreciations.

Empirical Evidence

Pástor, Stambaugh, and Taylor (2021) provide compelling evidence consistent with this mechanism.[2] They document:

[2] Pástor, L., R. F. Stambaugh, and L. A. Taylor (2021). "Sustainable Investing in Equilibrium." *Journal of Financial Economics* 142(2), 550–571.

1. Green stocks (those with high ESG scores) have lower expected returns than brown stocks, consistent with equation (7.8)

2. During periods of unexpectedly strengthening ESG preferences, green stocks outperformed brown stocks, consistent with equation (7.12)

3. The pattern reversed during periods when ESG concerns temporarily weakened (e.g., the COVID-19 pandemic in early 2020, when investors focused on immediate economic concerns)

Their empirical analysis suggests that ESG concerns have strengthened substantially over the past two decades, generating significant outperformance for green stocks despite their lower expected returns going forward.

Implications for Investors

This extension has important implications:

Timing shifts in ESG preferences can generate substantial returns, but requires correctly anticipating changes in societal and institutional mandates.

- **Historical performance may be misleading.** Green stocks may have outperformed in the past due to unexpectedly strengthening mandates, but this does not imply higher expected returns going forward

- **Timing matters.** Investors who correctly anticipate shifts in ESG preferences can earn substantial returns
- **There is no "free lunch."** The lower expected returns on green assets represent a steady-state equilibrium; outperformance occurs only during transitions when preferences shift
- **Policy changes create investment opportunities.** Major policy shifts (e.g., new carbon taxes, mandatory ESG disclosure, fossil fuel divestment campaigns) can trigger sudden changes in c, creating gains for investors positioned in green assets

7.6 Extension 2: Skill and Imperfect Information

The second extension considers the case where ESG scores are not perfectly known or constant. Instead, suppose an asset's ESG score evolves over time as companies improve (or worsen) their sustainability practices. Investors who can predict these changes may earn excess returns.

ESG Score Dynamics

Let g_t denote the ESG score at time t. Suppose the score evolves as:

$$g_{t+1} = g_t + \Delta g_{t+1} \tag{7.13}$$

where Δg_{t+1} represents the change in ESG score. In general, $\mathbb{E}[\Delta g_{t+1}] = 0$ (random walk), so the average investor cannot predict ESG improvements.

However, some investors may possess *skill* in forecasting ESG changes. Define:

Investors with skill in predicting ESG improvements can earn excess returns, similar to investors with skill in traditional security analysis.

- Δg_{t+1}: the actual ESG score change
- $\mathbb{E}[\Delta g_{t+1}]$: the market's expectation of the ESG change (assumed to be zero)
- $\hat{\Delta g}^i_{t+1}$: investor i's forecast of the ESG change

An investor has skill if their forecast is informative:

$$\hat{\Delta g}^{i}_{t+1} = \theta \Delta g_{t+1} + \epsilon^{i}_{t+1} \tag{7.14}$$

where $\theta \in [0, 1]$ measures skill ($\theta = 0$ means no skill; $\theta = 1$ means perfect foresight) and ϵ^{i}_{t+1} is noise.

Returns to Skilled Investors

Consider an investor with skill θ who holds an asset that subsequently experiences an ESG score change of Δg. From equation (7.8), the expected return at time t (before the change is known) is:

$$\mu_t = \mu_m \beta_m - c(g_t - g_m) \tag{7.15}$$

At time $t + 1$, after the ESG improvement becomes public, the expected return adjusts to:

$$\mu_{t+1} = \mu_m \beta_m - c(g_{t+1} - g_m) = \mu_m \beta_m - c(g_t + \Delta g - g_m) \tag{7.16}$$

The price must adjust so that the new expected return holds. This generates a realized return at time $t + 1$ of:

The excess return from ESG skill is proportional to both the mandate strength c and the ESG score change Δg.

$$\text{Realized return}_{t+1} = \mu_m \beta_m - c(g_t - g_m) + c \cdot \Delta g \tag{7.17}$$

The last term, $c \cdot \Delta g$, represents the capital gain from the ESG improvement. An investor with skill θ can expect to earn:

$$\mathbb{E}[\text{Excess return}^i] = \theta c \mathbb{E}[\Delta g \mid \text{forecast}] \tag{7.18}$$

This excess return has several important features:

1. It is proportional to skill θ: better forecasters earn higher returns
2. It is proportional to mandate strength c: excess returns are larger when the market cares more about ESG
3. It depends on the magnitude of ESG changes Δg: larger improvements (or deteriorations) create larger returns
4. It can be positive or negative: investors who correctly predict ESG deteriorations can profit by underweighting or shorting those assets

Implications

This framework suggests several important points:

Active sustainable investing can add value through superior ESG analysis, similar to how traditional active management adds value through superior fundamental analysis.

- **Active ESG investing can add value.** Just as some investors have skill in predicting earnings or cash flows, some may have skill in predicting ESG improvements. This skill can generate alpha.

- **ESG data and analysis matter.** The excess returns in equation (7.17) depend on correctly forecasting Δg. Investment in ESG research, engagement with companies, and analysis of sustainability trends can generate valuable information.

- **First-movers have advantages.** Investors who identify ESG improvements before they become widely known can purchase assets before prices adjust. This creates incentives for proprietary ESG research.

- **The skill explanation coexists with the mandate explanation.** Even if the average green asset has lower expected returns due to mandates (Extension 1), skilled investors can earn excess returns by predicting ESG changes (Extension 2). Both channels operate simultaneously.

- **ESG integration is not just about exclusion.** Rather than simply screening out "bad" companies, sophisticated sustainable investors actively seek companies whose ESG profiles are likely to improve, generating both financial returns and real-world impact.

7.7 *Conclusion*

This chapter has developed a comprehensive framework for understanding sustainable investing from the investor's perspective. The CAPM with mandates resolves an apparent puzzle: investors rationally hold green assets despite lower expected returns because they derive utility from meeting ESG mandates or because they possess skill in predicting ESG improvements.

The key insights are:

The CAPM with mandates framework shows how investor preferences and skill affect asset prices, expected returns, and the potential for sustainable investing to generate both financial returns and real-world impact.

1. **Green assets can have lower expected returns in equilibrium.** When investors have ESG mandates or preferences, assets with high ESG scores trade at premium prices, resulting in lower expected returns. This is consistent with green companies having higher expected earnings—the higher earnings are capitalized into higher prices.

2. **Mandates explain steady-state return differences.** The parameter c in equation (7.8) captures how much investors care about ESG characteristics. As societal and institutional preferences for sustainability have strengthened, c has increased, compressing expected returns on green assets.

3. **Unexpected preference shifts generate realized returns.** When ESG mandates unexpectedly strengthen ($\Delta c > 0$), green assets experience capital gains that can substantially exceed their lower expected returns. Historical outperformance of sustainable investments reflects this mechanism.

4. **Skill in ESG analysis can generate alpha.** Investors who can predict ESG improvements before they are widely known can earn excess returns proportional to their skill. This creates a role for active sustainable investing similar to traditional active management.

5. **Multiple channels coexist.** Some investors hold green assets to meet mandates (accepting lower returns), while others hold them to exploit ESG improvement opportunities (seeking higher returns). Both channels operate simultaneously in financial markets.

The framework also connects to broader questions about impact. Recall from Chapter 2 that financial returns depend on changes in internalized value V^I, not total value V. When investors with ESG mandates bid up prices of green assets, they increase the internalized value that companies perceive, potentially influencing corporate behavior. Thus, investor action through capital allocation can complement the other channels of internalization discussed in Chapter 3.

Looking ahead, understanding investor incentives is crucial for designing policies and products that channel capital toward sustainable outcomes. Chapters 8 and 9 will explore how investors can maximize real-world impact, not just financial returns.

Exercises

1. **CAPM with Mandates Mechanics**

   Consider a market with two assets and two investor types:

   Assets:

   - Asset A: $\mu_A = 8\%$, $\sigma_A = 15\%$, $g_A = 0.8$ (green)
   - Asset B: $\mu_B = 10\%$, $\sigma_B = 20\%$, $g_B = 0.2$ (brown)
   - Correlation: $\rho_{AB} = 0.3$

   Investors:

   - Type 1 (50% of wealth): mandate $\bar{g}_1 = 0.7$
   - Type 2 (50% of wealth): mandate $\bar{g}_2 = 0.3$
   - Both types have risk aversion $\gamma = 2$

   Assume the mandate penalty parameter is $c = 5$.

   (a) Construct the covariance matrix Σ for these two assets.

   (b) Calculate the market portfolio weights X_m (assume equal market capitalization).

   (c) What is the wealth-weighted average mandate $\bar{g}_m$?

   (d) Using equation (7.3), calculate the optimal portfolio for each investor type.

   (e) Verify that market clearing holds: $X_m = 0.5X_1 + 0.5X_2$.

   (f) How would your answer to part (d) change if c increased to 10? Interpret economically.

2. **Pricing Implications**

   Suppose the market portfolio has expected return $\mu_m = 9\%$, and the market ESG score is $g_m = 0.5$. The mandate strength is $c = 4$.

(a) Consider three assets with identical market betas ($\beta_m = 1.2$) but different ESG scores:

- Asset X: $g_X = 0.3$ (brown)
- Asset Y: $g_Y = 0.5$ (neutral)
- Asset Z: $g_Z = 0.8$ (green)

Calculate the expected return for each asset using equation (7.8).

(b) Asset Z (green) has expected cash flows of \$12 per share next period and zero growth. What is its current price? (Hint: Use $P = \frac{E[CF]}{r}$.)

(c) Now suppose the mandate strength unexpectedly increases from $c = 4$ to $c = 6$. What is the new expected return on Asset Z? What is the new price?

(d) What is the realized return on Asset Z from the price change in part (c)? Decompose this into the component explained by $\mu_m \beta_m$, the original mandate effect, and the unexpected mandate change using equation (7.12).

(e) Explain intuitively why Asset Z experiences a capital gain even though its expected future return *decreases*.

3. **Unexpected Mandate Changes and Portfolio Returns**

Consider a portfolio with the following holdings:

Asset	Weight	Market Beta	ESG Score
Stock A	30%	1.1	0.2
Stock B	40%	0.9	0.6
Stock C	30%	1.3	0.9

Assume $\mu_m = 8\%$, $g_m = 0.5$, and initially $c = 3$.

(a) Calculate the portfolio's overall ESG score.

(b) Calculate the expected return for each stock using equation (7.8).

(c) What is the portfolio's expected return (weighted average of individual stock expected returns)?

(d) Now suppose c unexpectedly increases from 3 to 5 (i.e., $\Delta c = 2$). Calculate the realized return for each stock using equation (7.12).

(e) What is the portfolio's realized return from this unexpected mandate change?

(f) Compare two investors: Investor Green holds this portfolio, while Investor Brown holds the market portfolio (with ESG score $g_m = 0.5$). Which investor benefits more from the unexpected strengthening of ESG mandates? Why?

(g) Discuss: Can an investor systematically earn excess returns by holding a green-tilted portfolio? What must be true for this strategy to work?

4. **Skill in ESG Forecasting**

Consider an investor who specializes in analyzing ESG improvements in the technology sector. The investor has identified a company with:

- Current ESG score: $g_0 = 0.4$
- Market beta: $\beta_m = 1.2$
- Market expected return: $\mu_m = 7\%$
- Market ESG score: $g_m = 0.5$
- Mandate strength: $c = 4$

The investor forecasts that the company will implement a major sustainability initiative next year, improving its ESG score to $g_1 = 0.7$ (i.e., $\Delta g = 0.3$).

(a) What is the stock's current expected return based on equation (7.8)?

(b) If the investor's forecast is correct and the ESG improvement materializes, what will be the realized return using equation (7.17)?

(c) What is the excess return (alpha) generated by correctly forecasting the ESG improvement?

(d) Suppose the investor has skill $\theta = 0.6$ (imperfect foresight). On average, across many such forecasts, what excess return can the investor expect to earn?

(e) Now suppose mandate strength doubles to $c = 8$. How does this affect:
   i. The initial expected return on the stock?
   ii. The excess return from correctly predicting the ESG improvement?

(f) Discuss: How is ESG-based alpha similar to, and different from, traditional fundamental analysis alpha?

5. **Sustainable Investing Strategies: Mandates versus Skill**

   Compare three investment strategies:

   Strategy M (Mandate): Hold a portfolio with ESG score = 0.8, accepting whatever returns this generates.

   Strategy S (Skill): Actively select stocks expected to improve ESG scores, targeting ESG score improvements of $\Delta g = 0.2$ per year.

   Strategy H (Hybrid): Maintain ESG score = 0.7 while actively seeking ESG improvers within that constraint.

   Market parameters:

   - $\mu_m = 8\%$, $g_m = 0.5$, $c = 5$
   - Average stock has $\beta_m = 1.0$

(a) For Strategy M, calculate the expected return assuming the portfolio has $\beta_m = 1.0$ and $g = 0.8$.

(b) For Strategy S, assume the investor can identify stocks with $\beta_m = 1.0$ and average current ESG score $g = 0.5$, which will improve by $\Delta g = 0.2$. Calculate the expected realized return using equation (7.17).

(c) For Strategy H, assume the portfolio has $\beta_m = 1.0$ and $g = 0.7$, and the investor can identify ESG improvements of $\Delta g = 0.15$ within the high-ESG universe. Calculate the expected realized return.

(d) Rank the three strategies by expected return. Which is highest? Why?

(e) Now suppose mandate strength unexpectedly increases from $c = 5$ to $c = 7$. How do the realized returns for each strategy change? Which strategy benefits most?

(f) Discuss the trade-offs between these strategies in terms of:
   i. Financial returns
   ii. ESG impact (portfolio ESG score)
   iii. Contribution to changing corporate behavior
   iv. Scalability (can large institutional investors implement the strategy?)

(g) For a large pension fund with both fiduciary duties to beneficiaries and a sustainability mandate, which strategy (or combination) would you recommend? Justify your answer.

Notes

The CAPM with mandates framework builds on several important papers in sustainable finance. The original theoretical model appears in Pástor, Stambaugh, and Taylor (2021), "Sustainable Investing in Equilibrium," *Journal of Financial Economics* 142(2), 550–571. Their model demonstrates how investor preferences for sustainability characteristics affect equilibrium asset prices and expected returns.

Empirical evidence for lower expected returns on green assets comes from multiple sources. Pástor, Stambaugh, and Taylor (2022), "Dissecting Green Returns," *Journal of Financial Economics* 146(2), 403–424, decompose the returns on sustainable investments and find that outperformance during 2019–2021 reflects unexpected strengthening of ESG preferences rather than higher expected returns. Hong and Kacperczyk (2009), "The Price of Sin: The Effects of Social Norms on Markets," *Journal of Financial Economics* 93(1), 15–36, show that "sin stocks" (tobacco, alcohol, gaming) have higher expected returns, consistent with the CAPM with mandates prediction that shunned stocks trade at discounts.

The skill-based interpretation of ESG alpha relates to active management more broadly. Berk and van Binsbergen (2015), "Measuring Skill in the Mutual Fund Industry," *Journal of Financial Economics* 118(1), 1–20, develop methods for measuring manager skill that can be applied to ESG-focused funds. Busch, Bauer, and Orlitzky (2016), "Sustainable Development and Financial Markets: Old Paths and New Avenues," *Business & Society* 55(3), 303–329, review evidence on whether ESG integration generates financial alpha.

The growth statistics for sustainable investing come from multiple sources. The Global Sustainable Investment Alliance (GSIA) publishes biennial reports tracking assets under management in sustainable investment strategies across regions. Bloomberg and MSCI provide data on ESG fund coverage of global market capitalization. Specific examples (Norwegian Oil Fund, ABP, BlackRock) are drawn from public reports and press releases from these institutions.

The connection between investor mandates and corporate behavior—touched on briefly in the conclusion—is developed more fully in Hart and Zingales (2017), "Companies Should Maximize Shareholder Welfare Not Market Value," *Journal of Law, Finance, and Accounting* 2(2), 247–275. They argue that when shareholders care about externalities, value maximization should incorporate these preferences. Oehmke and Opp (2022), "A Theory of Socially Responsible Investment," working paper, model how impact-motivated investors can influence corporate behavior through capital allocation.

The distinction between financial returns (based on internalized value V^I) and total value (V) connects to the framework developed in Chapter 2. When investors bid up prices of green assets, they increase V^I without necessarily changing V directly. However, if higher V^I influences corporate decisions (through cost of capital effects), it can indirectly affect total value creation. This mechanism is explored further in Chapters 8 and 9.

Part III

Going for Impact

Chapter 8
Firm Impact

8.1 Introduction

Can firms create value through sustainable finance activities? This question lies at the heart of corporate sustainability strategy. As discussed in Chapter 6, green bond issuance has exploded from less than \$1 billion in 2007 to over \$500 billion in 2021—a 600-fold increase. Yet this growth presents a puzzle.

Consider the economics of green bond issuance. When a company issues a green bond rather than a conventional bond, it:

Green bonds impose additional costs and constraints on issuers compared to conventional bonds, raising the question: why issue them?

- **Restricts investment flexibility:** Proceeds must be committed to certified green projects, limiting managerial discretion
- **Incurs additional costs:** Third-party verification and ongoing reporting requirements increase administrative expenses
- **Accepts monitoring:** External verification creates accountability for how funds are deployed

A seemingly superior strategy would be to issue conventional bonds and then invest the proceeds in green projects if those projects have positive net present value. This approach preserves flexibility, avoids verification costs, and allows management to allocate capital optimally without constraints.

Yet firms enthusiastically issue green bonds despite these apparent disadvantages. Moreover, empirical evidence suggests that markets reward green bond announcements with positive stock price reactions. How can we reconcile this behavior with value maximization?

This chapter develops a rigorous framework for understanding firm impact through sustainable finance. We proceed in three steps:

The chapter establishes the null hypothesis (ESG-MM irrelevance), then examines violations that create value through green bonds.

1. **Establish the benchmark:** We develop an "ESG-Modigliani-Miller" (ESG-MM) theorem showing that under certain assumptions, capital structure choices involving ESG characteristics are irrelevant to firm value

2. **Identify deviations:** We examine four specific violations of ESG-MM assumptions that can make green bonds value-creating

3. **Examine empirical evidence:** We analyze Caroline Flammer's influential study documenting positive stock market reactions to green bond announcements

Understanding when and why sustainable finance creates firm value is essential for corporate treasurers designing capital structures, investors evaluating corporate actions, and policymakers considering interventions in sustainable finance markets.

8.2 The ESG-Modigliani-Miller Benchmark

The famous Modigliani-Miller theorem established that under perfect market conditions, a firm's capital structure is irrelevant to its value—the mix of debt and equity doesn't affect enterprise value, only how total value is divided among claimholders. Can we extend this logic to green bonds and other ESG-linked securities?

Setup and Assumptions

Feldhütter and Pedersen (forthcoming) develop an ESG extension of the Modigliani-Miller framework.[1] Consider a firm with assets A that generate:

- Cashflows v_A (dividends, earnings, free cash flows)

[1] Feldhütter, P., and L. H. Pedersen (forthcoming). "Is Capital Structure Irrelevant with ESG Investors?" *Review of Financial Studies*.

- Externalities s_A (environmental and social impacts)

The firm chooses its capital structure—the set of securities to issue, which represent claims on the firm's cashflows and externalities. For simplicity, consider two securities:

Cashflows and externalities are allocated across securities. Green bonds might have lower externalities per dollar of cashflow than conventional bonds.

- Debt D with cashflows v_D and externalities s_D
- Equity E with cashflows v_E and externalities s_E

By construction, cashflows and externalities must add up:

$$v_D + v_E = v_A \tag{8.1}$$

$$s_D + s_E = s_A \tag{8.2}$$

The key assumptions of the ESG-MM framework are:

1. **Linear pricing:** Asset prices depend linearly on cashflows and externalities
2. **Additive cashflows:** Total cashflows equal the sum of individual security cashflows (equation (8.1))
3. **Additive ESG:** Total externalities equal the sum of individual security externalities (equation (8.2))

Under these assumptions, the price of any asset n is given by:

The pricing kernel m captures risk-adjusted expected returns, while η represents the shadow price of externalities.

$$p_n = \mathbb{E}(mv_n) + \frac{\eta}{1+r^f} s_n \tag{8.3}$$

where m is the pricing kernel, $\eta \geq 0$ is the value of externalities, and r^f is the risk-free rate.

A Concrete Example

To make this concrete, consider a coal mining company:

Initial situation:

- Firm has coal mining assets generating emissions of 1 gigaton CO_2 per year
- Using a social cost of carbon (SCC) of \$100 per ton, total externalities are $s_A = -\$100$ billion

- Currently financed entirely with equity: $E = 100\%$, $D = 0\%$
- Therefore: $s_E = -\$100$ billion, $s_D = \$0$

New investment:

- Firm invests in wind farm project with zero emissions: $s' = \$0$
- Finances this by issuing green bonds: $D = 60\%$ of total assets after investment
- New total externalities: $s_A = -\$100$ billion (unchanged from coal operations)

Allocation of externalities: Under equation (8.2), if debt represents 60% of assets and equity 40%:

- Proportional allocation: $s_D = -\$60$ billion, $s_E = -\$40$ billion
- This seems wrong! The green bonds finance the clean wind farm, not the dirty coal mine

This example highlights the tension in the additivity assumption. We'll return to this issue when examining deviations from ESG-MM.

The ESG-MM Proposition

Given the assumptions above, we can prove the ESG-MM irrelevance result:

[ESG-MM I] With linear pricing and additive ESG scores, the total enterprise value equals the value of cashflows and externalities and is not affected by capital structure.

For any capital structure, the total value of the firm is:

$$\begin{aligned} p_E + p_D &= \mathbb{E}(mv_E) + \frac{\eta}{1+r^f}s_E + \mathbb{E}(mv_D) + \frac{\eta}{1+r^f}s_D \\ &= \mathbb{E}(m(v_E + v_D)) + \frac{\eta}{1+r^f}(s_E + s_D) \\ &= \mathbb{E}(mv_A) + \frac{\eta}{1+r^f}s_A = p_A \end{aligned} \tag{8.4}$$

That is, the enterprise value equals that of an unleveraged firm for any capital structure.

This result has a powerful implication:

[ESG-MM II] With the assumptions of ESG-MM I, investment decisions are independent of financing decisions.

ESG-MM I implies that investment decisions are independent of financing decisions, just as in traditional MM.

If capital structure doesn't affect firm value, then the choice of how to finance green projects—whether through green bonds, conventional bonds, or equity—is irrelevant. The value created comes from the project's NPV, not from the financing vehicle.

Implications

The ESG-MM benchmark establishes a crucial null hypothesis: *absent market imperfections, green bonds should not create value beyond the NPV of the underlying projects they finance.* This provides the intellectual foundation for asking: when and why do we observe value creation from green bonds in practice?

Just as violations of traditional MM assumptions (taxes, bankruptcy costs, asymmetric information, agency conflicts) create rationales for optimal capital structure, violations of ESG-MM assumptions create rationales for sustainable finance instruments like green bonds.

8.3 Deviation 1: Non-Additivity of ESG Scores

The first and perhaps most important deviation from ESG-MM concerns the additivity assumption. In practice, ESG scores of individual securities may not simply add up to the firm's total ESG score.

The Problem with Proportional Allocation

Return to our coal mine example from Section 8.2. Suppose the firm:

1. Starts with coal mining assets (100% equity financed) generating $s_A = -\$100$ billion in externalities

2. Issues green bonds to finance a wind farm investment with $s' = \$0$ externalities

3. After the investment, has capital structure: 60% debt (green bonds), 40% equity

The standard proportional allocation assumes:

$$s_D = 0.6 \times s_A = -\$60\text{b}, \quad s_E = 0.4 \times s_A = -\$40\text{b} \tag{8.5}$$

Proportional allocation treats debt and equity as having the same ESG characteristics as the overall firm, which may not reflect economic reality.

But this seems economically incorrect. The green bonds specifically finance the clean wind farm, while the equity holders retain ownership of the polluting coal mine. A more accurate allocation might be:

$$s_D = \$0\text{b (wind farm)}, \quad s_E = -\$100\text{b (coal mine)} \tag{8.6}$$

Impact on Security Values

This non-additivity has profound implications for valuation. Using equation (8.3):

Under proportional allocation:

$$\begin{aligned} p_E &= \mathbb{E}(mv_E) + \frac{\eta}{1+r^f}(-\$40\text{b}) \\ p_D &= \mathbb{E}(mv_D) + \frac{\eta}{1+r^f}(-\$60\text{b}) \end{aligned} \tag{8.7}$$

Under project-specific allocation:

$$\begin{aligned} p_E &= \mathbb{E}(mv_E) + \frac{\eta}{1+r^f}(-\$100\text{b}) \\ p_D &= \mathbb{E}(mv_D) + \frac{\eta}{1+r^f}(\$0\text{b}) \end{aligned} \tag{8.8}$$

The difference in equity value between these two allocations is:

$$\Delta p_E = \frac{\eta}{1+r^f} \times \$60\text{b} \tag{8.9}$$

When green bonds "absorb" some of the firm's negative externalities under proportional allocation, existing equity holders benefit through higher valuation.

If investors use proportional allocation (perhaps due to data limitations or rating agency methodologies), issuing green bonds can increase the value of existing equity by more than the NPV of the green project itself! This creates a rationale for green bond issuance even when the underlying project has zero or modest positive NPV.

Why Non-Additivity Matters

Non-additivity arises when:

- **Earmarked proceeds:** Green bonds finance specific projects with different ESG characteristics than existing assets
- **Data limitations:** Rating agencies and investors cannot perfectly track which securities fund which projects
- **Reporting conventions:** ESG scores are computed at the firm level and allocated mechanically to securities
- **Covenant structures:** Green bond covenants restrict use of proceeds, creating a real separation between securities

The key insight is that green bond issuance can create value by changing how the market allocates the firm's total externalities across different securities, even if total externalities remain constant.

8.4 Deviation 2: Segmented Markets

The second deviation from ESG-MM arises when markets for green and conventional securities are segmented—that is, when different investor clienteles demand different types of securities and cannot perfectly arbitrage between them.

The Role of Short-Sale Constraints

Consider two investor types:

Short-sale constraints prevent ESG investors from arbitraging away price differences between green and brown securities with identical cashflows.

- **ESG investors:** Have mandates or preferences for green securities; willing to accept lower returns
- **Conventional investors:** Care only about financial returns; indifferent to ESG characteristics

In a frictionless market, conventional investors could short green bonds (which trade at premium prices) and buy conventional bonds (which trade at discounts) to arbitrage away any price differences. This arbitrage would enforce ESG-MM: two bonds with identical cashflows would have identical prices regardless of their ESG labels.

However, short-sale constraints in bond markets are substantial:

- Corporate bonds are difficult and expensive to borrow
- Many investors (pension funds, mutual funds) face regulatory or charter restrictions on short selling
- Repo markets for corporate bonds are less developed than for government bonds

With short-sale constraints, the arbitrage mechanism breaks down. ESG investors can bid up green bond prices without fear that conventional investors will short the expensive green bonds and buy cheaper conventional bonds.

Implications for Cost of Capital

When markets are segmented, the cost of capital for green projects can be lower than for brown projects with identical cashflows:

Market segmentation creates a "greenium"—lower yields on green bonds compared to conventional bonds with identical credit risk and cashflows.

$$r_{\text{green}} < r_{\text{brown}} \quad \text{for same } v_D \tag{8.10}$$

This "greenium" has been documented empirically. Zerbib (2019) finds that green bonds trade at a yield premium of 2 basis points on average.[2] Larcker and Watts (2020) find larger effects for certain issuer types and market segments.

[2] Zerbib, O. D. (2019). "The Effect of Pro-Environmental Preferences on Bond Prices: Evidence from Green Bonds." *Journal of Banking & Finance* 98, 39–60.

For firms, this creates a clear rationale for green bond issuance: by tapping into the ESG investor base, firms can lower their cost of capital for green projects. Even if the project would have positive NPV at conventional borrowing rates, the green bond allows the firm to capture additional value from the price premium ESG investors are willing to pay.

8.5 Deviation 3: Signaling and Commitment

The third deviation from ESG-MM arises from information asymmetries. Green bond issuance can serve as a credible signal of firm quality or as a commitment device to ensure green investments are actually undertaken.

Signaling Green Project Quality

Managers have better information than outside investors about the quality of potential green investments. When a firm issues a green bond to finance a specific project:

Green bonds serve as costly signals: only firms with genuinely valuable green projects can justify the verification costs and restricted flexibility.

- **Third-party verification** provides independent validation that the project meets green standards
- **Ongoing reporting** creates transparency about project implementation and performance
- **Use-of-proceeds restrictions** demonstrate management confidence that green projects will perform

These features make green bonds a costly signal. Firms with low-quality green projects would not want to issue green bonds because:

1. Verification might reveal the projects don't meet standards
2. Reporting would expose poor performance
3. Restrictions would prevent reallocation to better alternatives if green projects fail

Only firms with genuinely valuable green projects can credibly signal quality through green bond issuance. This signaling value creates a positive stock price reaction even if the market already expected the firm to invest in some green projects.

Commitment to Green Investment

A related but distinct rationale is commitment. Consider a firm that announces plans to invest in renewable energy. Investors might worry:

Green bond covenants create binding commitments to deploy capital in green projects, solving time-consistency problems.

> *"Will management actually follow through? Or will they divert funds to brown projects with higher short-term returns once they have the capital?"*

By issuing a green bond with use-of-proceeds covenants, the firm makes a binding commitment. The legal structure of the bond prevents management from using funds for non-green purposes. This commitment can increase the value of both debt and equity:

- **Debt value increases:** Bondholders willing to pay more for green bonds (the greenium discussed in Section 8.4)
- **Equity value increases:** Shareholders benefit from the credible commitment to valuable green investments that might otherwise not be undertaken due to time-consistency problems

Signaling Future Environmental Performance

Beyond signaling about specific projects, green bond issuance can signal the firm's overall strategic direction. A firm that issues green bonds demonstrates:

Green bonds signal long-term environmental strategy, potentially lowering the firm's cost of capital for future green investments.

- Commitment to sustainability as a core business principle
- Capability in executing green projects
- Willingness to subject itself to external environmental scrutiny

This broader signaling can reduce the firm's future cost of capital for green projects. If investors believe the firm is genuinely committed to environmental improvement, they may be more willing to fund future green initiatives on favorable terms.

8.6 Deviation 4: Salience and Greenwashing

The fourth deviation recognizes that investors have limited attention and imperfect information about firm ESG characteristics.

The Salience Channel

Even if a firm has strong environmental performance, investors may not be aware of it due to:

Green bond issuance makes firm environmental performance salient to investors who might otherwise overlook it.

- Information overload (thousands of publicly traded firms)

- Lack of standardized ESG disclosure
- Complexity of environmental metrics
- Focus on financial metrics in traditional analysis

Issuing a green bond creates a highly visible signal that draws investor attention to the firm's environmental credentials. The issuance is:

- Covered by financial media
- Included in green bond indices
- Tracked by specialized ESG data providers
- Discussed in sustainability conferences and reports

This salience effect can increase the firm's valuation even if the underlying environmental performance was already strong. Essentially, the green bond helps the firm overcome investor inattention.

The Greenwashing Risk

The flip side of salience is greenwashing—creating false impressions of environmental performance through strategic disclosure. A firm with poor overall environmental performance might:

Greenwashing occurs when firms use green bonds to create misleading impressions about overall environmental commitment.

- Issue green bonds to finance a small wind farm
- Heavily publicize this green investment
- Downplay much larger carbon-intensive operations

If investors have limited attention or imperfect information, they might falsely perceive the firm as highly sustainable based on the green bond issuance, despite weak overall performance.

The existence of greenwashing creates tension in the market:

- **For genuine green firms:** Green bonds help communicate authentic environmental commitment
- **For greenwashers:** Green bonds provide a way to mislead investors about environmental performance

- **For investors:** Must distinguish genuine sustainability from greenwashing

This has led to increasing emphasis on:

- Stringent third-party verification standards
- Comprehensive environmental disclosure beyond specific green bond projects
- Integration of green bond data with overall firm ESG metrics
- Regulatory scrutiny of green bond issuance and labeling

8.7 Empirical Evidence: The Flammer Study

Having established theoretical reasons why green bonds might create value, we now examine empirical evidence. Caroline Flammer's influential 2021 study provides rigorous evidence that markets do indeed reward green bond issuance.

Research Design

Flammer analyzes stock market reactions to corporate green bond announcements using event study methodology.[3] The approach:

[3] Flammer, C. (2021). "Corporate Green Bonds." *Journal of Financial Economics* 142(2), 499–516.

Sample:

- 384 green bond issuances by publicly traded firms
- Time period: 2013–2018
- Multiple countries and industries

Event study design:

- Event date ($t = 0$): Announcement of green bond issuance
- Estimation window: 200 trading days before first event window ([-220, -21])
- Event windows: [-20, -11], [-10, -6], [-5, 10], [11, 20], [21, 60] days around announcement

Market model:

$$R_{it} = \alpha_i + \beta_i \times R_{mt} + \varepsilon_{it} \tag{8.11}$$

where R_{it} is the return on stock i on day t, R_{mt} is the market return, and (α_i, β_i) are estimated via OLS over the estimation window.

Abnormal returns:

$$AR_{it} = R_{it} - \hat{R}_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i \times R_{mt}) \tag{8.12}$$

Cumulative abnormal returns:

$$CAR_{i,[t_1,t_2]} = \sum_{t=t_1}^{t_2} AR_{it} \tag{8.13}$$

The average CAR across all $N = 384$ green bond issues provides the key test statistic.

Main Results

The results provide strong evidence of positive market reaction:

The 0.489% abnormal return in the announcement window represents substantial value creation, especially given the short time period.

Event Window	CAR	Std. Error
[-20, -11]	-0.129	0.157
[-10, -6]	0.051	0.245
[-5, 10]	**0.489****	**0.241**
[11, 20]	-0.029	0.218
[21, 60]	-0.122	0.645

Table 8.1: Stock market reaction to green bond announcements. The announcement window [-5, 10] shows a cumulative abnormal return of 0.489%, significant at the 5% level. Source: Adapted from Flammer (2021).

Key findings:

1. **Positive and significant reaction:** Stock returns exceed normal market returns by 0.489% during the announcement window

2. **Timing:** The effect is concentrated around the announcement date, not in pre-announcement or post-announcement windows

3. **Magnitude:** For a $10 billion firm, this represents approximately $49 million in value creation

Interpretation

The positive stock price reaction indicates that investors view green bond issuance as value-creating beyond the NPV of underlying projects. This is consistent with one or more of the deviations from ESG-MM discussed earlier:

The empirical evidence confirms that green bonds create value through channels beyond simple project NPV.

- **Non-additivity:** Equity holders benefit from ESG score reallocation
- **Segmented markets:** Firms access lower-cost capital from ESG investors
- **Signaling:** Market learns about valuable green projects and overall environmental strategy
- **Salience:** Investors become aware of firm's environmental strengths

Flammer's additional cross-sectional tests provide further insights:

- Effects are stronger for firms with greater environmental commitment
- Effects are stronger when green bonds are certified by third parties
- Effects are weaker for firms with prior greenwashing concerns

These patterns suggest that signaling and commitment mechanisms are particularly important drivers of the positive market reaction.

8.8 Connecting to the Total Value Framework

The analysis in this chapter connects directly to the Total Value Framework developed in Chapter 2. Recall the fundamental equation:

$$V = V^I - V^E = V^C + \iota V^E \tag{8.14}$$

where V is total value, V^I is internalized value (what markets price), V^E is external value (externalities), V^C is cash value, and ι is the internalization parameter.

Green bond issuance affects firm value through multiple channels:

Green bonds can increase both cash value V^C and external value V^E, working through changes in internalization ι.

Impact on Cash Value (V^C)

Green bonds can increase cash value by:

1. **Lowering cost of capital:** The greenium (Deviation 2) reduces financing costs
2. **Enabling positive-NPV projects:** Commitment (Deviation 3) allows firms to credibly pursue projects that might otherwise be forgone
3. **Attracting ESG investors:** Non-additivity (Deviation 1) reallocates value to equity holders when green bonds absorb negative externalities

Impact on External Value (V^E)

Green bonds can also affect external value:

1. **Direct project impact:** Financing renewable energy, energy efficiency, or pollution reduction reduces negative externalities
2. **Signaling broader commitment:** Increases market confidence in firm's environmental trajectory, potentially influencing future investment decisions

Impact on Internalization (ι)

Perhaps most importantly, green bonds can affect the internalization parameter:

Green bonds increase transparency and accountability, potentially raising the degree to which firms internalize their externalities.

1. **Increased transparency:** Ongoing reporting makes environmental impacts more visible
2. **Enhanced monitoring:** Third-party verification creates accountability

3. **Stakeholder engagement:** Green bonds attract environmentally-focused investors who monitor firm behavior

Higher ι means the firm faces greater consequences for its environmental impacts, creating incentives to reduce negative externalities and pursue positive environmental outcomes.

8.9 Conclusion

This chapter has developed a comprehensive framework for understanding how firms can create value through sustainable finance activities, particularly green bond issuance. The key insights are:

Firms create value through green bonds by exploiting specific market imperfections: non-additivity, segmentation, information asymmetries, and attention constraints.

1. **The ESG-MM benchmark establishes the null:** Under perfect markets with linear pricing and additive ESG, capital structure is irrelevant. Green bonds should not create value beyond project NPV.

2. **Four deviations create value:**

   - Non-additivity: Green bonds can reallocate externalities across securities, benefiting existing stakeholders
   - Segmented markets: Tapping ESG investor demand lowers cost of capital through the greenium
   - Signaling and commitment: Credibly communicating project quality and strategic direction
   - Salience: Overcoming investor inattention to highlight environmental strengths

3. **Empirical evidence confirms value creation:** Flammer (2021) documents 0.489% abnormal returns around green bond announcements, representing substantial value creation.

4. **Connection to Total Value:** Green bonds affect firm value through cash value (V^C), external value (V^E), and internalization (ι), with the latter potentially creating long-run strategic advantages.

For corporate financial officers, these findings suggest that green bonds can be valuable tools for financing sustainability initiatives, but the value creation depends on specific conditions:

- Strong third-party certification to enable credible signaling
- Genuine environmental commitment to avoid greenwashing penalties
- Access to ESG investor base to capture the greenium
- Clear communication strategy to maximize salience effects

For investors, the evidence indicates that green bond announcements contain valuable information about firm quality and strategy, justifying positive market reactions even absent immediate cashflow changes.

Looking ahead, Chapter 9 will examine the complementary question: how can investors create impact through their capital allocation decisions?

Exercises

1. **ESG-MM Mechanics**

   A manufacturing firm has total assets with cashflows $v_A = \$500\text{M}$ and externalities $s_A = -\$200\text{M}$ (representing pollution damages). The firm is currently 100% equity financed.

   (a) Using the pricing equation $p_n = \mathbb{E}(mv_n) + \frac{\eta}{1+r^f} s_n$, write the expression for current equity value p_E. Assume $\mathbb{E}(m) = 0.9$, $\eta = 0.5$, and $r^f = 0.05$.

   (b) The firm issues debt equal to 60% of total assets, using proceeds to repurchase equity. Under proportional allocation, what are v_D, v_E, s_D, and s_E?

   (c) Calculate the new values p_D and p_E under the proportional allocation. Verify that $p_D + p_E = p_A$ (the ESG-MM result).

   (d) Now suppose the firm issues green bonds (60% of assets) specifically to finance a clean energy project with $v' = \$300\text{M}$ and $s' = \$0$. The existing dirty assets have

$v_{\text{old}} = \$200\text{M}$ and $s_{\text{old}} = -\$200\text{M}$. Under project-specific allocation, what are s_D and s_E?

(e) Calculate p_E under project-specific allocation. Compare to part (c). Which allocation method gives higher equity value? Explain the economic intuition.

(f) If ESG investors use proportional allocation (due to data limitations) but the true allocation is project-specific, does the firm create or destroy value by issuing green bonds? Quantify the effect.

2. **The Greenium and Cost of Capital**

A utility company plans to invest $1 billion in solar power capacity. The project generates annual cashflows of $80M in perpetuity. The company can finance through either:

- Conventional bonds at 6% yield
- Green bonds at 5.8% yield (a 20 basis point greenium)

(a) Calculate the NPV of the solar project if financed with conventional bonds. Is it positive?

(b) Calculate the NPV if financed with green bonds. How much additional value does the greenium create?

(c) Suppose the solar project also generates positive externalities worth $15M per year (reduced pollution, health benefits, etc.). Calculate the total value created using the Total Value Framework: $V = V^C + V^E$.

(d) The firm's CFO argues: "We should always use green bonds when available, since they have lower yields." Is this correct? Under what conditions would conventional bonds be preferable?

(e) How might the greenium change over time as more firms issue green bonds? What would happen to the value creation opportunity?

(f) Discuss: If green bonds have systematically lower yields, why don't all firms relabel their bonds as "green"? What prevents this?

3. **Event Study Analysis**

   You are analyzing stock price reactions to green bond announcements for a sample of 50 firms. You have estimated the market model for each firm and calculated abnormal returns (AR) around the announcement date (t=0).

   The average daily abnormal returns (in

Day	Average AR (%)
-5	0.05
-4	-0.03
-3	0.02
-2	0.08
-1	0.15
0	0.32
+1	0.18
+2	0.05
+3	-0.02
+4	0.00
+5	0.01

   (a) Calculate the cumulative abnormal return (CAR) for the event window [-5, +5].

   (b) Calculate the CAR for the announcement window [-1, +1]. Why might this window be preferable to [-5, +5]?

   (c) If the average firm in your sample has market capitalization of $8 billion, how much total value is created by the green bond announcement (in dollars)?

   (d) Propose a cross-sectional test to examine which types of firms experience larger announcement effects. What firm characteristics would you examine? Why?

   (e) Suppose CAR[-5,-2] = 0.12%. What might explain positive returns before the official announcement date?

   (f) Design a difference-in-differences analysis to test whether the market reaction differs between first-time green bond issuers and repeat issuers.

4. **Signaling and Commitment**

   An oil & gas company is considering two financing strategies for a $500M investment in carbon capture technology:

   Strategy A: Issue conventional bonds and announce plans to invest in carbon capture

   Strategy B: Issue green bonds with use-of-proceeds covenants requiring carbon capture investment

   (a) Using a simple signaling model, explain why Strategy B might be more credible to investors than Strategy A.

   (b) Suppose there are two types of firms: "Green" (genuinely committed to carbon capture) and "Greenwashing" (preferring to divert funds to oil drilling if possible). Construct a 2×2 payoff matrix showing the costs and benefits of each financing strategy for each firm type.

   (c) What conditions are necessary for Strategy B (green bonds) to serve as a separating equilibrium?

   (d) The green bond requires third-party verification costing $2M. How does this cost affect the signaling equilibrium?

   (e) Suppose that after issuing green bonds, the oil price spikes, making drilling much more profitable than carbon capture. Can the firm legally redirect the green bond proceeds to drilling? What are the consequences if it tries?

   (f) Beyond the specific carbon capture project, what broader strategic signal does green bond issuance send about the firm's long-term direction?

5. **Integrating the Deviations**

   Consider a large retail company that issues a $300M green bond to finance energy-efficient store retrofits. The stock price increases by 1.2% on the announcement date.

   (a) Decompose the 1.2% stock price increase into components potentially attributable to:

      i. Project NPV at conventional discount rates

      ii. Greenium (lower cost of capital)

   iii. Non-additivity effects
   iv. Signaling value

   Make reasonable numerical assumptions to illustrate your decomposition.

(b) The company has existing conventional bonds outstanding. How might green bond issuance affect the value of these existing bonds? Consider both the non-additivity and signaling channels.

(c) Suppose the retrofit projects reduce the company's annual carbon emissions by 100,000 tons. Using a social cost of carbon of \$50/ton, calculate the annual externality reduction. How does this relate to the stock price reaction?

(d) Three months after the green bond issuance, an NGO publishes a report accusing the company of labor rights violations in its supply chain. How might this affect:
   i. The value of the green bonds?
   ii. The company's ability to issue future green bonds?
   iii. Investor perception of the initial green bond announcement?

(e) Design a comprehensive green finance strategy for this retailer that:
   i. Maximizes value creation through the four deviation channels
   ii. Minimizes greenwashing risks
   iii. Balances environmental impact and shareholder value

(f) Reflect: If the ESG-MM theorem holds in perfect markets, does that mean green bonds are only valuable because of market imperfections? Or is there a broader role for green bonds in facilitating the transition to a sustainable economy?

Notes

The ESG-Modigliani-Miller framework builds on Feldhütter and Pedersen (forthcoming), "Is Capital Structure Irrelevant with ESG Investors?" which extends the classic Modigliani and Miller (1958) irrelevance theorem to incorporate externalities and ESG investor preferences. The original MM theorem appears in Modigliani, F., and M. H. Miller (1958), "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review* 48(3), 261–297.

Caroline Flammer's empirical analysis of green bonds is published as Flammer, C. (2021), "Corporate Green Bonds," *Journal of Financial Economics* 142(2), 499–516. This influential study combines event study methodology with difference-in-differences analysis and provides comprehensive evidence on stock market reactions, operating performance changes, and environmental outcomes following green bond issuance.

Evidence on the "greenium"—the yield difference between green and conventional bonds—comes from several sources. Zerbib, O. D. (2019), "The Effect of Pro-Environmental Preferences on Bond Prices: Evidence from Green Bonds," *Journal of Banking & Finance* 98, 39–60, finds an average premium of 2 basis points. Larcker, D. F., and E. M. Watts (2020), "Where's the Greenium?" *Journal of Accounting and Economics* 69(2–3), 101312, examines heterogeneity in the greenium across issuer types and finds larger effects for certain sectors and firm characteristics.

The role of green bonds in corporate signaling is explored in Flammer, C., and P. Kacperczyk (2016), "The Impact of Stakeholder Orientation on Innovation: Evidence from a Natural Experiment," *Management Science* 62(7), 1982–2001, which examines how stakeholder commitments affect innovation strategies. The commitment role of green bonds connects to broader corporate finance literature on financial covenants and managerial discretion, surveyed in Rajan, R. G., and L. Zingales (1995), "What Do We Know about Capital Structure? Some Evidence from International Data," *Journal of Finance* 50(5), 1421–1460.

The greenwashing concern has received increasing attention. Delmas, M. A., and V. C. Burbano (2011), "The Drivers of Greenwashing," *California Management Review* 54(1), 64–87, examine why firms engage in greenwashing and its consequences. Kim, E. H., and T. P. Lyon (2015), "Greenwash vs. Brownwash: Exaggeration and Undue Modesty in Corporate Sustainability Disclosure," *Organization Science* 26(3), 705–723, distinguish between overclaiming (greenwashing) and underclaiming (brownwashing) environmental performance.

The connection to the Total Value Framework builds on Chapter 2's analysis of internalization. The relationship between corporate finance decisions and externality internalization is further developed in Hart, O., and L. Zingales (2017), "Companies Should Maximize Shareholder Welfare Not Market Value," *Journal of Law, Finance, and Accounting* 2(2), 247–275, which argues that shareholder preferences over externalities should influence corporate decision-making.

Market data on green bond growth comes from the Climate Bonds Initiative, which tracks issuance volumes, sector composition, and geographic distribution. Their annual State of the Market reports provide comprehensive statistics on the evolution of green bond markets globally.

Chapter 9
Investor Impact

9.1 Introduction

Sustainable investing has grown explosively over the past two decades. By 2024, sustainable investment strategies governed approximately 90% of global assets under management (AUM), representing trillions of dollars in capital committed to environmental, social, and governance considerations.[1] Yet a fundamental question remains: Does this massive reallocation of capital actually reduce negative externalities and advance sustainability goals?

[1] This dramatic growth reflects both changing investor preferences and increasing recognition of sustainability risks in financial markets.

This chapter examines how investors can create real-world impact through their investment decisions. We organize our analysis around two primary channels through which sustainable investing might affect firm behavior and externalities:

1. **The discount rate channel**: By preferentially buying green assets and avoiding brown ones, sustainable investors might raise green asset prices and lower brown asset prices, thereby reducing the cost of capital for green firms and increasing it for brown firms. This would make green projects more attractive and brown projects less viable.

2. **The dividend channel**: If consumers, employees, or other stakeholders care about corporate sustainability, firms with better ESG performance might generate higher cash flows, creating financial incentives for improved ESG practices independent of investor preferences.

We also examine a third mechanism—**shareholder engagement**—through which investors directly influence corporate decision-making through voting, dialogue, and activism.

Our investigation reveals a sobering picture. Despite the enormous growth in sustainable investing, the evidence for meaningful real-world impact remains limited. While there is some evidence for a "greenium" (lower returns on green assets), its magnitude appears modest and its interpretation contested. More troublingly, firms that receive inflows of sustainable capital do not consistently reduce their emissions—in some cases, they actually increase them.

Why has sustainable investing failed to deliver the impact many hoped for? We identify several key challenges: measurement difficulties, noisy ESG ratings, short-term capital flows, and greenwashing. Understanding these obstacles is essential for designing more effective sustainable investment strategies and for setting realistic expectations about what financial markets can achieve without complementary policy action.

9.2 The Growth of Sustainable Investing

Before examining investor impact mechanisms, we first document the extraordinary growth of sustainable investing to understand the scale of capital reallocation at stake.

Sustainable investing encompasses various strategies including negative screening, ESG integration, thematic investing, and impact investing.

Historical Development

Sustainable investing evolved from niche ethical investing strategies in the 1960s and 1970s to mainstream practice by the 2020s. Early adopters, primarily religious organizations and values-driven investors, used negative screens to avoid "sin stocks" (tobacco, alcohol, weapons). The modern era of sustainable investing began in the 2000s with:

- Launch of the UN Principles for Responsible Investment (PRI) in 2006
- Development of ESG data providers (MSCI, Sustainalytics, Refinitiv)

- Creation of sustainable indices (FTSE4Good, MSCI ESG Leaders)
- Regulatory disclosure requirements (EU SFDR, TCFD)

By 2024, sustainable investing had become the dominant paradigm, with the UN PRI reporting over $120 trillion in assets under management from more than 5,000 signatory institutions.

Diverse Motivations

Why do investors pursue sustainable strategies? The motivations are heterogeneous:

1. **Financial risk management**: ESG factors may predict future cash flow risks or regulatory changes
2. **Values alignment**: Investors want portfolios consistent with their ethical beliefs
3. **Impact creation**: Investors seek to reduce negative externalities through capital allocation
4. **Client demand**: Asset managers respond to beneficiary preferences for sustainable investments
5. **Regulatory compliance**: Mandates require consideration of sustainability factors

These different motivations have important implications for investor behavior and market impact. An investor focused solely on financial risk will behave differently from one genuinely committed to reducing emissions, even if both employ ESG screens.

9.3 *The Discount Rate Channel: Theory*

The discount rate channel represents the most direct mechanism through which sustainable investors might influence corporate behavior. The logic is straightforward: if sustainable investors preferentially demand green assets and shun brown ones, this should increase green asset prices (lowering their expected returns and cost of capital) while decreasing brown asset prices (raising their expected returns and cost of capital).

The Mechanism

Consider a simple example with two firms: Green Inc. and Brown Inc. Both firms have identical cash flows and risks from a fundamental perspective, but they differ in their environmental impact. Now suppose a significant fraction of investors develop preferences for green assets.

This preference shift creates two effects:

1. **Price effect**: Green Inc.'s stock price rises as sustainable investors buy, while Brown Inc.'s price falls as they sell or refuse to hold it
2. **Expected return effect**: Higher prices for Green Inc. imply lower expected future returns (all else equal), while lower prices for Brown Inc. imply higher expected future returns

The expected return differential—the excess return that brown assets must offer to compensate investors for holding them—is sometimes called the **pollution premium** or **carbon premium**. From the firm's perspective, this translates into a cost of capital differential: Green Inc. can raise capital more cheaply than Brown Inc.

Impact on Investment Decisions

The cost of capital differential should affect real investment decisions. Suppose both firms face a potential project requiring \$100M in investment that will generate \$8M per year in perpetuity. For simplicity, assume no growth and no taxes.

If Green Inc. faces a cost of equity of 6%, the project's NPV is:

$$NPV_{\text{Green}} = -100 + \frac{8}{0.06} = -100 + 133.3 = +33.3 \text{ million} \quad (9.1)$$

If Brown Inc. faces a cost of equity of 10% due to the carbon premium, the same project's NPV is:

$$NPV_{\text{Brown}} = -100 + \frac{8}{0.10} = -100 + 80 = -20 \text{ million} \quad (9.2)$$

Green Inc. would accept the project while Brown Inc. would reject it. Over time, this should lead to more green investment and less brown investment, reducing aggregate emissions.

Conditions for Effectiveness

For the discount rate channel to create meaningful impact, several conditions must hold:

1. **Sufficient capital committed**: The amount of sustainable capital must be large enough to meaningfully affect prices

2. **Limited arbitrage**: Conventional investors must not fully offset sustainable investors' trades

3. **Financing constraints**: Firms must actually face meaningful costs when raising capital (not all investment is internally financed)

4. **Persistent effects**: The cost of capital differential must persist long enough to affect long-term investment decisions

With 90% of AUM employing some sustainability criteria, condition (1) would seem satisfied. But do we observe the predicted effects in practice?

9.4 *The Discount Rate Channel: Evidence*

Measuring the greenium or carbon premium empirically is challenging. We examine three influential studies that shed light on whether the discount rate channel is operating in financial markets.

Study 1: Hsu, Li, and Tsou (2023)—The Pollution Premium

Hsu, Li, and Tsou (2023) sort firms by carbon emission intensity (emissions per dollar of assets) within industries and construct long-short portfolios.[2]

[2] The within-industry sort controls for the fact that some industries (e.g., utilities, materials) are inherently more carbon-intensive than others (e.g., software, services).

Methodology The authors:

1. Obtain Scope 1 and Scope 2 emissions data from corporate disclosures
2. Calculate emission intensity as total emissions divided by total assets
3. Within each industry, sort firms into quintiles based on emission intensity
4. Form a long-short portfolio: long the highest-emission quintile, short the lowest

Key Findings The high-minus-low emission intensity portfolio generates a striking 4.42% annual return over their sample period. This return persists after controlling for standard risk factors (market, size, value, profitability, investment). The pollution premium appears economically large and statistically significant.

Interpretation The authors interpret this as evidence that high-emission firms face higher expected returns—equivalently, they have higher costs of capital. This is consistent with sustainable investors avoiding carbon-intensive firms, depressing their prices and raising their expected returns.

However, an important question remains: Is this a pure preference-based premium, or does it reflect compensation for genuine carbon-related risks (regulatory, physical, reputational)? We return to this question below.

Study 2: Zhang (2024)—Carbon Returns Across the Globe

Zhang (2024) raises a critical methodological concern about studies finding carbon premiums: emissions data may contain forward-looking information that biases return calculations.

The Forward-Looking Bias Problem Emissions data for year t are typically reported in corporate sustainability reports published in year $t+1$ or even $t+2$. Moreover, these emissions are often estimated based on sales and production data that may not be finalized until well after year t ends. This means that when we measure "year t emissions," we may actually be incorporating information that only became available to investors during year $t+1$ or $t+2$.

If high-emission firms happened to experience negative shocks during $t+1$ and $t+2$ (perhaps due to emerging climate regulations or changing consumer preferences), their low returns in those years would be incorrectly attributed to their t emission intensity, creating a spurious pollution premium.

Methodology Zhang addresses this by:

1. Carefully tracking the actual reporting dates of emissions data
2. Re-running pollution premium tests with sufficient lags to ensure emissions information was truly available to investors when returns are measured
3. Controlling for various forward-looking cash flow proxies

Key Findings After addressing forward-looking bias:

- The carbon premium becomes statistically insignificant in global samples
- In U.S. markets, the carbon premium actually becomes *negative* (green assets have higher expected returns than brown assets)
- Much of the apparent premium in earlier studies reflects correlation between emission intensity and future cash flow shocks, not a pure pricing effect

These findings cast serious doubt on whether a meaningful greenium exists in current markets.

Study 3: Pástor, Stambaugh, and Taylor (2022)—Dissecting Green Returns

Pástor, Stambaugh, and Taylor (2022) take a different approach, examining the time-series behavior of green-minus-brown (GMB) portfolio returns and relating them to shocks in climate concerns.

The authors construct a climate concern index from media coverage of climate change, extracting unexpected shocks using time-series methods.

Methodology The authors:

1. Sort stocks by ESG scores (using MSCI ratings) across industries
2. Form a long-short portfolio: long high-ESG stocks, short low-ESG stocks
3. Measure media climate change concern using text analysis of major newspapers
4. Extract unexpected shocks to climate concern from an AR(1) model
5. Regress GMB returns on climate concern shocks

Key Findings

- GMB returns are strongly positively correlated with climate concern shocks
- During periods of rising climate concern (e.g., 2013-2018), green stocks dramatically outperformed brown stocks
- This outperformance reflects *unexpected* price increases, not steady greenium
- The pattern is consistent with green stocks benefiting from positive demand shocks as more investors adopt sustainable mandates

Implications The findings suggest that much of green assets' strong performance in the 2010s reflected a **transition effect**—the one-time price impact as sustainable investing grew from niche to mainstream—rather than a steady-state greenium. As Pastor and Stambaugh note in their theoretical work, once the transition is complete, green assets should deliver *lower* expected returns in equilibrium (the greenium works in the opposite direction from the pollution premium).

Reconciling the Evidence

How do we reconcile these seemingly contradictory findings? Several observations help:

1. **Sample periods matter**: Studies covering the 2010s may capture large transition effects; more recent samples show weaker effects

2. **Measurement matters**: Careful treatment of data timing and forward-looking bias substantially affects results

3. **Transition vs. steady state**: We may have experienced price impacts during the growth phase of sustainable investing without establishing a persistent cost of capital differential

4. **Arbitrage limits**: Even large sustainable capital flows may have limited price impact if conventional investors provide offsetting trades

The current evidence suggests the greenium, if it exists, is small, inconsistent across markets, and potentially weakening over time. This implies the discount rate channel may have limited power to drive real changes in corporate behavior.

9.5 *The Dividend Channel*

Recall from Chapter 2 that firm value can be expressed as:

$$V_{i,t} = \sum_{n=0}^{\infty} \frac{D^c_{i,t,n}}{\exp(n\mu^c_{i,t,n})} - \sum_{n=0}^{\infty} \frac{D^e_{i,t,n}}{\exp(n\mu^e_{i,t,n})} \tag{9.3}$$

where D^c represents cash dividends and D^e represents externality dividends. The discount rate channel operates through μ; the dividend channel operates through D.

Mechanisms

Several mechanisms might connect ESG performance to cash flows:

1. **Consumer preferences**: Customers may pay price premiums for products from sustainable firms or boycott products from unsustainable ones
2. **Employee productivity**: Workers may be more motivated and productive at firms aligned with their values, or sustainable firms may attract better talent
3. **Operational efficiency**: Reducing emissions or waste often improves resource efficiency and lowers costs
4. **Risk mitigation**: Better ESG practices may reduce regulatory fines, litigation costs, or disruptions from environmental or social incidents
5. **Innovation**: Focus on sustainability may spur product innovation and open new markets

If these mechanisms are strong enough, firms might improve ESG performance purely for financial reasons, even without any greenium or investor pressure. This would be a form of **private value alignment**—what's good for society happens to also be profitable.

This is the most optimistic scenario: market forces alone drive sustainability without requiring investor preferences, government intervention, or sacrificing returns.

Evidence: Meier, Servaes, Wei, and Xiao (WP)

Meier, Servaes, Wei, and Xiao examine whether consumer preferences create dividend channel effects using extraordinarily granular data: barcode-level sales from retail stores.

Methodology The authors:

1. Obtain scanner data tracking individual product sales across thousands of stores
2. Link products to parent companies and obtain company-level ESG scores
3. Examine how sales respond to changes in ESG scores and to exogenous shocks in sustainability salience (e.g., local climate disasters)
4. Use difference-in-differences designs to establish causal effects

Key Findings

- Higher ESG scores are associated with significantly higher product sales
- The effect is stronger for consumer-facing categories (food, personal care) than industrial products
- Local climate disasters increase sales of high-ESG companies' products relative to low-ESG companies
- The sales impact is economically meaningful, suggesting material cash flow effects

Implications This evidence suggests the dividend channel may indeed operate—consumers care about corporate sustainability and act on those preferences. However, several caveats apply:

1. The effect, while significant, is modest relative to the scale of required emissions reductions
2. Consumer ESG sensitivity may reflect specific product categories or demographics not generalizable across all sectors
3. Firms may respond to consumer preferences through *greenwashing* (improving ESG scores without changing real practices) if scores are noisy

Nevertheless, the dividend channel evidence is more encouraging than the discount rate channel evidence, suggesting consumer and stakeholder preferences may be more powerful tools for driving corporate sustainability than investor portfolio allocation alone.

9.6 Real Effects: The Van Binsbergen and Brøgger Study

The ultimate test of investor impact is whether sustainable capital flows actually change firm behavior and reduce negative externalities. Van Binsbergen and Brøgger (2022) provide one of the first large-scale empirical studies of this question.[3]

[3] Van Binsbergen, J., and A. Brøgger (2022), "Real Effects of Sustainable Investing," working paper.

Research Design

The Challenge Simply correlating sustainable investment flows with emissions changes faces severe endogeneity problems. Firms that attract sustainable capital may already be on improving trajectories; both capital flows and emissions may respond to common factors like climate policy expectations; and reverse causality looms large (lower emissions attract sustainable capital rather than vice versa).

The Solution: Index Inclusion Events The authors exploit a quasi-experimental setting: inclusion in the FTSE4Good Developed Index. When a firm is added to this widely-tracked sustainability index:

- It receives substantial inflows from index-tracking funds and ESG investors who use the index for screening
- The timing of inclusion depends partly on mechanical index rules, providing exogenous variation
- We can compare included firms to similar firms just below inclusion thresholds (a difference-in-differences design)

Data The study combines:

1. FTSE4Good index constituent data (2001-2022)
2. Trucost emissions data (Scope 1 and Scope 2)
3. Financial data from standard sources

Key Findings

The results are striking—and troubling for sustainable investing advocates.

Aggregate Trends Figure 9.1 shows average emissions for firms inside versus outside the FTSE4Good index. While both groups reduced emissions over the sample period, firms *outside* the index reduced emissions faster. The aggregate decline in corporate emissions appears driven primarily by non-sustainable-index firms.

Figure 9.1: Average emissions over time for firms in versus out of FTSE4Good index

Event Study: Index Inclusion Figure 9.2 presents the key result: emissions trajectories before and after index inclusion, relative to control firms.

Figure 9.2: Difference-in-differences estimates of emissions around index inclusion

The pattern reveals:

1. **Pre-inclusion improvement**: In the years before index inclusion, firms significantly reduced emissions relative to peers. This is consistent with firms optimizing to meet index criteria and attract sustainable capital.

2. **Post-inclusion deterioration**: After gaining index membership and receiving sustainable capital inflows, firms *increased* emissions relative to peers. By year +5, the pre-inclusion gains had been largely reversed.

Interpretation and Implications

Why do firms increase emissions after receiving sustainable capital? Several explanations emerge:

Weak Incentives If the greenium is small (as section 9.4 suggests), firms face weak financial incentives to maintain low emissions once index inclusion is secured. The cost of capital benefit may be insufficient to justify ongoing emission reduction investments.

Noisy Ratings ESG ratings are notoriously noisy and inconsistent across providers. A firm can game metrics (e.g., improve disclosure without changing real practices) or exploit measurement errors. Once inside the index, monitoring may be imperfect.

Greenwashing Firms may engage in superficial ESG improvements to attract capital, then revert to business-as-usual practices. This is especially likely if investors cannot easily observe real environmental performance or if exclusion from indices requires egregious deterioration.

Selection Effects Firms at the margin of index inclusion may not be genuinely committed to sustainability. They differ from firms comfortably inside (true green leaders) and firms far outside (brown firms with no ESG pretensions). Marginal firms may be precisely those most prone to greenwashing.

The Van Binsbergen and Brøgger findings suggest that current sustainable investing practices have not been effective at driving real emissions reductions through the discount rate channel. Capital flows to "sustainable" firms, but those flows don't consistently translate into improved environmental outcomes.

9.7 Engagement and Stewardship

Beyond portfolio allocation, investors can attempt to influence corporate behavior through **engagement**—direct dialogue, proxy voting, shareholder resolutions, and activism.

Major institutional investors like BlackRock, Vanguard, and State Street have built substantial stewardship teams dedicated to engaging portfolio companies on ESG issues.

Engagement Mechanisms

Engagement takes several forms:

1. **Private dialogue**: Investors meet with management to discuss ESG concerns and encourage improvements

2. **Proxy voting**: Investors vote on shareholder resolutions related to climate disclosure, emissions targets, board diversity, etc.

3. **Shareholder proposals**: Investors file resolutions for shareholder votes on specific ESG actions

4. **Public campaigns**: Activist investors launch public pressure campaigns to force changes

5. **Board representation**: In extreme cases, investors seek board seats to directly influence strategy

Evidence on Effectiveness

Evidence on engagement effectiveness is mixed:

Positive Evidence

- Dimson, Karakas, and Li (2015) find successful engagements are followed by improved ESG performance and stock returns
- Firms subjected to successful environmental shareholder proposals do reduce emissions
- The Say on Climate movement has pushed hundreds of companies to adopt emissions reduction targets

Skeptical Evidence

- Most shareholder proposals fail or receive low vote shares
- Even when proposals pass, implementation is often weak
- Large passive investors (who collectively own 20%+ of most companies) have been criticized for limited engagement
- Engagement success may be concentrated among firms already inclined toward sustainability

Challenges

Several obstacles limit engagement effectiveness:

1. **Free-rider problems**: Engagement is costly but benefits are shared across all shareholders
2. **Misaligned incentives**: Asset managers may not internalize their clients' engagement preferences
3. **Limited leverage**: In diversified portfolios, no single investor has enough stake to force change

4. **Short-termism**: Fund flows and manager evaluation focus on short-term returns, discouraging costly long-term engagement

Engagement represents an important complement to portfolio allocation, but it is not a panacea. Effective engagement requires resources, commitment, and willingness to accept potential short-term financial costs—qualities that may be in short supply among many asset managers.

9.8 Challenges and the Path Forward

The evidence reviewed in this chapter paints a sobering picture: despite massive growth in sustainable investing, clear evidence of real-world impact remains elusive. Understanding why impact has been limited points toward potential improvements.

Key Challenges

1. Measurement and Data Quality ESG ratings are noisy, inconsistent across providers, and gameable. Firms can improve scores without changing real practices. Better measurement is foundational to everything else.

2. Confounding and Attribution Distinguishing investor impact from broader trends (climate policy, technological change, shifting consumer preferences) is empirically challenging. Most firms are subject to multiple simultaneous influences.

3. Limited Price Impact If conventional investors provide offsetting trades (arbitrage), sustainable investor demand may have minimal price effects and thus minimal cost of capital impact.

4. Greenwashing When ESG measurement is noisy and enforcement weak, firms have incentives to appear sustainable without bearing the costs of genuine change.

5. Transition vs. Steady State Much of green asset outperformance may reflect one-time transition effects rather than persistent return differentials that change investment incentives.

Potential Solutions

Improve Measurement Standardized, mandatory, audited disclosure of material ESG metrics would reduce noise and gaming. The International Sustainability Standards Board (ISSB) and similar efforts aim to establish rigorous disclosure standards comparable to financial accounting.

Focus on High-Impact Opportunities Rather than broad ESG integration, investors might concentrate capital and engagement on specific high-impact areas (e.g., financing clean energy deployment, transitioning heavy industry).

Coordinate Engagement Collective engagement efforts (Climate Action 100+, NZAM) can overcome free-rider problems and increase leverage over companies.

Complement Policy Investor action alone may be insufficient. Carbon pricing, regulatory mandates, and public investment can amplify market-based mechanisms.

Align Incentives Fund manager compensation, client mandates, and performance evaluation should explicitly reward real-world impact, not just ESG ratings or short-term returns.

9.9 Conclusion

Sustainable investing has transformed from niche strategy to dominant paradigm in less than two decades. This represents a remarkable shift in investor preferences and a potential powerful tool for addressing climate change and other sustainability challenges. Yet our review of the evidence reveals a troubling gap between aspiration and achievement.

The discount rate channel—sustainable investors lowering green firms' cost of capital—appears to generate small and inconsistent effects. The greenium, if it exists, is modest and may be shrinking. Firms that receive sustainable capital inflows do not consistently reduce emissions; in some cases, they increase them. Engagement shows promise but faces significant obstacles.

Why has impact been limited? The core challenges are measurement difficulties, noisy ESG ratings, limited price impact due to arbitrage, and greenwashing enabled by weak accountability. These are not insurmountable obstacles, but addressing them requires serious reforms: better disclosure standards, stronger enforcement, coordinated engagement, and realistic expectations about what financial markets can achieve without complementary government action.

Does this mean sustainable investing has failed? Not necessarily. We may be in a transition period where measurement and accountability mechanisms are still developing. The dividend channel evidence suggests consumer and stakeholder preferences create real incentives for improved ESG performance. And even if current practices have limited impact, the massive capital mobilization demonstrates potential for future effectiveness if the foundations are strengthened.

The key lesson is that sustainable investing is not a magic bullet. It is one tool among many for addressing sustainability challenges. Used wisely, with rigorous measurement, strong accountability, and realistic expectations, investor capital allocation and engagement can contribute to reducing negative externalities. But it must be complemented by effective government policy, technological innovation, and changing consumption patterns. Finance alone cannot solve climate change—but without finance, solutions will be harder to implement and slower to scale.

Exercises

1. **Discount Rate Channel Mechanics**

   Consider an economy with two types of investors: conventional investors (fraction ϕ) who care only about expected returns, and sustainable investors (fraction $1 - \phi$) who have preferences for green assets.

   (a) Suppose a green firm and brown firm have identical cash flows (both generate \$10M per year in perpetuity). If the risk-free rate is 2% and both firms have the same risk profile (requiring a 4% risk premium), what should be the price of each firm's equity in a world with only conventional investors?

(b) Now suppose sustainable investors have preferences that make them willing to accept 100 basis points lower return on green assets. If sustainable investors comprise 40% of the market ($\phi = 0.6$), and conventional investors are risk-neutral arbitrageurs, what are the equilibrium prices and expected returns for the green and brown firms?

(c) Both firms face an investment opportunity requiring \$50M that will increase perpetual cash flows by \$3M per year. Using the equilibrium costs of capital from part (b), which firm(s) should accept the project? What is the NPV for each?

(d) Explain intuitively why a larger fraction of sustainable investors (ϕ smaller) would strengthen the impact on investment decisions.

2. **Interpreting the Hsu-Li-Tsou Pollution Premium**

Hsu, Li, and Tsou (2023) document a 4.42% annual return spread between high-emission and low-emission firms within industries.

(a) Explain two fundamentally different interpretations of this return spread: one based on investor preferences (greenium) and one based on risk.

(b) Suppose the pollution premium entirely reflects risk compensation for future carbon regulations. What does this imply about the effectiveness of sustainable investing via the discount rate channel?

(c) Zhang (2024) finds the carbon premium becomes insignificant or negative after controlling for forward-looking bias and cash flow effects. Explain what "forward-looking bias" means in this context and why it could create a spurious pollution premium.

(d) Design an empirical test to distinguish between the preference-based and risk-based explanations for any observed carbon premium. What data would you need? What would constitute evidence favoring each interpretation?

3. **The Pástor-Stambaugh-Taylor Transition Effect**

   Pástor, Stambaugh, and Taylor (2022) find that green stocks outperformed brown stocks during periods of rising climate concern (2013-2018), but this outperformance was associated with unexpected shifts in preferences rather than steady return differentials.

   (a) Explain the distinction between a "transition effect" (one-time price adjustment as sustainable investing grows) and a "steady-state greenium" (permanent return differential). Use a simple numerical example.

   (b) Draw a graph showing green asset prices over time during a transition from 10% sustainable investors to 40% sustainable investors, occurring between year 5 and year 15. Mark where transition returns occur versus where steady-state returns would be observed.

   (c) If green asset outperformance during 2013-2018 was mainly transition effect, what should we expect for green versus brown returns during 2024-2030? Explain your reasoning.

   (d) What are the implications for investor impact if most of green assets' historical outperformance reflected transition effects rather than steady-state return differentials?

4. **Van Binsbergen-Brøgger Findings and Mechanisms**

   Van Binsbergen and Brøgger (2022) find that firms reduce emissions before FTSE4Good index inclusion but increase emissions afterward, relative to control firms.

   (a) Why is index inclusion a useful quasi-experimental setting for studying real effects of sustainable investing? What confounds does it help address?

   (b) Propose three distinct explanations for the post-inclusion emission increases. For each explanation, describe what additional empirical evidence would support or refute it.

(c) Suppose the greenium is very small (10 basis points) but ESG rating noise is high (correlation between actual environmental performance and ESG score is only 0.3). Use a simple cost-benefit framework to explain why firms might greenwash rather than genuinely improve.

(d) Design an index inclusion methodology that would reduce incentives for greenwashing while maintaining ability to channel capital to genuinely sustainable firms.

5. **Dividend Channel Evidence**

   Meier, Servaes, Wei, and Xiao find that products from firms with higher ESG scores have higher sales, particularly after local climate disasters.

   (a) Explain how this evidence relates to the dividend channel from the Total Value Framework. How could consumer preferences affect $D^c_{i,t,n}$?

   (b) The effect is stronger for consumer-facing products (food, personal care) than industrial inputs. Why might this be the case? What does it imply about the generalizability of dividend channel impacts?

   (c) Suppose the sales boost from a one-standard-deviation ESG score improvement is 2%. A firm generates $1B in annual revenue and has a 10% profit margin. If the cost of improving ESG scores by one standard deviation is $15M per year, should the firm do it purely for financial reasons? Show your calculation.

   (d) Compare the dividend channel mechanism to the discount rate channel. Which seems more likely to drive real corporate behavior change based on current evidence? Justify your answer.

6. **Engagement Effectiveness**

   Consider a large passive index fund that owns 8% of a major oil company. The fund's clients have expressed preferences for climate action.

(a) Explain the free-rider problem that limits engagement incentives. Why might the fund under-invest in engagement from a social perspective?

(b) Suppose successful engagement would reduce the oil company's Scope 1 and 2 emissions by 15% but cost $500M in NPV (lower production, earlier asset retirement). The engagement campaign would cost the fund $2M. Should the fund engage if it owns $10B of the company's $125B market cap? Consider both private and social incentives.

(c) How does your answer change if 10 other large institutional investors collectively own another 30% and would coordinate their engagement efforts and share costs?

(d) Describe three structural changes to the asset management industry that would better align engagement incentives with client sustainability preferences.

7. **Integrated Assessment**

You are the CIO of a $50B pension fund whose beneficiaries have expressed strong preferences for climate impact. You are designing a sustainable equity strategy.

(a) Based on the evidence in this chapter, assess the likely real-world impact of three alternative strategies:

(i) Broad ESG integration using commercial ESG ratings

(ii) Focused exclusion of fossil fuel producers

(iii) Impact-focused private equity financing clean energy projects

For each strategy, discuss expected impact through discount rate channel, dividend channel, and engagement. Use specific evidence from the studies reviewed.

(b) Design a measurement framework for assessing whether your fund's sustainable investing strategy is creating real-world impact. What metrics would you track? How would you address attribution challenges?

(c) Your fund's board asks whether sustainable investing has been effective to date at reducing global emissions. Based on this chapter's evidence, how would you answer? Be specific about what the evidence shows and doesn't show.

8. **The Greenium Under Different Market Structures**

   Consider how market structure affects the potential for a greenium.

   (a) In a market where all investors can freely buy or sell any asset (no short-sale constraints) and only 20% of investors have sustainability preferences, explain why conventional investors' arbitrage would limit the greenium.

   (b) Now suppose short-selling green assets is prohibited (or very costly) but short-selling brown assets is feasible. How does this affect the potential greenium? Which assets (green or brown) are more affected by the short-sale constraint?

   (c) Empirically, green firms tend to be growth firms (low book-to-market) while brown firms tend to be value firms (high book-to-market). What implications does this have for measuring carbon premiums while controlling for the value factor?

   (d) If sustainable investing continues to grow from 90% to 99% of AUM, what should happen to the greenium in your analysis? Would this increase or decrease sustainable investing's impact?

Notes

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Technical Notes

On Measuring the Greenium: Distinguishing preference-based return differentials from risk-based premiums is fundamentally challenging. Even if we control for all standard risk factors, a remaining "greenium" could reflect either (1) investor preferences, or (2) an omitted risk factor related to climate transition. The interpretation matters enormously for policy: a preference-based greenium creates impact; a risk-based premium does not (it merely compensates investors for bearing climate risk).

On Forward-Looking Bias: Zhang's (2024) insight about emissions data timing is crucial for empirical work. Researchers must carefully track not just when emissions occurred, but when information about those emissions became available to investors. This requires understanding corporate reporting timelines, estimation methods, and data provider release schedules.

On Index Inclusion Studies: While index inclusion provides valuable quasi-experimental variation, it's not a perfect natural experiment. Firms may anticipate inclusion and adjust behavior beforehand; index providers may adjust inclusion criteria in response to firm behavior; and firms just above and below thresholds may differ in unobserved ways. Careful research design and robustness checks are essential.

On Attribution: Separating investor impact from other forces driving corporate ESG improvements (regulation, technology, consumer preferences) is perhaps the most difficult challenge in this literature. Even well-designed studies can typically only measure the *marginal* impact of sustainable investment flows, holding other factors constant—not the total impact of all forces combined.

Chapter 10
Outstanding Issues

10.1 Introduction

In the preceding chapters, we developed a framework for thinking about sustainability in finance, examined how firms and investors can create impact, and reviewed the empirical evidence on whether sustainable finance is delivering on its promises. The verdict has been sobering: despite massive growth in sustainable investing, clear evidence of real-world impact remains elusive. Firms receiving sustainable capital do not consistently reduce emissions. ESG portfolios do not reliably earn lower returns (suggesting limited greenium). And greenwashing appears widespread.

This chapter examines a fundamental obstacle underlying these disappointing outcomes: **measurement frictions**.[1] If investors cannot accurately identify which firms are truly sustainable, sustainable capital will be misallocated. If firms can improve their ESG ratings through superficial changes rather than genuine emissions reductions, they will greenwash. If regulators cannot verify corporate sustainability claims, enforcement will be weak.

[1] By "frictions" we mean impediments that prevent markets from functioning efficiently. In the context of sustainable finance, measurement frictions prevent capital from flowing to genuinely sustainable firms and create opportunities for greenwashing.

We organize our analysis around three interconnected problems:

1. **ESG ratings disagreement**: Major ESG rating providers (MSCI, Sustainalytics, Refinitiv, S&P, Moody's) produce ratings that correlate only modestly with each other—far less

than credit ratings from different agencies

2. **Corporate disclosure gaps**: Unlike financial reporting, which follows centuries-old standards (GAAP, IFRS), sustainability reporting lacks universally accepted standards, consistent enforcement, and independent auditing

3. **Greenwashing incentives**: When measurement is noisy and enforcement weak, firms face strong incentives to appear sustainable without bearing the costs of genuine change

These three problems form a vicious cycle: poor disclosure standards lead to noisy ratings, which create greenwashing opportunities, which further undermine the credibility of ratings and discourage genuine sustainability improvements. Breaking this cycle requires addressing all three components simultaneously.

The good news is that substantial progress is underway. The International Sustainability Standards Board (ISSB) has developed comprehensive disclosure standards. The EU's Corporate Sustainability Reporting Directive (CSRD) mandates extensive reporting and third-party assurance. Regulators are beginning to police greenwashing claims. And financial innovation—including market-based ESG scores derived from derivatives prices—may provide more objective sustainability measures.

Whether these reforms will suffice remains an open question. The challenges are formidable: sustainability encompasses dozens of dimensions (carbon emissions, water use, biodiversity, labor practices, board diversity, etc.), many of which are difficult to measure and involve subjective value judgments. Unlike credit risk, which reduces to a single probability (default), there is no consensus on what "sustainability" means or how to weight different environmental and social considerations.

This chapter provides a rigorous analysis of these measurement challenges and evaluates potential solutions. Understanding these frictions is essential for anyone working in sustainable finance—whether as an investor trying to allocate capital effectively, a corporate manager trying to demonstrate genuine sustainability, or a policymaker trying to design effective regulations.

10.2 The ESG Ratings Landscape

Before analyzing what's wrong with ESG ratings, we first describe how the ESG ratings industry evolved and how it currently operates.

Historical Development

ESG ratings emerged in the 1980s to help values-driven investors screen investments. The first major provider was Eiris (Ethical Investment Research Service), founded in France in 1983. Seven years later, Kinder, Lydenberg, Domini (KLD) launched in the United States. These early providers manually collected data from corporate reports and constructed proprietary ratings based on their assessment of corporate social responsibility.

Early ethical investing focused on negative screens—avoiding "sin stocks" like tobacco, alcohol, and weapons manufacturers.

The industry remained niche until the 2000s, when mainstream financial institutions began acquiring ESG data providers:

- **2009**: MSCI acquires KLD, bringing ESG ratings into mainstream index construction
- **2019**: Morningstar acquires 40% of Sustainalytics
- **2019**: Moody's acquires Vigeo Eiris (formerly Eiris)
- **2019**: S&P acquires RobecoSAM
- **Ongoing**: Refinitiv (now LSEG) expands ESG ratings based on Asset4 methodology

By 2024, these "Big Six" providers dominated the market, with nearly all major institutional investors subscribing to at least one (and often multiple) ESG rating services.

How ESG Ratings Are Constructed

Despite superficial similarities, ESG rating methodologies differ substantially across providers. A typical process involves:

1. **Data collection**: Gather information from corporate sustainability reports, regulatory filings, news sources, NGO reports, and direct corporate outreach
2. **Attribute measurement**: Convert qualitative and quantitative information into scored indicators (e.g., board independence percentage, Scope 1 emissions intensity, diversity metrics)
3. **Materiality assessment**: Determine which ESG issues are most relevant for each industry (e.g., carbon emissions matter more for utilities than software firms)
4. **Aggregation**: Combine individual indicators into pillar scores (Environmental, Social, Governance) and an overall ESG rating

Crucially, providers differ at *every* stage: which data sources they use, how they measure individual attributes, which issues they deem material, and how they weight components in the final rating.

MSCI, for example, uses a 0-10 scale; Sustainalytics uses a risk-based score where lower is better; Refinitiv uses percentile ranks. Even comparing ratings requires normalization.

Differences from Credit Ratings

ESG ratings superficially resemble credit ratings, but three fundamental differences create far greater challenges:

1. Objective versus Values-Based Credit ratings measure a single, objective outcome: probability of default. While credit rating agencies may disagree on the *estimate*, they agree on what they're measuring. ESG ratings, in contrast, require value judgments: Is carbon emissions reduction more important than board diversity? Should firms be evaluated on outcomes (emissions levels) or processes (climate governance)? Different stakeholders legitimately disagree.

2. Mature versus Nascent Standards Credit analysis draws on centuries of accounting standards, bankruptcy law, and financial statement auditing. Comparable sustainability reporting standards are only now emerging (see Section 10.4). This means ESG raters often work with incomplete, inconsistent, and unaudited data.

3. *Issuer-Pay versus Investor-Pay* Credit rating agencies are paid by the firms they rate, creating potential conflicts of interest (firms "shop" for favorable ratings). ESG rating agencies are paid by investors, which eliminates this conflict but creates a different one: providers compete by offering ratings that align with investor preferences rather than objective sustainability assessment.[2]

These differences help explain why ESG ratings are noisier than credit ratings, as we examine next.

[2] This may explain why ESG ratings tend to favor large, developed-market firms with extensive disclosure—exactly the firms that institutional investors prefer to hold.

10.3 The Ratings Disagreement Problem

If different ESG rating providers were measuring the same underlying "sustainability," their ratings should correlate highly—as credit ratings do. They don't.

The Berg-Kölbel-Rigobon Study

Berg, Kölbel, and Rigobon (2022) provide the definitive analysis of ESG rating divergence.[3] They compare ratings from six major providers (MSCI, Sustainalytics, Refinitiv, S&P, Moody's, Morningstar) for a large sample of firms.

[3] Berg, F., J. F. Kölbel, and R. Rigobon (2022), "Aggregate Confusion: The Divergence of ESG Ratings," *Review of Finance* 26(6), 1315-1344.

Key Findings

1. **Low correlations**: Pairwise correlations between providers range from 0.38 to 0.71, with an average of 0.54. For comparison, correlations between credit ratings from different agencies exceed 0.95.

2. **Governance especially noisy**: While Environmental and Social ratings show modest agreement, Governance ratings correlate at only 0.30 across providers—barely better than random.

3. **Systematic, not random**: The disagreement is not mere noise. Providers systematically weight different attributes, leading to predictable patterns (e.g., firms with good environmental performance but poor labor practices are rated highly by some providers and poorly by others).

Figure 10.1 illustrates the divergence: for the same set of firms, providers produce ratings that scatter widely.

Figure 10.1: ESG rating divergence across providers. Each dot represents a firm. The x-axis shows one provider's rating; the y-axis shows another provider's rating for the same firm. Perfect agreement would place all dots on the 45-degree line. The wide scatter indicates substantial disagreement.

Sources of Divergence

Berg, Kölbel, and Rigobon decompose rating divergence into three sources:

1. Scope Divergence (38% of variation) Providers measure different attributes. For example:

- Provider A includes 50 environmental indicators; Provider B includes 35, with only 20 overlapping
- Some providers include controversial weapons screening; others focus solely on operational ESG issues
- Materiality frameworks differ: Provider A emphasizes financially material ESG risks; Provider B emphasizes stakeholder impact regardless of financial materiality

2. Measurement Divergence (56% of variation) Even for the same attribute, providers measure differently:

- Carbon emissions: Some providers use reported Scope 1+2; others estimate Scope 3; some use intensity (emissions per revenue); others use absolute levels
- Board diversity: Some count any female board member; others require multiple or calculate percentages; some include other diversity dimensions
- Data sources: Provider A uses only corporate disclosures; Provider B incorporates news sentiment and NGO reports

3. Weight Divergence (6% of variation) Providers aggregate indicators differently:

- Equal weighting versus materiality-based weighting

- Industry-relative versus absolute scoring
- Whether to penalize controversies or focus on proactive policies

Surprisingly, weight divergence—the most visible difference across methodologies—explains the least variation. The real problem is that providers measure fundamentally different things.

Implications

What does this mean for sustainable investing?

Portfolio Construction An investor screening for "high ESG" stocks will select dramatically different portfolios depending on which rating provider they use. Empirically, portfolios formed on different providers' ratings overlap by only 50-60%—meaning nearly half the holdings differ.

Corporate Strategy A firm trying to improve its ESG rating faces a dilemma: improving on Provider A's criteria may not improve (or may even worsen) ratings from Provider B. Firms that try to optimize all ratings simultaneously face impossible trade-offs.

Greenwashing Opportunities When ratings are noisy, firms can "ratings shop"—emphasizing dimensions that specific providers weight heavily while neglecting others. This allows cosmetic improvements to boost ratings without genuine sustainability gains.

Research and Evaluation Academic studies and practitioner analyses often rely on a single ESG data provider. If different providers yield different answers to the same research question (e.g., "Do high-ESG firms outperform?"), this casts doubt on the robustness of findings.

10.4 Corporate Disclosure Standards

Why are ESG ratings so noisy? A fundamental problem is that corporate ESG disclosure remains far less standardized and rigorous than financial disclosure.

The Disclosure Gap

Consider the contrast between financial and sustainability reporting:

Table 10.1: Financial versus sustainability reporting

Dimension	Financial Reporting	Sustainability Reporting
Standards	GAAP, IFRS (global)	Fragmented (GRI, SASB, TCFD, etc.)
Mandatory?	Yes (for public firms)	Often voluntary
Audited?	Always (by independent CPAs)	Rarely
Enforcement	SEC, securities regulators	Limited
Penalties	Significant (fraud, delisting)	Minimal
History	Centuries	Decades

This disclosure gap creates cascading problems:

Financial reporting standards evolved over centuries in response to crises (e.g., the 1929 crash led to SEC disclosure requirements). Sustainability standards are developing far more rapidly but still lag in comprehensiveness and enforcement.

1. **Incomplete data**: Many firms, especially smaller companies and those in emerging markets, disclose little or no ESG data

2. **Inconsistent definitions**: Firms report what they choose, how they choose. One company's "renewable energy percentage" may count purchased renewable energy credits; another's may count only on-site generation

3. **Unaudited claims**: Without independent verification, firms can misreport, misclassify, or simply exaggerate sustainability performance

4. **Gaming and greenwashing**: When reporting is voluntary and unaudited, firms strategically disclose favorable information while concealing unfavorable information

Voluntary Disclosure Frameworks

Before mandatory standards emerged, several voluntary frameworks gained adoption:

Global Reporting Initiative (GRI) Launched in 1997, GRI provides comprehensive sustainability reporting guidelines covering environmental, social, and governance topics. It emphasizes stakeholder impact (not just investor-relevant information) and is widely used globally.

Sustainability Accounting Standards Board (SASB) Founded in 2011, SASB focuses on financially material ESG information for investors. It provides industry-specific standards identifying which ESG topics matter most for value creation in each sector.

Task Force on Climate-related Financial Disclosures (TCFD) Established in 2015 by the Financial Stability Board, TCFD provides recommendations for climate-related financial risk disclosure, organized around four pillars: governance, strategy, risk management, and metrics/targets.

Carbon Disclosure Project (CDP) CDP operates a disclosure system where firms report environmental data in response to investor and customer requests. It focuses primarily on climate change, water, and forests.

While valuable, voluntary frameworks suffer from two problems: (1) firms selectively adopt frameworks that present them favorably, and (2) even within a framework, firms cherry-pick what to disclose. This is changing as regulators mandate specific disclosure standards.

Mandatory Disclosure Regulation

Three major regulatory initiatives are standardizing and mandating ESG disclosure:

EU Corporate Sustainability Reporting Directive (CSRD) Effective 2024-2025, CSRD requires all large EU companies and listed

SMEs to report detailed sustainability information according to European Sustainability Reporting Standards (ESRS). Key features:

- Covers environmental (climate, pollution, biodiversity, etc.), social (workforce, communities), and governance matters
- Requires "double materiality" assessment: firms must report on how sustainability issues affect the company AND how the company affects society/environment
- Mandates third-party assurance (audit) of sustainability disclosures
- Phased implementation covering approximately 50,000 companies by 2028

International Sustainability Standards Board (ISSB) Created by the IFRS Foundation in 2021, ISSB develops global baseline sustainability disclosure standards. The first two standards (2023) cover:

- IFRS S1: General sustainability-related financial disclosures
- IFRS S2: Climate-related disclosures (building on TCFD)

ISSB standards focus on *enterprise value creation* (investor perspective) rather than double materiality. Many jurisdictions are adopting or aligning with ISSB standards.

SEC Climate Disclosure Rule (Proposed, facing legal challenges) Would require US public companies to disclose:

- Governance of climate risks
- Material climate risks and their impacts on strategy and operations
- Scope 1 and 2 greenhouse gas emissions (Scope 3 if material or if firm has set targets)
- Attestation of emissions data for large accelerated filers

Challenges Ahead

Even with mandatory disclosure, significant challenges remain:

Scope 3 Emissions While Scope 1 (direct emissions) and Scope 2 (purchased electricity) are relatively straightforward to measure, Scope 3 (value chain emissions—suppliers and product use) involves estimation, allocation challenges, and boundary questions. Yet for many firms (e.g., Apple, whose product use dominates its carbon footprint), Scope 3 dwarfs Scopes 1 and 2.

Forward-Looking Information Investors want to know firms' *future* sustainability trajectory, not just historical performance. But forward-looking disclosure (transition plans, emissions reduction targets, climate scenario analysis) involves subjective assumptions and creates legal liability risks if targets are missed.

Global Fragmentation Despite ISSB's efforts to create global baselines, jurisdictions are adopting different standards (EU's double materiality versus ISSB's enterprise value focus). Multinational firms may face conflicting reporting requirements.

Assurance Capacity Requiring audits of sustainability reports strains the accounting profession's capacity. Few auditors have deep ESG expertise, and sustainability data involves judgments (materiality assessments, estimation methodologies) that differ from traditional financial auditing.

10.5 Greenwashing

When ESG ratings are noisy and disclosure standards weak, firms face powerful incentives to engage in **greenwashing**—misleadingly conveying an impression of environmental responsibility without substantive action.

The term "greenwashing" combines "green" (environmentalism) and "whitewashing" (covering up wrongdoing). It was coined in the 1980s to describe hotels claiming environmental benefits from guests reusing towels while making no other sustainability efforts.

Forms of Greenwashing

Greenwashing takes many forms:

1. Symbolic Actions Firms announce high-profile but inconsequential sustainability initiatives while continuing business-as-usual on material issues. Example: An oil company promotes a small renewable energy division while continuing to invest billions in fossil fuel exploration.

2. Selective Disclosure Firms highlight favorable sustainability metrics while omitting unfavorable ones. Example: Reporting Scope 1 and 2 emissions reductions while Scope 3 emissions (the firm's main impact) increase.

3. Vague Commitments Firms announce ambitious long-term targets without credible transition plans or interim milestones. Example: Pledging "net zero by 2050" with no detail on how this will be achieved or whether it relies on unproven carbon removal technologies.

4. Label Manipulation Firms rebrand conventional products or activities as "green," "sustainable," or "ESG" without substantive changes. Example: Fossil fuel companies issuing "sustainability-linked bonds" where the sustainability link is weak or easily gamed.

5. Ratings Gaming Firms strategically focus on metrics that rating providers weight heavily, even if those metrics don't reflect genuine environmental performance. Example: Improving board diversity or climate disclosure quality (both easily observable) while making no progress on actual emissions reductions (harder to verify).

The Greenwashing Decision

We can model greenwashing as a firm's choice between genuine improvement (costly but effective) versus superficial improvement (cheap but ineffective).

Let:

- c_G = cost of genuine emissions reduction

- c_S = cost of superficial improvements (better disclosure, symbolic actions, etc.)
- Δs_G = expected improvement in ESG score from genuine action
- Δs_S = expected improvement in ESG score from superficial action
- α = correlation between ESG score and true environmental performance (measurement quality)
- r = probability of being caught greenwashing
- P = penalty if caught

If ESG ratings perfectly measure true performance ($\alpha = 1$), then $\Delta s_G > \Delta s_S$ and genuine action dominates. But if ratings are noisy ($\alpha < 1$), superficial improvements can boost scores at lower cost.

The firm chooses genuine action only if:

$$\Delta s_G - c_G > \Delta s_S - c_S - rP \tag{10.1}$$

This shows that greenwashing is more attractive when:

1. **Ratings are noisier** (lower α): Superficial actions can fool rating systems
2. **Genuine action is costlier** (higher c_G): For emissions-intensive firms, genuine reductions are expensive
3. **Enforcement is weak** (lower r or P): Firms face little penalty for greenwashing

Evidence of Greenwashing

Several empirical patterns suggest greenwashing is widespread:

Talk-Action Gap Firms increasingly discuss climate and sustainability in corporate communications, but actual emissions reductions lag far behind rhetorical commitments. Research finds that climate-related disclosure has increased dramatically while emissions trajectories show minimal change for most sectors.

Green Bond Puzzles Recall from Chapter 8 that green bond issuers experience positive stock returns at announcement but do not consistently reduce emissions post-issuance. This pattern is consistent with investors rewarding the "green" signal while firms use green bonds as greenwashing tools rather than for genuine transition.

ESG Fund Performance Many funds marketed as "ESG" or "sustainable" hold portfolios barely distinguishable from conventional funds. Analysis of fund holdings often reveals only modest differences in ESG characteristics, suggesting "greenwashing" extends to asset managers seeking to attract sustainable capital flows.

Index Inclusion Effects The Van Binsbergen-Brøgger findings (discussed in Chapter 9) that firms increase emissions *after* sustainable index inclusion provide perhaps the most direct evidence: firms clean up enough to get included, then revert to business-as-usual.

Regulatory Response

Regulators are beginning to police greenwashing, though enforcement remains nascent:

- **EU Green Claims Directive** (proposed): Would require substantiation and verification of environmental claims in advertising
- **SEC enforcement actions**: The SEC has brought cases against investment managers for misleading ESG claims about portfolio composition
- **Greenwashing litigation**: Private lawsuits alleging misleading sustainability claims are increasing, though outcomes remain uncertain
- **Fund labeling rules**: EU's Sustainable Finance Disclosure Regulation (SFDR) creates categories for sustainable funds with specific disclosure requirements to reduce mislabeling

Whether these efforts will substantially reduce greenwashing depends on enforcement intensity and the underlying measurement infrastructure improving.

10.6 Solutions and Future Directions

Fixing the measurement infrastructure for sustainable finance requires attacking the problem from multiple angles. We review promising directions.

Standardized, Audited Disclosure

The ISSB and CSRD initiatives discussed in Section 10.4 represent major progress. For disclosure standards to work, three elements are essential:

1. Comprehensive Scope Standards must cover all material ESG dimensions and require firms to disclose negative information, not just positive initiatives. The CSRD's double materiality approach (requiring firms to report both financial ESG risks and societal impacts) is more comprehensive than investor-focused approaches.

2. Independent Assurance Without auditing, disclosure is cheap talk. Third-party verification by qualified auditors (as CSRD mandates) is critical. However, auditing sustainability information raises novel challenges: verifying forward-looking statements, assessing materiality judgments, and evaluating highly technical information (e.g., greenhouse gas emissions calculations).

3. Meaningful Enforcement Disclosure requirements only work if violations carry real penalties. This requires resourced regulators willing to investigate and sanction non-compliance.

Harmonized Rating Methodologies

Could rating providers converge on common methodologies to reduce noise? Several barriers exist:

- Providers compete on methodology differentiation
- Legitimate differences in philosophy (stakeholder impact versus investor materiality)
- Different user needs (pension funds versus activist investors may want different information)

Regulatory intervention might help. The EU is considering regulation of ESG rating providers (similar to credit rating agency regulation), potentially requiring transparency in methodologies and governance standards.

Market-Based ESG Scores

A radical alternative: derive ESG measures from financial market prices rather than rating agency judgments.

Just as options prices reveal market-implied volatility, perhaps derivatives tied to firms' future ESG performance could reveal market-implied ESG quality.

The Concept Create financial instruments whose payoffs depend on firms' future ESG performance (e.g., emissions levels in five years). Market prices of these instruments would aggregate all available information about expected ESG outcomes, providing an objective, forward-looking, hard-to-game ESG measure.

Implementation Challenges

1. Requires liquid markets in ESG derivatives (which don't yet exist at scale)
2. Defining payoff triggers: What precisely does the derivative pay based on?
3. Long time horizons: ESG outcomes play out over years, making derivatives valuation difficult
4. Potential manipulation: Firms might try to manipulate their own ESG derivative prices

Promising Variation: Emissions Futures Rather than firm-level derivatives, market-wide emissions futures (contracts tied to aggregate emissions in specific sectors or regions) could provide forward-looking emissions trajectory information less subject to individual firm manipulation.

Early research finds that when such contracts exist, they provide more timely and less noisy signals than backward-looking reporting or rating agency assessments. However, scaling this approach faces significant practical hurdles.

Technology and Data Innovation

Technological advances may reduce measurement costs and improve accuracy:

Satellite and Remote Sensing Satellite data can directly observe certain environmental impacts (deforestation, methane leaks, air quality) without relying on corporate disclosure. Several startups now provide emissions monitoring services based on satellite imagery and AI analysis.

Supply Chain Tracking Blockchain and RFID technologies enable more granular tracking of supply chain sustainability (e.g., verifying conflict-free minerals, tracking product carbon footprints from source to sale).

Alternative Data Natural language processing of corporate disclosures, news, social media, and employee reviews can supplement traditional ESG data, potentially identifying risks (e.g., labor violations, emerging controversies) faster than annual reporting cycles.

While promising, these technologies do not eliminate the fundamental challenges of defining what to measure and how to aggregate diverse information into actionable scores.

10.7 *Conclusion*

We began this book with a simple question: Can finance help solve sustainability challenges? We developed a framework showing how externality internalization increases total value. We examined how firms and investors might drive internalization through transition strategies, green bonds, portfolio allocation, and engagement. And we reviewed disappointing empirical evidence suggesting sustainable finance has achieved limited real-world impact so far.

This chapter identified a core reason why: **we cannot manage what we cannot measure**, and sustainability measurement remains deeply flawed. ESG rating providers disagree dramatically about which firms are sustainable. Corporate disclosure is incomplete, inconsistent, and often unaudited. Greenwashing is rampant because firms can improve ESG perceptions through superficial actions while avoiding costly genuine improvements.

These are not insurmountable problems. Mandatory disclosure standards are being implemented globally. Rating methodologies may converge or be regulated for transparency. Technology is improving measurement capabilities. And as enforcement strengthens, greenwashing will become riskier.

But measurement challenges also reveal a deeper tension: sustainability is inherently multidimensional and value-laden in ways that financial metrics are not. There is broad agreement on what "profitable" means; there is far less agreement on what "sustainable" means. Should sustainability prioritize carbon emissions or biodiversity? Worker welfare or community impact? Outcome metrics or governance processes?

Different stakeholders—investors, employees, communities, future generations—have legitimately different priorities. This means there may be no single "correct" ESG rating, just as there is no single "correct" ethical framework. The best we can hope for is transparency: clear disclosure of what firms are doing, clear explanation of how ratings are constructed, and informed choice by investors about which sustainability dimensions they care most about.

Even imperfect measurement, if transparent and improving, can drive progress. As long as there is *some* relationship between ESG metrics and genuine environmental performance, capital flows toward high-ESG firms will create incentives for improvement. As long as greenwashing carries *some* risk of exposure and reputational harm, firms will undertake at least some genuine sustainability actions. And as measurement improves—through better disclosure, refined methodologies, and technological innovation—the signal strengthens relative to noise.

The sustainable finance revolution is real. Trillions of dollars are flowing toward ESG-conscious strategies. But whether this capital reallocation will meaningfully reduce emissions, protect biodiversity, improve labor conditions, and address other sustainability challenges depends critically on solving the measurement problem. This is the outstanding issue on which the effectiveness of sustainable finance ultimately rests.

Exercises

1. **Rating Divergence Analysis**

   Suppose three ESG rating providers evaluate the same firm on three dimensions: carbon emissions (E), labor practices (S), and board structure (G). Each provider assigns scores from 0-100.

Provider	E Score	S Score	G Score
Provider A	80	60	90
Provider B	65	85	70
Provider C	75	55	45

   (a) If each provider weights the three dimensions equally to form an overall ESG score, what is each provider's overall score for this firm?

   (b) Now suppose Provider A weights dimensions as (E=50%, S=25%, G=25%), Provider B weights (E=25%, S=50%, G=25%), and Provider C weights (E=33%, S=33%, G=33%). Recalculate overall scores.

   (c) Calculate the correlation between overall scores across the three providers. How does this correlation compare to the typical 0.54 correlation Berg et al. document?

   (d) If an investor screens for "top quartile ESG" firms using these three providers, would this firm be included? What does this reveal about portfolio construction dependence on provider choice?

2. **Greenwashing Incentives**

   Consider a firm choosing between genuine emissions reduction (G) and greenwashing (W). The payoffs depend on ESG rating quality:

   - Genuine action: costs $100M, increases true ESG by 20 points, increases measured ESG score by 20α (where α is rating accuracy)
   - Greenwashing: costs $10M, increases true ESG by 0, increases measured ESG score by $15(1-\alpha)$
   - Benefit of 1-point ESG score increase: $5M in firm value (from cheaper capital, reputation, etc.)

   (a) If $\alpha = 1$ (perfect rating accuracy), what is the net benefit of each strategy? Which does the firm choose?

   (b) If $\alpha = 0.5$ (moderate noise), recalculate. Which strategy is chosen?

   (c) Find the threshold level of α below which the firm prefers greenwashing.

   (d) Now suppose greenwashing carries a 20% chance of being exposed, with a penalty of $50M if caught. How does this change the threshold α?

   (e) What does this model suggest about the relationship between rating quality and greenwashing incentives? What policy interventions would reduce greenwashing?

3. **Scope Divergence Decomposition**

   Berg et al. decompose rating divergence into scope, measurement, and weight effects. Consider a simplified example:

   Provider A measures attributes {A1, A2, A3} with weights {0.4, 0.3, 0.3}.

   Provider B measures attributes {A2, A3, A4} with weights {0.5, 0.3, 0.2}.

   For a given firm:

   - A1 score: 80

- A2 score: 60 (Provider A) vs. 70 (Provider B measures differently)
- A3 score: 50 (both agree)
- A4 score: 90

(a) Calculate Provider A's overall rating for this firm.

(b) Calculate Provider B's overall rating.

(c) Decompose the difference into:

  (i) Scope effect: What would the difference be if both providers measured the same attributes but with their own measurement and weights?

  (ii) Measurement effect: Contribution of measuring A2 differently

  (iii) Weight effect: Contribution of different weighting schemes

(d) Which source of divergence is largest in this example? How does this compare to Berg et al.'s empirical findings?

4. **Double Materiality**

The EU's CSRD requires "double materiality" assessment: firms must disclose ESG information if it is either (a) financially material to the firm (affects enterprise value) or (b) material to society/environment (significant external impact).

(a) Consider a small textile manufacturer with minimal climate change exposure (located in stable region, low energy costs) but significant water pollution as a byproduct of operations. Under financial materiality only (ISSB approach), would water pollution likely be deemed material? Under double materiality (CSRD)? Explain.

(b) Now consider a large technology company with significant energy consumption (data centers) making it exposed to carbon pricing risk. Its consumer electronics products contain conflict minerals sourced from regions with human rights concerns, but these represent <1% of input costs. Analyze materiality of (a) carbon emissions and (b) conflict minerals under both frameworks.

(c) What are the advantages of double materiality from a societal perspective? What are the disadvantages from an investor perspective?

(d) Some argue double materiality creates excessive disclosure burden and confuses investor-focused reporting with stakeholder-focused reporting. Others argue it provides a more complete picture of corporate impact. Which view do you find more persuasive? Justify your position.

5. **Audit Challenges in Sustainability Reporting**

You are an auditor tasked with verifying a company's sustainability report. Consider three claims the company makes:

Claim 1: "Our Scope 1 and 2 greenhouse gas emissions in 2024 were 1.5 million tons CO2e."

Claim 2: "We have implemented robust climate governance including board-level oversight and scenario analysis consistent with TCFD recommendations."

Claim 3: "Our business model is aligned with a 1.5°C warming scenario and we are on track to achieve net-zero emissions by 2050."

(a) For each claim, describe what evidence you would examine to verify it.

(b) Which claim is most objectively verifiable? Which is least? Explain the differences.

(c) Traditional financial auditing focuses on historical financial statements. How does sustainability assurance differ? What new skills or expertise would auditors need?

(d) The company's net-zero target relies heavily on purchasing carbon offsets rather than reducing absolute emissions. The offsets come from forestry projects whose permanence and additionality are uncertain. How should an auditor treat this in verifying the net-zero claim?

6. **Market-Based ESG Scores**

Consider a proposal to create "emissions futures" contracts that pay based on a firm's emissions level in 5 years. Specifically, the contract pays \$100 - 10×(future emissions intensity) where emissions intensity is measured as tons CO_2e per \$1M revenue.

(a) If a firm currently has emissions intensity of 8 and is expected to maintain this level, what should the contract price be (assuming a 5% discount rate and risk-neutrality)?

(b) Now suppose the firm announces a credible transition plan to reduce emissions intensity to 5 within 5 years. How should the contract price change?

(c) Suppose instead the firm announces a plan but the market doubts its credibility. The contract price increases only slightly. What does this reveal about market beliefs regarding the firm's ESG trajectory?

(d) Compare this market-based ESG measure to traditional ESG ratings. What are the advantages? What are the disadvantages?

(e) What practical challenges would prevent widespread adoption of such contracts? How might these be overcome?

7. **Integrated Measurement and Impact Analysis**

You advise a large pension fund with \$50B in assets that wants to "maximize climate impact" through its investment portfolio.

(a) The fund is considering three strategies:

(i) Divest from all fossil fuel companies (approximately \$5B current exposure)

(ii) Engage with high-emitting portfolio companies to encourage transition (would affect \$15B in holdings)

(iii) Increase allocation to renewable energy infrastructure (could deploy up to \$3B)

For each strategy, discuss: (a) how you would measure its climate impact, (b) what data/metrics you would need, (c) what attribution challenges you face, and (d) how ESG rating quality affects your ability to implement the strategy effectively.

(b) The fund's consultant proposes using a "portfolio carbon footprint" metric (weighted average emissions intensity of holdings). Critically evaluate this metric: What does it measure? What does it miss? How could it be gamed?

(c) Design an alternative measurement framework for assessing the fund's climate impact. What metrics would you track? How would you address attribution (separating the fund's impact from broader trends)? How would you account for measurement uncertainty?

(d) Based on the evidence in this chapter and Chapter 9, which of the three strategies above is most likely to create real-world emissions reductions? Justify your answer.

Notes

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Technical Notes

On Correlation Interpretation: The 0.54 average correlation between ESG ratings means that only about 29% (0.54^2) of the variation in one provider's ratings is explained by another provider's ratings. This is remarkably low for measures ostensibly capturing the same construct and has profound implications for research, investment, and policy that rely on ESG data.

On Scope 3 Emissions: Measuring value chain emissions involves double-counting risks (one firm's Scope 3 is another's Scope 1) and boundary questions (how far up/down the chain should firms report?). The GHG Protocol provides guidance, but substantial judgment remains. For many firms, Scope 3 is estimated using economic input-output models rather than measured directly.

On Double Materiality Philosophy: The debate between financial materiality (ISSB) and double materiality (CSRD) reflects deeper disagreements about the purpose of corporate disclosure. Financial materiality serves investors' capital allocation decisions. Double materiality serves broader stakeholder accountability. These purposes can conflict when societal impacts don't affect firm value (e.g., pollution in regions with weak enforcement).

On Auditing Forward-Looking Statements: Traditional auditing verifies historical facts. Sustainability reporting includes forward-looking elements (transition plans, emissions targets, scenario analyses) that cannot be "verified" in the traditional sense. Auditors can verify that disclosure is "prepared in accordance with" frameworks and that assumptions are "reasonable," but cannot opine on whether future targets will actually be met. This creates legal risk for both firms and auditors.

Chapter 11
Doing Internalization Assessments

Throughout this course, we have developed the Total Value Framework and explored how the internalization parameter ι shapes firm value, investment returns, and market equilibrium. This final chapter provides a practical guide to conducting an internalization assessment—the core analytical skill for sustainable finance practitioners.

An internalization assessment evaluates how changes in externality pricing affect firm valuation. This workshop-style chapter walks through the complete process: from identifying externalities and estimating their magnitude, to incorporating them into discounted cash flow models, to sensitivity analysis across different internalization scenarios.

11.1 *The Internalization Assessment Framework*

Recall that the Total Value Framework decomposes firm value into two components:

$$V^{TV} = V^I - V^E \tag{11.1}$$

where V^{TV} is total value to society, V^I is internalized value (what accrues to shareholders), and V^E is externalized costs (borne by society).

The internalization parameter $\iota \in [0, 1]$ measures the extent to which externalities are priced into firm operations:

When $\iota = 0$, firms bear none of their externality costs (pure externalization). When $\iota = 1$, firms bear the full social cost (complete internalization). Most real-world situations involve partial internalization with $0 < \iota < 1$.

$$V^I(\iota) = V^{FF} - \iota \cdot V^E \tag{11.2}$$

where V^{FF} is traditional fundamental firm value (before externality costs).

An internalization assessment examines how firm value changes as ι increases—modeling the impact of carbon pricing, stricter environmental regulations, changing social norms, or investor pressure.

11.2 Step 1: Identify and Quantify Externalities

The first step is identifying the firm's material externalities and quantifying their physical magnitude.

Externality Identification

For each potential externality, assess:

1. **Materiality**: Is the externality significant relative to firm operations?

2. **Attribution**: Can the externality be credibly linked to firm activities?

3. **Measurability**: Can the externality be quantified with reasonable accuracy?

   Common categories include:

- **Environmental**: Greenhouse gas emissions (Scope 1, 2, 3), water consumption, waste generation, biodiversity impact, pollution

- **Social**: Labor practices, workplace safety, community health impacts, human rights in supply chain

- **Governance**: Although primarily internalized through agency costs, poor governance can create externalities through systemic risk or market manipulation

Quantification Methods

Direct Measurement For owned operations (Scope 1 and 2 emissions, direct water use, on-site waste), use:

- Emissions monitoring systems
- Utility bills and resource consumption data
- Regulatory reporting (EPA, EU ETS, etc.)

Activity-Based Estimation For indirect impacts (Scope 3 emissions, supply chain effects):

- Industry emission factors × activity level
- Supply chain spend × emission intensities by sector
- Life cycle assessment (LCA) databases

Example: Carbon Emissions Quantification Consider a manufacturing firm with:

- Annual Scope 1 emissions: 50,000 tonnes CO_2e (measured)
- Annual Scope 2 emissions: 30,000 tonnes CO_2e (calculated from electricity use)
- Estimated Scope 3 emissions: 120,000 tonnes CO_2e (supply chain analysis)
- Total carbon footprint: 200,000 tonnes CO_2e annually

11.3 Step 2: Assign Monetary Values

The next step converts physical externalities into monetary terms—estimating V^E.

Valuation Approaches

Market Prices When externalities are already partially priced:

- Carbon: EU ETS price, voluntary carbon credit prices, implicit carbon prices from regulations

- Water: Local water utility rates, scarcity-adjusted shadow prices
- Waste: Disposal fees, landfill taxes

Social Cost Estimates For unpriced or underpriced externalities:

- Social cost of carbon (SCC): Government estimates range from \$50-\$200 per tonne CO_2e
- Health damages: Value of statistical life (VSL) × attributable mortality/morbidity
- Ecosystem services: Avoided damage costs, replacement costs

Regulatory Projections Forward-looking assessments should incorporate:

- Expected carbon price trajectories (IEA scenarios, policy announcements)
- Planned regulatory changes (phase-outs, stricter standards)
- Sector-specific transition plans

Example: Monetizing Carbon Externality

Using our manufacturing firm with 200,000 tonnes CO_2e annual emissions:

Current State ($\iota_0 = 0.15$):

- EU ETS covers 40% of emissions at €80/tonne = €6.4M annual cost
- Remaining 60% unpriced
- Internalized cost: 0.15 × 200,000 × €100 (blended rate) = €3M

Full Internalization ($\iota = 1$):

- Social cost of carbon: €150/tonne (IEA 2°C scenario, 2030)
- Full externality value: 200,000 × €150 = €30M annually

Incremental Internalization:

$$\Delta Cost = (1 - 0.15) \times 30M = 25.5M \text{ additional annual cost} \quad (11.3)$$

This €25.5M represents the firm's exposure to carbon pricing risk.

11.4 Step 3: Gordon Growth Model with Externalities

The Gordon Growth Model provides a simple framework for incorporating externalities into firm valuation. Recall the standard formula:

$$P = \frac{D_1}{r - g} \quad (11.4)$$

where D_1 is next year's dividend, r is required return, and g is perpetual growth rate.

Adjusting for Externalities

Under the Total Value Framework, we modify the Gordon model to account for internalization:

$$V^I(\iota) = \frac{D_1 - \iota \cdot E_1}{r - g} \quad (11.5)$$

where E_1 is the perpetual annual externality cost. This assumes:

1. Externality magnitude grows at rate g (proportional to business growth)
2. Internalization level ι remains constant
3. Both dividends and externalities are perpetual

Worked Example: Utility Company Valuation

Base Case (Traditional Valuation):

- Expected dividend next year: D_1 =\$500M*Requiredreturn* :r = 8%

- Growth rate: $g = 2\%$

- Equity value: $V^{FF} = \frac{\$500M}{0.08-0.02} = \$8,333M$

Externality Assessment:

- Annual CO_2 emissions: 10 million tonnes
- Current carbon price (partial regulation): $40/tonne → $400M (already in costs)
- Social cost of carbon: $150/tonne → $1,500M full cost
- Unpriced externality: $E_1 = \$1,500M - \$400M = \$1,100M$
- Current internalization: $\iota_0 = \frac{\$400M}{\$1,500M} = 0.27$

Valuation Under Increased Internalization:
At $\iota = 0.5$ (moderate carbon pricing):

$$V^I(0.5) = \frac{\$500M - 0.5 \times \$1,100M}{0.06} \tag{11.6}$$

$$= \frac{\$500M - \$550M}{0.06} = -\$833M \text{ (negative equity value!)} \tag{11.7}$$

This suggests the firm cannot maintain current dividend levels under substantial carbon pricing. A more realistic assessment incorporates operational responses.

Dynamic Adjustment Model

Firms respond to internalization by reducing externalities. A more sophisticated model includes abatement:

$$V^I(\iota) = \frac{D_1 - A(\iota) - \iota \cdot E_1(\iota)}{r - g} \tag{11.8}$$

where:

- $A(\iota)$ = abatement cost (e.g., clean technology investment)
- $E_1(\iota)$ = residual externality after abatement
- Typically $A'(\iota) > 0$ and $E_1'(\iota) < 0$ (higher internalization drives more abatement)

Extended Example:

Suppose the utility can reduce emissions 30% at $400M annual cost:

- Abatement investment: $A = \$400M$
- Residual emissions: 7 million tonnes
- Residual externality at $150/tonne: $E_1 = \$1,050M$
- Current internalization on residual: 0.27 × $1,050M = $284M

At $\iota = 0.5$:

$$V^I(0.5) = \frac{\$500M - \$400M - 0.5 \times \$1,050M}{0.06} \tag{11.9}$$

$$= \frac{\$100M - \$525M}{0.06} = -\$7,083M \tag{11.10}$$

Still negative, but the abatement option reduced losses from $14,167M to $7,083M.

11.5 Step 4: Scenario Analysis

Internalization is uncertain—carbon prices, regulations, and social norms evolve unpredictably. Best practice conducts scenario analysis across multiple ι pathways.

Standard Scenarios

Business-as-Usual (BAU) ι increases slowly from current levels

- Reflects gradual policy tightening
- Moderate carbon price growth (2-3% real annually)
- Probability: 30-40%

Paris-Aligned Transition ι reaches 0.7-0.8 by 2030

- Aggressive climate policy (carbon price $150-$200/tonne by 2030)
- Stringent regulations across sectors
- Probability: 30-40%

Delayed Transition ι remains low until 2030, then rapid increase

- Policy paralysis followed by crisis response
- Abrupt carbon price shocks
- High stranded asset risk
- Probability: 20-30%

Valuation Under Scenarios

For each scenario, project:

1. Internalization trajectory: ι_t for $t = 1, 2, \ldots, T$
2. Externality costs: $E_t(\iota_t)$ incorporating abatement responses
3. Abatement costs: $A_t(\iota_t)$
4. Adjusted cash flows: $CF_t = CF_t^{FF} - A_t - \iota_t \cdot E_t(\iota_t)$

   Then discount to present value:

$$V^I = \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t} + \frac{CF_{T+1}/(r-g)}{(1+r)^T} \tag{11.11}$$

Example: Multi-Scenario Valuation

Using the utility company from above, project three scenarios:
BAU Scenario:

- ι increases from 0.27 to 0.40 by 2030
- Firm invests $2B in efficiency (reduces emissions 15%)
- NPV of equity: $6.8B (18% below traditional valuation)

Paris-Aligned:

- ι reaches 0.75 by 2030
- Firm invests $5B in renewables transition (reduces emissions 60%)
- NPV of equity: $3.2B (62% below traditional valuation)

Delayed Transition:

- $\iota = 0.30$ until 2030, then jumps to 0.80 in 2031
- Limited time for adjustment → high costs
- NPV of equity: $2.1B (75% below traditional valuation)

Probability-weighted expected value:

$$E[V^I] = 0.35 \times \$6.8B + 0.40 \times \$3.2B + 0.25 \times \$2.1B = \$4.1B \tag{11.12}$$

This represents 51% downside relative to traditional valuation—material transition risk.

11.6 Step 5: Sensitivity Analysis and Key Drivers

Internalization assessments involve numerous assumptions. Sensitivity analysis identifies key value drivers and uncertainty ranges.

Critical Variables

Test sensitivity to:

1. **Social cost of carbon**: Range $50-$250/tonne
2. **Internalization speed**: Years to reach target ι
3. **Abatement cost curve**: Cost of emissions reductions
4. **Discount rate**: Climate risk premium
5. **Scope 3 boundary**: Inclusion/exclusion of value chain emissions

Tornado Diagram Analysis

Rank variables by impact on valuation. For the utility example:

Internalization level and discount rate drive the widest value ranges, indicating these are priority areas for further analysis.

Variable	Low Case	High Case
Social cost of carbon ($/tonne)	$3.8B (at $75)	$4.5B (at $200)
Internalization by 2030	$5.2B (at $\iota = 0.5$)	$2.8B (at $\iota = 0.9$)
Abatement cost	$4.5B (low cost)	$3.6B (high cost)
Discount rate	$3.2B (at 10%)	$5.4B (at 6%)

Table 11.1: Sensitivity of equity value to key assumptions (base case: $4.1B)

11.7 Step 6: Interpretation and Investment Implications

The final step translates technical analysis into actionable insights.

Red Flags

Internalization assessments may reveal:

- **Negative equity value** under plausible scenarios → fundamental business model at risk
- **High sensitivity to ι** → concentrated transition risk
- **Large Scope 3 externalities** → vulnerable to value chain regulations
- **Limited abatement options** → inflexible cost structure

Investment Decisions

Different investor types interpret internalization risk differently:

Traditional Investors Focus on financial materiality:

- Probability-weight scenarios by regulatory likelihood
- Discount firms with high unpriced externalities
- Monitor policy developments for early warning signals

ESG-Integrated Investors Incorporate total value perspective:

- Avoid firms with large negative V^{TV} (total value destroyers)

- Favor firms positioned for high-ι regimes
- Engage management on transition planning

Impact Investors Maximize positive externalities:

- Seek firms with positive V^E (social benefit generators)
- Accept lower V^I for higher V^{TV}
- Support business models that internalize benefits (e.g., renewable energy)

Portfolio Applications

At portfolio level, internalization assessment enables:

1. **Transition risk budgeting**: Limit exposure to high-externality sectors
2. **Scenario-based stress testing**: Portfolio value under carbon price shocks
3. **Relative value identification**: Mispricing between firms with similar externalities but different market valuations
4. **Hedging strategies**: Offset carbon risk through renewable energy allocations

11.8 Practice Exercises

Exercise 1: Basic Gordon Growth with Carbon

An oil refining company has the following characteristics:

- Annual dividend: $200M
- Required return: 10%
- Growth rate: 1%
- Annual CO_2 emissions: 5 million tonnes
- Current carbon price: $30/tonne (already internalized in costs)

- Social cost of carbon: $120/tonne

Tasks:

1. Calculate traditional equity value (ignoring externalities)
2. Calculate unpriced externality E_1
3. Calculate equity value if ι increases from current level to 0.60
4. What carbon price would make equity value zero?

Exercise 2: Abatement Decision

A cement manufacturer faces:

- Current emissions: 2 million tonnes CO_2 annually
- Option A: Reduce emissions 40% at $80M annual cost
- Option B: Reduce emissions 70% at $180M annual cost
- Expected carbon price trajectory: $50/tonne (2025) → $150/tonne (2035)
- Discount rate: 8%

Tasks:

1. Calculate NPV of each abatement option over 10 years
2. At what carbon price does Option A break even?
3. At what carbon price does Option B become preferred to Option A?
4. What does this imply about optimal abatement timing?

Exercise 3: Comparative Valuation

Two electric utilities operate in the same market:

- **Utility A**: 80% coal generation, 2M tonnes CO_2/year, $400M EBITDA
- **Utility B**: 60% renewables, 0.5M tonnes CO_2/year, $350M EBITDA

- Both trade at 8× EBITDA multiples
- Expected carbon price: \$100/tonne by 2030

Tasks:

1. Calculate enterprise value for each utility (before carbon costs)
2. Calculate annual carbon cost at \$100/tonne for each utility
3. Assuming neither can reduce emissions, what happens to relative valuations?
4. What EBITDA multiple would equalize enterprise values after carbon costs?
5. Which utility represents better value for a 10-year investor?

Exercise 4: Scenario-Based Valuation

An automotive manufacturer has:

- Current production: 1 million vehicles/year, 60% ICE, 40% EV
- ICE externality: \$5,000/vehicle (lifecycle emissions)
- Current $\iota = 0.10$ (fuel taxes only)
- Free cash flow: \$2B annually (before externality adjustments)

Scenarios:

- **Slow transition**: ICE share declines to 40% by 2030, $\iota = 0.30$
- **Fast transition**: ICE share declines to 10% by 2030, $\iota = 0.60$
- **ICE ban**: ICE prohibited from 2028, $\iota = 1.0$ for remaining ICE

Tasks:

1. Calculate annual externality cost in 2030 under each scenario
2. Estimate required capital expenditure to achieve production mix shifts
3. Project FCF in 2030 under each scenario
4. Calculate probability-weighted enterprise value (assign your own probabilities)

11.9 Common Pitfalls and Best Practices

Common Mistakes

Overreliance on Current Prices Using today's carbon price to value long-lived assets ignores policy trajectories. Always incorporate forward price curves.

Ignoring Abatement Responses Assuming firms passively accept internalization costs overlooks strategic adaptation. Model realistic operational responses.

Scope 3 Boundaries Inconsistent treatment of value chain emissions across comparables biases relative valuations. Standardize scope definitions.

Double-Counting When multiple firms in a value chain report the same Scope 3 emissions, portfolio-level externality estimates become inflated. Use "attributed" rather than "reported" emissions.

Static Discount Rates Climate risk may warrant time-varying or scenario-specific discount rates. High-uncertainty scenarios should use higher hurdle rates.

Best Practices

1. **Start with materiality**: Focus on externalities that exceed 5% of EBITDA under realistic scenarios
2. **Use multiple valuation methods**: Cross-check Gordon growth results with DCF and multiples approaches
3. **Incorporate optionality**: Real options framework captures value of flexibility (delay, expand, abandon)
4. **Transparent assumptions**: Document all key assumptions and provide sensitivity ranges
5. **Update regularly**: Internalization assessments require annual refresh as policies evolve

6. **Peer comparison**: Benchmark firm externality intensity against sector averages
7. **Forward-looking data**: Prioritize firms' transition plans over historical emissions

11.10 Beyond Carbon: Multi-Dimensional Externalities

While carbon provides a clear worked example, comprehensive internalization assessment extends to other externalities.

Water Risk

For water-intensive industries (agriculture, beverages, semiconductors):

- Quantify water consumption in water-stressed basins
- Estimate shadow prices using scarcity multipliers
- Model internalization through water pricing, allocation restrictions, or tradable permits

Biodiversity Impact

Emerging frameworks (TNFD) push for biodiversity internalization:

- Identify operations in high-biodiversity areas
- Estimate ecosystem service dependencies (pollination, flood control)
- Value using replacement cost or avoided damage methods

Social Externalities

Labor practices, health impacts, and inequality effects:

- Quantify: Worker injury rates, community health outcomes
- Monetize: Using VSL, medical costs, productivity losses
- Internalization: Through liability exposure, reputation damage, regulatory mandates

Aggregation Approaches

When multiple externalities are material:

1. **Additive**: $V^E = V^E_{carbon} + V^E_{water} + V^E_{social}$ (assumes independence)

2. **Scenario-specific**: Different externalities internalize along different timelines

3. **Correlated**: Some externalities move together (e.g., coal generation impacts both carbon and local air quality)

11.11 Conclusion: From Theory to Practice

The internalization assessment framework developed in this chapter bridges the conceptual Total Value Framework with practical valuation. By systematically identifying externalities, estimating their magnitude, and modeling their financial impact under different internalization scenarios, analysts can:

- Identify mispriced transition risk in current valuations
- Stress-test portfolios against policy shifts
- Allocate capital toward firms positioned for high-ι regimes
- Engage companies on material externality reduction

As regulatory frameworks converge toward mandatory climate disclosures and rising carbon prices, internalization assessment shifts from niche sustainable finance technique to mainstream fundamental analysis. The firms and investors who master this approach early will hold a durable competitive advantage.

The journey from Chapter 1's Grand Challenges to this practical epilogue illustrates sustainable finance's evolution: from identifying externalities and market failures, through developing theoretical frameworks and transmission channels, to actionable valuation methods. The internalization parameter ι provides a unifying thread—a single metric that captures the complex dynamics of sustainability transitions and their financial implications.

The path forward is clear: sustainability is not separate from finance. It is the future of finance.

Further Reading

- **Valuation methods**: Koller, Goedhart, and Wessels (2020), *Valuation: Measuring and Managing the Value of Companies*, 7th ed.
- **Carbon pricing**: Stiglitz et al. (2017), "Report of the High-Level Commission on Carbon Prices," Carbon Pricing Leadership Coalition
- **Scenario analysis**: TCFD (2017), "Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures"
- **Social cost of carbon**: Rennert et al. (2022), "Comprehensive evidence implies a higher social cost of CO_2," *Nature*
- **Abatement costs**: McKinsey (2023), "Global Energy Perspective"

Part IV

Tufte Examples

Chapter 12
The Design of Tufte's Books

The pages of a book are usually divided into three major sections: the front matter (also called preliminary matter or prelim), the main matter (the core text of the book), and the back matter (or end matter).

The front matter of a book refers to all of the material that comes before the main text. The following table from shows a list of material that appears in the front matter of *The Visual Display of Quantitative Information*, *Envisioning Information*, *Visual Explanations*, and *Beautiful Evidence* along with its page number. Page numbers that appear in parentheses refer to folios that do not have a printed page number (but they are still counted in the page number sequence).

	Books			
Page content	*VDQI*	*EI*	*VE*	*BE*
Blank half title page	(1)	(1)	(1)	(1)
Frontispiece[1]	(2)	(2)	(2)	(2)
Full title page	(3)	(3)	(3)	(3)
Copyright page	(4)	(4)	(4)	(4)
Contents	(5)	(5)	(5)	(5)
Dedication	(6)	(7)	(7)	7
Epigraph	–	–	(8)	–
Introduction	(7)	(9)	(9)	9

[1] The contents of this page vary from book to book. In *VDQI* this page is blank; in *EI* and *VE* this page holds a frontispiece; and in *BE* this page contains three epigraphs.

The design of the front matter in Tufte's books varies slightly from the traditional design of front matter. First, the pages in front matter are traditionally numbered with lowercase roman numerals (*e.g.*, i, ii, iii, iv, . . .). Second, the front matter page numbering sequence is usually separate from the main matter page numbering. That is, the page numbers restart at 1 when the main matter begins. In contrast, Tufte has enumerated his pages with arabic numerals that share the same page counting sequence as the main matter.

There are also some variations in design across Tufte's four books. The page opposite the full title page (labeled "frontispiece" in the above table) has different content in each of the books. In *The Visual Display of Quantitative Information*, this page is blank; in *Envisioning Information* and *Visual Explanations*, this page holds a frontispiece; and in *Beautiful Evidence*, this page contains three epigraphs.

The dedication appears on page 6 in *VDQI* (opposite the introduction), and is placed on its own spread in the other books. In *VE*, an epigraph shares the spread with the opening page of the introduction.

None of the page numbers (folios) of the front matter are expressed except in *BE*, where the folios start to appear on the dedication page.

THE FULL TITLE PAGE of each of the books varies slightly in design. In all the books, the author's name appears at the top of the page, the title it set just above the center line, and the publisher is printed along the bottom margin. Some of the differences are outlined in the following table.

Feature	*VDQI*	*EI*	*VE*	*BE*
Author				
Typeface	serif	serif	serif	sans serif
Style	italics	italics	italics	upright, caps
Size	24 pt	20 pt	20 pt	20 pt
Title				
Typeface	serif	serif	serif	sans serif
Style	upright	italics	upright	upright, caps
Size	36 pt	48 pt	48 pt	36 pt
Subtitle				
Typeface	–	–	serif	–
Style	–	–	upright	–
Size	–	–	20 pt	–
Edition				
Typeface	sans serif	–	–	–
Style	upright, caps	–	–	–
Size	14 pt	–	–	–
Publisher				
Typeface	serif	serif	serif	sans serif
Style	italics	italics	italics	upright, caps
Size	14 pt	14 pt	14 pt	14 pt

THE TABLES OF CONTENTS in Tufte's books give us our first glimpse of the structure of the main matter. *The Visual Display of Quantitative Information* is split into two parts, each containing some number of chapters. His other three books only contain chapters—they're not broken into parts.

12.1 *Typefaces*

Tufte's books primarily use two typefaces: Bembo and Gill Sans. Bembo is used for the headings and body text, while Gill Sans is used for the title page and opening epigraphs in *Beautiful Evidence*.

Since neither Bembo nor Gill Sans are available in default LaTeX installations, the Tufte-LaTeX document classes default to using Palatino and Helvetica, respectively. In addition, the Bera Mono typeface is used for `monospaced` type.

The following font sizes are defined by the Tufte-LaTeX classes:

Edward R. Tufte

The Visual Display
of Quantitative Information

SECOND EDITION

Graphics Press · Cheshire, Connecticut

Edward R. Tufte

Envisioning Information

Graphics Press · Cheshire, Connecticut

Edward R. Tufte

Visual Explanations

Images and Quantities, Evidence and Narrative

Graphics Press · Cheshire, Connecticut

EDWARD R. TUFTE

BEAUTIFUL EVIDENCE

GRAPHICS PRESS LLC

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LaTeX size	Font size	Leading	Used for
`\tiny`	5	6	sidenote numbers
`\scriptsize`	7	8	–
`\footnotesize`	8	10	sidenotes, captions
`\small`	9	12	quote, quotation, and verse environments
`\normalsize`	10	14	body text
`\large`	11	15	B-heads
`\Large`	12	16	A-heads, TOC entries, author, date
`\LARGE`	14	18	handout title
`\huge`	20	30	chapter heads
`\Huge`	24	36	part titles

Table 12.1: A list of LaTeX font sizes as defined by the Tufte-LaTeX document classes.

12.2 *Headings*

Tufte's books include the following heading levels: parts, chapters,[2] sections, subsections, and paragraphs. Not defined by default are: sub-subsections and subparagraphs.

[2] Parts and chapters are defined for the `tufte-book` class only.

Heading	Style	Size
Part	roman	24/36×40 pc
Chapter	italic	20/30×40 pc
Section	italic	12/16×26 pc
Subsection	italic	11/15×26 pc
Paragraph	italic	10/14

Table 12.2: Heading styles used in *Beautiful Evidence*.

Paragraph Paragraph headings (as shown here) are introduced by italicized text and separated from the main paragraph by a bit of space.

12.3 *Environments*

The following characteristics define the various environments:

Environment	Font size	Notes
Body text	10/14×26 pc	
Block quote	9/12×24 pc	Block indent (left and right) by 1 pc
Sidenotes	8/10×12 pc	Sidenote number is set inline, followed by word space
Captions	8/10×12 pc	

Table 12.3: Environment styles used in *Beautiful Evidence*.

Chapter 13
On the Use of the **`tufte-book`** *Document Class*

The Tufte-LaTeX document classes define a style similar to the style Edward Tufte uses in his books and handouts. Tufte's style is known for its extensive use of sidenotes, tight integration of graphics with text, and well-set typography. This document aims to be at once a demonstration of the features of the Tufte-LaTeX document classes and a style guide to their use.

13.1 *Page Layout*

Headings

This style provides A- and B-heads (that is, `\section` and `\subsection`), demonstrated above.

If you need more than two levels of section headings, you'll have to define them yourself at the moment; there are no pre-defined styles for anything below a `\subsection`. As Bringhurst points out in *The Elements of Typographic Style*,[1] you should "use as many levels of headings as you need: no more, and no fewer."

[1] Robert Bringhurst. *The Elements of Typography*. 3.1. Hartley & Marks, 2005. ISBN: 0-88179-205-5

The Tufte-LaTeX classes will emit an error if you try to use `\subsubsection` and smaller headings.

In his later books,[2] Tufte starts each section with a bit of vertical space, a non-indented paragraph, and sets the first few words of the sentence in small caps. To accomplish this using this style, use the `\newthought` command:

[2] Edward R. Tufte. *Beautiful Evidence*. First. Graphics Press, LLC, May 2006. ISBN: 0-9613921-7-7

```
\newthought{In his later books}, Tufte starts...
```

13.2 Sidenotes

One of the most prominent and distinctive features of this style is the extensive use of sidenotes. There is a wide margin to provide ample room for sidenotes and small figures. Any `\footnotes` will automatically be converted to sidenotes.[3] If you'd like to place ancillary information in the margin without the sidenote mark (the superscript number), you can use the `\marginnote` command.

[3] This is a sidenote that was entered using the `\footnote` command.

This is a margin note. Notice that there isn't a number preceding the note, and there is no number in the main text where this note was written.

The specification of the `\sidenote` command is:

`\sidenote[`⟨*number*⟩`][`⟨*offset*⟩`]{`*Sidenote text.*`}`

Both the ⟨*number*⟩ and ⟨*offset*⟩ arguments are optional. If you provide a ⟨*number*⟩ argument, then that number will be used as the sidenote number. It will change of the number of the current sidenote only and will not affect the numbering sequence of subsequent sidenotes.

Sometimes a sidenote may run over the top of other text or graphics in the margin space. If this happens, you can adjust the vertical position of the sidenote by providing a dimension in the ⟨*offset*⟩ argument. Some examples of valid dimensions are:

`1.0in    2.54cm    254mm    6\baselineskip`

If the dimension is positive it will push the sidenote down the page; if the dimension is negative, it will move the sidenote up the page.

While both the ⟨*number*⟩ and ⟨*offset*⟩ arguments are optional, they must be provided in order. To adjust the vertical position of the sidenote while leaving the sidenote number alone, use the following syntax:

`\sidenote[][`⟨*offset*⟩`]{`*Sidenote text.*`}`

The empty brackets tell the `\sidenote` command to use the default sidenote number.

If you *only* want to change the sidenote number, however, you may completely omit the ⟨*offset*⟩ argument:

`\sidenote[`⟨*number*⟩`]{`*Sidenote text.*`}`

The `\marginnote` command has a similar *offset* argument:

`\marginnote[`⟨*offset*⟩`]{`*Margin note text.*`}`

13.3 *References*

References are placed alongside their citations as sidenotes, as well. This can be accomplished using the normal `\cite` command.[4]

[4] The first paragraph of this document includes a citation.

The complete list of references may also be printed automatically by using the `\bibliography` command. (See the end of this document for an example.) If you do not want to print a bibliographyn at the end of your document, use the `\nobibliography` command in its place.

To enter multiple citations at one location,[5] you can provide a list of keys separated by commas and the same optional vertical offset argument: `\cite{Tufte2006,Tufte1990}`.

[5] Edward R. Tufte. *Beautiful Evidence*. First. Graphics Press, LLC, May 2006. ISBN: 0-9613921-7-7, Edward R. Tufte. *Envisioning Information*. Cheshire, Connecticut: Graphics Press, 1990. ISBN: 0-9613921-1-8

```
\cite[⟨offset⟩]{bibkey1,bibkey2,...}
```

13.4 *Figures and Tables*

Images and graphics play an integral role in Tufte's work. In addition to the standard `figure` and `tabular` environments, this style provides special figure and table environments for full-width floats.

Full page–width figures and tables may be placed in `figure*` or `table*` environments. To place figures or tables in the margin, use the `marginfigure` or `margintable` environments as follows (see figure 13.1):

```
\begin{marginfigure}
   \includegraphics{helix}
   \caption{This is a margin figure.}
   \label{fig:marginfig}
\end{marginfigure}
```

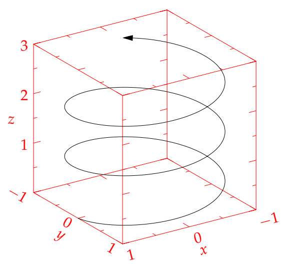

Figure 13.1: This is a margin figure. The helix is defined by $x = \cos(2\pi z)$, $y = \sin(2\pi z)$, and $z = [0, 2.7]$. The figure was drawn using Asymptote (`http://asymptote.sf.net/`).

The `marginfigure` and `margintable` environments accept an optional parameter ⟨*offset*⟩ that adjusts the vertical position of the figure or table. See the "Sidenotes" section above for examples. The specifications are:

```
\begin{marginfigure}[⟨offset⟩]
   ...
\end{marginfigure}
```

```
\begin{margintable}[⟨offset⟩]
  ...
\end{margintable}
```

Figure 13.2 is an example of the `figure*` environment and figure 13.3 is an example of the normal `figure` environment.

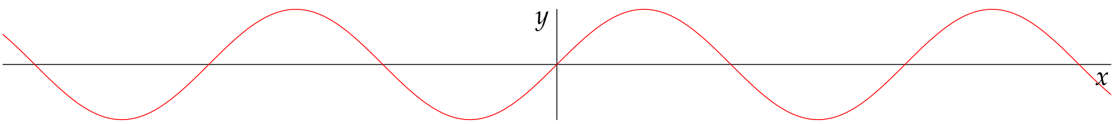

Figure 13.2: This graph shows $y = \sin x$ from about $x = [-10, 10]$. *Notice that this figure takes up the full page width.*

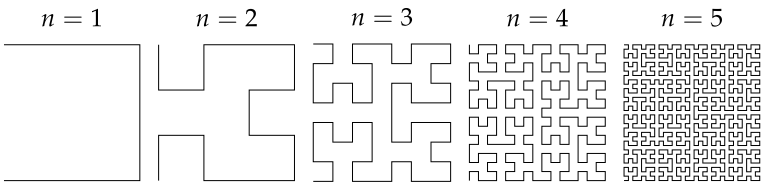

Figure 13.3: Hilbert curves of various degrees n. *Notice that this figure only takes up the main textblock width.*

As with sidenotes and marginnotes, a caption may sometimes require vertical adjustment. The `\caption` command now takes a second optional argument that enables you to do this by providing a dimension ⟨*offset*⟩. You may specify the caption in any one of the following forms:

```
\caption{long caption}
\caption[short caption]{long caption}
\caption[][⟨offset⟩]{long caption}
\caption[short caption][⟨offset⟩]{long caption}
```

A positive ⟨*offset*⟩ will push the caption down the page. The short caption, if provided, is what appears in the list of figures/tables, otherwise the "long" caption appears there. Note that although the arguments ⟨*short caption*⟩ and ⟨*offset*⟩ are both optional, they must be provided in order. Thus, to specify an ⟨*offset*⟩ without specifying a ⟨*short caption*⟩, you must include the first set of empty brackets `[]`, which tell `\caption` to use the default "long" caption. As an example, the caption to figure 13.3 above was given in the form

```
\caption[Hilbert curves...][6pt]{Hilbert curves...}
```

Table 13.1 shows table created with the `booktabs` package. Notice the lack of vertical rules—they serve only to clutter the table's data.

Margin	Length
Paper width	8 1/2 inches
Paper height	11 inches
Textblock width	6 1/2 inches
Textblock/sidenote gutter	3/8 inches
Sidenote width	2 inches

Table 13.1: Here are the dimensions of the various margins used in the Tufte-handout class.

OCCASIONALLY LaTeX will generate an error message:

```
Error: Too many unprocessed floats
```

LaTeX tries to place floats in the best position on the page. Until it's finished composing the page, however, it won't know where those positions are. If you have a lot of floats on a page (including sidenotes, margin notes, figures, tables, etc.), LaTeX may run out of "slots" to keep track of them and will generate the above error.

LaTeX initially allocates 18 slots for storing floats. To work around this limitation, the Tufte-LaTeX document classes provide a `\morefloats` command that will reserve more slots.

The first time `\morefloats` is called, it allocates an additional 34 slots. The second time `\morefloats` is called, it allocates another 26 slots.

The `\morefloats` command may only be used two times. Calling it a third time will generate an error message. (This is because we can't safely allocate many more floats or LaTeX will run out of memory.)

If, after using the `\morefloats` command twice, you continue to get the `Too many unprocessed floats` error, there are a couple things you can do.

The `\FloatBarrier` command will immediately process all the floats before typesetting more material. Since `\FloatBarrier` will start a new paragraph, you should place this command at the beginning or end of a paragraph.

The `\clearpage` command will also process the floats before continuing, but instead of starting a new paragraph, it will start a new page.

You can also try moving your floats around a bit: move a figure or table to the next page or reduce the number of sidenotes. (Each sidenote actually uses *two* slots.)

After the floats have placed, LaTeX will mark those slots as unused so they are available for the next page to be composed.

13.5 Captions

You may notice that the captions are sometimes misaligned. Due to the way LaTeX's float mechanism works, we can't know for sure where it decided to put a float. Therefore, the Tufte-LaTeX document classes provide commands to override the caption position.

Vertical alignment To override the vertical alignment, use the `\setfloatalignment` command inside the float environment. For example:

```
\begin{figure}[btp]
    \includegraphics{sinewave}
    \caption{This is an example of a sine wave.}
    \label{fig:sinewave}
    \setfloatalignment{b}% forces caption to be bottom-aligned
\end{figure}
```

The syntax of the `\setfloatalignment` command is:

`\setfloatalignment{`⟨*pos*⟩`}`

where ⟨*pos*⟩ can be either `b` for bottom-aligned captions, or `t` for top-aligned captions.

Horizontal alignment To override the horizontal alignment, use either the `\forceversofloat` or the `\forcerectofloat` command inside of the float environment. For example:

```
\begin{figure}[btp]
```

```
    \includegraphics{sinewave}
    \caption{This is an example of a sine wave.}
    \label{fig:sinewave}
    \forceversofloat% forces caption to be set to the left of the float
\end{figure}
```

The `\forceversofloat` command causes the algorithm to assume the float has been placed on a verso page—that is, a page on the left side of a two-page spread. Conversely, the `\forcerectofloat` command causes the algorithm to assume the float has been placed on a recto page—that is, a page on the right side of a two-page spread.

13.6 *Full-width text blocks*

In addition to the new float types, there is a `fullwidth` environment that stretches across the main text block and the sidenotes area.

```
\begin{fullwidth}
Lorem ipsum dolor sit amet...
\end{fullwidth}
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

13.7 *Typography*

Typefaces

If the Palatino, Helvetica, and `Bera Mono` typefaces are installed, this style will use them automatically. Otherwise, we'll fall back on the Computer Modern typefaces.

Letterspacing

This document class includes two new commands and some improvements on existing commands for letterspacing.

When setting strings of ALL CAPS or SMALL CAPS, the letterspacing—that is, the spacing between the letters—should be increased slightly.[6] The `\allcaps` command has proper letterspacing for strings of FULL CAPITAL LETTERS, and the `\smallcaps` command has letterspacing for SMALL CAPITAL LETTERS. These commands will also automatically convert the case of the text to upper- or lowercase, respectively.

[6] Robert Bringhurst. *The Elements of Typography*. 3.1. Hartley & Marks, 2005. ISBN: 0-88179-205-5, p.32

The `\textsc` command has also been redefined to include letterspacing. The case of the `\textsc` argument is left as is, however. This allows one to use both uppercase and lowercase letters: The Initial Letters Of The Words In This Sentence Are Capitalized.

13.8 Document Class Options

The `tufte-book` class is based on the LaTeX `book` document class. Therefore, you can pass any of the typical book options. There are a few options that are specific to the `tufte-book` document class, however.

The `a4paper` option will set the paper size to A4 instead of the default US letter size.

The `sfsidenotes` option will set the sidenotes and title block in a sans serif typeface instead of the default roman.

The `twoside` option will modify the running heads so that the page number is printed on the outside edge (as opposed to always printing the page number on the right-side edge in `oneside` mode).

The `symmetric` option typesets the sidenotes on the outside edge of the page. This is how books are traditionally printed, but is contrary to Tufte's book design which sets the sidenotes on the right side of the page. This option implicitly sets the `twoside` option.

The `justified` option sets all the text fully justified (flush left and right). The default is to set the text ragged right. The body text of Tufte's books are set ragged right. This prevents needless hyphenation and makes it easier to read the text in the slightly narrower column.

The `bidi` option loads the `bidi` package which is used with XƎLaTeX to typeset bi-directional text. Since the `bidi` package needs to be loaded before the sidenotes and cite commands are defined, it can't be loaded in the document preamble.

The `debug` option causes the Tufte-LaTeX classes to output debug information to the log file which is useful in troubleshooting bugs. It will also cause the graphics to be replaced by outlines.

The `nofonts` option prevents the Tufte-LaTeX classes from automatically loading the Palatino and Helvetica typefaces. You should use this option if you wish to load your own fonts. If you're using XƎLaTeX, this option is implied (*i.e.*, the Palatino and Helvetica fonts aren't loaded if you use XƎLaTeX).

The `nols` option inhibits the letterspacing code. The Tufte-LaTeX classes try to load the appropriate letterspacing package (either pdfTeX's `letterspace` package or the `soul` package). If you're using XƎLaTeX with `fontenc`, however, you should configure your own letterspacing.

The `notitlepage` option causes `\maketitle` to generate a title block instead of a title page. The `book` class defaults to a title page and the `handout` class defaults to the title block. There is an analogous `titlepage` option that forces `\maketitle` to generate a full title page instead of the title block.

The `notoc` option suppresses Tufte-LaTeX's custom table of contents (TOC) design. The current TOC design only shows unnumbered chapter titles; it doesn't show sections or subsections. The `notoc` option will revert to LaTeX's TOC design.

The `nohyper` option prevents the `hyperref` package from being loaded. The default is to load the `hyperref` package and use the `\title` and `\author` contents as metadata for the generated PDF.

Chapter 14
Customizing Tufte-LaTeX

The Tufte-LaTeX document classes are designed to closely emulate Tufte's book design by default. However, each document is different and you may encounter situations where the default settings are insufficient. This chapter explores many of the ways you can adjust the Tufte-LaTeX document classes to better fit your needs.

14.1 File Hooks

If you create many documents using the Tufte-LaTeX classes, it's easier to store your customizations in a separate file instead of copying them into the preamble of each document. The Tufte-LaTeX classes provide three file hooks: `tufte-common-local.tex`, `tufte-book-local.tex`, and `tufte-handout-local.tex`.

`tufte-common-local.tex` If this file exists, it will be loaded by all of the Tufte-LaTeX document classes just prior to any document-class-specific code. If your customizations or code should be included in both the book and handout classes, use this file hook.

`tufte-book-local.tex` If this file exists, it will be loaded after all of the common and book-specific code has been read. If your customizations apply only to the book class, use this file hook.

`tufte-common-handout.tex` If this file exists, it will be loaded

after all of the common and handout-specific code has been read. If your customizations apply only to the handout class, use this file hook.

14.2 Numbered Section Headings

While Tufte dispenses with numbered headings in his books, if you require them, they can be anabled by changing the value of the `secnumdepth` counter. From the table below, select the heading level at which numbering should stop and set the `secnumdepth` counter to that value. For example, if you want parts and chapters numbered, but don't want numbering for sections or subsections, use the command:

```
\setcounter{secnumdepth}{0}
```

The default `secnumdepth` for the Tufte-LaTeX document classes is -1.

Heading level	Value
Part (in `tufte-book`)	-1
Part (in `tufte-handout`)	0
Chapter (only in `tufte-book`)	0
Section	1
Subsection	2
Subsubsection	3
Paragraph	4
Subparagraph	5

Table 14.1: Heading levels used with the `secnumdepth` counter.

14.3 Changing the Paper Size

The Tufte-LaTeX classes currently only provide three paper sizes: A4, B5, and US letter. To specify a different paper size (and/or margins), use the `\geometrysetup` command in the preamble of your document (or one of the file hooks). The full documentation of the `\geometrysetup` command may be found in the `geometry` package documentation.[1]

[1] Hideo Umeki. *The `geometry` package*. `http://ctan.org/pkg/geometry`. Dec. 2008, p.33

14.4 *Customizing Marginal Material*

Marginal material includes sidenotes, citations, margin notes, and captions. Normally, the justification of the marginal material follows the justification of the body text. If you specify the `justified` document class option, all of the margin material will be fully justified as well. If you don't specify the `justified` option, then the marginal material will be set ragged right.

You can set the justification of the marginal material separately from the body text using the following document class options: `sidenote`, `marginnote`, `caption`, `citation`, and `marginals`. Each option refers to its obviously corresponding marginal material type. The `marginals` option simultaneously sets the justification on all four marginal material types.

Each of the document class options takes one of five justification types:

`justified` Fully justifies the text (sets it flush left and right).

`raggedleft` Sets the text ragged left, regardless of which page it falls on.

`raggedright` Sets the text ragged right, regardless of which page it falls on.

`raggedouter` Sets the text ragged left if it falls on the left-hand (verso) page of the spread and otherwise sets it ragged right. This is useful in conjunction with the `symmetric` document class option.

`auto` If the `justified` document class option was specified, then set the text fully justified; otherwise the text is set ragged right. This is the default justification option if one is not explicitly specified.

For example,

```
\documentclass[symmetric,justified,marginals=raggedouter]{tufte-book}
```

will set the body text of the document to be fully justified and all of the margin material (sidenotes, margin notes, captions, and citations) to be flush against the body text with ragged outer edges.

THE FONT AND STYLE of the marginal material may also be modified using the following commands:

```
\setsidenotefont{⟨font commands⟩}
\setcaptionfont{⟨font commands⟩}
\setmarginnotefont{⟨font commands⟩}
\setcitationfont{⟨font commands⟩}
```

The `\setsidenotefont` sets the font and style for sidenotes, the `\setcaptionfont` for captions, the `\setmarginnotefont` for margin notes, and the `\setcitationfont` for citations. The ⟨*font commands*⟩ can contain font size changes (e.g., `\footnotesize`, `\Huge`, etc.), font style changes (e.g., `\sffamily`, `\ttfamily`, `\itshape`, etc.), color changes (e.g., `\color{blue}`), and many other adjustments.

If, for example, you wanted the captions to be set in italic sans serif, you could use:

```
\setcaptionfont{\itshape\sffamily}
```

Chapter 15
Compatibility Issues

When switching an existing document from one document class to a Tufte-LaTeX document class, a few changes to the document may have to be made.

15.1 *Converting from `article` to `tufte-handout`*

The following `article` class options are unsupported: `10pt`, `11pt`, `12pt`, `a5paper`, `b5paper`, `executivepaper`, `legalpaper`, `landscape`, `onecolumn`, and `twocolumn`.

The following headings are not supported: `\subsubsection` and `\subparagraph`.

15.2 *Converting from `book` to `tufte-book`*

The following `report` class options are unsupported: `10pt`, `11pt`, `12pt`, `a5paper`, `b5paper`, `executivepaper`, `legalpaper`, `landscape`, `onecolumn`, and `twocolumn`.

The following headings are not supported: `\subsubsection` and `\subparagraph`.

Chapter 16
Troubleshooting and Support

16.1 Tufte-LaTeX Website

The website for the Tufte-LaTeX packages is located at `http://code.google.com/p/tufte-latex/`. On our website, you'll find links to our SVN repository, mailing lists, bug tracker, and documentation.

16.2 Tufte-LaTeX Mailing Lists

There are two mailing lists for the Tufte-LaTeX project:

Discussion list The `tufte-latex` discussion list is for asking questions, getting assistance with problems, and help with troubleshooting. Release announcements are also posted to this list. You can subscribe to the `tufte-latex` discussion list at `http://groups.google.com/group/tufte-latex`.

Commits list The `tufte-latex-commits` list is a read-only mailing list. A message is sent to the list any time the Tufte-LaTeX code has been updated. If you'd like to keep up with the latest code developments, you may subscribe to this list. You can subscribe to the `tufte-latex-commits` mailing list at `http://groups.google.com/group/tufte-latex-commits`.

16.3 Getting Help

If you've encountered a problem with one of the Tufte-LaTeX document classes, have a question, or would like to report a bug, please send an email to our mailing list or visit our website.

To help us troubleshoot the problem more quickly, please try to compile your document using the `debug` class option and send the generated `.log` file to the mailing list with a brief description of the problem.

16.4 Errors, Warnings, and Informational Messages

The following is a list of all of the errors, warnings, and other messages generated by the Tufte-LaTeX classes and a brief description of their meanings.

```
Error:  \subparagraph is undefined by this class.
```

The `\subparagraph` command is not defined in the Tufte-LaTeX document classes. If you'd like to use the `\subparagraph` command, you'll need to redefine it yourself. See the "Headings" section on page 249 for a description of the heading styles availaboe in the Tufte-LaTeX document classes.

```
Error:  \subsubsection is undefined by this class.
```

The `\subsubsection` command is not defined in the Tufte-LaTeX document classes. If you'd like to use the `\subsubsection` command, you'll need to redefine it yourself. See the "Headings" section on page 249 for a description of the heading styles availaboe in the Tufte-LaTeX document classes.

```
Error:  You may only call \morefloats twice.  See the
        Tufte-LaTeX documentation for other workarounds.
```

LaTeX allocates 18 slots for storing floats. The first time `\morefloats` is called, it allocates an additional 34 slots. The second time `\morefloats` is called, it allocates another 26 slots.

The `\morefloats` command may only be called two times. Calling it a third time will generate this error message. See page 253 for more information.

`Warning: Option '`⟨*class option*⟩`' is not supported -- ignoring option.`

This warning appears when you've tried to use ⟨*class option*⟩ with a Tufte-LaTeX document class, but ⟨*class option*⟩ isn't supported by the Tufte-LaTeX document class. In this situation, ⟨*class option*⟩ is ignored.

`Info: The 'symmetric' option implies 'twoside'`

You specified the `symmetric` document class option. This option automatically forces the `twoside` option as well. See page 256 for more information on the `symmetric` class option.

16.5 *Package Dependencies*

The following is a list of packages that the Tufte-LaTeX document classes rely upon. Packages marked with an asterisk are optional.

- xifthen
- ifpdf*
- ifxetex*
- hyperref
- geometry
- ragged2e
- chngpage *or* changepage
- paralist
- textcase
- soul*
- letterspace*
- setspace
- natbib *and* bibentry
- optparams
- placeins
- mathpazo*
- helvet*
- fontenc
- beramono*
- fancyhdr
- xcolor
- textcomp
- titlesec
- titletoc

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