LUCAS CHEDID CIDIN SPERIDIÃO

FINANCIAL MATERIALITY OF FOREST-RISK COMMODITIES AND THE COST OF EQUITY: A BRAZILIAN SUPPLY CHAIN PERSPECTIVE

São Paulo
2024

LUCAS CHEDID CIDIN SPERIDIÃO

FINANCIAL MATERIALITY OF FOREST-RISK COMMODITIES AND THE COST OF EQUITY: A BRAZILIAN SUPPLY CHAIN PERSPECTIVE

Graduation work presented at Escola Politécnica da Universidade de São Paulo for the accomplishment of the *Diploma de Engenharia de Produção*.

São Paulo
2024

LUCAS CHEDID CIDIN SPERIDIÃO

FINANCIAL MATERIALITY OF FOREST-RISK COMMODITIES AND THE COST OF EQUITY: A BRAZILIAN SUPPLY CHAIN PERSPECTIVE

Graduation work presented at Escola Politécnica da Universidade de São Paulo for the accomplishment of the *Diploma de Engenharia de Produção*.

Advisor:

Professor João Amato Neto

São Paulo
2024

Catalogação-na-publicação

Speridião, Lucas
FINANCIAL MATERIALITY OF FOREST-RISK COMMODITIES AND THE COST OF EQUITY: A BRAZILIAN SUPPLY CHAIN PERSPECTIVE / L. Speridião -- São Paulo, 2024.
113 p.

Trabalho de Formatura - Escola Politécnica da Universidade de São Paulo. Departamento de Engenharia de Produção.

1.Commodities de risco florestal 2.Custo de capital próprio 3.ESG 4.Gestão da cadeia de suprimentos 5.Sustentabilidade corporativa I.Universidade de São Paulo. Escola Politécnica. Departamento de Engenharia de Produção II.t.

Dedico esse trabalho à minha família, que sempre confiou e torceu pelo meu sucesso. Amo vocês!

ACKNOWLEDGMENTS

Dizem que a POLI é a escola da nossa vida... e realmente muito do que acontece hoje para mim na minha vida é devido ao que eu pude recolher de experiências lá. Experiências essas que envolveram diversos dos meus melhores amigos de hoje em dia, em que corríamos contra o tempo para aprender tudo para uma prova; que conversávamos rapidamente para preparar uma apresentação; que nos reuníamos antes de festas na casa deles; que viajávamos na Europa curtindo o intercâmbio e aproveitávamos para nos ver; que dávamos risada ao lembrar de fatos acontecidos nos primeiros anos de faculdade, que éramos mais imaturos, curiosos com o que aprenderíamos, mas que percebemos a sorte que tivemos de nos encontrar e passar todos esses anos juntos. Agradeço por tê-los comigo durante essa jornada chamada Escola Politécnica. Com vocês realmente ficou muito mais fácil de fazer matérias difíceis, apresentações em pouco tempo, trabalhos árduos e momentos difíceis. Agora com cada um indo para um caminho, percebemos ainda mais como foi bom aproveitar a melhor faculdade de engenharia do país juntos.

Agradeço também a minha família, que me apoiou sempre e confiaram que seria possível eu viver tudo isso.

Agradeço aos professores, que me ensinaram o que puderam.

Agradeço, por fim, ao Professor João Amato Neto, meu orientador, que sempre muito solícito e sábio, me ajudou a concluir este trabalho.

"When the last tree has been cut down, the last fish caught, the last river poisoned, only then will we realise that one cannot eat money"

-- Indigenous proverb

ABSTRACT

Despite increasing global awareness of the environmental impacts of deforestation, the issue remains significant, particularly in Brazil's forest-risk commodity (FRC) sector. Companies reliant on commodities like soy, beef, and palm oil contribute substantially to deforestation, yet they often face limited accountability from investors and minimal pressure from consumers. This study investigates the financial materiality of FRC exposure and its effect on the cost of equity, specifically examining whether companies dependent on deforestation-linked commodities are perceived as higher-risk by investors. Drawing on theoretical frameworks such as Signaling, Stakeholder, Agency, and Legitimacy Theories, this research adopts a mixed-methods approach, combining quantitative analysis through linear regression with qualitative insights from interviews with industry stakeholders. Quantitative data sources include Forest IQ, which monitors corporate exposure to deforestation, and Refinitiv Eikon, providing financial, control, and ESG metrics. While the financial materiality of FRCs demonstrated positive significance in one model, its impact varied across others, highlighting the complex nature of assessing deforestation-related financial risks. The qualitative analysis revealed that both companies and investors recognize significant challenges arising from the lack of effective tracking systems, certifications for medium and small suppliers, and standardized deforestation metrics within ESG disclosures. These limitations complicate accountability, allowing unsustainable practices to continue unchecked, especially in complex supply chains reliant on forest-risk commodities. The study's findings emphasize that company size, tenure, and implementation costs impact the application of mitigation strategies, with certifications, commitment to deforestation-free supply chains, and transparency in ESG reporting identified as the most effective practices for mitigating financial risks. This research provides practical recommendations to promote accountability, encourage responsible practices, and support efforts to reduce deforestation in high-impact sectors, addressing the need to align corporate operations with sustainability goals.

Keywords – forest-risk commodities; cost of equity; ESG; deforestation; investor perceptions; supply chain management; corporate sustainability; environmental risk.

RESUMO

Apesar da crescente conscientização global sobre os impactos ambientais do desmatamento, o problema permanece significativo, especialmente no setor de commodities de risco florestal (CRF) no Brasil. Empresas que dependem de commodities como soja, carne bovina e óleo de palma contribuem substancialmente para o desmatamento, mas muitas vezes enfrentam pouca responsabilização por parte dos investidores e pouca pressão dos consumidores. Este estudo investiga a materialidade financeira da exposição a CRFs e seu efeito sobre o custo de capital próprio, examinando especificamente se empresas dependentes de commodities associadas ao desmatamento são percebidas como mais arriscadas pelos investidores. Com base em quadros teóricos como as Teorias de Sinalização, Stakeholders, Agência e Legitimidade, esta pesquisa adota uma abordagem de métodos mistos, combinando análise quantitativa via regressão linear com insights qualitativos de entrevistas com partes interessadas do setor. As fontes de dados quantitativos incluem o Forest IQ, que monitora a exposição corporativa ao desmatamento, e o Refinitiv Eikon, que fornece métricas financeiras, de controle e de ESG. Embora a materialidade financeira das CRFs tenha mostrado significância positiva em um modelo, seu impacto variou em outros, destacando a complexidade de avaliar riscos financeiros associados ao desmatamento. A parte qualitativa revelou que tanto empresas quanto investidores reconhecem desafios significativos decorrentes da falta de sistemas de rastreamento eficazes, certificações para fornecedores de médio e pequeno porte e de métricas padronizadas de desmatamento nas divulgações ESG. Essas limitações complicam a responsabilização, permitindo que práticas insustentáveis continuem sem controle, especialmente em cadeias de suprimentos complexas que dependem de commodities de risco florestal. Os resultados do estudo ressaltam que o tamanho, tempo da empresa e custo de implementação impactam na aplicação das estratégias de mitigação, sendo certificações, comprometimento com cadeias de suprimento livre de desmatamento e transparência no reporte ESG as práticas mais eficazes para mitigar riscos financeiros. Essa pesquisa oferece recomendações práticas para promover a responsabilidade, incentivar práticas responsáveis e apoiar esforços para reduzir o desmatamento em setores de alto impacto, abordando a necessidade de alinhar as operações corporativas com os objetivos de sustentabilidade.

Palavras-Chave – commodities de risco florestal; custo de capital próprio; ESG; desmatamento; percepções dos investidores; gestão da cadeia de suprimentos; sustentabilidade corporativa; risco ambiental.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

CAPM	*Capital Asset Pricing Model*
CER	*Corporate Environmental Responsibility*
COE	*Cost of Equity*
CSR	*Corporate Social Responsibility*
ESG	*Environmental, Social, and Governance*
FRC	*Forest-Risk Commodity*
GHG	*Greenhouse Gas*
INPE	*National Institute for Space Research*
MCDM	*Multi-Criteria Decision-Making*
REDD+	*Reducing Emissions from Deforestation and Forest Degradation*
CSR	*Corporate Social Responsibility*
SDGs	*Sustainable Development Goals*
VIF	*Variance Inflation Factor*

CONTENTS

1 INTRODUCTION

1.1 Deforestation, ESG and SDGs

In recent years, ESG (Environmental, Social, and Governance) factors have emerged as important considerations not only when strategic planning and business frameworks are developed but also during portfolio management by investors worldwide. Moreover, ESG criteria in the financial world and in decision making processes is not anymore a niche concern but it can be seen as an essential approach that reflects a broader view towards sustainable development and responsible investing. As it can also be viewed as a move because of regulatory pressures, this trend shows also a growing recognition of the positive long-term impact of sustainable practices in financial performance (WHELAN et al., 2021).

The Agenda 2030 by the United Nations and the 17 Sustainable Development Goals (SDGs) emphasize the global attention and commitment to sustainable development, and among the goals, some more specific targets that are closely related to environmental sustainability, such as the Goal 15 – Life on Land, that the Global Goals describe as "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" and the Goal 13 - Climate Action, being related to "Take urgent action to combat climate change and its impacts", both calling for the protection, preservation, restoration and a more sustainable use of terrestrial ecosystems, as showed in the Figure 1:

Figure 1: The 17 Sustainable Development Goals

Source: United Nations website (2024)

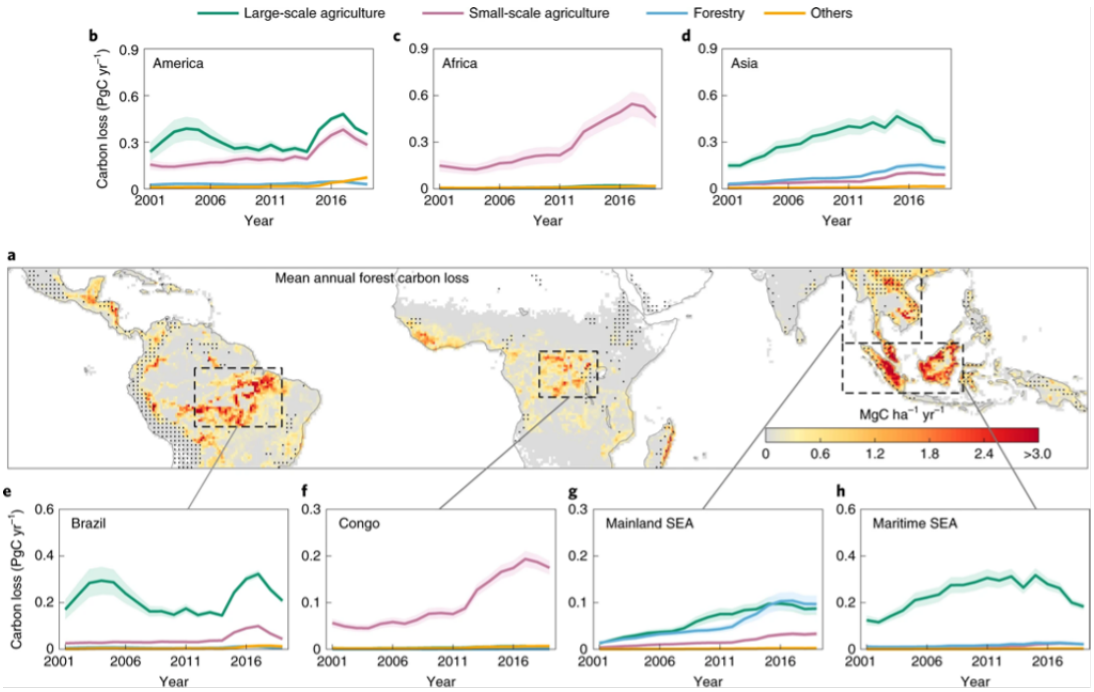
Additionally, other relevant intergovernmental organizations, like the European Union, put focus in this topic, for instance, in the "New EU Forest Strategy for 2030" released in July 2021. This document also aligns with that objective, showing that afforestation, forest management, and reforestation are also essential to combat climate change and biodiversity losses, and tries to find possible ways to shrink this environmental issue.

In this context, it is clear that forests are essential in maintaining a balance in ecological terms, being an important factor in carbon sinks, preserving biodiversity, and also supporting millions of live hoods. Forests cover almost a third of the world's area, and are classified differently depending on the geographical location, climate, and vegetation. Among the most important ones is the tropical rainforest, located near the equator, having a wide range of different species and capturing a lot of carbon in the atmosphere, but highly threatened by deforestation. Also, temperate forests, in regions with different seasons, helping in climate regulation; boreal forests, also known as taiga, covering parts of the North hemisphere, and mangrove forests close to the coastlines are vital for marine biodiversity.

Nevertheless, cases of deforestation persist across the globe, because of the expansion

of agriculture, logging, infrastructure development, forest-risk commodities (FRCs), which are agricultural and extractive commodities — such as soy, beef, palm oil, and timber — that are significant drivers of deforestation, particularly in tropical regions like the Amazon, and other activities that threat those benefits and provoke far reaching economic and social implications, as reiterated by the global frameworks and regulations proposed as presented before. There is an urgency of addressing deforestation, as the Food and Agriculture Organization of the Nations (2015) estimated that the world loses almost 10 million hectares of forest each year, an area roughly one third the size of Italy. Moreover, deforestation has a great impact not only in climate change, and accounts for nearly 20% of global greenhouse gas emissions (Global Forest Watch, 2022), being relevant for carbon loss. Figure 2 shows the regional carbon loss during the last 2 centuries:

Figure 2: Regional Carbon Loss from Deforestation



Source: Nature Communications (2022)

As we can see, the primary driver of forest carbon loss across tropical regions is the conversion to agricultural land, with some regional variations. In tropical America, large-scale commodity agriculture, particularly in Brazil, dominates, though small-scale agriculture is increasingly significant. Brazil has the highest annual forest carbon loss globally. In tropical Africa, small-scale agriculture drives significant forest carbon loss, especially in the Congo rainforest. Moreover, in tropical Asia, agricultural expansion, including plantation rubber and oil-palm, is the major driver, with Indonesia and Malaysia leading in forest carbon loss (YU; ZENG; SEARCHINGER, 2022). Deforestation has negative

impacts in climate change, but also for the decrease in biodiversity, as forests are home for almost all species of animals and plants. Additionally, deforestation strongly impacts societies, as many indigenous communities still rely just on forests for their livelihoods.

Besides that, it is possible to say that companies involved in or linked to deforestation, for instance those relying on commodities drivers of deforestation, which generates 40% of deforestation globally (HOSONUMA; OUTROS, 2012), can be facing both direct and indirect risks. Direct risks include regulatory penalties, litigation and greater operational costs. Indirectly, another risk is the reputational risk, that can change brand loyalty and consumer trust, also being seeing negatively on the media, influencing the choice of buying more products from brands with strong sustainability credentials. As a further matter, there is an increasing trend among investors to prioritize companies with high Environmental, Social, and Governance (ESG) scores.

The environmental aspect of ESG is influenced by some practices and policies, such as carbon emissions, use of resources, waste management, and involvement with deforestation—a critical issue affecting not only ecological balance but also corporate accountability and investor confidence. Thus, addressing deforestation is essential for companies trying to improve or maintain high ESG scores, which can be achieved through sustainable practices, transparency, and securing environmental certifications. Regarding deforestation, international mechanisms like REDD+ (Reducing Emissions from Deforestation and Forest Degradation) were developed to incentivize countries to reduce emissions coming from deforestation with financial support. Also, the growing market of carbon credits, as McKinsey estimates a market of $50 billion by the end of 2030, allowing companies to invest in projects related to forest conservation, highlight the increase integration of environmental view into corporate strategies, being a possible way for companies to demonstrate commitment to sustainability, with an improvement in their ESG scores and a decrease in perceived risks.

As we see recent changes in regulatory and market developments, there is not only an urgency to address forest-related issues, but also to intensify the creation of measures against it. In this context, there have been some notable legislative progressions, for example the European Parliament's approval of the EU's Nature Restoration Law, which commands that member states need to restore at least 20% of their terrestrial and marine areas by 2030, despite some political resistance. Additionally, the European Central Bank has identified nature loss as one of their critical focus areas for the next two years, so also reflecting a shift in policy priorities, which may impact financial markets significantly. Likewise, now on the market front, nature-related funds have shown substantial

growth, such as biodiversity-labelled funds reaching about $1.4 billion in assets by the end of 2023, which represents an increase from $984 million at the end of 2022 (Environmental Finance). All these trends stress a change towards investments that explicitly consider ecological impacts, signaling a broader financial sector response to environmental concerns.

Concurrently, some theories - agency theory, legitimacy theory, stakeholder theory, and others - may help to explain why companies have different positions related to deforestation, especially when we see some action and policies being taken or not, because usually shareholders aim for long-term sustainability gains, while managers might prioritize short-term financial benefits, potentially at the cost of environmental integrity. This misalignment, together with not environmentally adequate practices that possibly generate more uncertainties for the companies, can lead investors to perceive higher risks, and so they may demand greater returns on their investments, which may instigate changes in the cost of equity of a company.

1.2 Investors and ESG

With the growing trend of ESG and more acknowledgment of its importance nowadays, many investors start shifting from only a financial perspective, but also including ESG overall performance to analyze companies they are investing. Cote (2022) for the Harvard Business School Insights, suggests an approach that would look for these 7 criteria when building a portfolio with ESG factors being considered:

1. **Negative Screening**: This strategy involves excluding specific companies or sectors from a portfolio based on predefined criteria, such as excluding fossil fuel companies to reduce climate impact.

2. **Positive Screening**: Opposite to negative screening, this method selects top performing companies within an industry based on specific performance measures, like the lowest carbon footprint or most diverse boards.

3. **Portfolio Tilt**: Investors increase the proportion of ESG investments in their portfolio while maintaining sector weights to match a target index, balancing ESG goals with a low-risk investment approach.

4. **ESG Integration**: This involves embedding ESG considerations into a firm's existing investment process without specific exclusion or inclusion criteria, positioning

companies with high ESG ratings as opportunities to enhance returns.

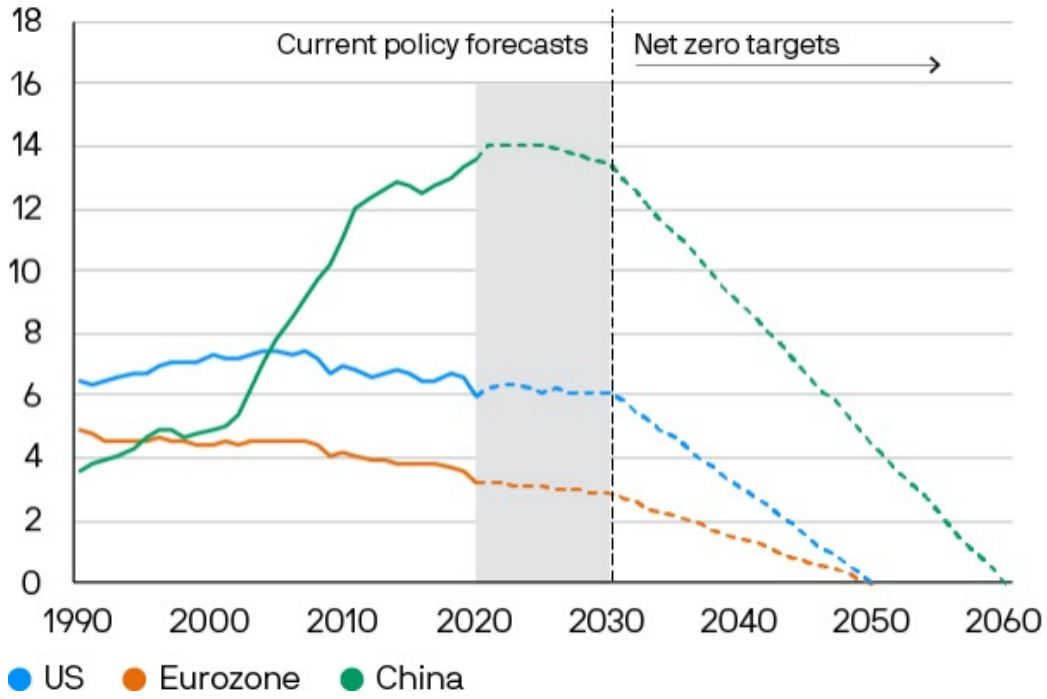
5. **Shareholder Action**: Investors use their influence to encourage companies to pursue ESG opportunities, viewing ESG attention as linked to business resilience and financial performance.

6. **Activist Investing**: Investors buy equity in a company to influence its operations and push for ESG initiatives, aiming to realize returns when the company's new ESG strategies succeed.

7. **Sustainability-Themed Investing**: This strategy focuses on investing in companies that address specific sustainability issues, such as waste management, by creating an index of companies excelling in that area.

Another factor that reflected the importance of ESG in investing, was the Paris Agreement, assigned in 2016 with the objective of limiting global warming, since 70 countries represent 75% of global greenhouse gas emissions (JP Morgan, 2022), incentivising striving targets over the next years. The Figure 3 exhibit in the US, Europe and China levels of emissions:

Figure 3: Greenhouse gas emissions and targets

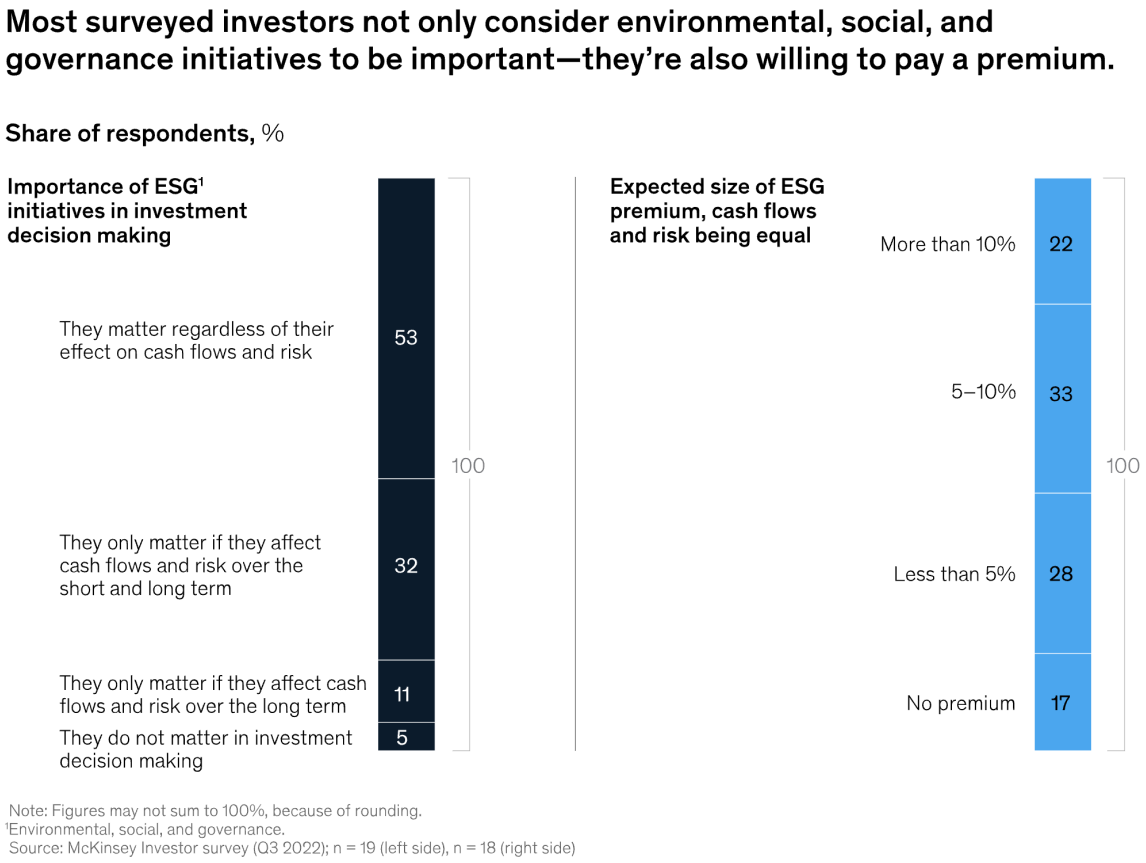


Source: Climate Action Tracker (2020)

Thus, policy modifications will be required, for example new spending on initiatives that are climate-friendly, with possible additional regulations and taxes. In this context,

ESG integration is a basic element related to the incorporation of financially significant ESG factors as extra inputs to investment decision-making, evaluating now ESG issues, such as climate risk, natural resource usage, etc. Additionally, research of McKinsey shows that currently investors care about ESG even if it is not correlated with the financial flows (Figure 4):

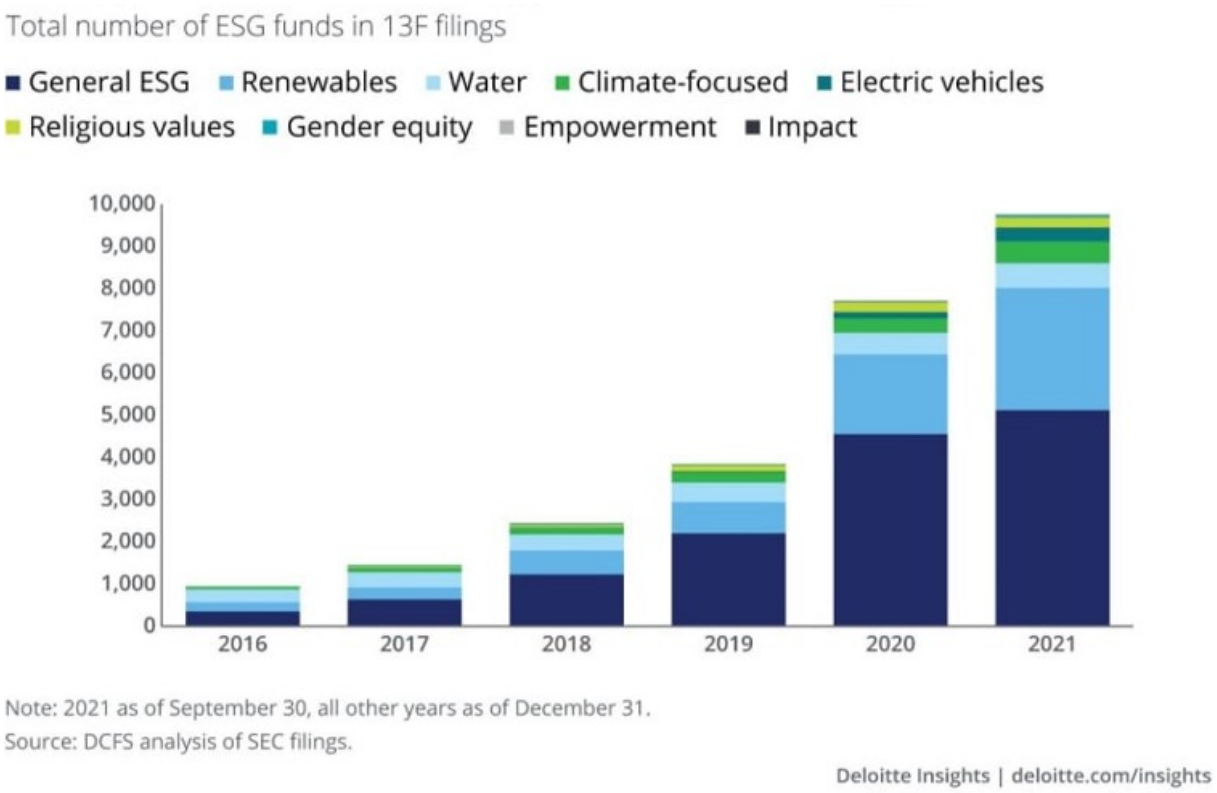
Figure 4: Importance of ESG in investing



Source: McKinsey Investor Survey (2022)

Nevertheless, the importance of ESG in investing is also seen in the ESG-aligned funds, that have seen major growth across all the 13F filings since 2016, especially Climatefocused ones, which indicates that investments that contribute with environmental sustainability are becoming more important, suggesting a strategic change towards a transition to a low-carbon economy, as it can be seen in Figure 5:

Figure 5: ESG-aligned funds



Source: DCFS analysis of SEC filings (2021)

1.3 Research Problem, Objectives and Relevance

1.3.1 The Research Problem

Despite a global awareness of the harmful environmental impacts of deforestation, this issue still persists, especially in Brazil's forest-risk commodity sector and companies that depend on this type of product. These companies often operate in ways that can contribute to forest degradation, yet they are not consistently held accountable by investors or even pressured by customers regarding these practices. One of the challenge is connected with the limited transparency and effectiveness of tracking systems for FRCs in supply chains, making it difficult to integrate the deforestation metrics into a standard ESG evaluations.

In Brazil, both the lack of standardized reporting frameworks and clear measurement patterns related to deforestation contributes to this problem, resulting in low visibility of the environmental risks associated with FRCs in ESG disclosures. As one possible consequence, companies continue to execute unsustainable practices without significant

pressure to change, leading to more deforestation and threatening the environment.

1.3.2 Objectives of the Study

This study has three main objectives:

1. To understand the relationship between the forest-risk commodities (FRCs) and the cost of equity, along with other key financial and environmental variables, so we can assess how exposure to deforestation risks influences financial performance and risk perception from investors;

2. To analyze how investors have the perception of risk about FRCs and what are the challenges of tracking supply chains and reporting of deforestation, which might be impacted within the ESG frameworks, allowing the unsustainable practices to continue;

3. To propose specific measures that companies and investors can adopt to increase accountability and improve tracking systems in their supply chains.

Finally, based on these insights and considering the FRCs sector and companies that depend highly on them, this study will try to propose actions that aim to give a more responsible and sustainable approach, which can help to diminish deforestation and mitigate its associated financial and environmental risks.

1.3.3 Significance and Relevance

This research have its relevance both academically and practically, because it addresses a gap in sustainable finance and production engineering, with focus on the critical need to enhance the transparency and accountability in the forest-risk commodity sector. This study can give us insights of how sustainable practices, or the lack of it, can impact the production processes and supply chain management within these high-risk industries. In the field of Production Engineering, understanding the impact of FRCs and the integration of deforestation metrics into ESG evaluations is essential to achieve better decision-making processes regarding resource allocation, supplier selection, and risk mitigation strategies in supply chains.

On the other hand, academically, this study can contribute to the field since it presents new studies about how on ESG measures there are a lack of impact of FRCs and in-

sufficient tracking systems which enable unsustainable practices, going through the intersection of environmental risk, financial performance, and supply chain management. Moreover, this research have as an objective to provide outputs and recommendations for investors, companies and production engineers, supporting the development of responsible practices that help to align corporate behavior with environmental and financial sustainability goals when designing and implementing more transparent and sustainable supply chains. In addition, this analysis is important for the understanding of the broader implications of environmental sustainability, more specifically the dependence on FRCs on investment decisions in the context of increasing global emphasis on responsible business practices. Ultimately, it emphasizes the importance of production engineering in helping to mitigate deforestation and creating supply chains that are both efficient and ecologically responsible, contributing to a more sustainable economy.

1.4 Research Structure

To provide a more complete and comprehensive understanding of this topic, this study is structured in 7 chapters (considering this Introduction as the first one):

- **Chapter 2 - Literature Review**: This chapter presents a review of recent research on deforestation, ESG factors, and their impacts on financial performance. The literature provides a basis for understanding the broader topic and the current gaps, establishing so the foundational context for this study.
- **Chapter 3 - Theoretical Framework and Hypothesis Development**: Here, the theoretical framework underlying the research is detailed, covering key concepts like the Signaling Theory, Stakeholder Theory, and other relevant theories that lead to the hypothesis. This chapter lays out the rationale and assumptions that shape the study's hypothesis.
- **Chapter 4 - Methodology**: This chapter describes the data sources, collection methods, and analytical approach employed in the study. It helps to explain how data on deforestation exposure and financial performance metrics were gathered and prepared, and details of the methodology used.
- **Chapter 5 - Analysis**: In this chapter, both quantitative and qualitative analyses are presented. Quantitative analysis includes the statistical findings on the relationship between deforestation metrics and financial variables, while qualitative insights

offer perspectives from investment firms and companies regarding deforestation risk and supply chain management.

- **Chapter 6 - Findings**: This chapter discusses the findings within a broader context, to evaluate potential solutions.
- **Chapter 7 - Conclusion and Future Research**: The final chapter synthesizes the main findings, highlighting the contributions of this study to the fields of finance, environmental sustainability, and production engineering. It also provides practical recommendations for investors, companies, and policymakers, and suggests avenues for future research.

Through this structure, this study aims to clarify the links between ESG practices, deforestation, and financial performance, contributing with insights for both academia and industry stakeholders, with a Brazilian supply chain perspective to complement the research started at Politecnico di Milano by Speridião (2024).

2 STATE-OF-THE-ART

In the State-of-the-art chapter, a detailed overview of the existing literature on environmental issues and deforestation impact on the cost of equity is presented, after a thorough search on Science Direct, Google Scholar, and Scopus. This literature review is a relevant component in developing a picture of the recent state of the art. Moreover, to provide a solid foundation for our understanding of the previously mentioned relationship, the analysis begins with an in-depth look of the literature on environmental risk factors and their financial implications. This research intends to highlight the established concepts in environmental economics and finance, allowing for a deeper comprehension of the financial consequences of deforestation. To acquire an exhaustive understanding of this issue, it is first necessary to dive deeper into the risks of environmental issues companies can be exposed to and risks perceived by investors, also having an overview of some case studies, as well as going further in the literature review related to forests-related issues. The basis of this knowledge is crucial to understand the more specific impacts caused by the companies' relation FRCs from a financial view. After it, it will be possible to delve deeper into the complexity of how deforestation can affect investor behaviour, since with this analysis we can amplify the understanding of the relationship between environmental deterioration and business financial measures. Also, a detailed study of challenges for tracking supply chains, methods for monitoring supply chains and policies in Brazil. Furthermore, it makes it easier to later apply the quantitative and qualitative analysis and comprehend the methods and results.

2.1 Literature Review: ESG Performance and Cost of Equity

This section provides an analysis of the most recent research in the field of ESG performance, with a focus on Environmental, and the cost of equity. The aim is to go through the literature and investigate discoveries and underlying theories that help

us understand how Environmental factors may affect a company financial measures and perceived risks. Additionally, the drivers of ESG scores, along with an explanation of what is included in the E pillar of ESG, a theoretical foundation of Signaling Theory, Stakeholder Theory, and Agency Theory, Legitimacy Theory and the meaning of the cost of equity will be presented. Real-life case studies that integrate all these topics will also be discussed to understand possible relations between the environmental issues and/or policies and variations of the cost of equity.

2.1.1 ESG and the E Pillar

Environment, Social, and Governance (ESG) performance emerged as an important concept for corporate finance and investing. Even though the framework was first developed by the United Nations Global Compact in the 2000s to the urge businesses to adopt sustainable and socially responsible practices, these themes had already been discussed since the 1970s. One contribution is from the Club of Rome's report to MIT, "The Limits to Growth", which emphasized that the growth in a finite environment. After that, in 1987, the report "Our Common Future", by the World Commission on Environment and Development of the United Nations, tried to synthesize the concept of sustainable development, aligning closely with the concepts of ESG. The Principles for Responsible Investment (PRI), in 2006, set ESG drivers when they were launched by the UNEP Finance Initiative. This framework originally provided six principles stimulating investors to include ESG criteria into their investment analysis. The ESG framework contains three components, each one addressing a distinct aspect:

- **Environmental (E)**: This component can assess a company's impacts on natural environment, from actions such as climate change mitigation, resource conservation, waste management, pollution control and deforestation. The evaluation includes policies, practices and performance.

- **Social (S)**: This examines how a company can manage relationships with its employees, suppliers, customers and communities. Key issues may include labor practices, human rights, diversity and inclusion. This factor can be assessed, for example, through the company's contribution to society, generation of jobs, and ethical contacts with its employees.

- **Governance (G)**: This last component focuses on internal practices and policies related to governance, which can go from board composition, executive compensation, transparency, shareholders right, to anti-corruption measures.

Many studies on ESG share a similar theoretical foundation and demonstrate how ESG principles are closely related to the concept of Corporate Social Responsibility (CSR). Also, the COVID-19 pandemic and the intensification of climate change have further emphasized the importance of the ESG agenda. These events have augmented the need for improved corporate management, also highlighting the importance of sustainability and responsible business practices (IRIGARAY; STOCKER, 2022).

As suggested by Romero (2021), there is a direct and positive link of ESG practices and the 2030 Agenda, as discussed in the introduction, a global framework to be adopted by all United Nations Member States, consisting in 17 Sustainable Development Goals (SDGs), providing clear targets for companies and also governments to achieve. This enhances the commitment to socio-environmental responsibility actions and helps improving the transparency of policies.

On the other hand, Belinky (2021) warns for the risk of complacency "arising from the false belief that the ESG perspective alone can solve sustainability challenges," and the inaccurate view that ESG represents "an evolution" of corporate responsibility. Additionally, he emphasizes the need for mechanisms to assess the extent to which ESG-labeled products and instruments truly align with the SDGs and their targets.

There are several rating agencies that provide ESG data scores, especially in the last two decades, in reaction to the investors' informational requests to focus on more sustainable businesses (ESCRIG-OLMEDO et al., 2019). Without a global accepted and accurate description of ESG metrics, each of those agencies have created their own methodology to measure ESG performance based on the standards and indicators they choose (BILLIO et al., 2020). To a better foundation to the understanding of the following topics, Li e Polychronopoulos (2020) acknowledged the fact that companies can be ranked differently depending on the agency considered, also recommending investors to choose the agency that relate most to the investors' own preferences. Also, they presented a typology to distinguish the most famous methodologies of ESG scores and the rating agencies, as followed:

1. **Fundamental**: ESG data providers that collect publicly available data, usually from company reports and their websites, sharing with users, such as Bloomberg and Refinitiv

2. **Comprehensive**: rating agencies that mix publicly data with produced by analysts over surveys, independent analysis and interviews, for example MSCI, ISS and Sustainalytics

3. **Specialists**: agencies dedicated to one specific ESG factor, whether environmental, social or governance, e.g., Carbon Disclosure Project and Equileap

Therefore, in the context of ESG, it is important to assess the criteria and metrics used by agencies, to have a more reliable and consistent evaluation of a companies' sustainable performance. And more specifically to the "E" – environmental – Li e Polychronopoulos (2020) showed this difference between agencies, with scores varying more than 400%, which can lead to disagreements, ratifying the findings of Christensen, Serafeim e Sikochi (2022), complicating investors' decisions and companies' efforts to properly address their sustainable practices and ESG ratings.

In Figure 6 we can see how different factors are considered depending on the provider:

Figure 6: Different E pillar ratings

Facebook Environmental Rating Breakdown by Provider as of December 31, 2017

Provider 1			Provider 2		
Category	Score	Weight	Category	Score	Weight
Environmental Strategy	37	33.0%	Operations Incidents	100	22.3%
Minimizing Environmental Impacts from Energy Use	68	33.0%	Green Procurement Policy	0	10.0%
Management of Environmental Impacts from Personal Transportation	30	33.0%	Sustainable Products & Services	0	10.0%
Pollution Prevention	0	0.0%	Environmental Management System	20	6.7%
Green Products and Services	0	0.0%	Env. Management System (EMS) Cert.	0	6.7%
Protection of Biodiversity	0	0.0%	Environmental Supply Chain Incidents	100	6.7%
Protection of Water Resources	0	0.0%	Product & Service Incidents	100	6.7%
Atmospheric Emissions	0	0.0%	Environmental Policy	0	3.3%
Waste Management	0	0.0%	Environmental Fines and Penalties	100	3.3%
Local Pollution	0	0.0%	CDP Participation	0	3.3%
Impacts of Product Use and Disposal	0	0.0%	Scope of GHG Reporting	0	3.3%
Supply Chain: Environmental Factors	0	0.0%	GHG Reduction Program	50	3.3%
			Renewable Energy Program	100	3.3%
			Carbon Intensity	20	3.3%
			Carbon Intensity Trend	20	3.3%
			Renewable Energy Use	100	3.3%
Provider 1 E Score		**45**	**Provider 1 E Score**		**51**
Z-Score		**1.29**	**Z-Score**		**-0.45**
E Score (Percentile)		**90.00%**	**E Score (Percentile)**		**39.00%**
E Score		**0.77**	**E Score**		**0.23**

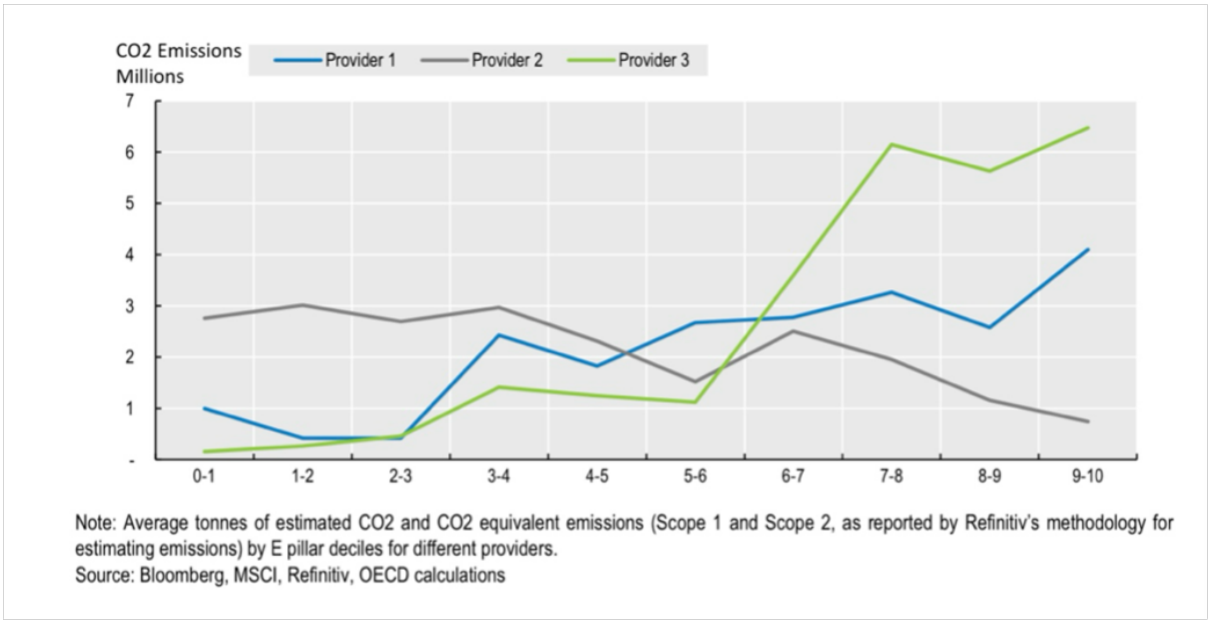
Source: Research Affiliates, LLC.

Source: Research Affiliates (2020)

And not only we can observe from this figure the differences in the categories, but also the different weights attributed to each of them, what calls the attention for the different scores depending on the provider chosen to assess ESG scores. And in the context of the E pillar, it has been receiving more attention recently, and it is a great way to answer if a company's behavior is affecting the environment (DRAGOMIR; BATAE; FELEAGA,

2020). It is in growing attention, so that we can see a more competitive market for eco-friendly products and services, as highlighted by Boffo e Patalano (2020). Also, in their report, a study of the correlation between CO2 emitted and the overall E pillar score was conducted, and obtained the answer that different providers stipulated different E scores, as shown in Figure 7:

Figure 7: Different scores for the E pillar compared with CO2 emissions



Source: Boffo and Patalano (2020)

As investors are each time more aware of risks coming from the impacts of activities in the E pillar, it is seen an expanded usage of the E-scores recently for analyses and decision-making processes. As also said before, the quality and availability of data about the use of resources, emissions, and so on, from different providers generate a variation in those assessments. And more specifically to the E pillar, its metrics hardly distinguish different pollutants (oxides of sulfur, nitrogen or greenhouse gases for example), leading to financial implications for both companies and investors Apergis, Poufinas e Antonopoulos (2022).

2.1.1.1 Signaling Theory

The Signaling Theory was introduced by Michael Spence in the 1970s, and it is key to understand how companies can reduce their information asymmetry between with stakeholders when different and incomplete information may appear (CONNELLY et al., 2011). Usually, one side, sending the information, chooses how they are going to communicate

it, which is the signal and the other party, the receiver, chooses how to interpret the signal. Nevertheless, most of the times, there is the asymmetry information about quality and intention. Quality is when the other party is not aware of the achievements of the other one and intention when one party is concerned about the other party's behavior or intentions. Inside of the ESG context, this theory explains how firms use their ESG scores/performances to signal their commitment to more sustainable and ethical practices, which might influence the perception of investors and market behaviour.

More specific to the E pillar - environmental issues, signaling theory suggests that firms with robust environmental practices use these activities to signal better management quality and a possible lower risk profile to investors and other stakeholders. The relevance of this matter is also present when there is incomplete information about the internal practices and policies of a company, as well as prospects (COWAN; GUZMAN, 2020). In particular, the Signaling Theory is more effective in contexts where the information asymmetry is significant, and that can be applied to when there is an ESG reporting related to environmental issues and sustainability. Besides that, it is known that if a company often actively engage in strategies leading to deforestation mitigation and report the progress of this activity, it can be a signal of their long-term commitment to environmental sustainability, which may be received as a good sign for stakeholders. This can improve their reputation, as also possibly reduces perceived risks by attracting more investors looking for environmental aspects. Moreover, it is possible to say that ESG factors nowadays are prioritizing the decision-making processes and portfolio creation of investors, and with an effective signaling of solid environmental practices can differentiate companies in a competitive market, leading to a better perception from investors and more likely to lower capital costs (NAFFA; FAIN, 2020).

Another key concept in the Signaling Theory is the regulatory compliance, also known as "environmental overcompliance". In this context, when any firm goes beyond the minimum legal requirements, they might, for instance, signal their great environmental performance and commitment to sustainability, and this can be a strategic move to attract investments in general and build better relationships with stakeholders, which can be beneficial in industries with high environmental risks, such as forestry and agriculture. To sum up, overcompliance can signal a firm's dedication to environmental management and its proactive approach to managing potential environmental liabilities, and so enhancing its overall market position and reducing possible perceived risks (DENICOLO, 2008).

According to Fu (2023), when we investigate ESG factors, signaling requires an approach with attention, since comprehensive engagement in ESG practices can signal a

firm's strong commitment to sustainability and reduce risk, although the associated costs with those practices and complexities can eventually lead to more volatility if it is not managed in the right way. Nevertheless, this emphasizes the importance of a strategic approach related to ESG signaling, where firms may also carefully select which aspects of their sustainability efforts they want to highlight. Successful signaling requires transparency and also consistency in the ESG communications, ensuring that stakeholders receive clear information about a firm's sustainability initiatives, for example, and that can support long-term sustainable growth.

2.1.1.2 Stakeholder Theory

The Stakeholder Theory has its origins in the 1960s, when the Standford Research Institute created the concept of stakeholder, by the fact that companies have the support of shareholders and need to satisfy their requests, but also all parties including customers, employees, suppliers, creditors, community might also be affected (FREEMAN, 1984) and it is possible to say that is a theory related to the business ethic and organizational management (SCHALTEGGER; LüDEKE-FREUND; HANSEN, 2019).

Stakeholder Theory postulates that any group or individual who can affect or is affected by the achievement of an organization's objectives should be considered in the company's decision-making processes. This approach implies that there is a sort of social contract between businesses and society. This represents a company's real credibility and approval, be it by the public or its stakeholders, emphasizing ethical corporate decision-making (BEBER; RANGEL, 2020). Moreover, the increased international market connectivity is a consequence of the evolving technological advancements and, alongside updated regulatory frameworks, it shows the pressure on companies to consider socio-environmental issues in their operations (FILHO, 2002).

Also, ESG activities can help in conflicts between managers and stakeholders, in a more cooperative environment. This happens because of the alignment of interests, by addressing wider social and environmental responsibilities, which can improve reputation, attract talent, and build customer loyalty (NG; REZAEE, 2015). In addition, other recent research supports the integration of Stakeholder Theory within the context of ESG practices. As a matter of fact, the impact of ESG practices on financial performance within Shariah-compliant firms were examined. It was found that ESG engagement is positively related to firm performance, consistent with Stakeholder Theory. This suggests that combining ESG and Shariah screenings can enhance firm value by promoting more

ethical and transparent practices, thus attracting new markets and investors (LEE; ISA, 2020).

Signori et al. (2021) explored the relationship between ESG ratings and value creation for stakeholders in European companies, revealing that while ESG ratings are often used as proxies for social responsibility, they should not be the only indicators of value creation for stakeholders. Instead, ESG ratings should be considered as one component of a broader value creation strategy, highlighting the need to refine these indices to better capture stakeholder value creation. Additionally, Campos e Queiroz (2023) analyzed how the circular economy is being internalized by Brazilian B Corporations from a Stakeholder Theory perspective. Their analyses indicate that successful implementation of circular economy practices requires active stakeholder engagement, particularly with customers and the community. Hence, this study emphasizes the strategic role of stakeholders in driving sustainability initiatives and the transition towards a more sustainable economy.

2.1.1.3 Agency Theory

The Agency Theory talks about the existing relationship between principals (shareholders) and their agents (managers). As managers may prioritize some of their interests, a conflict that surges with the principals, an assortment of disagreements, because some agents won't follow their requests. On the other hand, this conflict can also emerge when the principals don't act in the same direction that the managers wanted to. To reduce this phenomenon, some typical measures can be follows, such as more transparency, bonuses and even restrictions. When ESG factors are incorporated, there may be a mitigation of this issue, since they bring more transparency and long-term thinking. Besides, new approaches to this problem are related to ESG, as suggested by Bonham e Riggs-Cragun (2023) that argument that CEOs have the power to influence the distribution of the firm's outcome, what can include ESG performance. Indeed, this perspective is useful to align managerial actions with shareholder interests, since it directly rewards outcomes that shareholders care about, such as reduced carbon emissions or improved social governance, lowering their risks.

Thus, when integrating ESG metrics into compensation contracts, companies can reduce agency problems and promote more sustainable, and long-term business practices. Also in that research, Bonham e Riggs-Cragun (2023) draw the attention to the fact that shareholders may want high both financial and ESG performances. As shareholders may want high profits, that doesn't mean earned with high emissions and, likewise they

may prefer lower emissions, but it doesn't mean to lose profit. Thus, it argues about "green innovations" that need to reduce emissions, but also continue to be profitable for the company. So, this could be achieved in the same model as said before, through ESG-performed-based stock awards, highlighting the importance of the sustainable development.

Additionally, Agency Theory is frequently related to ESG disclosure (HELFAYA; MORRIS; ABOUD, 2023), as it represents a tool that can reduce the level of information asymmetry, and so reducing the risks (MANITA et al., 2018). As a matter of fact, when disclosing their ESG performances, companies can also diminish exposure to environmental risks, agency costs and reputational risks.

2.1.1.4 Legitimacy Theory

The Legitimacy Theory is based on the premise that an organisation can exist and flourish through social acceptance (GUTHRIE; PARKER, 1989). As a result, this theory contends that companies must disclose certain information (community involvement, human resources, physical resources, environmental contributions, and product and service contributions) to persuade society that their organisational activities are permissible and add social value. Under the increasing pressure of social media and stakeholder attention, ESG disclosure offers potential businesses benefits such as increased transparency, employee motivation, and improved reputation and brand value, thereby avoiding the market stigma associated with a reputation for environmental recklessness.

Finally, from a legitimacy standpoint, corporate legitimacy is achieved by publishing more usable information on ESG that enables stakeholders analyse the impact of their companies on society and the environment. Reber, Gold e Gold (2022) discovered that sustainability reporting is a major type of corporate communication that organizations engage in with their strategic purpose, therefore boosting the legitimacy of the firm. Organizations use ESG reporting to demonstrate to the public their conformity with societal norms. As a result, it is a significant driver for companies to publish more ESG information to legitimise their presence and promote long-term growth through community approval. This can be used to persuade society that firms are meeting their expectations by adhering to their social norms (ECCLES; SALTZMAN, 2011).

2.1.2 ESG and Risk Reduction

For the purpose of understanding better the relationship between ESG performance and cost of equity, it is essential to first look into the concept of cost of equity. The cost of equity is a key concept in finance, since it represents the return that investors expect for providing capital to a company (ROSS, 2005). Besides, it serves as a benchmark for evaluating investment projects and is integral to determining the net present value (NPV) of future cash flows. There are some models to quantify this expectation, that will be explained in detail later, but all of these models work with the idea of risk. After all, to comprehend this argument, we should dive deeper in understanding what risk is and its various types.

Whenever someone invests, whether in stocks, bonds or mutual funds, it deals with the choice of allocating assets, and risk is any uncertainty with respect to that particular investment that could have negative consequences in their financial welfare and usually investors expect higher returns in those kind of investments with higher risks, which contains one fundamental idea in the finance world, that is the relation between risk and return. And there are several motives why that specific investment can alter its value, going up or own, but we can split in two categories: systematic risk and idiosyncratic risk. The former, also known as market risks, includes all political and macroeconomic risks, affecting the market. The latter, on the other hand, affects only the specific industry or even just the company, such as regulatory changes, new management, and others (BABENKO; BOGUTH; TSERLUKEVICH, 2013).

More than just improving business performance, with sustainability management, companies can reduce their social, political and market risks (SCHALTEGGER; BURRITT, 2018). In this direction, through CSR (Corporate Social Responsibility) activities companies can manage their idiosyncratic risk (GIULI; KOSTOVETSKY, 2014), generate not only a better reputational capital, but also improve risk management practices, that could impact the probability of risk ex-ante and losses ex-post (LU et al., 2021). In that same study, it was concluded that the use of CSR to mitigate risks depends on the context of the firm. When it is a high-risk environment, such as companies that depend on commodities that are drivers of deforestation, investors take a closer look to the CSR performance as a tool to reduce risk, compared to companies operating in low-risk environments.

Besides, the ESG-related information can reduce the information asymmetries, making it easier for investors to assess risks faced by the companies. In addition, with ESG

disclosure firms have a better reputation, alleviating the negative impact of possible crises, thus reducing idiosyncratic risk (FIORILLO et al., 2023). Overall, market participants are more likely to have higher ESG ratings in their portfolio, due to the lower risk and performance. Still in ESG disclosure, Atif e Ali (2021) got to the conclusion that the companies with higher Environmental, Social, and Governance disclosure face lower default risk. In other words, firms with higher ESG disclosure can reduce their vulnerability to external shocks (FIORILLO et al., 2023).

Within the environmental pillar (E-pillar) of ESG, the disclosure of climate risks is essential for mitigating financial risks and enhancing corporate stability. Ilhan, Sautner e Vilkov (2021) emphasize the significant role of climate risk disclosures to reduce the firm-level risks since it decreases economic uncertainty, lowering conflict costs, and improving transparency. Institutional investors, particularly those from countries with stringent environmental norms and regulations, demand robust climate risk disclosures. Moreover, this demand drives firms to adopt better environmental practices, which leads to more accurate ad clear vision of climate risks and opportunities and according to Krueger, Sautner e Starks (2020), also climate risk information with high quality is critical for informed investment decisions and regulatory efforts to protect financial stability. All of these findings show the importance of integrating environmental disclosures within ESG, as a move to foster long-term corporate resilience as well as investor confidence, lowering risks.

2.1.3 ESG, CSR and Cost of Equity: Specific Studies and Findings

To obtain a better understanding of the relationship between environmental performance and disclosure and cost of equity, we can analyze the past studies by different scholar that conducted research in this field together with the previous review of the literature. As written, as companies disclosure environmental policies and activities, they can reduce their risks, whether decreasing uncertainties or gaining more investor confidence, which will also help in possible variations in the cost of equity. The Corporate Environmental Responsibility (CER) investment by companies refers to practices that are voluntarily undertaking towards less negative impacts in the environment, focusing on initiatives to reduce carbon footprint, management of waste and conservation of resources. Ghoul et al. (2018) found that firms with higher CER have significantly lower cost of equity capital, especially if the firm invests in environmental policies, and that the companies should disclose this information to the public. Moreover, he emphasizes

that usually low CER are related to smaller investor base and higher perceived risks. One important thing in this study is that firm-specific determinants such as industry, country and year were controlled in the model.

Another study is to understand possible mechanisms for the change in the cost of equity because of higher CSR. Breuer et al. (2018) explain that there are two primary mechanisms: the risk channel and the investor base channel. The former says that firms with low engagement in CSR activities are perceived as riskier by investors, be it because potential litigation, regulatory measures or reputational damages, compared to those that engage, reducing possible conflicts with stakeholders and having fewer adverse events, such as environmental scandals, thus lowering the risk. The latter is that when a firm has a strong investor base, with investors that support sustainable practices, it can reduce their cost of equity, more than the previous one if the country has more investor protection.

A deeper exploration into specific studies underscores the tangible financial impacts of environmental management on corporate finances, particularly concerning the cost of equity. Chava (2014) provided a detailed analysis showing that companies engaged in poor environmental practices not only face heightened regulatory scrutiny but also bear increased costs of equity. This relationship arises because investors perceive these companies as riskier, given their potential exposure to environmental mishaps, which could lead to hefty fines and cleanup costs. Furthermore, the study indicates that these companies are often penalized by the market through a higher risk premium, reflecting the additional risks investors assume when investing in such firms.

Also, Sharfman e Fernando (2008) in their research examined how companies that implement robust environmental risk management strategies experience a reduction in their cost of equity. Their research highlights that effective environmental management is not only about compliance but also about operational excellence and strategic risk management, which are critical components of overall corporate governance. Their findings suggest that companies that proactively manage their environmental footprint can reduce the volatility of their returns, thereby making them more attractive to risk-averse investors.

Connors e Silva-Gao (2008) provided a sector-specific study within the electric utility industry, showing that firms with high levels of chemical emissions have a higher cost of equity. This study vividly illustrates how environmental risks specific to an industry can impact financial metrics. The high cost of equity associated with greater emissions is attributed to the increased risk of regulatory penalties and the potential for reputational

damage, both of which can deter investment and affect shareholder value negatively.

In another significant contribution to the literature, Crifo, Forget e Teyssier (2015) explored how both positive and negative disclosures about a company's environmental performance impact its market valuation. Their findings reveal that the market reacts more strongly to negative ESG disclosures than to positive ones. This asymmetry suggests that while investors reward good environmental performance, they punish environmental failures more severely. This behavior underscores the importance of maintaining a strong environmental track record as a means of safeguarding corporate value.

Moreover, studies such as those by Friede, Busch e Bassen (2015) synthesize the results from over 2,000 empirical studies and conclude that there is a strong positive correlation between robust environmental performance and financial performance. This aggregated evidence reinforces the notion that good environmental practices are closely aligned with enhanced shareholder value and reduced financial risks. Lastly, an innovative approach by Gillan, Koch e Starks (2021) was adopted to analyze the impact of ESG factors, particularly environmental factors, on financial performance. Their study synthesizes findings across multiple industries and geographical regions, providing robust evidence that strong environmental performance is consistently linked to lower costs of capital, including both equity and debt. These studies collectively articulate a clear and compelling case for the integration of environmental considerations into corporate strategy and financial analysis. By demonstrating how effective environmental management can lead to lower perceived risks and hence lower cost of equity, they provide a valuable framework for companies aiming to enhance their financial stability and market valuation through sustainable practices.

2.2 Literature Review: Deforestation and its financial implications

In this section, there is going to be presented an analysis of research related to deforestation caused by companies and the financial impacts of this activity, as well as the challenges of tracking deforestation and deforestation in Brazil, which will enable a better understanding of risk perception, for finally, try to connect with the cost of equity. The goal is to investigate the literature and to exhibit the most recent findings and theories related to the topic. Additionally, the relation between deforestation and the "E" in ESG, also with a discussion of and if investors perceive risks from companies that have exposure to deforestation. Real-life case studies will help to give a broader view of the possible

correlation for the exposure to deforestation and/or policies against it and discrepancies of the cost of equity.

2.2.1 Classifications of Deforestation

When we talk about forest-related issues, it is important to define each possible problem involving the deforestation of natural ecosystems. The most famous used expression is deforestation, that usually relates to the clear-cutting, the practice of removing trees in a specific area, for the conversion to another land use, therefore impacting the biodiversity and possibly leading to further long-term ecological damages. In this case, we do not expect trees to regrow. On the other hand, forest degradation is usually more related to the reduction in the density of trees in a specific area, not changing the use of it. The trees in this case are expected to regrow and the change is temporary. When we think of deforestation, it is important to address its causes. Ritchie (2021) defined five reasons:

- **Commodity driven deforestation**: represents the long-term conversion of forests to other land uses, be it agriculture, mining or energy infrastructure
- **Urbanization**: also long-term and permanent conversion of forest to towns and roads
- **Shifting agriculture**: medium scale conversion of forests to farming, but this time forests regrow after it is abandoned
- **Forestry production**: like logging, for products including timber, paper and pulp, and regrow after
- **Wildfires**: destroying forests temporarily, if nothing else changes, can regrow after depending on the level of the fire.

So, commodity-driven deforestation is deforestation, since the change is permanent, and it represents more than one quarter of global forest loss, being 27% from commodity-driven deforestation, with 95% taking place in the tropics (RITCHIE, 2021).

2.2.2 Forest-Related Risks and Investor Perceptions

With ESG topics being a trend in recent years, strategies of investors to phase out deforestation and land use conversion risks in their portfolios are increasing. Since deforestation risks mean material risks for them, forest-related issues are now a mainstream

issue, as they are increasingly becoming more aware of the relation between climate change and the impacts of deforestation. Besides, these forest-related issues can bring other kinds of risk, such as market, reputational, regulatory, and operational risks that can impact in the companies' financials. More than just managing risks, investors have urge to assess and consider these risks in their portfolios (AIGCC, 2024).

Specific to deforestation, the literature identifies some of the risks that directly impact investor behavior and corporate valuation. Furthermore, Nolte et al. (2017) discuss the regulatory and financial penalties faced due to deforestation practices and Broom (2021) delves into reputational risks, noting that negative public perception linked to deforestation can lead to consumer boycotts, severely damaging brand value and diminishing future cash flows. Additionally, Busch e Ferretti-Gallon (2017) address the operational risks associated with deforestation, such as supply chain disruptions that can result in raw material shortages and cost volatility. Moreover, a study by New York University's Stern School of Business found that deforestation-free supply chains in Brazilian beef production generated positive financial returns, coming from enhanced innovation, risk management, operational efficiency, customer loyalty, improved relations with suppliers and employees, as well as reputational gains. In case of deforestation, operational and reputational damages often result in increased financial risk, which can escalate a firm's cost of equity.

Also, Eccles, Ioannou e Serafeim (2012) contribute to by suggesting that weak ESG performance, particularly related to environmental degradation such as deforestation, can significantly raise investor concerns. This is because investors are increasingly using ESG criteria to assess potential risks and returns on their investments, viewing poor ESG performance as indicative of broader management issues or operational inefficiencies that could reduce returns.

2.2.3 Methods for Monitoring Deforestation

To implement traceability in supply chains, companies need to get information of every stage of the product's lifecycle. In light of this, partnering with more specialized firms for verification and monitoring is often required to have an effective traceability. There are certification bodies, that provide independent validation of sustainable sourcing practices. These organizations go through audits and inspections of farms and suppliers, confirming or not the compliance with environmental standards. The certified companies must maintain detailed records of these certifications and share them with buyers to prove

compliance at each step, allowing them to meet regulatory and consumer expectations for sustainability (BALLOU, 2003; LAMBIN E.F., 2018).

Furthermore, bigger companies are also adopting digital technologies to support traceability. For instance, Geographic Information Systems (GIS), satellite monitoring and blockchain technology are used to ensure more accurate and real-time tracking and data recording, which allow companies to monitor land use changes. This monitoring can provide record of the origin and alert companies to potential sustainability issues on the ground. Also, blockchain technology enhances traceability, since it creates a decentralized ledger, which records each transaction securely and transparently. Each time a commodity changes the tier, a new "block" of data is added, creating a digital record through the supply chain (MORAN D., 2020; SHAPIRO, 2006).

Likewise, for the traceability to be effective in FRC supply chains, one key mechanism is collaboration, which means that companies usually need to work with local communities, NGOs, technology providers, and then government to create a more robust and transparent traceability process. For example, technology firms offer satellite imagery services that are useful to monitor land use, such as Global Forest Watch, and blockchain can help to ensure that the records continue to be secure and unalterable. Moreover, an example of NGOs, the World Wildlife Fund, provide help in environmental protection and ethical sourcing, since they assist companies in meeting high sustainability standards. Also, the government has a essential role in creating standards, which demand companies to certify their supply chain practices through regulatory requirements, being one example the European Union's Regulation on Deforestation-Free Products (LAMBIN E.F., 2018).

Finally, with existing certifications, the use of digital technology, and collaboration with stakeholders and competitors, firms can create a better and more effective traceability system, which ensures compliance with environmental commitments, like zero deforestation in supply chains. Through these, companies can also provide more transparency to their consumers and meet the regulatory standards, as well as contribute to global sustainability goals, since they will reduce their environmental impact (BOWERSOX et al., 2012; LAMBIN E.F., 2018).

2.2.4 Challenges of Tracking FRCs Supply Chains

There are some challenges when tracking supply chains of companies that depend on FRCs, not only because of the complexity and the varying levels of the supply chain, but also the transparency between the involved stakeholders. In this context, the global

nature of these supply chains involves many actors in many geographies, which makes it difficult to implement standardized tracking mechanisms. For example, the Brazilian soy industry can illustrate this issue, since it is characterized by high volumes that are produced by many tiers of suppliers, some operating in regions with limited supervision, complicating the ability to monitor practices consistently (ERMGASSEN E.K.H.J., 2020). Additionally, the complexities in cattle supply chains are increased as cattle can be raised on deforested land and transferred through multiple farms, thus, creating layers of opacity that hinder traceability (GARRETT R.D., 2019).

Moreover, certifications and standards, for example the Round Table on Responsible Soy (RTRS) and the Forest Stewardship Council (FSC) for timber, are becoming more common and firms are relying more on them. However, these tools, most of the times, do not guarantee deforestation-free supply chains, since those certifications end up covering only a portion of the supply chain, and the lack of uniform global standards allows changes in the scope and strictness of deforestation commitments (LAMBIN E.F., 2018). Furthermore, while certification provides a starting point, it does not ensure the adherence of all suppliers, particularly smaller ones who may lack the resources or incentives to comply fully (BAGER; LAMBIN, 2022). Basically, this happens because of the variability that can lead to "leakage" markets, in which the non-compliant products are circulated outside certified channels, and as a consequence, undermine the intended impact of certifications.

Moreover, as new technological tools, like satellite monitoring, blockchain, and Geographic Information Systems (GIS) can introduce new possibilities in improving traceability across supply chains, they also present limitations. In this regard, although data from satellites can monitor forest cover and also detect deforestation events, it may not be enough to track specific agricultural practices or distinguish the legal from the illegal activities. Additionally, for blockchain technologies, it can be seen as good for improving transparency, but it is often challenging to implement on a large scale, especially in rural areas with limited digital infrastructure (MORAN D., 2020). As a result of this, while technology can support the monitoring of forest-risk commodities, it is not a standalone solution for these limitations. Integrating these tools with strong governance support and stakeholder collaboration can be important to trace and verify FRCs supply chains effectively and to make more progress toward reducing deforestation (MOFFETTE F., 2021).

2.2.5 Policies for Deforestation-free Supply Chains in Brazil

The Brazilian government is implementing policies and initiatives, with a great focus on the Amazon region and other critical biomes. One of these initiatives is the *Plano de Prevenção e Controle do Desmatamento na Amazônia Legal (PPCDAm)*, launched in 2004, and has been a important policy, containing measures for monitoring, controlling illegal land use and promoting sustainable practices. This program is managed across some government agencies and focuses on incentivizing sustainable land use, utilizing technologies for satellite monitoring, and regulating land tenure through tools like the *Cadastro Ambiental Rural (CAR)*, a digital registry for rural properties (ASSUNCAO; GANDOUR; ROCHA, 2015). With these policies, and encouraging sustainable practices, monitoring land use, and improving transparency within supply chains, the Brazilian government aims to curb illegal deforestation and support global environmental goals, but face some challenges (NEPSTAD; STICKLER; ALMEIDA, 2014).

Even with these advances, the complexity of supply chains in Brazil creates a significant challenge for the implementation of fully traceable and deforestation-free supply chains. In this context, the beef and soy products, among Brazil's largest export sectors, are composed of highly fragmented supply chains with some limited transparency and weak traceability (GARRETT; KOH; LAMBIN, 2019). So, this lack of traceability makes it challenging to verify the origins of some products, which increases the risk of deforestation-linked products entering international markets. Besides, efforts to increase transparency and accountability are addressing these concern, including certifications and public-private partnerships, but require further development to become effective on a large scale (GIBBS et al., 2015).

On top of that, since Brazil is a huge exporter, another key point to meet is international regulatory standards, such as the European Union's Regulation on Deforestation-Free Products (EUDR), which introduces opportunities and obstacles. While the existing monitoring tools in Brazil are aligned with the requirements of the EUDR, there are still gaps that remain in ensuring compliance across sectors and regions (Climate Policy Initiative, 2023). Additionally, pressure from stakeholders and conflicts over land rights complicate efforts to implement these policies. Furthermore, there is also the need for financial and technical resources, that are critical to support these initiatives, particularly in rural and remote areas. To ensure the effectiveness of deforestation-free supply chains, Brazil faces the challenge of balancing international trade demands with sustainable environmental management (HENDERS; PERSSON; KASTNER, 2015).

2.3 Synthesis of the Literature and Identification of Gaps

The existing literature on the relation between ESG performance and cost of equity indicates that there is an emerging agreement among the scholarly community that good ESG performance, especially regarding the environmental aspect, reduces cost of equity. These theories include signaling theory, stakeholder theory, agency theory, and legitimacy theory supporting this relation. According to signaling theory, firms that are able to adopt and implement good environmental standards do so as a way of diseasing information to the market that its products are of high quality and have low risks associated with them. Some scholars based on stakeholder theory suggest that when firms consider the interest of a myriad of stakeholder including the environmental activist the firm is likely to be perceived to be less risky and sustainable. Agency theory reveals that the decision of managers to disclose information on ESG creates a constraint on information asymmetry that helps to decrease agency costs and cost of equity. This can be explained with the help of legitimacy theory which suggests that business practices that are congruent with societal norms and expectations like, environmental ones, are deemed more legitimate and, therefore, entailing less risk.

Several empirical works have indeed shown that there exists a positive association between the degree of environmental commitment and Cost of Equity. Existing evidence has indicated that firms with high CER scores, firms that implement environmental policies and those firms who are able to control for environmental risks tend to exhibit reduced cost of equity. This is because investors consider those companies to be less probable to have shocks related to increased environmental risks, regulatory fines, and reputational costs.

But there are some mixed results and research limitations to the topic. Despite such recognition, most of the research entail some strength in the environmental performance and financial performance. These discrepancies may be attributed to differences in methods applied, ESG data and rating scales, and/or the company and industries under analysis.

The second major drawback associated with the general approach to environmental sustainability is the lack of attention to specific environmental threats like the deforestation. Though research has explored the relationship between total environmental concerns and the cost of equity, little is known pertaining to the relationship between particular environmental issues including deforestation and the cost of equity. To fill this gap, this

study will focus on our research question. In the area of deforestation and its financial consequences, the presence of new knowledge on the risks related to deforestation is especially emphasized among investors. These risks include regulatory fines, brand deterioration, threat to supply chain and raise risk capital. Implementing deforestation risks as a factor in investment decisions is having an expanding trend and companies with links to deforestation risks are experiencing call-out and potential divestment.

According to research, companies that engage in deforestation activities are likely to be financially disadvantaged since their cost of equity capital increases, but it is still a gap in this field of research, as we found few articles about it. This is the case because investors deemed these companies as having higher risk profiles given their vulnerability to environmental damages, legal proceedings and consumer backlash.

Nevertheless, there are limitations and risks when it comes to the evaluation and prevention of deforestation. The global and fragmented nature of supply chains, the absence of an industry-wide consensus on deforestation measurement, and the wide range of firm disclosures create challenges for investors when evaluating deforestation risks. Also, there is a lack of comprehensive understanding of the channels through which financial effects of deforestation are manifested and vary across the sectors and geographic locations.

Moreover, within the challenges of tracking forest-risk commodity (FRC) in supply chains, even with the advancements in certification and digital monitoring, traceability remains complex and costly. Besides, multi-tiered supply chains with many participants, from smallholders to large corporations, can lead to gaps in oversight and incomplete data on sourcing practices. Certification can provide foundational standards but frequently cover only a portion of the chain, leaving gaps where non-certified or deforestation-linked commodities can enter. Technologies like Geographic Information Systems (GIS), satellite monitoring, and blockchain offer tools to enhance transparency, but these require more investments and depend on digital infrastructure, which may not be present in rural production areas. Moreover, the mix of commodities at various stages, a common practice in sectors like soy and beef, undermines individual traceability efforts and makes it difficult to ensure that final products meet environmental commitments.

In conclusion, the literature review reflects an increasing focus on environmental factors, such as deforestation and their implications for finance and investments. It is believed that environment sensitivity is positively related to a company's cost of equity but there is still the need for research especially regarding deforestation. This study thus seeks to make a research addition by studying the association between deforestation exposure and

cost of equity to provide insights about forest-risk commodities and their relevance on corporate finance and investment decisions.

3 HYPOTHESIS DEVELOPMENT

As explained earlier, the main focus of this study is to assess whether or not forestrelated issues in companies' activities have an impact on the cost of equity for firms. Therefore, in line with our objectives, we seek to assess the relationship between a firm's level of deforestation associated with their revenues and the cost of equity, to understand how environmental aggressiveness and sustainability issues are reflected in the perceived risks by investors. Thus, this study provides a new and useful input into researching the relationship between ESG/CSR performance and financial measures. More specifically, the following research question is developed: being resource use one aspect of the E pillar, when we look at it alone, does it reflect in changes of the cost of equity?

As pointed out in section 2 of this study, titled State of the Art, there is an increasing awareness among investors of sustainable business practices and with these their profitability. The observed increase in the demand for sustainable investments implies that the continuation of sustainable investing is attributable to both industry regulation and evolving standards among investors. However, there are factors that can have impacts on the way that deforestation activities are seen, and on how these activities reflect on a company's cost of equity.

Firstly, information about environmental performance and its connection with lower financial risk is available and proved, however, it is still questionable if the definite type of activity connected with deforestation can have unique difficulties and risks. Issues concerning environmental degradation, loss of species and biological diversity, and climate change are some which could worsen the costs firms facing deforestation related risks expose themselves to when issuing equities. Thus, these risks may also rise in terms of awareness being specially enhanced among investors and regulators due to the progressing focus on environmental challenges.

Furthermore, the current study examines the effects of deforestation, which has not attracted much attention among scholars yet, on cost of equity in comparison to the overall ESG criteria. Following the themes of ESG characteristics and their connection

with performance, the emphasis on deforestation directly relating to and distinguishing itself from other ESG factors enables identifying how concrete environmental issues affect investors' perceptions and financial results. This gives rise to questions to whether the cost of equity is a realizable cost by increasing the level of deforestation and showing the enhanced image in practice.

Also, the level of sustainable investment also depends on how companies fulfil and disclose their obligations to limit other environmental impacts, such as deforestation. In turn, this implies that there could be increased effectiveness in risk management through transparent reporting and proactive management of environmental risks, which in effect translates to a difference in the perceived risk and hence reduction of the cost of equity. On the other hand, higher cost of equity is brought about by poor management of the effects of deforestation activities that tends to attract more fines, regulatory actions, and loss of reputation that jointly translate to a higher cost of equity.

The need to examine the major factors that would form the basis of decision making with regards to the cost of equity deforestation, becomes quite significant. Thus, it goes beyond merely making it its aim to complement a lack of texts; it is considered a noteworthy and relevant endeavour. This realization will give a more comprehensive view of the general trends of sustainable investing and the impact this area might have towards positive contributions to environmental sustainability.

To increase corporate governance standards, it requires companies to alter their behaviours, ensuring they do not negatively impact the environment and the society such as through poor management of FRCs. To begin, it is necessary to find out how such a shift can be effectuated through policy support, both at the level of individual firms, at the national level, and on the global platform. Nevertheless, this goal remains out of reach without a proper understanding of the behavior of firms and their determinants in terms of environment and its responsibilities financial consequences. Little research focuses on the external environmental factors and their effects on the financial specific items like the influences of deforestation.

To address this gap and expand the existing body of knowledge, we have chosen to elucidate the intricate interplay between a company's deforestation activities and its cost of equity. We further contribute to the literature by examining the heterogeneity of these effects across different sectors and regions. To achieve the objectives just presented, we must remember that in Chapter 2 we have conducted a comprehensive review of the existing literature concerning ESG performance and deforestation. Now, our focus shifts

towards an in-depth exploration of concepts related to the cost of equity and the more specific theories that can help us to explain possible changes.

3.1 Theoretical Framework

3.1.1 Cost of Equity

The Cost of Equity Capital is an important concept in finance, defined as the return investors require after investing in a company's equity. So, it can be seen as a compensation for the risk associated with owning shares of the company, being essential to investing decisions, capital budgeting, valuation and others.

There are many methods that were developed to calculate the Cost of Equity, and understanding what is behind it is a great tool to see how is related to risk and so, will help us understand better the main topic of this study. The most famous methods that are seen in the academy, also that are used, are: Capital Asset Pricing Model (CAPM), Arbitrage Pricing Theory (ATP), the Fama-French Three-Factor Model, and the Dividend Discount Model (DDM) that are going to be studied in detailed next.

3.1.1.1 Capital Asset Pricing Model (CAPM)

The CAPM Model was developed in the 1960s by Sharpe (1964), Lintner (1965) and Mossin (1966), building on the work of Harry Markowitz on portfolio theory and it is nowadays one of the most used models for the calculation of the cost of equity. This model includes the expected return relating to its relative risk and the market as a whole, as shown in the equation 3.1:

$$r_e = r_f + \beta \cdot (r_m - r_f) \tag{3.1}$$

where:

r_e is the return on equity.

r_f is the risk-free rate, represented by the interest rate of a 10-year Treasury bond.

r_m is the market return, derived from the market portfolio's rate of return.

β is the beta coefficient, which measures a stock's sensitivity to market risks.

The market risk premium is calculated as the difference between the market return and the risk-free rate ($r_m - r_f$). Thus, the risk premium of a stock is the product of beta and the market risk $\beta \cdot (r_m - r_f)$. In summary, the expected cost of equity capital (COE) is the sum of the risk-free return and the risk premium.

The beta (β) coefficient plays a crucial role as it quantifies the level of systematic risk and indicates how a company's stock price moves in relation to the market. Specifically:

- If β is 1, the stock moves in line with the market.
- If β is less than 1, it indicates that the stock is less volatile than the market.
- If β is greater than 1, it means that the stock is more volatile than the market.

3.1.1.2 Arbitrage Pricing Theory (ATP)

The ATP model is a more complex model compared to the CAPM, and it was first developed by Stephen Ross (1976), extending the CAPM as it considers multiple factors that might affect a stock's return. The equation 3.2 shows this model:

$$r_e = r_f + \beta_1 \cdot F_1 + \beta_2 \cdot F_2 + \cdots + \beta_n \cdot F_n \tag{3.2}$$

where:

r_e is the return on equity.

r_f is the risk-free rate, represented by the interest rate of a 10-year Treasury bond.

β_n is the beta coefficient for factor F_n, which measures a stock's sensitivity to factor F_n.

F_n is the risk premium associated with factor n.

This method acknowledges multiple factors affecting the return on equity, such as GDP growth, interest rates, inflation, and so on. By incorporating various factors into the model, it provides a more comprehensive view of the different risks and opportunities that can impact the stock's performance.

3.1.1.3 Fama-French Three-Factor Model

This model was created by Eugene Fama alongside with Kenneth French (1993), and it also expands the CAPM as it adds two additional factors to calculate in a more precise

way the stock returns. These factors are the size and book-to-market ratio of firms. The equation 3.3 shows the parameters:

$$r_e = r_f + \beta_1 \cdot (r_m - r_f) + \beta_2 \cdot \text{SMB} + \beta_3 \cdot \text{HML} + \epsilon \tag{3.3}$$

where:

r_e is the return on equity.

r_f is the risk-free rate, represented by the interest rate of a 10-year Treasury bond.

β_1 is the beta coefficient for the market risk premium $(r_m - r_f)$.

β_2 is the beta coefficient for the SMB (Small Minus Big) factor, representing the return spread of small minus large stocks (size effect).

β_3 is the beta coefficient for the HML (High Minus Low) factor, representing the spread of cheap minus expensive stocks (value factor).

ϵ is the regression error term.

This model adds the size and value factors compared to the CAPM, suggesting that smaller companies and those with a high book-to-market ratio tend to outperform.

3.1.1.4 Dividend Discount Model (DDM)

The DDM model are useful for companies that pay regular dividends, and it was developed by John Burr Williams (1938) in the book "The Theory of Investment Value". The equation 3.4 exhibits the formula:

$$r_e = \frac{D_1}{P_0} + g \tag{3.4}$$

where:

r_e is the return on equity.

D_1 represents the dividends per share.

P_0 is the price per share.

g is the growth rate of dividends.

This formula is more useful for firms with stable and predictable dividend growth.

After a better understanding of the concept of Cost of Equity and analyzing some of the most famous models, we can see that it is key to understand how investors perceive risks in companies. Each model addresses different aspects of risk and macroeconomic considerations by assessing various variables to estimate this critical measure more accurately. Examining these equations will help us better quantify and analyze the relationship between deforestation exposure and the cost of equity, and whether there is an impact on the perception of risks by investors.

3.2 Hypothesis Development

Companies that are prone to use larger amounts of FRCs in their operations could be considered riskier by investors. These commodities comprise palm oil, soy, beef, and timber are inherently associated with deforestation and other environmental-related problems thus introducing great regulatory, operational, as well as reputation risks. Organizations that depend on such products risk regulatory actions from governments, and / or NGOs as well as legal sanctions, boycotts, and lawsuits.

It is important to underline that Environmental, Social, and Governance (ESG) elements are widely considered nowadays, which signify the general tendency towards SRI. In their research, Ghoul et al. (2011) and Breuer et al. (2018) show that cost of equity for firms with low ESG standards are greater due to elevated perceived risk. The firms in question are regarded as the candidates for the regulatory fining, operational disruptions, and reputational consequences; that, in turn, increases their beta within the framework of the CAPM and essentially raises the cost of their equity.

Corporate environmental responsibility, as a specific form of CSR, applies to the nonacceptance of environmentally negative impacts and the promotion of sustainability. However, for organizations which has much of their revenue from forest-risk commodities is a very difficult thing to achieve. Ghoul et al. (2018) observed that companies receiving lower CER tend to have increased cost of equity capital thus this reveals that investors regard firms with large environmental threats unfavorably. According to Busch e Ferretti-Gallon (2017), firms that do not actively manage environmental risks run a higher risk of assume risk and thus make tying their cost of capital higher. This is especially the case with firms linked to deforestation, which have to operate with many, often conflicting standards and measures, as well as public scrutiny.

Michael Spence signaled the information asymmetry in the market and stated that firms can improve the market data through signaling, for instance, strong ESG reports on sustainability initiatives. In the case of the firms that bear a clear connection with the FRCs, signaling may not necessarily provide adequate solutions for the investors. Still, as Clark, Feiner e Viehs (2015) positive, clear and consistent ESG disclosures are beneficial in improving investor perception through reporting on the firms' ESG actions, although the claims must be supported by actions. even if a firm achieves a high level of sustainability, they may still have revenue streams stemming from deforestation activities, which will still have investors remain sceptical about sustainability initiatives resulting in perceived higher risk and therefore a higher requisite risk premium.

He pointed out stakeholder theory which postulates that the interests of all the stakeholders should be considered to mitigate the risks and cost of equity. The following are the pressures from stakeholders for firms that are heavily dependent on FRCs. For instance, these pressures can lead to tensions, crises, or public relations disasters if poorly managed. As found by Hillman e Keim (2001), mistaken stakeholder management does not only exacerbate financial performance issues but also increases the cost of equity. Business involved in the FRCs risk confronting the environmental activist, the regulatory agency, and other related communities, which escalate the perceived risk.

According to Jensen e Meckling (1976) it is possible to have an agency problem, where incentives lead to short-term goals and neglect of the sustainable perspective. Hence, Bonham e Riggs-Cragun (2023) opining that the integration of ESG metrics into executive compensation could occur but remains an issue, being business risks in relation to deforestation commodities. These inherent risks lead to the perception of high risk and consequently, a high cost of equity.

Empirical evidence supports the notion that strong environmental practices are crucial for lowering perceived financial risks. Companies involved in deforestation and other environmentally harmful activities face significant financial risks, including regulatory penalties, reputational damage, and operational disruptions. Eccles, Ioannou e Serafeim (2014) provide evidence that companies failing to manage these risks effectively face higher costs of equity due to increased investor skepticism and required risk premiums. Conversely, companies that manage to reduce their dependence on FRCs can mitigate these risks, although the inherent financial materiality of FRCs still poses a significant challenge. Based on these theoretical perspectives and empirical findings, the following hypotheses are proposed:

Hypothesis: *There is a significant positive correlation between the cost of equity and the financial materiality of forest-risk commodities.*

Basically, with this hypothesis, it is now clearer to have a more comprehensive understanding of the objective of this study, which is, to analyze if a higher percentage of revenue from FRCs is expected to increase the cost of equity, indicating that companies heavily reliant on these commodities are perceived as riskier by investors, as the hypothesis suggests so.

4 METHODOLOGY

In this chapter, it is going to be discussed the steps of the data collection, an explanation of the data base and some metrics, a detailed description of the econometric model employed in the succeeding analyses and the variables in the study, to clarify the model and give a foundation to the discussion after, as well as the methodology for the qualitative part. The hypothesis will be tested by examining the relationship between the level of revenues derived from FRCs and the cost of equity, as calculated using the CAPM and other relevant models. The analysis will control for various factors, including firm size, growth opportunities, leverage, market-to-book ratio, profitability, and overall ESG scores, to isolate the impact of the financial dependence on FRCs on the cost of equity. By integrating these insights, the hypotheses provide a comprehensive framework for understanding how sustainability practices related to FRCs influence a firm's financial performance and cost of equity. This approach not only strengthens the theoretical foundation of the study but also offers practical insights for companies and investors on the financial challenges presented by heavy reliance on forest-risk commodities. In conclusion, this section will be a meticulous picture of the methodology used and even explain why this study is being written and will give a clearer motivation to study this topic.

4.1 Research Design

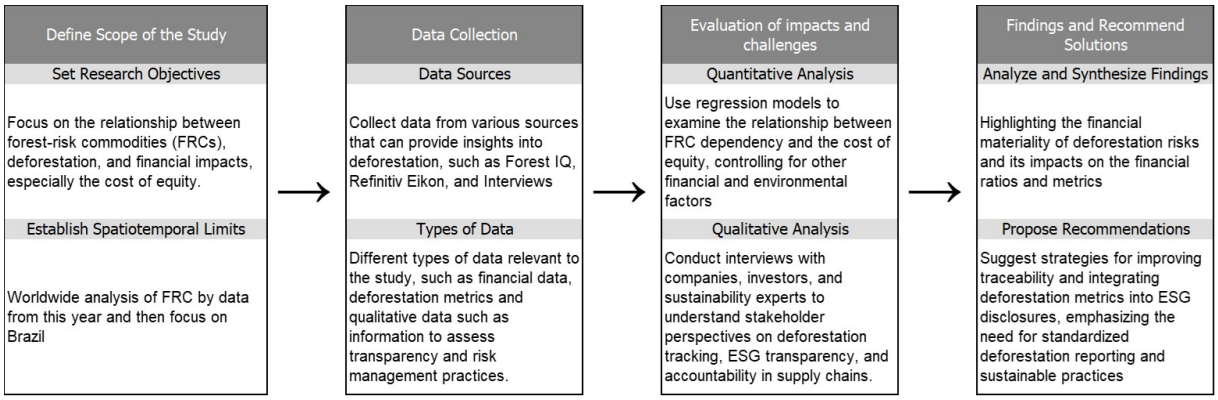
This study adopts a mixed-methods approach, combining quantitative and qualitative analysis to examine the financial and environmental impacts associated with forest-risk commodities. The quantitative component involves linear regression analysis to investigate the relationship between FRC dependency and the cost of equity, as well as other financial performance metrics. Data sources include Forest IQ, which provides detailed tracking of corporate exposure to deforestation, and Refinitiv Eikon, which supplies comprehensive financial, control, and ESG metrics. To complement the quantitative analysis, qualitative insights are gathered from interviews with companies and investors, allowing the study to capture perspectives on ESG transparency, the effectiveness of current supply

chain strategies, and investor perceptions of environmental risk.

4.1.1 Methodology Flowchart

The following diagram provides an overview of the research flow, illustrating each stage in the study's methodology—from the initial literature review to hypothesis formulation, methodology development, and data analysis. This visual aims to clarify the logical progression and interconnectedness of each research phase:

Figure 8: Methodology Flowchart



Source: The author

4.2 Objectives

This study has three objectives:

1. To understand the relationship between the forest-risk commodities (FRCs) and the cost of equity, along with other key financial and environmental variables, so we can assess how exposure to deforestation risks influences financial performance and risk perception from investors;

2. To analyze how investors have the perception of risk about FRCs and what are the challenges of tracking supply chains and reporting of deforestation, which might be impacted within the ESG frameworks, allowing the unsustainable practices to continue;

3. To propose specific measures that companies and investors can adopt to increase accountability and improve tracking systems in their supply chains.

This research design and these objectives provide a comprehensive framework for assessing the financial materiality of deforestation risks, exploring investor perceptions, and proposing actionable solutions to enhance transparency and accountability within high-impact sectors.

4.3 Data

4.3.1 Data Collection

The collection of primary data for this study is drawn from the Forest IQ database, a large databank that contains details of ongoing deforestation processes the world over. Presently, Forest IQ comprises of an authoritative system that offers precise metrics and analysis of the environmental data that is compiled to compare the world's forests and their loss, rates of deforestation, and other related factors that are indicative of these acts. Founded in 2005, Forest IQ has become an important tool for the researchers, policy makers and business organization and individuals who are in the quest of finding the solutions to the negative effects of deforestation. Defining goals of the database is to provide detailed insight of the deforestation and corporations through satellite imagery, ground reports, and economic indices. The data was collected from the Forest IQ database, which is available online and it was released in November 2023 and last updated in May 2024, which is going to ensure that the results obtained are up to date. This recent data includes updated information on the current situation of the level of deforestation that companies are exposed to and will be surely useful for the development of this study.

In the context of Forest IQ, this research is concerned with one of the indicators, namely "Metric 2", which, in turns, estimates the extent to which a company's revenues rely on dismissed activities associated with deforestation. This specific metric is selected because it creates a straight, measurable connection between business profitability and its impact on the environment. The financial imposts option presents the potential for directly quantifying the impacts of deforestation by reviewing the revenues that arise from the corresponding economic practices. Investor perception is an essential aspect, which can be even better captured by this metric (if it is at any level), and it quantifies the degree to which a firm generates their profits via commodities exposed to deforestation. The research hypothesis is that the extent to which a firm depends on deforestation linked revenues to fund its projects or operations will be accompanied by a correspondingly higher cost of equity due to the perceived risk by investors of legal consequences, image

problems and physical, loss of access to mainly forested land.

Metric 2 of Forest IQ gives a financial score of companies that are connected with deforestation by estimating the correlation between the total revenues of companies and the commodities which can be associated with deforestation, including palm oil, soy, beef, leather, timber, pulp and paper, natural rubber, cocoa, coffee, gold, and coal. It is evident from the methodology document that the categorization of companies is done relative to their revenues from these commodities following vulnerability to deforestation risks of account. Any organisation that is involved in sub-industries that has a higher deforestation score is given a higher materiality score meaning it has more impacts on the company. This categorization is useful in the sense that it affects most investors who are starting to adjust to the influence of ESG aspects, primarily, the environmental ones.

The collection of the data entails developing a list of categories that will help identify information sources from the database of Forest IQ. They include identifying companies in relevant industries with a high level of involvement in deforestation. When it comes to each of these companies, Metric 2 reveals the index of their revenues resulting from deforestation.

Moreover, we will gather information on financial data that we need to employ in the calculation of the cost of equity such as the overall market returns as well as risk-free rate and other financial indicator specific to the company under analysis. Additional control variables include size of the firm, growth opportunities, industry type, leverage, market to book, and return on equity that would also be taken to get a complete control on the final result. Refinitiv Eikon will be used for analyzing the financial data where the superior market data analytics platform provides extensive coverage of the phenomenon under inspection encompassing, financial markets performance, financial statements, and selected economic indicators. It is a vital tool for research, as Refinitiv Eikon offers real-time and historical data, analysis and visualization tools, and news feeds. It contains reviews and quotes high stock shares, financial reports, and data on stock exchange showing that it has an ability to offer accurate financial analysis of financial information stored in it. Thus, in this study, the cost of equity and other financial/ESG variables are validated through the integration of data from Refinitiv Eikon and the forest environmental data from Forest IQ, establishing a strong empirical model to embrace the corporate environmental management look into the expectation of how deforestation activities may drive the cost of equity.

The current position of the data from the 2023 release of Forest IQ, with the in-

formation till May 2024 enabled us achieving the most recent estimates of deforestation impacts. The approach that Forest IQ has used in their work as evidenced in the documents provided by the company is laudable as it collects data from multiple trusted sources such as the Forest 500, ZSL SPOTT, Trase, RSPO, SEI York among others. Hence, this sources combination improves the quality and the credibility of information and, thus, creates a powerful instrument for analysing the financial relevance of activities linked with deforestation, as the goal of this work.

4.3.2 Data Cleaning

Prior to the beginning of the analysis, it was necessary to collect and clean the data to get the most accurate result. The first database was the one from Forest IQ, where there was information of the dependence on FRCs of 2,109 unique companies, with headquarters in 78 countries.

Then, it was needed to filter to the publicly traded companies, since to correlate the cost of equity with the level of deforestation, as explained in the model, some of the control variables are key financial ratios, only available in Refinitiv Eikon for the listed companies. Then, after filtering, there was a total of 707 listed companies.

After that, through Refinitiv Eikon using the identifier of the companies (RIC), it was possible to connect the companies in the Forest IQ with those in this platform. Cleaning the data with any missing values, a total of 487 companies had all the variables to proceed with the analysis:

Table 1: Data Scorecard

Step	Justification	Total Companies
Forest IQ	Companies with available financial materiality	2,109
Publicly traded	Listed companies with Cost of Equity available in Refinitiv Eikon	707
All Refinitiv Eikon ratios	Removal of companies with any missing values	487

Source: The author

4.4 Quantitative Analysis

4.4.1 Ordinary Least Squares (OLS) Regression

OLS regression is a commonly used statistical method for estimating relationships between a dependent variable and one or more independent variables. The goal of OLS is to minimize the sum of the squared differences between observed and predicted values, producing the best linear unbiased estimates (BLUE) under certain assumptions. OLS regression is particularly useful for testing hypotheses about relationships among variables, as it allows researchers to quantify the impact of independent variables on the dependent variable.

In this study, OLS regression is used to investigate the relationship between FRC dependency and the cost of equity for companies, assessing whether increased exposure to deforestation risks affects financial perceptions. By employing this approach, we can measure the strength and direction of the relationship between FRC dependency (independent variable) and cost of equity (dependent variable), controlling for other relevant factors.

4.4.2 Fixed Effects Model

Fixed effects are introduced in the OLS model to account for unobserved heterogeneity within certain groups, such as countries, industries, or firms, that might influence the outcome variable. In this case, applying fixed effects controls for potential biases caused by time-invariant characteristics unique to each group that may impact cost of equity independently of FRC exposure. For instance:

- Country Fixed Effects: Countries may have different regulatory environments, economic conditions, or environmental policies that affect cost of equity.
- Industry Fixed Effects: Different industries vary in terms of ESG practices, risk profiles, and investor perceptions, which can influence financial outcomes in ways not directly related to FRC dependency.

By including fixed effects, we can isolate the impact of FRC exposure on cost of equity by controlling for these unobserved, time-invariant factors. This approach aligns with studies by Chen et al. (2023) and Di Tommaso and Thornton (2020), which employ

fixed effects to account for group-specific differences and reduce bias in the estimated coefficients.

4.4.3 Model Construction

To test the Hypothesis 1, and have learnt from Chen et al. (2023) and Di Tommaso and Thornton (2020), we can proceed with OLS regression model with fixed effects, as showed in Equation (4.1):

$$COE_i = \phi_0 + \phi_1 FM_i + \phi C + \Sigma IND_i + \Sigma CT_i + \epsilon_i \tag{4.1}$$

where:

COE_i is the cost of equity capital for firm i.

FM_i is the deforestation metric for firm i.

ϕ_0 is the intercept term.

ϕ_1 is the coefficient for the deforestation variable.

C is the control variable matrix, including Size, Growth, Leverage, Book-to-Market, Current Ratio, Return on Assets, Number of Analysts, Resources use, Emissions, Environmental Innovation Score, Social and Governance Scores.

ΣIND_i accounts for industry-specific effects.

ΣCT_i accounts for country-specific effects.

ϵ_i is the error term.

4.4.4 Rationale and Limitation of the Model

This model is suitable for addressing the Hypothesis because it enables us to observe the direct relationship between FRC exposure and cost of equity while controlling for potential confounding factors that might distort the results. By using fixed effects, the model reduces omitted variable bias by controlling for variables that are constant within groups but vary across them. Also, there is the alignment with Prior Research: Studies by Chen et al. (2023) and Di Tommaso and Thornton (2020) highlight the utility of fixed effects OLS in contexts where the researcher must account for unobserved heterogeneity

across entities. Their use of this model in environmental and ESG studies provides a foundation for employing it in this study.

While OLS with fixed effects is a powerful tool, it does have limitations:

- Potential for Multicollinearity: If some control variables are highly correlated with fixed effects or with each other, multicollinearity could affect the precision of the coefficient estimates.
- Assumptions of Linearity: OLS assumes a linear relationship between the independent and dependent variables. If the relationship between FRC exposure and cost of equity is non-linear, alternative methods may be required.

4.4.5 Variable Design

4.4.5.1 Dependent variable

The Cost of Equity, as already given the theoretical foundation in chapter 3, is a measure of required rate of return by a firm's shareholders for investing in it. Basically, it represents the opportunity cost for investors, since it can reflect the return they get of investing in that specific company instead of other or in an alternative investment. To summarize all the various models proposed to study the calculation of COE, we can highlight the Capital Asset Pricing Model (CAPM), which was developed by Sharpe (1964) and Lintner (1965), considering the risk-free, beta, and market risk. Another famous model is the Arbitrage Pricing Theory (APT) created by Ross (1976), estimating the cost of equity by considering some macroeconomic factors that might affect the return, such as inflation, interest rate, GDP growth..., which can make the model to be a little more complex. A third alternative is to use the Fama-French ThreeFactor Model, by Fama and French (1993), which expands the CAPM since it adds two factors, the size and value ones. In this study, we are going to use the value of the Cost of Equity given in the Refinitiv Eikon database.

4.4.5.2 Independent variable

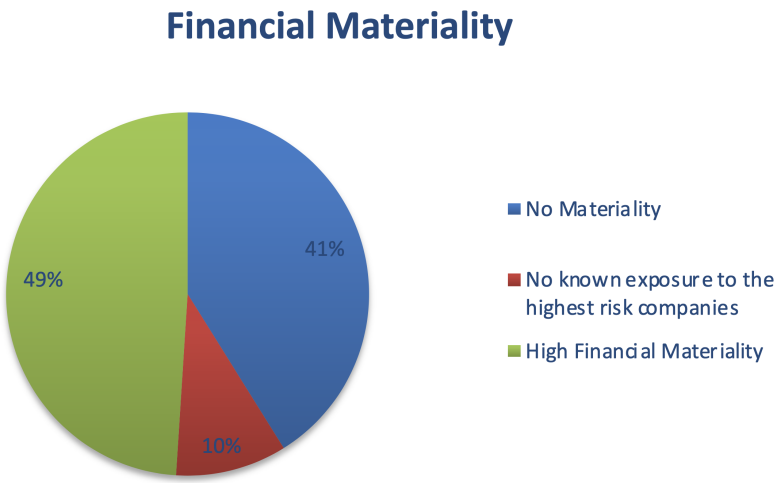
The independent variable is the level of exposition to deforestation by a company, being taken from Forest IQ, more specifically, the Metric 2. This metric scores are assigned based on the proportion of revenues from deforestation-related activities, using a scale

that reflects financial exposure - Metric 2 scores are assigned based on the proportion of revenues from deforestation-related activities, using a scale that reflects financial exposure:

1. **Critical Materiality (5 points)**: Business entities generating well above average revenue (more than 51%) from some of the yet sustainable sources such as deforestation.
2. **Very High Materiality (4 points)**: The second type is companies with enough revenue amounts (from 31 to 50%), but slightly lower revenue dependency.
3. **High Materiality (3 points)**: Businesses that have a high degree of business dependence (from 6 to 30%).
4. **Moderate Materiality (2 points)**: Small pool of firms moderately dependent on revenues (less than 6%).
5. **No Materiality (0 points)**: Pertaining to the profit and loss sheet, the investigation includes only companies with low or no dependence on income from deforestation.

These scores assist the investors in determining to what rate or degree a company's poor performance is associated with environmental erosion enabling the investors to make the right strategic investment decision based on risk assessment. The companies have different scores, as followed:

Figure 9: Financial Materiality of forest-risk commodities of companies in Forest IQ



Source: The author

4.4.5.3 Control variables

For the control variables, several key factors that typically influence a firm's cost of equity were included and were also used by the authors in this field of study (e.g., Di Tommaso & Thornton, 2020, Mio, Fasan, and Scarpa 2023, Chen et al. 2023). Specifically, we control for firm size (Size), revenues growth rate (Growth), leverage (Leverage), market-to-book ratio (M2B), profitability (ROA), current ratio (CR) and analyst coverage (NUM), as well as country and industry. All the variables, including the cost of equity, ESG scores, and the control variables, were collected from the Refinitiv database as said before.

4.4.6 Summary of Variables

To have a more comprehensive understanding of the analysis, Table 2 summarizes and defines the variables used in R, a popular software and language for econometric analysis, and it shows the data source of each variable:

Table 2: Variables Definition and Data Source

Variable Name	**Variable**	**Variable Type**	**Data Source**	**Variable Definition**
COE_i	Cost of Equity	Dependent	Refinitiv	Cost of Equity Capital for firm i (calculated by Refinitiv)
FM_i	Financial Materiality of FRCs	Independent	Forest IQ	Financial exposure to deforestation for firm i
$SIZE_i$	Size	Control	Refinitiv	Annual average of total assets of firm i
GRW_i	Growth	Control	Refinitiv	Growth rate of total income of firm i
$LEVG_i$	Leverage	Control	Refinitiv	Asset-liability ratio of firm i
$M2B_i$	Market-to-book ratio	Control	Refinitiv	Book-to-Market ratio of firm i
ROA_i	Return on Assets	Control	Refinitiv	Return on Assets for firm i
NUM_i	Analyst Coverage	Control	Refinitiv	Unique analysts issuing earnings per share forecasts for firm i
CR_i	Current Ratio	Control	Refinitiv	Current Ratio for firm i
RES_i	Resources Use Score	Control	Refinitiv	Resources Use Score for firm i
EMI_i	Emissions Score	Control	Refinitiv	Emissions Score for firm i
INN_i	Environment Innovation Score	Control	Refinitiv	Environment Innovation Score for firm i
SOC_i	Social Score	Control	Refinitiv	Social Score for firm i
GOV_i	Governance Score	Control	Refinitiv	Governance Score for firm i

Source: Compiled by the author using data from Refinitiv and Forest IQ

4.5 Qualitative Analysis

4.5.1 Semi-structured Interviews

The qualitative component of this study was elaborated to get the perspectives of companies and investors, on the relationship between FRCs, financial performance, challenges of traceability in supply chains and implementation of zero-deforestation commitments through interviews and sustainability reports. The objective is to understand stakeholder perceptions of ESG transparency, the limitations of current tracking systems for deforestation, and the accountability challenges faced by FRC-dependent companies. These semi-structured interviews provide qualitative insights that complement the quantitative analysis, allowing for a deeper exploration of how environmental risks are perceived and managed within the industry, as demonstrated by Bager e Lambin (2022).

Participants were asked to provide answers and insights that reflect diverse views on deforestation risks, ESG practices and supply chain management challenges envolving FRC. Invitations were extended to executives, analysts, sustainability roles, and founders of FRC-dependent companies, as well as investors focused on ESG criteria, although a lot of them refused to participate, even with a grated full anonymity, so interviewees are non-random and also may have led by a self-selection bias.

Interviews were conducted using a semi-structured format, allowing for a consistent set of core questions while also enabling participants to share additional insights as they wanted to. An interview guide was developed with questions covering topics such as:

- The perceived impact of FRC exposure on financial risk and cost of equity
- Current practices and challenges in tracking deforestation and reporting in ESG frameworks
- Views on the adequacy of existing accountability and tracking mechanisms
- Recommendations for improving ESG transparency and deforestation tracking

Each interview lasted approximately 10-20 minutes, conducted via a call or video-conference. All participants were informed of the study's purpose, and consent was obtained to record, transcribe, and analyze their responses, ensuring confidentiality.

4.5.2 Qualitative Analysis Techniques

Thematic analysis was used to analyze the interview data, combining deductive and inductive coding approaches. Initially, deductive codes were applied based on research questions and theoretical themes, such as “Risk management”, “Transparency” and “Zero deforestation commitments”. Following this, an inductive coding phase allowed additional themes to emerge from participants’ answers, ensuring that unexpected insights were captured. Additionally, while semi-structured interviews allowed flexibility, they may not capture all nuances of stakeholder perspectives on deforestation risks. However, the mixed-methods approach—incorporating both qualitative insights and quantitative analysis—helps to mitigate these limitations, providing a comprehensive view of the financial and environmental challenges faced by FRC-dependent companies.

5 ANALYSIS

This chapter begins with a presentation of the descriptive statistics, allowing us to get initial insights and closely explore the variables. and an overall analysis before focusing on the analysis. After that, a comprehensive discussion of the relationship of cost of equity with the dependence on forest-risk commodities is presented, including more valuable and interesting findings when crossing this data. Finally, this approach helps to investigate the research objectives and enhances the validity of conclusions, underscoring the importance of the methodological steps in this empirical research. Complementing the quantitative results, qualitative insights derived from semi-structured interviews with key industry stakeholders—including companies, investment funds, and ESG-focused investors—add depth to the analysis. These interviews reveal perceptions of deforestation risk, ESG challenges, and the complexities of implementing sustainable practices within FRC supply chains. The combination of quantitative and qualitative methods provides a holistic view of how deforestation impacts financial metrics and investor attitudes, enhancing the study's validity and offering a well-rounded understanding of the research objectives. This integrated approach underscores the importance of both data-driven insights and stakeholder perspectives in assessing the financial risks associated with deforestation.

5.1 Quantitative Analysis of Deforestation and Cost of Equity

This section presents a quantitative analysis aimed at investigating the relationship between deforestation exposure —particularly through FRCs — and the cost of equity for companies. Given the rising importance of Environmental, Social, and Governance (ESG) considerations, particularly in sectors linked to environmental degradation, this analysis seeks to determine if a company's dependency on FRCs and associated deforestation risks impact its financial metrics, specifically the cost of equity. By analyzing data on deforestation exposure, financial performance, and ESG scores, we aim to understand how

the financial materiality of environmental risks, such as deforestation, influences investor perceptions and ultimately affects the cost of equity. The results of this analysis will offer insights into the extent to which environmental risks are reflected in financial outcomes and whether companies with higher FRC dependency face heightened financial scrutiny.

5.1.1 Descriptive Statistics

5.1.1.1 Numeric variables

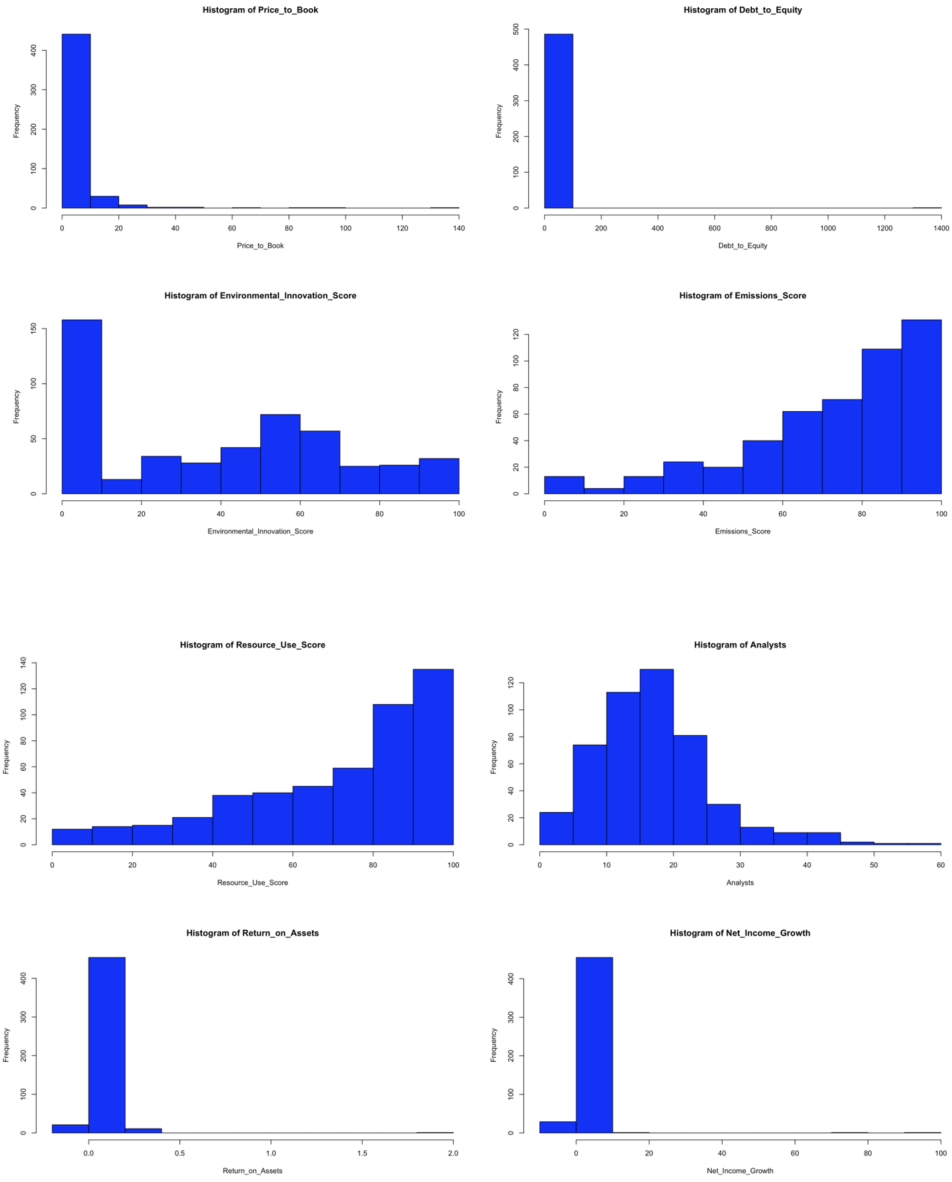
Table 3: Data Summary Statistics

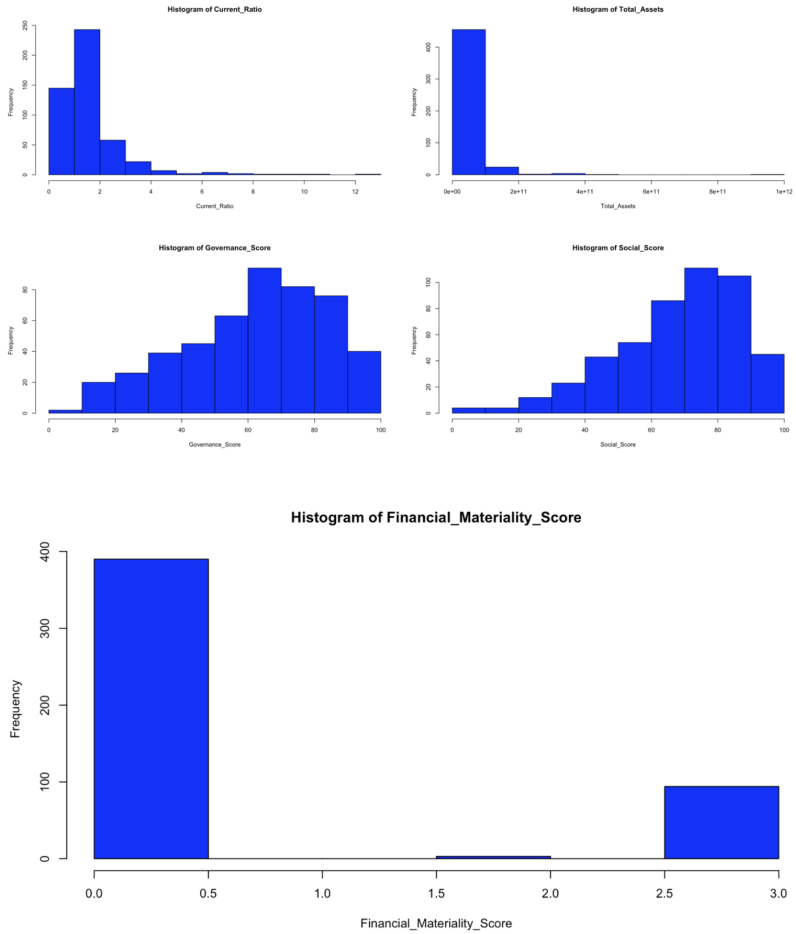
Variable	Mean	Std Dev	Min	25th Percentile	Median	75th Percentile	Max
COE	0.09	0.03	0.04	0.07	0.08	0.10	0.22
FM	0.59	1.19	0.00	0.00	0.00	0.00	3.00
SIZE	3.2×10^{10}	6.5×10^{10}	1.2×10^{8}	5.8×10^{9}	1.3×10^{10}	3.1×10^{10}	9.3×10^{11}
GRW	0.61	5.36	-0.41	0.07	0.12	0.22	90.98
LEVG	3.79	60.93	0.00	0.28	0.64	1.26	1345.20
M2B	4.70	9.88	0.21	1.29	2.20	4.18	133.76
CR	2.55	0.45	1.80	2.03	2.45	2.83	3.20
ROA	0.07	0.10	-0.12	0.03	0.05	0.09	1.98
NUM	17.51	8.71	0.00	11.50	17.00	22.00	57.00
RES	71.19	24.97	0.00	54.20	79.97	90.81	99.92
EMI	72.99	23.12	0.00	61.08	79.51	90.77	99.92
INN	38.68	31.89	0.00	0.00	43.58	60.50	99.84
SOC	68.13	18.89	0.42	56.50	71.82	82.77	97.55
GOV	62.20	21.45	8.00	47.14	65.29	79.37	97.64

Source: The author

Additionally, to understand the distribution of the numerical variables in the dataset, histograms of the control variables and the independent variable were plotted (Figure 10) to analyze then the distribution and possible skewness asymmetries, consequently if there was the need to transform them to get better and more accurate results.

Figure 10: Histograms of the numeric variables

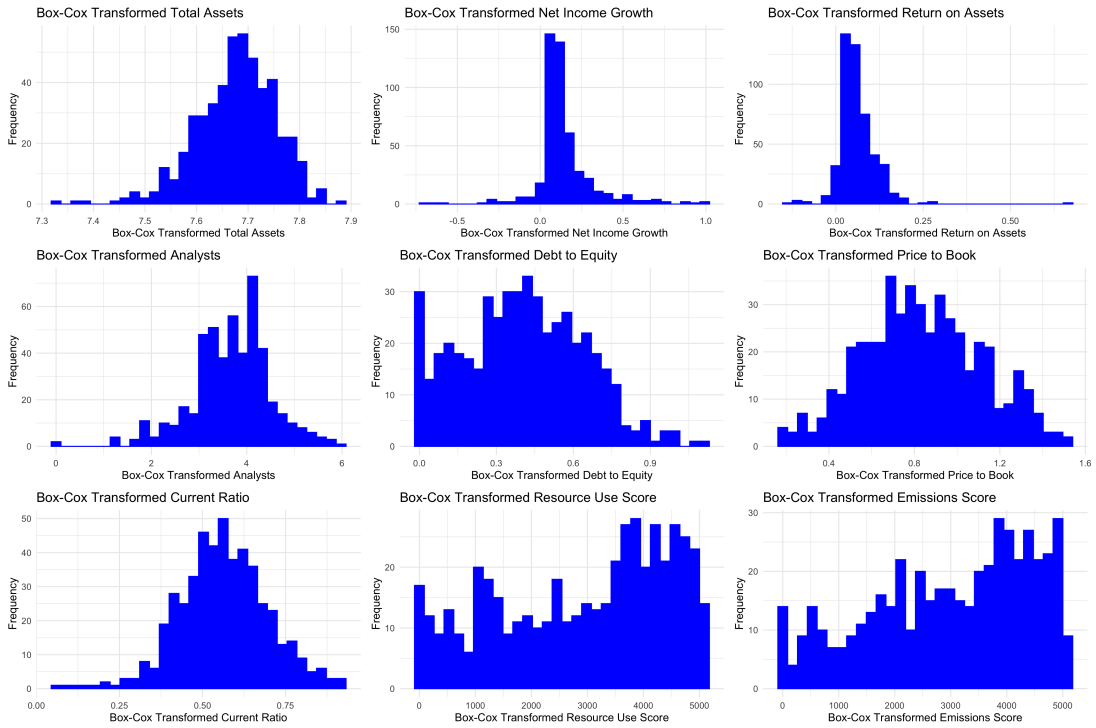




Source: Compiled by the author using R

Moreover, to be even more certain about the skewness of the histograms, skewness values were obtained in R. Those variables that had a skewness lower than -1 and greater than 1 were transformed first using the Logarithmic and Cube Root Transformations. However, even with these transformations, the skewness of some variables did not have significant symmetry. Thus, the Box-Cox transformation was applied to the variables, which is a more sophisticated approach to transform data into a normal shape. After that, all the variables had improved their skewness, as showed in Figure 11:

Figure 11: Histograms of the numeric variables after transformation



Source: Compiled by the author using R

Thus, with the Box-Cox transformations, the variables presented a reduction in the skewness and resulted in a more balanced distribution, beneficial for the subsequent analysis. Also, a scaling of the variables was done due to the difference of intervals.

5.1.1.2 Categorical variables

In this study, there are a total of 43 different industries and 42 different countries. In the tables below the most frequent ones are showed and their respective count:

Table 4: 10 Most Frequent Industries

Industries	**Count**
Software & IT Services	89
Chemicals	54
Electric Utilities & IPPs	44
Telecommunications Services	40
Professional & Commercial Services	33
Real Estate Operations	30
Healthcare Providers & Services	17
Food & Tobacco	17
Media & Publishing	11
Specialty Retailers	10

Source: The author

Table 5: 10 Most Frequent Countries

Countries	**Count**
United States of America	135
United Kingdom	39
Japan	34
China	31
India	21
Germany	20
Hong Kong	17
France	14
Brazil	13
Canada	13

Source: The author

After that, it was conducted a Pearson's Chi-squared test to analyze if there was any association between Industries and Countries, and it was performed using R. The output is showed below, if the most relevant industries and countries:

	Chemicals	Electric Utilities & IPPs	Professional & Commercial Services	Software & IT Services	Telecommunications Services
China	4	1	1	8	1
India	4	0	0	7	1
Japan	6	0	3	9	3
United Kingdom	3	1	3	5	2
United States of America	12	17	15	35	2

Figure 12: Pearson's Chi-squared test Industries and Countries

```
        Pearson's Chi-squared test

data:  cross_tab
X-squared = 1815.9, df = 1722, p-value = 0.05669
```

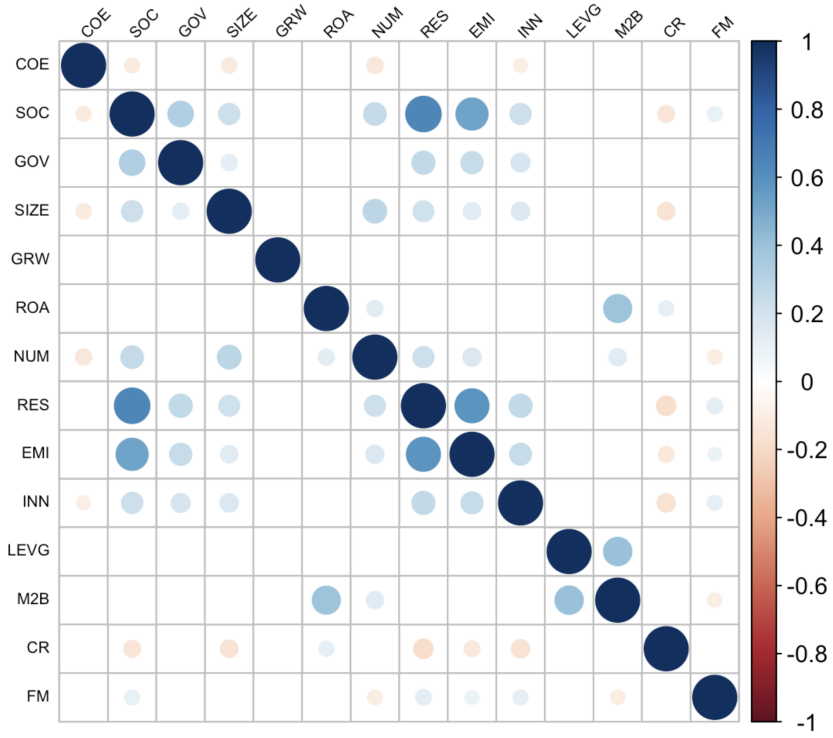
Source: Compiled by the author using R

Thus, it is possible to conclude that with a p-value slightly above the significance level of 0.05, the variables have no statistically significant association considering the 0.05 level, which can be interpreted as the distribution of industries is relatively week independent of the countries. Although this result can simplify the analysis, since there are many industries and countries, and in the 0.1 level there could have some association, that will be considered, given some concerns of multicollinearity or interactions between these categorical variables.

5.1.1.3 Correlation between variables

To get a more comprehensive understanding of the variables in this study, the following Correlation Matrix (Figure 13) shows the significant (p-value level of 0.05) relationship between the financials and financial materiality of FRCs variables. The color intensity as well as the size of the circles represent the correlations, with blue indicating positive correlations (higher the value of the variable, higher the cost of equity) and red negative correlations (higher the value of the variable, lower the cost of equity):

Figure 13: Correlation Matrix



Source: Compiled by the author using R

In the first moment, we can see that the Cost of Equity has strong negative correlations with Firm Size (Total Assets), Social, Number of Analysts, and Environmental Innovation, as also proved by recent research (Y Chen et al., Wu et al.). As also commented in previous chapters this could be explained by the greater stability and lower perceived risks associated with these firms. Moreover, in this matrix is also possible to see the positive correlation between Social and Governance, implying that usually firms with good social scores are going to also have strong governance practices. Also, both show positive correlations with Size, which can indicate that bigger firms tend to include these criteria in their practices. Besides, in this matrix it is not possible to see the FM (Financial Materiality of FRCs) correlation with cost of equity, since it is statistically significant only for 0.1 level, and with a positive coefficient of 0.08, indicating that as the dependence on FRCs tends to increase, cost of equity would increase.

The correlation matrix reveals an interesting positive correlation between FM and RES (Resource Use Score), EMI (Emissions Score), and INN (Innovation Score). This relationship suggests several possible explanations for how FRC dependence may influence these ESG scores.

A positive correlation between FM and the Resource Use Score (RES) may indi-

cate that companies with a higher reliance on FRCs actively manage their resource use. This proactive approach could be driven by the high visibility and environmental impact associated with these commodities. Given that FRC-dependent companies operate in sectors heavily reliant on natural resources, they may adopt practices aimed at optimizing resource efficiency to meet regulatory standards and align with sustainability goals. Consequently, this effort may contribute to higher RES scores, reflecting a focus on material and resource management as part of their operational strategy.

Also, the positive correlation between FM and the Emissions Score (EMI) suggests that companies involved with FRCs are taking active measures to manage and reduce their greenhouse gas emissions. Since deforestation and land use changes are closely scrutinized for their impact on carbon emissions, these companies may face pressure to implement emission reduction initiatives as part of their ESG commitments. To mitigate risks related to environmental concerns, FRC-dependent firms may invest in cleaner technologies or emission control practices, leading to higher EMI scores. This alignment could indicate that companies heavily involved in FRCs strive to counterbalance their environmental impact through focused emission management.

Finally, the positive correlation between FM and the Innovation Score (INN) could imply that companies with a substantial dependency on FRCs invest more in innovation, particularly in sustainable practices and alternative materials. Companies with exposure to deforestation risks may feel pressured to innovate in order to address environmental concerns and enhance sustainability throughout their supply chains. This could result in increased investments in technologies and practices, such as sustainable farming techniques, alternative resources, or improved traceability systems. These efforts may drive up their Innovation Score, reflecting a forward-thinking approach to managing FRC-related risks through technological and process innovation.

Overall, these correlations are plausible within the context of FRC-dependent companies facing increased pressure from investors, consumers, and regulatory bodies to adopt sustainable practices and mitigate their environmental footprint. By improving their Resource Use, Emissions, and Innovation scores, these companies may aim to reduce the financial and reputational risks associated with deforestation and ESG concerns. However, the strength and true nature of these correlations should be further examined to ensure they reflect substantive efforts rather than superficial compliance or reporting practices.

5.1.2 OLS Model

As explained in the chapter 4, the Ordinary Least Squares (OLS) with fixed effects model is going to be executed, as follows again:

$$COE_i = \phi_0 + \phi_1 FM_i + \phi C + \Sigma IND_i + \Sigma CT_i + \epsilon_i \tag{5.1}$$

It is also important to elicit the transformations previously explained, to have a better distribution and skewness of some variables. Also, to account for industry and country effects, dummy variables for each were included in the dataset, resulting in a better control for unobserved heterogeneity that could influence the cost of equity across different scenarios.

After applying the OLS model with fixed effects in R, the following outcome can be evaluated to assess the model's quality and consider possible changes to have a more reliable model, as showed:

Figure 14: Summary Statistics of the OLS Regression Model

```
Residual standard error: 0.0177 on 390 degrees of freedom
Multiple R-squared:  0.7041,    Adjusted R-squared:  0.6313
F-statistic: 9.667 on 96 and 390 DF,  p-value: < 2.2e-16
```

Source: Compiled by the author using R

The first thing we can observe is the Residual standard error of 0.0177, relatively low, which suggests a good fit of the model, since deviations are small. Furthermore, the multiple of R-squared of approximately 70.4% indicates that the model can explain a substantial portion of the variance in the dependent variable – the cost of equity. Also, the value of F-statistic with the p-value less than 2.2e-16 shows that the model is statistically significant. Finally, the DF (Degrees of freedom) of 390 also means that the model is robust and provides good fit for the data presented. The Table 6 shows the estimates for the coefficients and the p-values:

Table 6: Regression Coefficients for the OLS Model

Variable	**Coefficient**	**Standard Error**	**t-value**	**p >|t|**
FM	0.0030	0.0015	1.9970	0.0466*
SIZE	-0.0032	0.0000	-2.1450	0.0326*
GRW	0.0017	0.0100	0.1700	0.8651
LEVG	0.0023	0.0053	1.9020	0.0579 .
M2B	-0.0045	0.0041	-3.1960	0.0015**
CR	0.0005	0.0073	0.4500	0.6529
ROA	-0.0018	0.0266	-1.4420	0.1500
NUM	0.0010	0.0008	0.7140	0.4757
RES	-0.0007	0.0000	-0.5260	0.5994
EMI	0.0025	0.0000	2.1240	0.0343*
INN	-0.0001	0.0000	-1.7100	0.0881 .
SOC	-0.0001	0.0001	-1.5280	0.1273
GOV	-0.0000	0.0000	-0.2570	0.7970
Industry	Controlled			
Country	Controlled			
N	487			
R^2	0.7			

Note: *p <0.05, **p <0.01, .p <0.1.

Source: Compiled by the author using R

The first thing noticeable is the financial materiality of FRCs score of 0.00297, which is positive and is statistically significant (p-value = 0.046553) at 0.05 level. Inside ESG criteria, Social has negative coefficient and Governance approximately 0, however both not statistically significant at conventional levels. Emissions with a low coefficient and statistically significant and Innovation negative coefficient, with a p-value significant at 0.10 level. Both effects of industry and country were taking into account in this analysis.

In the context of financial ratios and metrics, Size (total assets) and Book-to-Market have negative and significant (0.03355 and 0.001507 p-values respectively), indicating that larger companies and firms with higher price-to-book ratios tend to have lower cost of equity. Finally, if considering a 0.1 level, leverage can also impact the cost of equity, but since it has a positive coefficient, means that firms with higher leverage would have higher

cost of equities.

5.1.2.1 Multicollinearity check

When performing an OLS regression, it is important to account for possible multicollinearity in the variables, since even with reasonable values for R-squared and F-statistic, it is essential to check if there are correlations among the variables that could lead the model to be less accurate. One way to examine the multicollinearity is to use the Generalized Variance Inflation Factor (GVIF) and the Adjusted GVIF, as showed in Table 7:

Table 7: Variance Inflation Factor (VIF) for Multicollinearity

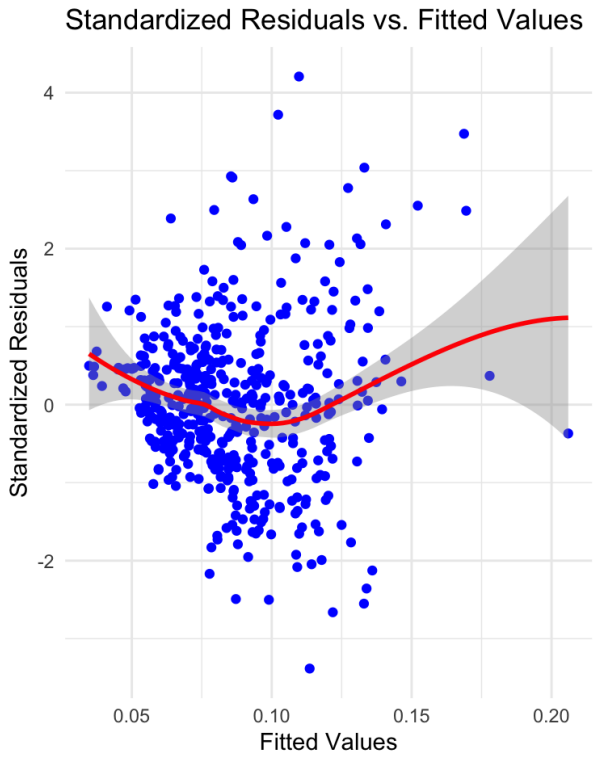
Variable	**GVIF**	**Adjusted GVIF**
FM	4.8563	2.2037
SIZE	3.4378	1.8541
GRW	1.7773	1.3331
LEVG	2.3347	1.5280
M2B	3.1058	1.7623
CR	2.1852	1.4782
ROA	2.2834	1.5111
NUM	3.2131	1.7925
RES	2.5663	1.6020
EMI	2.1528	1.4672
INN	1.8869	1.3736
SOC	2.9659	1.7222
GOV	1.5358	1.2393
Industry	4288.0613	1.1047
Country	1074.0373	1.0888

Source: Compiled by the author using R

Usually, when analyzing the VIF, the values above 5 indicate high correlation, between 1 and 5 moderate and 1 no correlation. As all of them fit inside the rule of lower than 5, this indicates that the model has acceptable levels of multicollinearity, although the financial materiality of forest-risk commodities variable with a GVIF of 4.86 warrants attention, even though is it not high.

Continuing to investigate the possible issues with the model, another method was to do a Scatterplot of Standardized Residuals versus Fitted Values to help assess the assumption of linearity and homoscedasticity, which is the constant variance of residuals in the model (Figure 15).

Figure 15: Scatterplot of Standardized Residuals vs. Fitted Values



Source: Compiled by the author using R

In this plot, we can observe that the pattern of residuals doesn't appear to be random around zero, showing potential issues with linearity, especially with the curvature, indicating this relationship. Additionally, the spread increases as fitted values increases, which can suggest heteroscedasticity, with the variance of residuals being different across the levels of the fitted values. This can lead to possible biased standard errors and be a signal of the need to address this issue.

Since there were signs of possible heteroscedasticity, the Breusch-Pagan test can be more assertive with values to confirm if there is this issue in the OLS Model we performed. In Table 8 we can see the results:

Table 8: Breusch-Pagan Test for Heteroscedasticity

Metric	**Value**
Breusch-Pagan Test Statistic (BP)	157.6136
Degrees of Freedom (df)	96
p-value	0.000075

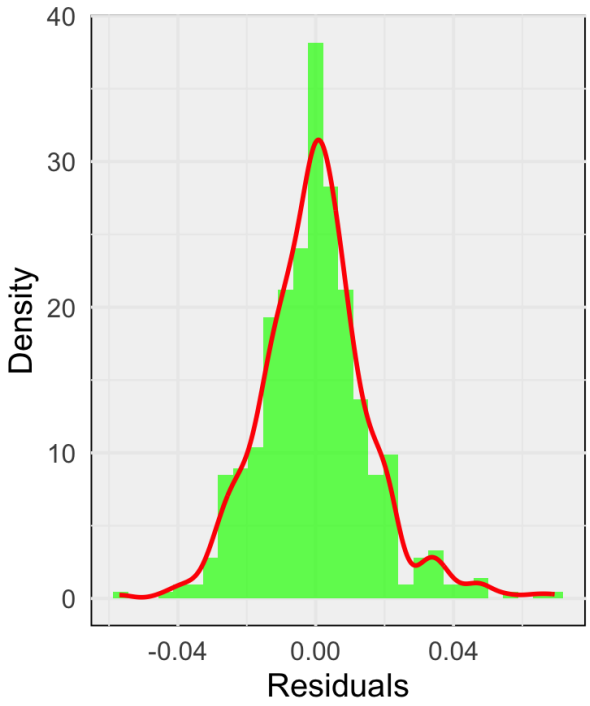
Source: Compiled by the author using R

As the p-value in this test is below 0.05, we reject the null hypothesis, which leads to a strong suggestion of the heteroscedasticity presence in the model. Also, the high value of the BP as 157.6136 shows even more probability for this to be present in this analysis.

5.1.2.2 Analysis of residual errors

It is also important to review the residuals, and under we can see in Figure 16 the histogram of residual errors, which shows the differences between the predicted and actual values. As in the model we expect a normal distribution, with a mean of zero, we can observe that the approximate normal distribution of residuals supports the assumption of normality of residuals. Also, the histogram and density plot indicate that residuals are small and symmetrically distributed around zero, with a shape deviating slightly but it does not appear to be impactful for the model. This suggests that the model fits the data as well, capturing the relationship in the data without significant bias.

Figure 16: Histogram of Residual Errors



Source: Compiled by the author using R

5.1.3 Second Model

To address the issue of heteroscedasticity, other models were evaluated, but the issue continued. So, another way to approach it, was with the Mixed-Effect Model and a

transformation of the dependent variable. The following formula represents the model:

$$COE_i = \phi_0 + \phi_1 FM_i + \phi C + (1|IND_{jk}/CT_j) + \mu_i + \epsilon_i \tag{5.2}$$

where:

COE_i is the cost of equity capital for firm i.

FM_i is the deforestation metric for firm i.

ϕ_0 is the intercept term.

ϕ_1 is the coefficient for the deforestation variable.

C is the control variable matrix, which includes factors like size, growth, leverage, etc.

$(1|IND_{jk}/CT_j)$ denotes intercepts for countries nested within industries, where CT_j represents the j-th country and IND_{jk} is the k-th industry within the j-th country.

μ_i is the unobserved individual-specific effect for firm i.

ϵ_i is the error term.

5.1.3.1 Mixed Effects Model

After applying the Mixed Effects model in R, the following outcome can be evaluated to assess the model's quality, as showed in Figure 17:

Figure 17: Summary statistics for the Mixed Effects Model

```
Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.93255 -0.55815  0.00055  0.58620  2.95493

Random effects:
 Groups   Name        Variance Std.Dev.
 IND:COU  (Intercept) 0.3650   0.6041
 COU      (Intercept) 0.6638   0.8148
 Residual             0.5032   0.7094
Number of obs: 487, groups:  IND:COU, 238; COU, 42
```

Source: Compiled by the author using R

As the scaled residuals seem to be around zero and no show of any extreme outliers, it is a sign that the residuals are well-behaved. Also, the effects for IND:COU shows that with the 487 observations, there are 238 IND:COU groups and 42 COU groups (COU here is the variable for Country).

Table 9: Regression Coefficients for Mixed Effects Model

Variable	**Coefficient**	**Standard Error**	**t-value**	**p >|t|**
FM	0.0569	0.0410	1.174	0.2415
SIZE	-0.1011	0.0000	-2.370	0.0183*
GRW	0.0440	0.0070	1.203	0.2297
LEVG	0.0288	0.0010	0.600	0.5489
M2B	-0.0160	0.0050	-0.352	0.7250
CR	-0.0001	0.0318	-0.004	0.9972
ROA	-0.0038	0.4020	-0.092	0.9267
NUM	0.0032	0.0060	0.061	0.9515
RES	0.0247	0.0020	0.425	0.6711
EMI	0.0629	0.0020	1.213	0.2257
INN	-0.0018	0.0010	-1.300	0.1944
SOC	-0.0682	0.0030	-1.127	0.2603
GOV	0.0086	0.0020	0.202	0.8398
IND:CT	238			
CT	42			
N	487			
R^2	0.676			

Note: *p <0.05.

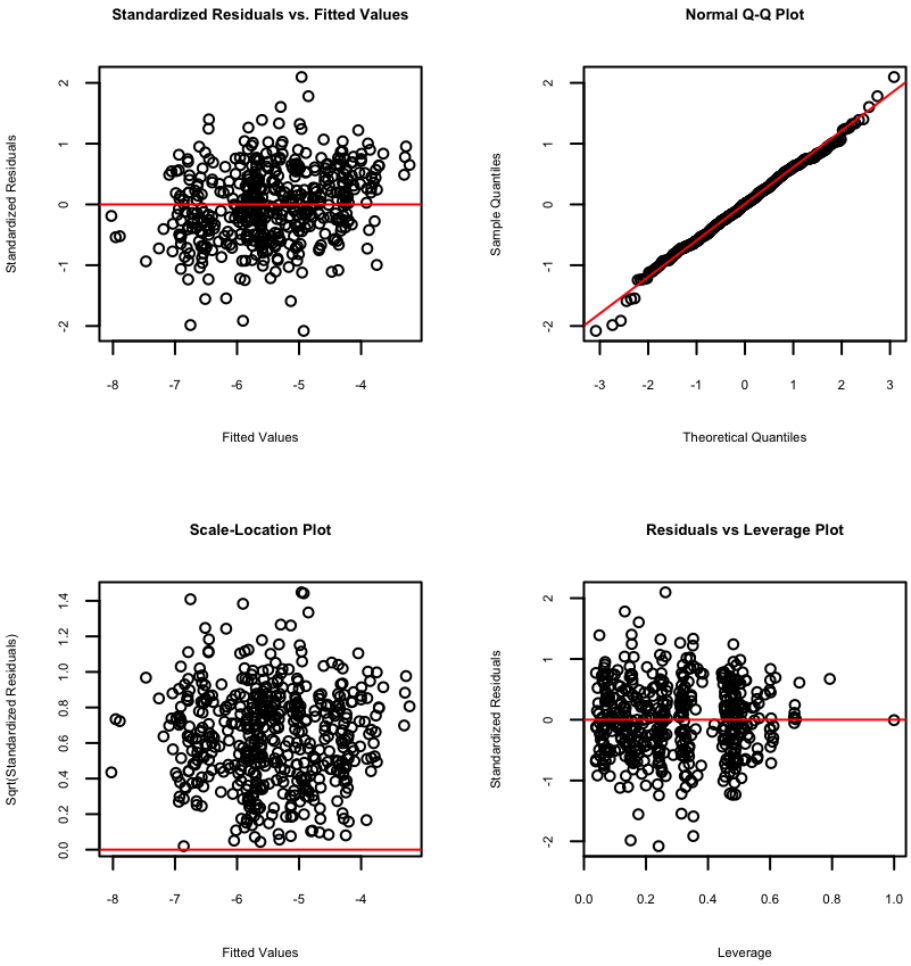
Source: Compiled by the author using R

In this model, the R-squared proves that the variables explain a great part of the variance of the dependent variable. Also, it is possible to conclude that only the size of firms has significant negative correlation with the cost of equity (p-value = 0.0183), thus again larger firms face lower cost of equities. In this model the financial materiality of FRCs coefficient is positive, although not being statistically significant, so it does not confirm the correlation of this variable with the cost of equity.

5.1.3.2 Multicollinearity check

Again, the multicollinearity check was done, and we can observe the following four plots to analyze this better:

Figure 18: Multicollinearity check of Mixed Effects Model



Source: Compiled by the author using R

The first plot on the top left shows the relationship between the standardized residuals and the fitted values of the model, and as there is no clear pattern and random scatter of points are around the horizontal axis (y = 0), we can firstly assume that there is homoscedasticity, so no more the issues with heteroscedasticity are encountered. The normal Q-Q plot indicates that residuals are approximately normally distributed, as the points follow the reference line well. Thirdly, the Scale-Location plot also supports the homoscedasticity since the horizontal red line in the bottom can suggest constant variance.

Finally, the last plot of Residual versus Leverage plot shows that there are no highly influential observations that could affect the model.

Again, the Breusch-Pagan Test for Heteroscedasticity was used to ensure that this model holds for homoscedasticity, and the results are in the Table 10:

Table 10: Breusch-Pagan Test for Heteroscedasticity in the Mixed Effects Model

Metric	Value
Breusch-Pagan Test Statistic (BP)	0.12347
Degrees of Freedom (df)	1
p-value	0.7253

Source: Compiled by the author using R

As the p-value is higher than 0.05, there is no significant evidence of heteroscedasticity in the model, which suggests that the model with also the previous analysis is appropriate for the data, so, key assumptions are met, and it is possible to continue to the interpretation of the results.

5.2 Qualitative Analysis

This section presents the qualitative findings derived from interviews conducted with Brazilian investment funds, investors and companies that use forest-risk commodities, as well as some sustainability reports from investor relations. The purpose of these interviews was to gain a deeper understanding of how investors perceive deforestation risks, particularly in the context of forest-risk commodities, and how these perceptions influence their investment decisions and the cost of capital for firms operating in Brazil and what companies are doing to minimize the risk perception in their supply chain.

5.2.1 Overview of the Interviews

The qualitative part of this study is based on interviews with Brazilian investment analysts, consulting firms and companies with dependency of FRCs. The funds were selected based on their presence in sectors related to environmental, social, and governance (ESG) criteria, as well as their exposure to companies operating in industries with high deforestation risk, such as agriculture, forestry, and mining.

A total of 10 interviews were conducted with fund analysts, investment analysts, con-

sultancies, ESG innovation roles and companies related to FRCs. The table summarizes the interviewees:

Table 11: Sample of Interview Participant Information

Code	Size	Type	Employee Position	Ownership	Type
I1	-	Investor	ESG Analyst	Private	PE Fund
I2	-	Investor	ESG Analyst	Private	PE Fund
I3	15	Investor	Analyst	Private	Investment Firm
C1	30	Corporate	Founder	Private	Consumer Goods
C2	+100k	Corporate	Sustainability	Public	Meat Processing
C3	+5000	Corporate	Sustainability	Public	Retailer
C4	+5000	Corporate	Sustainability	Public	Producer
C5	+10k	Corporate	Analyst	Public	Paper Manufacturing
N1	1000	Non-Corporate	Consultant	Private	Consultancy
N2	350	Non-Corporate	Partner	Private	Consultancy

Source: The author

The interviews were structured around key themes, including the importance of ESG in investment decisions, the specific role of deforestation risk in shaping investment strategies, and the perceived impact of these risks on the cost of capital for Brazilian companies.

5.2.2 Key Themes from Interviews

Many themes were discussed during the interviews, offering insights into how deforestation risk is perceived by Brazilian investors and how this risk is integrated (or not) into their investment processes.

5.2.2.1 Risk perception from investors

First, it is going to be analyzed from the perspective of investment firms, where concerns around FRC risks, mainly deforestation, are not always clear and center. They commented that when evaluating investments, certification and traceability are seen as good tools, possibly accelerating the approval process; however, they are not considered to be deal-breakers. Also, firms that demonstrate to have better sustainability practices, including certifications and transparent supply chains, are viewed more favorably. Yet,

all of these factors are supplementary to the financial profile, reflecting a more cautious approach where the ESG factors support investment decisions, but they are not the primary drivers. Although, according to one analyst interviewed, deforestation is relevant in their risk assessments for companies involved with forest-risk commodities:

> "Well, deforestation is an important environmental risk, and we definitely assess when executing due diligence, even though it can be hard to be accurate. But, let's say a company is unable to demonstrate sustainable practices, then it may raises the perceived risk." (I2)

It was common that participants indicated that while they recognize the importance of ESG practices and the possible risk of FRCs, these considerations are often secondary to most financial metrics, especially in the beginning of evaluations. So, this perspective can reflect a broader industry tendency to prioritize immediate financial returns over indirect environmental risks, unless those risks are material to financial performance. Likewise, some interviewees acknowledged that their portfolios lack direct investments in commodities and only occasionally include clauses related to deforestation or labor issues in contracts. However, climate-focused funds analysts argued that attention to deforestation and ESG standards may become a future priority as stakeholder expectations evolve worldwide.

Another theme from the interviews was the skepticism around carbon markets as an effective strategy to mitigate emissions. Interviewees expressed some doubts about the effectiveness of carbon credits, given the focus on credits tied to forest preservation and reforestation, areas not directly aligned with their investment sectors. This is due to the fact that carbon credits are often perceived as secondary to actual emissions reductions, with interviewees saying that companies should actually prioritize reducing their emissions rather than relying on offset mechanisms. While some companies within these portfolios do generate carbon credits through renewable energy projects, participants noted that low market demand and challenges in structuring credits have limited their financial appeal. As one interviewee said:

> "And we don't see it as an effective mitigation strategy, we prefer to focus on reducing the company's emissions even before offsetting. It's a necessary evil — we'll have to offset to achieve net-zero emissions, but it should only cover the residual." (I1)

Then, certifications were also a focus point as a critical factor in the initial screening of FRC investments, serving as a indicator of a company's ESG practices. Interviewees said that certification, though some have limitations, offers a starting point for assessing environmental standards and enables a better alignment with ESG criteria.

> "In the first screening, we look at the certifications the company holds because that's what can be assessed initially. However, during due diligence, we go as far as requesting contracts to analyze the clauses and understand whether this issue is addressed. If it's not, we include it as part of the ESG Action Plan we develop with the invested company." (I1)

One interviewee said that for mid-market companies that may lack advanced sustainability practices, the focus is on gradual improvement in ESG performance over the investment period rather than immediate compliance with high standards.

Participants also said that only certifications does not guarantee full traceability, but provide a baseline. In light of this, investors in these sectors often work with portfolio companies to introduce and enforce sustainability standards, and it may be new to some firms. Also, frequent ESG reviews and meetings with investors help to track these efforts, but, according to them, the challenges continue in implementing traceability standards across sectors. Moreover, funds that prioritize ESG emphasized the value of certifications, since they were seen as reliable indicators of a company's commitment to sustainability and responsible land use. Fund analysts noted that companies with these certifications are viewed as less risky investments, which may lower their cost of capital in the long run.

Even with the acknowledgment of deforestation as a significant risk, fund analysts expressed challenges in quantifying this risk in financial terms. The difficulty lies in translating environmental impacts into measurable financial outcomes that can be incorporated into traditional valuation models. Furthermore, some interviewees noted that, while they consider deforestation in their qualitative assessments, the lack of standardized metrics and the uncertainty around future regulations make it difficult to reflect this risk in a company's current financial standing.

5.2.2.2 Challenges in FRC supply chains

Participants consistently highlighted traceability as one of the most difficult aspects of managing forest-risk commodities within complex supply chains. For industries with extensive supply chains having multiple intermediaries, tracking deforestation from source

to end product remains a challenge. Interviewees explained that indirect suppliers—often small-scale producers are particularly difficult to monitor, as they may operate with limited transparency or regulatory oversight and this lack of direct visibility makes it challenging for companies to ensure that their raw materials are sourced responsibly. Likewise, even with the efforts of some companies to have more appropriate traceability systems, interviewees showed their concern about the costs involved in implementing monitoring across every supply chain level and its need. For some organizations, achieving complete traceability would require high investment in tools and infrastructure.

Also, when discussing potential solutions, some participants pointed to the important role of certification from suppliers, however, there was a shared acknowledgment that certification alone is often insufficient, particularly in sectors with highly fragmented supply chains. Interviewees said that while certification can be useful, it does not guarantee full visibility over indirect suppliers or other points in the supply chain where deforestation risks may occur. Thus, to address these gaps, companies are increasingly looking toward a combination of using certification, internal monitoring practices, and supplier engagement to reinforce their traceability efforts.

As well technology was commented during the interviews as a tool for enhancing transparency and improving the tracking of FRCs, including blockchain and satellite monitoring, which are becoming integral to real-time deforestation tracking and data integrity. Similarly, satellite monitoring can make possible the detection and response to deforestation events in near real-time, but some interviewees said that these promising technologies, come also with high costs and technical requirements that might limit accessibility, and this usually happens for smaller and medium companies. While the initial investment in technology can be high, they said that the long-term benefits in terms of risk mitigation and improved transparency might compensate the cost. As an insight, we can say that, as technology continues to evolve, these tools will become more accessible and enable a broader adoption across the FRCs sector.

5.2.2.3 Transparency and accountability

One important subject was the certifications that confirm a company's commitment to environmental sustainability, and these programs provide a structured approach to ensure that raw materials meet specific environmental criteria, which is important in sectors involved with deforestation risks. Interviewees said that certification helps companies to communicate their sustainability efforts, however, some of them raised concerns that

certifications alone may not cover every step in the supply chain, particularly in regions where small-scale suppliers operate outside formal regulatory frameworks and can search for other firms that might not require many certifications.

Interviewees explained that certification establishes a first recognition, but it needs to be part of a broader strategy to manage deforestation risks. In this sense, engaging directly with suppliers and conducting regular audits are additional measures that help to mitigate the possibility of deforestation. They also noted that certain regions lack the infrastructure needed to fully implement certification standards.

Transparency in ESG reporting was another theme, with the argument that clear and accurate disclosures are critical for building trust with investors, consumers, and other stakeholders. Also, ESG disclosures were described as a tool that can demonstrate corporate responsibility, showing that companies are working to address deforestation risks, and they noted that a transparent approach to reporting allows companies to communicate their environmental initiatives more effectively, providing investors and stakeholders with a clearer understanding of the actions taken. This transparency aligns with the growing trend of responsible investment, as stakeholders seek to support companies that prioritize sustainability. Ultimately, the interviews underscored that transparency in ESG reporting is not only about compliance, but also about enhancing the credibility of a company's commitment to sustainable practices in the FRC sector.

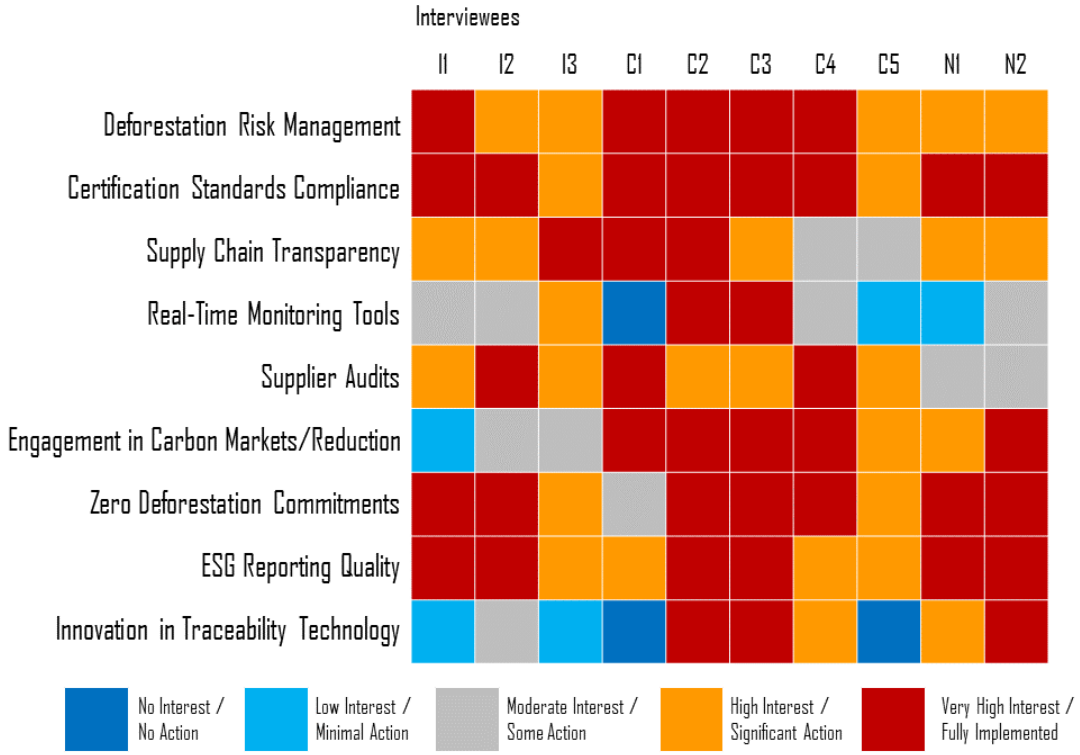
5.2.3 Thematic code analysis

In this section, a heat map was created to help the visual analysis and comparison of the levels of engagement and interest that different companies and investors demonstrate across key sustainability and deforestation-related strategies. By organizing topics of the interviewees into categories ranging from "No Interest/No action" to "Very High Interested/Fully Implemented," the heat map can offer a structured view of how various stakeholders prioritize and approach different practices. This tool is particularly valuable for identifying trends and discrepancies in areas such as deforestation risk management, certification compliance, and supply chain transparency. The heat map's color-coded scale allows for quick insights into each interviewee's level of commitment, making it easy to see where there is strong alignment and where gaps may exist.

The rows in the heat map represent common areas of interest and action across sustainability and deforestation-related practices:

- "Deforestation Risk Management" reflects the degree organizations actively address and mitigate risks associated with deforestation, underscoring the importance of preserving forest resources in their operational strategies;
- "Certification Standards Compliance" indicates the commitment of companies and investors to adopt industry-standard certifications as part of their sustainability framework;
- "Supply Chain Transparency" represents the efforts made by organizations to increase visibility and accountability throughout their supply chains;
- "Real-Time Monitoring Tools" showcases the level of interest in or adoption of advanced technologies, such as satellite tracking and blockchain, to detect and prevent deforestation activities in real-time;
- "Supplier Audits" capture the extent to which organizations are willing to conduct regular audits of their suppliers to verify adherence to sustainability and deforestation-related guidelines (this practice is essential for maintaining rigorous standards within complex supply chains);
- "Engagement in Carbon Markets/Reduction" represents the level of participation or interest in carbon credit markets or reduction, possibly not searching for a reduction of the deforestation firstly;
- "Zero Deforestation Commitments" indicate the organization's dedication to achieving a zero-deforestation goal within its operations or supply chain, a significant commitment to environmental stewardship;
- "ESG Reporting Quality" measures the level of detail, transparency, and reliability in the organization's ESG disclosures, including any specific reports on deforestation impacts;
- "Innovation in Traceability Technology" underscores the importance placed on developing or adopting technologies such as blockchain to improve the tracking of raw materials and ensure sustainable sourcing.

Figure 19: Heat Map of Areas of Interest/Action



Source: The author

Visualizing the map, we can take some initial insights about the willingness and capacity of companies to implement sustainability strategies regarding deforestation and that they are influenced by critical factors, including company size, public or private status, supply chain complexity, and the cost associated with strategies. So, the first insight is that larger companies generally have more ability to adopt the sustainability practices, as they have more access to resources to make this kind of investment, and usually they have in the organization structured departments dedicated to environmental, social, and governance (ESG) factors. In contrast, smaller companies may face resource limits that do not enable their much of engagement with these strategies, considering their cost.

Another insight we can take from the Heat Map and the interviews is the analysis of whether the company is publicly traded or private, since public companies usually are subject to scrutiny from investors and the general public. All of which create pressure to have more sustainable practices, and this exposure end up creating a stronger commitment to sustainability measures, as these companies are motivated to demonstrate transparency and accountability in their operations. But, for public companies, the in-

centive to maintain a positive image and be aligned with investor expectations, we see increased engagement in areas such as ESG reporting quality, certification standards compliance, and zero deforestation commitments. On the other hand, private companies may not face the same level of external pressure, what can lead to more variable commitment to these practices depending on their priorities and resources.

Finally, the complexity of a company's supply chain also change their strategies in diminishing the risk from FRCs. That being said, companies with extensive and complex supply chains, face more challenges, so managing deforestation risks and enforcing compliance with sustainability standards becomes more difficult as they have a greater number of suppliers, especially when many are indirect or small-scale suppliers. This complexity often draws attention to advanced monitoring systems and regular audits, which can be costly and logistically challenging to implement. Thus, companies with simpler supply chains may achieve higher levels of supply chain transparency and compliance in a easier way.

Lastly, the investment cost of implementing these strategies definitely impacts and should be an important consideration, mainly for smaller companies. For instance, strategies as real-time monitoring tools, supplier audits, and traceability technologies can represent a high initial investment and ongoing operational costs. Consequently, the cost factor often impacts the level of commitment companies can have.

6 FINDINGS

After reviewing the literature, developing the hypothesis and presenting the analysis with the models and multicollinearity and heteroscedasticity checks, we can discuss the results presented and provide insights for the financial implications of the dependence on FRCs and cost of equity. This chapter begins with the discussion of the overall results of both methods – OLS with fixed effects and Mixed Effects -, highlighting the most significant variables found and their relationship with the cost of equity given the diagnostics and tests to assess the quality of the models. Additionally, it is possible to address more specific research questions of this study, with a discussion of practical implications of the findings, as well as limitations and future research to be explored.

The OLS model with fixed effects (Industry and Country) showed a significant relationship between some variables and the dependent variable – cost of equity. More specifically, the Book-to-Market, Size (total assets), leverage, Emissions score and Environmental Innovation Score, and the Financial Materiality of forest-risk commodities, with a p-value of approximately 0.047. Despite the close R-square to 70% and the good fit of the residuals, some heteroskedasticity was detected, and so another model was developed to increase the reliability of the previous one. The Mixed-Effects model, which also included industry and country, provided an additional improvement to the model. With an R-square of around 68%, the model explained a substantial portion of the variance in the cost of equity, and the heteroscedasticity was rejected after the Breusch-Pagan test, since the p-value was greater than 0.05 and the GVIF test, with all the variables staying below the threshold of 10.

The findings revealed a nuanced understanding of the role of firm size, even though not consistently across models, we can affirm that larger firms usually face lower cost of equities, since it has a negative coefficient. Concurrently, this can be explained for some reasons and theories previously presented. Firstly, larger firms have greater power and stability, which also reduce perceived risks, decreasing the cost of equity. The Agency Theory similarly explains it, since larger firms usually have better governance structures,

mitigating possible agency costs and diminishing investor risk. It is also important to highlight that this relationship could be influenced by industry characteristics and market conditions.

Continuing in the first model, Book-to-Market, Emissions and dependence on FRCs variables demonstrated to be significant at 0.05 level, and leverage and environmental innovation at 0.1 level, although not fully captured in the Mixed-Effects model, as they do not show statistically significant effect. This could mean that under certain conditions those variables might influence the cost of equity, as also showed in other research, reflecting the importance of the consideration of environmental risks in financial assessments, although in the second model they did not show any significant results. In this context, there are some implications for theory and practice with this study. Theoretically, it supports the notion that some financial metrics, such as firm size, leverage and book-to-market, are essential and can influence the cost of equity. Besides, it shows the importance to consider environmental factors in financial models and in investing portfolios.

Certainly, there are some limitations and future research in this field that need to be carried out, as some criteria can also be amplified to capture all the possible variations in the correlation with the cost of equity. The ESG criteria – represented by the Social, Governance and Resource Use, Emissions, and Environmental Innovation – was the criteria of Refinitiv Eikon, and as also discussed in chapter 2, different agency ratings can impact the analysis of this factors. Another limitation could be the sample size, that may not be sufficient to detect all the significant relationships, as it was limited by the Forest IQ and the Refinitiv Eikon databases. Future research could consider larger datasets to increase the statistical power. Moreover, this study used a cross-sectional design, which means that the data is about one point in time, also because of the Forest IQ dataset, and a longitudinal design could provide more insights in the research question. Expanding the dataset and adding also the environmental disclosure of companies and other disclosure for ESG criteria, as well as the investigation if they are offsetting the carbon emissions with carbon credits could be useful. Also, investigating other financial impacts coming from action of environmental negative practices, particularly those related to deforestation, since it is a gap of the literature, could also provide more insights into sustainable finance. Finally, another possible reason for the non-significant financial materiality of forest-risk commodities can be that there is no effect, and simply investors are not considering this issue in their portfolios, even though it can lead to more risks and degradation of forests, as seen in the introduction with the consequences of deforestation.

The qualitative analysis highlights two different perspectives. From investors, we can

say that they understand that FRCs may generate risk for companies, but usually they are long term. On the other hand, obstacles were identified by companies and investors about the implementation of sustainability measures within supply chains related to forest-risk commodities. The interviewees talked about the lack of many reliable tracking systems, limited scope of certifications, and that there are not many standardized deforestation metrics in ESG disclosures as primary challenges. These gaps not only complicate accountability, but also enable the unsustainable practices to persist, especially when we look at complex supply chains where the control is challenging, which aligns with previous research that underscores the difficulties of monitoring environmental impact, in multi-tiered supply chains (BAGER; LAMBIN, 2022). Thus, these findings suggest an urgent need for comprehensive tracking systems, supplier audits and consistent deforestation metrics in ESG reporting to enhance accountability and transparency across supply chains, that can start with governmental policies.

Moreover, this study analyzed that company size, tenure, and the cost of implementation might impact how much companies can adopt mitigation strategies. From the interviews it is possible to say that larger and established companies with more resources and established structures are more likely to implement comprehensive sustainability practices, including certification from suppliers, real-time monitoring, and supplier audits. Nevertheless, firms that are smaller or younger often face budgetary and operational constraints that limit their ability to have a robust tracking and certification systems. This outcome supports prior studies showing that the scalability of sustainability practices is essential to making them accessible to a broader range of companies, thereby enabling more inclusive adoption across varying company sizes and capacities.

In terms of effective risk mitigation, it was identified that certification from suppliers, commitments to deforestation-free supply chains, and transparent ESG reporting as impactful practices for managing risks associated with deforestation. Also, a commitment to maintaining deforestation-free supply chains and transparent ESG disclosures offers a way for companies to visibly align with environmental standards, which aligns with previous findings that show transparent reporting is critical for strengthening investor confidence (ECCLES; IOANNOU; SERAFEIM, 2012).

In fact, these findings, limitations, and suggestions for the next studies highlight the importance of traditional financial metrics always analyzed to determine the variance of the cost of equity with ESG-related metrics, and while the deforestation metric investigated in this study may not have a strong impact on it, environmental risks can contribute to other factors that later can influence the financial performance. At last, future research

could explore more the mechanisms through which FRCs dependence could influence not only cost of equity, but also other financial and important metrics.

7 CONCLUSION AND FUTURE RESEARCH

This graduation work, on one hand, as proposed in the objectives section, helped to investigate the potential relationship between the financial materiality of forest-risk commodities (FRCs) and the cost of equity, aiming to present a comprehensive analysis of this relationship in the conclusion. So, through the examination of the correlation between these two metrics, this research offered a perspective of how deforestation risk and sustainability practices may be perceived by investors and their potential financial implications. On the other hand, it focused on understanding the investors' perception about FRCs and supply chain strategies that companies use to mitigate the risk, as also it was written in the objectives section.

In the Introduction, the main problem was discussed: deforestation and how it might be neglected by stakeholders. To give a more detailed perspective, the focus was to show that ESG criteria have gained importance in recent years within corporate strategies and investment decisions, what reflects a growing commitment to sustainable development. We saw that this shift is probably driven by regulatory pressures and an acknowledgment of the long-term financial benefits of sustainable practices. Moreover, the United Nations' Agenda 2030 represents the importance of sustainable development, mainly in the preservation of forests, as the rates of deforestation continue to rise. Also, with the importance of mechanisms like REDD+ and carbon credit markets shown, this study set out to address whether forest-related issues impact investor perceptions and correlate with the cost of equity, especially as investor strategies increasingly integrate ESG and climate-focused criteria, and what companies are doing to adress it.

Followed by the literature review, presented in the second chapter, where the theories and findings related to ESG and financial performance were presented, with a particular focus on the environmental (E) pillar and about deforestation, supply chain management in Brazil and its main challenges. With this section it is possible to understand more that the E pillar has become even more important in financial decision-making, as companies with stronger environmental practices are often perceived as lower risk by investors, consis-

tent with Signaling Theory. Additionally, studies have shown that companies with robust Corporate Environmental Responsibility (CER) are perceived as less risky, aligning with Agency Theory, which suggests that ESG metrics integrated into corporate strategies can facilitate alignment between managers and shareholders. Also, it was said that Brazil, even with some policies to mitigate FRCs deforestation, face challenges in tracking and monitoring supply chains.

Then, following the literature review, the next chapter presented the hypothesis developed from this theoretical framework. It showed that deforestation, linked to the large-scale use of certain commodities, might increase perceived risks among investors, potentially raising the cost of equity. After that, the methodology, in the fourth chapter, described the data sources, dependent and independent variables, control variables, and data cleaning processes that were used in this work. The quantitative analysis, which employed regression techniques such as Ordinary Least Squares (OLS) and Mixed Effects Models, tested the association between deforestation risk and cost of equity, with additional controls for country and industry variables. Also, a detailed description of the methodology for the qualitative part was presented, going through the methods and analysis used for this part. The fifth chapter presents these methods and results, examining whether the hypothesis holds and elaborating on the broader significance of the findings.

The study's quantitative analysis revealed that company size, as measured by total assets, was correlated with the cost of equity, while financial materiality related to forest-risk commodities was significant only in the first model, suggesting that its impact on cost of equity may be conditional. These results underscore the need for further research of environmental risks in financial assessments.

Furthermore, a significant addition to this research was the qualitative part, where insights from interviews with companies and investors showed some complexities in managing deforestation risk and related ESG practices. Investors acknowledged that FRCs may generate more risk to companies, but not in short-term and it is not what investors tend to look right away. Also, they acknowledged challenges arising from a lack of effective tracking systems, limited certification options for medium and small suppliers, and the absence of standardized deforestation metrics within ESG reporting. That being said, it is possible to say that these issues enable unsustainable practices to persist, specially within complex supply chains that rely on forest-risk commodities. As well showed in previous research, these findings highlight the need for comprehensive tracking systems and consistent deforestation metrics to improve transparency and corporate responsibility in ESG disclosures. Also, this part revealed that there is a possible relation between the

company size, tenure, and implementation costs with the feasibility of adopting mitigation strategies.

Ultimately, this study provides practical recommendations aimed at promoting accountability and responsible practices in sectors heavily reliant on forest-risk commodities. Thus, with alignment between firms and investors, particularly expectations, and by supporting certifications, ESG transparency, and deforestation-free commitments, companies can address the environmental risks associated with their operations when dealing with FRCs.

Future research needs to be developed, because in this study there were limitations such as the sample size, cross-sectional design, and the constraints of the dataset. Future study can analyze the FRCs from a longitudinal approach with a broader dataset, possibly incorporating environmental disclosures that go beyond ESG criteria. Also, exploring other financial impacts of environmentally harmful practices, especially those tied to deforestation, could further advance the field of sustainable finance. For the supply chain strategies part, a wider focus on a quantitative analysis of the tools companies are using to reduce deforestation from FRCs and their efficiency might generate new insights from future research. Besides, a global view of the challenges to track FRC supply chains would be interesting and would add value to all stakeholders. Finally, a detailed study of governmental policies and their effectiveness would also have a great impact for this field.

REFERENCES

WHELAN, T. et al. Esg and financial performance. uncovering the relationship by aggregating evidence from 2015-2020. 2021.

NATIONS, U. *Transforming our world: The 2030 Agenda for Sustainable Development*. 2015.

Global Forest Watch. *World Resources Institute*. 2022. Acessado em: Mai 2024. Disponível em: ⟨https://www.globalforestwatch.org/topics/commodities⟩.

YU, F.; ZENG, Z.; SEARCHINGER, T. D. Doubling of annual forest carbon loss over the tropics during the early twenty-first century. *Nature Sustainability*, v. 5, p. 444–451, 2022.

HOSONUMA, N.; OUTROS. Environmental research letters. *Environmental Research Letters*, v. 7, 2012.

COTE, C. *7 Strategies for ESG Investing: An Overview of Approaches*. 2022. Accessed: 2024-11-24. Disponível em: ⟨https://online.hbs.edu/blog/post/esg-investment-strategies⟩.

SPERIDIãO, L. C. C. *Financial materiality of forest-risk commodities: the impact on the cost of equity*. Master's Thesis — Politecnico di Milano, Scuola di Ingegneria Industriale e dell'Informazione, July 2024.

IRIGARAY, H. A. R.; STOCKER, F. Esg: new concept to old problems. *Cadernos EBAPE.BR*, v. 20, n. 4, p. 1–4, 2022.

ROMERO, R. V. F. S. *The financial market's adhesion to the SDGs through ESG practices: Santander Private Banking case study*. Tese (Doutorado) — Universidade Federal de Uberlândia, 2021.

BELINKY, A. Is your esg sustainable? *GVExecutive*, v. 4, 2021.

ESCRIG-OLMEDO, E. et al. Rating the raters: Evaluating how esg rating agencies integrate sustainability principles. *Sustainability*, v. 11, n. 3, p. 1–16, 2019.

BILLIO, M. et al. *Inside the ESG Ratings: (Dis)Agreement and Performance*. [S.l.], 2020.

LI, F. F.; POLYCHRONOPOULOS, A. *What a difference an ESG ratings provider makes!* [S.l.], 2020. Disponível em: ⟨https://www.researchaffiliates.com/documents/770-what-a-difference-an-esg-ratings-provider-makes.pdf⟩.

CHRISTENSEN, D. M.; SERAFEIM, G.; SIKOCHI, A. Why is corporate virtue in the eye of the beholder? the case of esg ratings. *Accounting Review*, v. 97, n. 1, p. 147–175, 2022.

DRAGOMIR, O. M.; BATAE, O. M.; FELEAGA, L. Environmental, social, governance (esg), and financial performance of european banks. *Journal of Accounting and Management Information Systems*, v. 19, n. 3, p. 480–501, 2020.

BOFFO, R.; PATALANO, R. *ESG Investing: Practices, Progress and Challenges*. [S.l.], 2020. Disponível em: ⟨https://www.oecd.org/finance/ESG-Investing-Practices-Progress-and-Challenges.pdf⟩.

APERGIS, N.; POUFINAS, T.; ANTONOPOULOS, A. Esg scores and cost of debt. *Energy Economics*, Elsevier, v. 112, n. C, p. 1–?, 2022.

CONNELLY, B. L. et al. Signaling theory: A review and assessment. *Journal of Management*, v. 37, n. 1, p. 39–67, 2011.

COWAN, K.; GUZMAN, F. How csr reputation, sustainability signals, and country-of-origin sustainability reputation contribute to corporate brand performance: An exploratory study. *Journal of Business Research*, v. 117, p. 683–693, 2020.

NAFFA, H.; FAIN, M. A factor approach to the performance of esg leaders and laggards. *Finance Research Letters*, v. 44, n. C, 2020.

DENICOLO, V. A signaling model of environmental overcompliance. *Journal of Economic Behavior & Organization*, v. 68, n. 1, p. 293–303, 2008.

FU, L. Why bad news can be good news: the signaling feedback effect of negative media coverage of corporate irresponsibility. *Organizational Environment*, v. 36, n. 1, p. 98–125, 2023.

FREEMAN, R. E. *Strategic management: A stakeholder approach*. [S.l.]: Pitman Publishing Inc., 1984.

SCHALTEGGER, S.; LüDEKE-FREUND, F.; HANSEN, E. G. Business models for sustainability: A co-evolutionary analysis of sustainable entrepreneurship, innovation, and transformation. *Organization & Environment*, v. 32, n. 1, p. 1–21, 2019.

BEBER, A. J.; RANGEL, R. R. Stakeholder capitalism: An essay on the new pragmatic and social capitalism. *Revista Metropolitana de Governança Corporativa*, v. 5, n. 1, p. 60–77, 2020.

FILHO, C. A. P. M. *Corporate social responsibility and value creation for organizations: A multi-case study*. Tese (Dissertação de Doutorado) — Universidade de São Paulo, 2002.

NG, A. C.; REZAEE, Z. Business sustainability performance and cost of equity capital. *Journal of Corporate Finance*, v. 34, p. 128–149, 2015.

LEE, S. P.; ISA, M. Environmental, social and governance (esg) practices and performance in shariah firms: Agency or stakeholder theory? *Asian Academy of Management Journal of Accounting and Finance*, 2020.

SIGNORI, S. et al. Stakeholder value creation: Comparing esg and value added in european companies. *Sustainability*, v. 13, n. 3, p. 1–16, 2021.

CAMPOS, A.; QUEIROZ, A. The internalisation of the circular economy and esg in brazilian b corps from the perspective of the stakeholder theory. *Sustainable Development*, John Wiley & Sons, Ltd., v. 31, n. 5, p. 3513–3527, Out 2023.

BONHAM, J.; RIGGS-CRAGUN, A. *Contracting on Aggregated Accounting Estimates*. [S.l.], 2023.

HELFAYA, A.; MORRIS, R.; ABOUD, A. Investigating the factors that determine the esg disclosure practices in europe. *Sustainability*, v. 15, n. 6, p. 5508, 2023.

MANITA, R. et al. Board gender diversity and esg disclosure: Evidence from the us. *Journal of Applied Accounting Research*, v. 19, 2018.

GUTHRIE, J.; PARKER, L. D. Corporate social reporting: A rebuttal of legitimacy theory. *Accounting and Business Research*, v. 19, n. 76, p. 343–352, 1989.

REBER, B.; GOLD, A.; GOLD, S. Esg disclosure and idiosyncratic risk in initial public offerings. *Journal of Business Ethics*, v. 179, n. 3, p. 867–886, 2022.

ECCLES, R. G.; SALTZMAN, D. Achieving sustainability through integrated reporting. *Stanford Social Innovation Review*, v. 9, n. 3, p. 56–61, 2011.

ROSS, S. A. *Capital structure and the cost of capital*. [S.l.], 2005. v. 15, n. 1.

BABENKO, I.; BOGUTH, O.; TSERLUKEVICH, Y. Idiosyncratic cash flows and systematic risk. June 2013. Unpublished manuscript.

SCHALTEGGER, S.; BURRITT, R. Business cases and corporate engagement with sustainability: Differentiating ethical motivations. *Journal of Business Ethics*, v. 147, n. 2, p. 241–259, 2018.

GIULI, A. D.; KOSTOVETSKY, L. Are red or blue companies more likely to go green? politics and corporate social responsibility. *Journal of Financial Economics*, v. 111, n. 1, p. 158–180, 2014.

LU, J. et al. The moderating role of corporate social responsibility in the association of internal corporate governance and profitability: Evidence from pakistan. *International Journal of Environmental Research and Public Health*, v. 18, n. 11, p. 5830, 2021.

FIORILLO, P. et al. Assessing the impact of green bond issuance on esg performance: A comprehensive analysis of green bond issuers' esg scores pre and post-issuance. In: *1st Conference on Sustainable Banking & Finance*. Napoli, Itália: [s.n.], 2023.

ATIF, M.; ALI, S. Environmental, social and governance disclosure and default risk. *Business Strategy and the Environment*, v. 30, n. 8, p. 3937–3959, 2021.

ILHAN, E.; SAUTNER, Z.; VILKOV, G. Carbon tail risk. *The Review of Financial Studies*, v. 34, n. 3, p. 1540–1571, 2021.

KRUEGER, P.; SAUTNER, Z.; STARKS, L. T. The importance of climate risks for institutional investors. *The Review of Financial Studies*, v. 33, n. 3, p. 1067–1111, 2020.

GHOUL, S. E. et al. Corporate environmental responsibility and the cost of capital: International evidence. *Journal of Business Ethics*, ?, p. ?, 2018.

BREUER, W. et al. Corporate social responsibility, investor protection, and cost of equity: A cross-country comparison. *Journal of Banking & Finance*, Elsevier, v. 96, n. C, p. 34–55, 2018.

CHAVA, S. *Environmental externalities and cost of capital*. [S.l.], 2014. Disponível em: ⟨https://doi.org/10.2139/ssrn.1677653⟩.

SHARFMAN, M. P.; FERNANDO, C. S. Environmental risk management and the cost of capital. *Strategic Management Journal*, 2008.

CONNORS, E.; SILVA-GAO, L. *The impact of environmental risk on the cost of equity capital: evidence from the toxic release inventory*. [S.l.], 2008.

CRIFO, P.; FORGET, V. D.; TEYSSIER, S. The price of environmental, social, and governance practice disclosure: An experiment with professional private equity investors. *Journal of Corporate Finance*, v. 30, p. 168–194, 2015.

FRIEDE, G.; BUSCH, T.; BASSEN, A. Esg and financial performance: Aggregated evidence from more than 2000 empirical studies. *Journal of Sustainable Finance & Investment*, v. 5, n. 4, p. 210–233, 2015.

GILLAN, S. L.; KOCH, A.; STARKS, L. T. Firms and social responsibility: A review of esg and csr research in corporate finance. *Journal of Corporate Finance*, v. 66, p. 101889, 2021.

RITCHIE, H. *Deforestation and forest loss*. 2021. Our World in Data. Acessado em: 25 jun. 2024. Disponível em: ⟨https://ourworldindata.org/deforestation⟩.

AIGCC. *Forest and Land Use - 2023 Year in Review*. [S.l.], 2024. Acessado em: 27 out. 2024. Disponível em: ⟨https://aigcc.net/wp-content/uploads/2024/03/AIGCC-Forest-and-Land-Use-Year-in-Review-2023-final.pdf⟩.

NOLTE, C. et al. Decentralized land use zoning reduces large-scale deforestation in a major agricultural frontier. *Ecological Economics*, v. 136, p. 30–40, 2017.

BROOM, D. M. A method for assessing sustainability, with beef production as an example. *Biological Reviews of the Cambridge Philosophical Society*, v. 10, 2021.

BUSCH, J.; FERRETTI-GALLON, K. What drives deforestation and what stops it? a meta-analysis. *Review of Environmental Economics and Policy*, v. 11, n. 1, p. 3–23, 2017.

ECCLES, R.; IOANNOU, I.; SERAFEIM, G. *Is sustainability now the key to corporate success?* 2012. The Guardian. Acessado em: 2024. Disponível em: ⟨https://www.theguardian.com/sustainable-business/sustainability-key-corporate-success⟩.

BALLOU, R. H. *Business Logistics Management*. 5. ed. Englewood Cliffs, NJ: Prentice-Hall, 2003.

LAMBIN E.F., G. H. H. R. C. K. F. L. G. R. L. P. d. W. Y. M. C. M. D. N. P. N. C. P. P. R. L. S. C. T. T. W. N. The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change*, v. 8, p. 109–116, 2018.

MORAN D., G. S. K. K. G. J. From satellite to supply chain: new approaches connect earth observation to economic decisions. *One Earth*, v. 3, p. 5–8, 2020.

SHAPIRO, J. F. *Modeling the Supply Chain*. 2. ed. Pacific Grove, CA: Duxbury Press, 2006.

BOWERSOX, D. J. et al. *Supply Chain Logistics Management*. 4. ed. New York, NY: McGraw-Hill, 2012.

ERMGASSEN E.K.H.J., A. B. G. J. B. L. M. B. S. G. R. zu. Using supply chain data to monitor zero deforestation commitments: an assessment of progress in the brazilian soy sector. *Environmental Research Letters*, v. 15, p. 035003, 2020.

GARRETT R.D., L. S. C. K. G. T. G. J. C. J. D. P. H. R. Criteria for effective zero-deforestation commitments. *Global Environmental Change*, v. 54, p. 135–147, 2019.

BAGER, S. L.; LAMBIN, E. F. How do companies implement their zero-deforestation commitments. *Journal of Cleaner Production*, Elsevier, v. 375, p. 134056, 2022.

MOFFETTE F., A.-G. J. S. K. P. A. The impact of near-real-time deforestation alerts across the tropics. *Nature Climate Change*, v. 11, p. 172–178, 2021.

ASSUNCAO, J.; GANDOUR, C.; ROCHA, R. Deforestation slowdown in the brazilian amazon: Prices or policies? *Environment and Development Economics*, v. 20, n. 6, p. 697–722, 2015.

NEPSTAD, D.; STICKLER, C. M.; ALMEIDA, O. T. Slowing amazon deforestation through public policy and interventions in beef and soy supply chains. *Science*, v. 344, n. 6188, p. 1118–1123, 2014.

GARRETT, R.; KOH, L. P.; LAMBIN, E. F. Explaining the persistence of low income and environmentally degrading land uses in the brazilian amazon. *World Development*, v. 119, p. 186–195, 2019.

GIBBS, H. K. et al. Brazil's soy moratorium. *Science*, v. 347, n. 6220, p. 377–378, 2015.

Climate Policy Initiative. *Brazilian environmental policies and the European Union's new regulation on deforestation-free products*. 2023. Climate Policy Initiative Report.

HENDERS, S.; PERSSON, U. M.; KASTNER, T. Trading forests: Quantifying the contribution of global commodity markets to emissions from tropical deforestation. *Environmental Research Letters*, v. 10, n. 12, p. 125012, 2015.

GHOUL, S. E. et al. Does corporate social responsibility affect the cost of capital? *Journal of Banking & Finance*, v. 35, n. 9, p. 2388–2406, 2011.

CLARK, G. L.; FEINER, A.; VIEHS, M. *From the stockholder to the stakeholder: How sustainability can drive financial outperformance*. [S.l.], 2015. Disponível em: ⟨https://doi.org/10.2139/ssrn.2508281⟩.

HILLMAN, A. J.; KEIM, G. D. Shareholder value, stakeholder management, and social issues: What's the bottom line? *Strategic Management Journal*, v. 22, n. 2, p. 125–139, 2001.

JENSEN, M. C.; MECKLING, W. H. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, v. 3, n. 4, p. 305–360, 1976.

ECCLES, R. G.; IOANNOU, I.; SERAFEIM, G. The impact of corporate sustainability on organizational processes and performance. *Management Science*, v. 60, n. 11, p. 2835–2857, 2014.

APPENDIX A – INTERVIEW GUIDES

A.1 Semi-Structured Interview Guide: Supply Chain, Transparency, and Sustainability Practices

Company Background

1. Can you start by describing your company's primary business activities and the main products or services you offer?
2. How does your company position itself within the industry?
3. Can you outline the role that forest-risk commodities (FRCs) play in your production processes?

Supply Chain Structure and Management

4. Could you describe your supply chain for forest-risk commodities? How many stages or tiers are involved from raw material sourcing to the final product?
5. How does your company choose its suppliers? Are there specific criteria or certifications you require them to meet?
6. Do you have direct relationships with all stages of your supply chain, or are certain parts managed through intermediaries?
7. What challenges do you face in maintaining visibility over your entire supply chain, and how do you address them?

Traceability and Tracking

8. How does your company track the origin of raw materials, particularly forest-risk commodities, in your supply chain?

9. Which tools or technologies do you use to monitor and trace these commodities?
10. Is there a certification or verification system in place for your raw materials? If so, which standards or certifications do you rely on?
11. How often do you conduct audits of your suppliers, and do you rely on third-party audits for compliance?

Transparency and Communication with Investors

12. How does your company communicate its supply chain practices and sustainability commitments to investors?
13. What specific information do you provide to investors regarding your sourcing of forest-risk commodities?
14. Have you developed metrics or reporting standards specifically related to supply chain transparency or environmental impact?
15. How do you handle inquiries from investors or stakeholders regarding deforestation risks or other environmental concerns associated with your supply chain?

Sustainability and Zero-Deforestation Goals

16. What sustainability goals has your company set, particularly regarding zero deforestation or reducing environmental impact?
17. Do you currently track greenhouse gas emissions or carbon footprint associated with your supply chain? If so, how is this data collected and reported?
18. How are sustainability goals integrated into the company's core operations and decision-making processes?

Compliance and Regulatory Alignment

19. Are there specific national or international regulations or policies that guide your sustainability and supply chain practices?
20. How does your company ensure compliance with these regulations, and how do they impact your supply chain management?

Challenges and Future Developments

21. What are the primary challenges your company faces in tracking, tracing, and ensuring the sustainability of your supply chain?

22. How is your company preparing to adapt to emerging regulations or market expectations related to sustainability?

23. Are there future technologies or innovations in supply chain management that you are considering implementing to enhance traceability or transparency?

Closing

24. Is there any additional information you would like to share about your company's approach to supply chain transparency, sustainability, or investor communication?

25. How can companies like yours further improve transparency and accountability in the FRC supply chain?

A.2 Semi-Structured Interview Guide: Deforestation Risk and Sustainable Investment Practices

Perception of Deforestation Risk in FRC Investments

1. How does your fund perceive the impact of deforestation risk on companies that invest in forest-risk commodities (e.g., soy, beef, timber)?
2. Does this risk have an immediate impact on investment decisions, or is it more of a long-term concern?

Carbon Markets and Carbon Credits

3. Does the fund view participation in carbon markets as a positive factor when evaluating companies?
4. Is the purchase or sale of carbon credits seen as an effective mitigation strategy for deforestation-related risks?

Real-Time Monitoring Systems for Deforestation

5. How do you assess companies that adopt real-time monitoring systems for deforestation within their supply chains?
6. Does this practice increase investor confidence that the company is committed to long-term sustainability?

ESG Policies and Practices for Effective Deforestation Mitigation

7. In your view, what types of ESG policies or practices should companies adopt to effectively mitigate deforestation risk?

Desired Solutions or Practices for Reducing Deforestation Risk

8. Are there any other solutions or practices you would like to see companies adopt to reduce deforestation risk?

Future of Environmental Risk Perception

9. In your opinion, how will the perception of environmental risk evolve over the next 5-10 years?

10. Do you expect deforestation risk to become more significant for investors as international regulations and social pressures increase?