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Analysis of CSR and ESG Investment Decision:

A real option insight on how companies are perceiving the investment and a guidance on future steps

Dissertação de Mestrado

Dissertation presented to the Programa de Pós-graduação em Administração de Empresas of PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Administração de Empresas.

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To my lovely daughter Clarisse,
source and destiny of all my efforts.

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Abstract

Borges, Lilianne Bastos de Sá; Pinto, Antônio Carlos Figueiredo; Dias, Marco Antonio Guimarães. **Analysis of CSR and ESG Investment Decision: a real option insight on how companies are perceiving the investment and a guidance on future steps.** Rio de Janeiro, 2022. 77 p. Dissertação de Mestrado - Departamento de Administração, Pontifícia Universidade Católica do Rio de Janeiro.

We studied the rationales of investing in CSR/ESG. We explored the several critics that the concept received over the years; and the recent rush of CEOs into signing commitments to lead their companies for the benefit of all stakeholders and of asset managers into incorporating environmental, social and governance (ESG) on their investment decision making process. To clarify the CSR/ESG investment choice and the investment behavior of the firms towards it, we drew on very recent empirical research articles on CSR/ESG to choose four different real options models. Using the models, we performed sensitivity analyses on the decision to become a socially responsible firm, to invest in CSR/ESG to capture a goodwill, as well as on the abandonment option and jump to zero probability. Our results suggest that the investment in CSR/ESG is valuable, but not for the reasons commonly presented. The investment creates an opportunity for the firm to limit its losses when involved in a reputational, environmental, or social damaging event. To keep the opportunity alive, the firm has to continuously invest in CSR/ESG initiatives, which may be more accessible to larger and stronger firms. We discuss whether this opportunity propels firms to engage in a reckless or unethical behavior and point out the contradiction between the possible incentive to malpractice and the concept's original purpose.

Keywords

Real Options; Corporate Social Responsibility (CSR); Environmental, Social and Governance (ESG); Investment Decision; Stakeholder Governance; Agency Theory

Resumo

Borges, Lilianne Bastos de Sá; Pinto, Antônio Carlos Figueiredo; Dias, Marco Antonio Guimarães. **Análise sobre a Decisão de Investimento em RSC e ASG: como as empresas estão percebendo o investimento pela perspectiva de opções reais e orientações para o futuro.** Rio de Janeiro, 2022. Número de páginas 77. Dissertação de Mestrado - Departamento de Administração, Pontifícia Universidade Católica do Rio de Janeiro.

Estudamos as razões para se investir em RSC/ASG. Exploramos as diversas críticas que o conceito recebeu ao longo dos anos; e o recente entusiasmo de CEOs se comprometendo em liderar suas empresas em benefício de todos os stakeholders e de gestores de ativos de incorporar aspectos ambientais, sociais e de governança (ESG) ao seu processo de tomada de decisão de investimento. Para esclarecer o investimento em RSC/ASG e o comportamento das empresas em relação a ele, nos baseamos em artigos bastante recentes de pesquisa empírica sobre RSC/ASG para a escolha de quatro modelos diferentes de opções reais. Utilizando os modelos, realizamos análises de sensibilidade sobre a decisão de se tornar uma empresa socialmente responsável, investir em RSC/ASG para capturar um benefício, bem como sobre a alternativa de abandono e a probabilidade de salto para zero. Nossos resultados sugerem que o investimento em RSC/ASG é valioso, mas não pelas razões comumente apresentadas. O investimento cria uma oportunidade para a empresa limitar suas perdas quando envolvida em um evento prejudicial à sua reputação, ao meio-ambiente ou à sociedade. Para manter a oportunidade viva, a empresa precisa investir continuamente em iniciativas de RSC/ASG, que podem ser mais acessíveis às empresas maiores e mais fortes. Discutimos se essa oportunidade impulsiona um comportamento imprudente ou antiético das empresas e apontamos a contradição entre o possível incentivo à irregularidade e o propósito original do conceito.

Palavras-Chave

Opções Reais; Responsabilidade Social Corporativa (RSC); Ambiental, Social e Governança (ASG); Decisão de Investimento; Stakeholders; Governança; Teoria da Agência

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1
Introduction

1.1.
Context

Over the last years, several discussions were held on how government, business and other players should use their power, resources, and knowledge to create a "positive change". The idea is to shift purely economic growth to a shared prosperity and environmentally sustainable growth. Many initiatives were drafted to push for more transformative regulatory policymaking, government financial incentives, corporate multi-objectives, and socially responsible investments. Also, numerous international organizations' reports, statements, proposals and codes of corporate governance have increasingly called for the necessary commitment and funds for the transition to a sustainable global economy (UN[1], 2020; WEF[2], 2019, 2020).

The compatibility of sustainable economy with competitiveness and growth continues to be questioned, hence the debate turned environment and equality to a moral case. Since then corporations' activities about being a better corporate citizen started to be referred as Corporate Social Responsibility (CSR) and how companies integrate environmental, social and governance concerns into their business models, as ESG (Environmental, Social and Governance) –an acronym was developed in 2004[3] (GILLAN *et al*., 2021). One difference between the two terms is that ESG includes governance explicitly while CSR covers its issues indirectly as they relate to environmental and social considerations (GILLAN *et al*., 2021).

Responding to the ongoing call, many CEOs voluntarily signed commitments to lead their companies for the benefit of all stakeholders and asset managers signed commitments to incorporate ESG into their investment decision making process. Nevertheless, altruistic corporations should be taken with a grain of salt.

[1] Report of the UN Economist Network for the UN 75th Anniversary, Shaping the Trends of Our Time, September 2020.
[2] The World Economic Forum, The Global Competitiveness Report 2019, and Global Competitiveness Report Special Edition 2020.
[3] IFC, Who Cares Wins — Connecting Financial Markets to a Changing World 2004.

After all, we continue to not expect our dinner to come “from the benevolence of the butcher, the brewer, or the baker”, as famously stated by Adam Smith (SMITH, 1776). The statement of extremely comprehensive objectives as positive change, shared prosperity and sustainable growth, along with the power given to international organizations to influence governments and markets, could easily catapult particular interests. As Olson (1965) explains, most of the action taken by or on behalf of groups of individuals is taken through organizations, which will perish if not furthering the interests of their members. Olson (1965) adds that is barely believable that large private organizations would be able to bring about voluntary contribution when the state “with all of the emotional resources at its command” resorts to compulsion to finance its most basic and vital activities.

Cornell and Damodaran (2020) argued that the hype regarding CSR/ESG has vastly outrun the reality of both what it is and what it can deliver. They say consultants, bankers and investment managers were made cheerleaders for the concept due to the potential money on CSR/ESG they make. Besides, negative effects on living standards are not limited to shareholders and corporations’ short-termism. It also includes firms’ contribution to inflationary pressures by the pass through of exogenous price increases (HEATH; NORMAN, 2004), firms’ several practices of tax avoidance (MARTINEZ, 2017), and firms’ unethical behavior and consequential spectacular corporate failures, corruption scandals and global financial crisis (STUBBS; ROGERS, 2013). However, these effects were not considered in the sustainability call.

Uncertain as the payoff is, firms and investors commitments to CSR/ESG are a corporate investment choice. Since it takes time to evolve as a corporate citizen and to integrate ESG concerns into its business models, CSR/ESG can be referred as an open-ended project that poses continuous sequential investment problems to the firm. As an open-ended project, the time and effort necessary to complete it, as well as its specific characteristics, are unknown. This technical uncertainty can only be resolved by undertaking the project or investing in further information. At the same time, market’s unpredictable changes increase the value of waiting for new information before committing resources. Also, investment in CSR/ESG is firm specific, meaning they cannot be recovered after spent.

Dixit and Pindyck (1994) postulated that the neoclassical investment theory failed to provide good empirical models of investment behavior and brought the financial option insight to solve for uncertainty, irreversibility and option value. The real options’ methodology is used to optimize decisions under uncertainties, clearly

distinguishing favorable scenarios from unfavorable ones. It is significant to shed light on CSR/ESG investment choice and the investment behavior of firms. In our study, we use four real options models and sensitivity analyses to provide a fresh perspective to previous studies on corporate social responsibility investing and to obtain guidance on future steps.

1.2. Research Problem

How can businessman, bankers and investors alike value a concept like "social responsibilities of business" –a suit-and-tied version of *Imagine*, "all the people sharing all the world" (LENNON, 1971)– that cannot find support in economics and finance, were heavily criticized by reputable senior researchers as Milton Friedman (FRIEDMAN, 1970) and Michael C. Jensen (JENSEN, 2002) for its analytical looseness and lack of rigor, and up to now lacks empirical evidence on its benefits to the firm and to society?

1.3. Research Objective

The objective of this study is to contribute to the debate around the rationales of investing in CSR/ESG. We aim to overview the agency theory, the stakeholders' role and representativeness and explore potential conflicts between organizations, firms, and individuals. Using the real options perspective and analytical solutions, we intend to arrive at general conclusions about the investment behavior of firms and the incentives and disincentives eventually in place.

1.4. Relevance of the Study

Today, stakeholder governance is claimed to be among the most important theoretical and practical contributions to the field of management (AMIS *et al.*, 2020). There is an increased awareness about sustainable development and the need to integrate community, stakeholder, economic and ecological concerns. The stakeholder theory raises a lot of concerns about agency problems and corporate governance is rooted in agency theory (FILATOTCHEV, 2008).

Freedom and latitude to act allow managers to further their own interests (TOSI, 2008). In response, a new form of regulatory constraint was necessary

when delegation, discretion and autonomy increased following the privatization, deregulation and decentralizing reforms that took place between 1980 and 2000. A multiplicity of new institutional layers of regulation were created, expanding the range of central controls (MINOGUE, 2002). Public agencies started to exercise, through discretion and autonomy, a sustained and focused control over socially valued activities (MAJONE, 1991). An 'alternative mode of public control' (MAJONE, 1999). As of today, corporate governance initial conflict radiated from managers and shareholders to shareholders and society, and their respective agents. As a consequence, society must either trust decision makers or establish corporate governance mechanisms to influence them.

Considering the importance of the matter, our research presents a different perspective to previous studies on corporate governance and corporate social responsibility investment. We extend the corporate social responsibility real option notion developed by Husted (2005) and shed light on how firms are perceiving and using the investment. We understand that the idea of the theory and empirical research should progress to a more context dependent understanding of corporate governance, that would prove to be more useful for practitioners and policymakers interested in applying corporate governance in particular situations (AGUILERA *et al*., 2008),

Despite the increasing attention given to corporate social responsibility and real options, studies applying real options theory to corporate social responsibility investing remains underexplored and new approaches need to be developed.

1.5. Delimitation of the Study

It is not the purpose of this study to provide a detailed review of the literature on corporate governance, corporate social responsibility (CSR), ESG-Investing or Socially Responsible Investing (SRI).

2
Theoretical Background

In this chapter, we contextualize the research problem.

2.1.
Corporate Social Responsibility

To introduce the concept of corporate social responsibility, it is important to first introduce the agency theory and then explore the several agency problems that corporate social responsibility rises.

According to Eisenhardt (1989), the agency theory addresses the contract governing the relationship between two cooperating parties, in which one party (principal) delegates work to another party (agent) who performs that work. It takes into consideration assumptions like self-interest, bounded rationality, risk aversion, goal conflict and possible purchase of information. Its structure applies in a variety of settings and typically ranges from macrolevel issues to microlevel dyad phenomena. It focusses on transferring the risk to the agent and resolving the trade-off between the cost of measuring the agent's behavior and the cost of measuring the outcome of his work. The theory's research follows two main strands: the positivist, which identifies situations where principal and agent are likely to have conflicting goals and indicates the mechanisms of governance that can limit the agent's self-serving behavior; and the principal-agent, which explores a general theory of the relationship between the principal and the agent and focus on determining the optimal contract between them.

As Friedman (1970) pinpointed, a corporate executive act as principal when he spends his own money, time and energy in what he voluntarily recognizes and assumes as "social responsibilities" to his family, conscience, feelings of charity, church, clubs, city, country, etc. However, when a corporate executive is serving as an agent of the stockholders, customers and employees, and acts conforming to his "social responsibility", he is spending someone else's money. He reduces the returns to stockholders, raises the price to customers, and lowers the wages of some employees for a general social interest that stockholders, customers and employees could embrace with their own money if they wished to do so. Even so,

the discussions of self-interest versus altruism dominated literatures as corporate social responsibility and finance (FREEMAN; PHILLIPS, 2002) and gave traction to the stakeholder theory.

The stakeholder theory was originated as a strategy for dealing with groups of individuals that affect the firm or is affected by it (FREEMAN, 2004). A practical approach for management (techniques and applications) to be more effective in identifying, analyzing, and negotiating with key stakeholder groups. But the critics that demand business to “understand the social effects of their actions” call for companies to maximize stakeholder interests over time and require management to influence, manage, and balance the relationships that can possibly affect the achievement of the company’s purpose (FREEMAN; PHILLIPS, 2002). For them, firms must sacrifice profits in the name of social interest, going voluntary beyond their legal and contractual obligations to guard their employees, surroundings, communities and investors, and even supporting the arts, universities, and other good causes (BÉNABOU; TIROLE, 2010).

The broad definition of stakeholders raises practical concerns as to how key stakeholder are identified, on what basis other stakeholders are classified as unimportant, and who is responsible for determining the criteria that distinguish important and unimportant stakeholders (SUNDARAM; INKPEN, 2004). Jensen (2002) adds that stakeholder theory provides no principled criterion for defining and measuring balance/tradeoffs between stakeholders.

Jensen (2002) adverted that corporate multi-objective allow managers to throw off “the value-seeking criterion and its enforcement by capital markets, the market for corporate control, and product markets”. He argued that a decision maker to choose rationally, needs an overall single dimensional objective to be maximized. He justified that it is logically impossible to simultaneously maximize competing objectives. How to define “better versus worse”? Current profits, market share or future growth? Olson (1965) explained that, in perfect competition, profit-maximizing firms reduce the aggregate profits, going against their interests as a group. They want the higher price for the industry's product at the same time they are interested in selling as much as they can. The only thing that keeps prices from falling in the competitive process is an outside intervention (government price supports, tariffs, cartel agreements, etc.). In this way, it is reasonable for a firm to advocate for corporate multi-objectives and pursue profit-maximization.

Heath and Norman (2004) recalled the nationalization of private enterprises during the 1960s as an attempt to use the state (and public law) as a governance

mechanism to institutionalize corporate extensive responsibilities to stakeholder groups. The experiment turned out to be a huge political and financial failure. The idea of sacrificing a certain amount of profit to advance a set of social objectives, as in a program of corporate social responsibility, made more difficult to impose effective discipline upon managers and let the state-owned enterprises not only lose money but also do a worse job promoting the public interest, under the explicit mandate to do so, than privately owned firms.

Goodpaster (1991) observed that law and regulation are seen as providing a voice for stakeholders that goes beyond market dynamics and typically a more liberal view advocates law and regulation should be used to include stakeholders in the strategic decision-making process. However, policy innovation is the result of scholars' conceptual variation of preexisting models and political selection from variants. When legislators and government executives delegate policy-making powers to independent institutions or international organizations, which have conflicting desires or goals, agency costs arise (MAJONE, 1991). Likewise, it raises problems of democratic legitimacy since non-majoritarian institutions or organizations are not directly accountable to the voters or to their elected representatives (MAJONE, 1999). Over and above, regulation is not simply to regard political, institutional and economic context and pass a law. Regulated activity requires specialized agencies entrusted with fact-finding, rulemaking, and enforcement formulation (SELZNICK, 1985). Not only regulatory instruments and procedures may be framed in ways to concede discretion over their detailed application (OGUS, 2002), but also regulatory design and implementation may be seriously weakened by regulatory capture –effective control or domination of regulatory mechanisms by the interests of those who are the object of regulation (MINOGUE, 2002).

Nevertheless, there is a tendency to discuss together social and economic effects of corporate action and push for new policies and regulations. Due to that, it is important for firms to understand all threats and opportunities in the short, medium and long-term. Will corporate social responsibility destroy firm-value? Or does environmental, social and governance add value to the firm? If so, how? How to refrain managers and directors from pursuing their own interests at the expense of society and the firm's financial claimants? Could new policies and regulations destroy business? How to prepare itself?

2.2.
Corporate Social Responsibility as an Investment

Corporate sustainability or social responsibility or environmental, social and governance is now, undoubtedly, relevant for investment decisions. It represents a growing concern for institutional investors and regulators (LOPEZ-DE-SILANES *et al*., 2019). Gillan *et al*. (2021) gave an overview of its current importance: in the last few years, most large public companies started to release or sustainability or corporate responsibility reports, net inflow to mutual funds with ESG mandates increased substantially, and an expressive number of institutional investors and service providers agreed to incorporate CSR/ESG issues into their investment analysis and decision-making processes. But because ESG strategies have been the bright spot in terms of new funds being launched and funds receiving inflows, concerns over potential “greenwashing” or “rainbow washing”, which means firms unfounded appropriation of environmental or social virtuosity in propaganda, is constantly raised (MATOS, 2020).

The academic research has followed with interest. The growing number of firms reporting data on environmental, social and governance (carbon emissions, water consumption, waste generation, employee satisfaction, customer-related information, product information, board diversity, political lobbying, anticorruption programs, etc.) advanced the research on CSR/ESG investing (AMEL-ZADEH; SERAFEIM, 2018). However, there are still several competing standards for how companies should disclose raw ESG data (LOPEZ-DE-SILANES *et al*., 2019), no consensus on the exact list of CSR/ESG issues and their materiality (MATOS, 2020), and a lack of objectivity, uniformity and transparency in the way ESG-focused agencies calculate their ESG performance ratings (STUBBS; ROGERS, 2013). Moreover, while several investors view lack of data standardization and comparability as a hurdle for examining firms’ ESG factors, it is still unclear what compels mainstream investors to use ESG information, if they use it at all (AMEL-ZADEH; SERAFEIM, 2018).

It is worth observing that the acronym ESG presents a marked dichotomy. As pointed out by Cornell and Damodaran (2020), governance is a measure of responsiveness of managers to their firms’ shareholders, while environmental and social awareness require managers to put the interests of other stakeholder groups above those of the shareholders. Accordingly, some authors (FERRÉS; MARCET, 2021; ALBUQUERQUE *et al*., 2019) excluded corporate governance attributes

from their firm-level social responsibility data analysis, utilizing non-governance aspects of CSR.

Some argue CSR/ESG activities could create value because they increase shareholder wealth, whether increasing cash flows (customers want to buy from firms that have good reputation in corporate responsibility, employees are more productive when they work for such firms) or decreasing the discount rate (by affecting the cost of capital) or maximizing shareholder utility (shareholders could value the environmental or social goods produced by CSR/ESG firms) (GILLAN *et al*., 2021). Cornell and Damodaran (2020) argued that the evidence that socially responsible firms have lower discount rates, and thereby investors have lower expected returns, is stronger than the evidence that socially responsible firms deliver higher profits or growth. It is also stronger the evidence that bad firms get punished, either with higher discount rates or a greater incidence of disasters and shocks.

Some propose CSR/ESG, through a variety of different channels, can affect many types of risk (systematic, regulatory, supply chain, product and technology, litigation, reputational and physical) (GILLAN *et al*., 2021). Lopez-de-Silanes *et al*. (2019) commented that the quantity of ESG data disclosed signals transparency and is correlated with decreased risk. Godfrey (2005) explained that corporate philanthropic activity generates a moral capital among stakeholders, capable of protecting the firm in adversity and mitigating negative stakeholder assessments and related sanctions. Stubbs and Rogers (2013) added the loss of reputation due to ethical, social or environmental issues can have a severe financial impact on companies, since most of their value relies on their brand name, goodwill and reputation. Ferrés and Marcet (2021) reported that the existing literature indicates that CSR/ESG policies have been successfully applied to mitigate the negative implications of the revelation of corporate misconduct. Some studies focus on the increase of CSR/ESG investing following a serious corporate scandal, whereas others focus on the more lenient conditions socially responsible firms receive from prosecutors in case of fraud detection.

In their research review in corporate finance on CSR/ESG issues, Gillan *et al*. (2021) highlighted that some results are quite robust (firms' ESG/CSR aspects are related to their country attributes, within-country market characteristics, and industry components), while other results are mixed. They resumed the ongoing most important and most debated questions: are the CSR/ESG choices affecting the firm's performance and valuation, or are the firm's performance and valuation

driving the ESG/CSR choices (increasing the capability to expend resources on ESG/CSR activities)? Are the firm's ESG/CSR activities reflecting the interest of shareholders or are they the outcome of managers acting in their own interests?

Applied econometrics –the use of disciplined data analysis paired with the machinery of statistical inference (ANGRIST; PISCHKE, 2015)– is usually used to answer those cause-and-effect questions. Yet possible existence of confounding factors, selection bias and endogeneity (omitted variables, simultaneity, and use of inaccurate proxies) may affect the CSR/ESG empirical research. Studies on the subject are also affected by the low quality of data used in historical analyses, inconsistency of data, incomparability between companies and lack of information (MATOS, 2020).

To shed light on CSR/ESG investing rationales and understand its threats and opportunities in the future, we need to bypass neoclassical investment theory and applied econometrics and observe actual investment behavior of firms, so we can get an insight on how companies are perceiving the investment.

2.2.1. Empirical Research on Commitment to CSR/ESG

Despite developments in CSR/ESG, strong inflow of investments into ESG mutual funds, several stakeholder-friendly commitments and growing disclosure of ESG data; skepticism is inevitable. Therefore, some authors have been testing whether corporate speech reflects corporate practice.

In 2019, the Business Roundtable (BRT)[4], a nonprofit association whose members are chief executive officers of major United States companies, released a new *Statement on the Purpose of a Corporation*, redefining its understanding to include that companies should deliver long-term value to all of their stakeholders and shareholders. Raghunandan and Rajgopal (2021a) confronted the advertised commitment to stakeholders made by publicly listed signatories of the statement, with their track record. They found no evidence that signatory firms, relative to a control sample, have engaged in such stakeholder-centric practices. On contrary, signatory firms committed (and paid for) more environmental and labor-related compliance violations than within-industry peers, had higher carbon emissions,

[4] https://www.businessroundtable.org/business-roundtable-redefines-the-purpose-of-a-corporation-to-promote-an-economy-that-serves-all-americans

opposed more often proxy resolutions suggested by minority shareholders, and relied more on government subsidies.

Kim and Yoon (2020) confronted the commitment to ESG made by active fund managers signatories of the *Principles for Responsible Investment* (PRI)[5] with their track record. PRI is a proponent of responsible investment among asset owners, investment managers and professional service partners to asset owners and/or investment managers, meaning they advocate for the assimilation of ESG issues into investment analyses and decision-making processes, in partnership with UNEP Finance Initiative and UN Global Compact. The authors found that signatories investment funds, regardless of their prior fund-level ESG score, had a significant increase in fund flow, but only a small number improved their fund-level ESG score. Notably, they voted less on environment related issues and their portfolio' stocks exhibited an increase in environment related controversies.

Besides, Raghunandan and Rajgopal (2021b) examined self-labelled ESG mutual funds that claim to invest in firms with stakeholder-friendly track records. They found the shareholdings of these mutual funds have worse track records for compliance with labor and environmental laws and pay more in fines for linked violations than non-ESG funds managed by the same financial institutions in the same year. Also, on average, the shareholdings emit more carbon, both in terms of raw emissions output and emissions intensity. They point the underdeliver was also identified by the U.S. Securities and Exchange Commission[6], which declared to have found "potentially misleading" claims and inadequate controls around ESG investing in a review of investment advisors and funds.

The three articles (RAGHUNANDAN; RAJGOPAL, 2021a, b; KIM; YOON 2020) presented the responsiveness of firms and mutual funds to stakeholder-centric behavior directive, as lacking sincerity after the hard data were analyzed. Lopez-de-Silanes *et al*. (2019) presented a similar perception. They concluded that the quantity of data disclosed by a company on the impact of its activity is strongly positively correlated to the quality of the data. A company with good-quality ESG data as a natural result of its operations has a minimal marginal cost to disclose it. Meaning that the actual quality of environmental and social aspects of the company's activity is of less importance. The same were reported by Iliev and Roth (2021), who observed that sustainability improvements, especially changes in the environmental performance, are concentrated in 'clean' industries, consistent with

[5] https://www.unpri.org/
[6] https://www.reuters.com/article/us-usa-sec-esg-idUSKBN2BW2SZ

the notion that firms in clean industries have lower costs to improve their environmental commitments, while 'dirty' industries improve their social performance scores, but not environmental performance.

This is sustained by the absence of consensus on what comprises a good company, with different raters using different metrics and measures (CORNELL; DAMODARAN, 2020). Reinforced by lingering doubts on whether incorporating mandatory and standardized disclosure requirements related to ESG into stewardship codes and comply-or-explain reporting is efficient (LOPEZ-DE-SILANES *et a*l., 2019).

2.2.2. Empirical Research on CSR/ESG Investing to Reduce Loses

The idea that the investment in social responsibility could create a goodwill for the firm, has been explored by some authors over the years. Husted (2005) presented a firm that withdrew a poisoned brand product from all the shelves of drug stores and supermarkets around the world to successfully reintroduced it after solving for the poison problem. For him, the positive outcome resulted from the goodwill created among consumers when the firm quickly responded to the crisis. Also, Cassimon *et al*. (2016) presented a firm that, to regain the support from its debt and equity holders, amid mounting pressure from stakeholders, stopped accepting new projects in a country heavily criticized for systematic human rights violations.

More recently, Hong *et al*. (2019) found that CSR/ESG firms prosecuted for paying foreign government officials to assist them to obtain or retain business under the Foreign Corrupt Practices Act (FCPA), received lower sanctions. FCPA enforcement fines follow guidelines of multiples of the revenues obtained from bribery, can easily reach billions of dollars, and typically are settled via bargaining between the parent company and prosecutors. They explain that the advantage to CSR/ESG firms might come from a halo effect of its reputation in a different jurisdiction, influencing the judgment, or from the benefit of the doubt given by prosecutors, which makes the settling easier and reduces the investigation costs, hence sanctions. They highlight that the firms ensnared in FCPA are commonly the largest firms in the corporate landscape, being sizable exporters that come from a broad cross-section of industries.

Hindkjaer and Slettan (2020) investigated the CSR/ESG ability to preserve firm value in the face of certain types of corporate scandals. They found that banks

significantly lose their market value following allegations of involvement in money laundering, tax evasion or sanctions breaches. Nevertheless, depending on their CSR/ESG overall rating measuring, they have a less negative abnormal return in the context of the wrongdoing. Their results confirmed that CSR/ESG performance have an insurance-like effect, it lowers future cash flows uncertainty, mitigates costly stakeholder sanctions, and potentially reduces any adverse cost of capital effects.

Ferrés and Marcet (2021) studied the timing and the stability of CSR/ESG investments in firms involved in illegal price fixing. They clarified that colluding firms had better CSR/ESG strengths, concerns, and total score records than non-colluding industry peers, and, before the cartel breakup, shared with them similar CSR/ESG patterns. However, after receiving the first notice of an official antitrust investigation, and during the prosecution years, the colluding firms substantially increased their CSR/ESG strengths. Although their CSR/ESG total score followed the dynamics of their CSR/ESG strengths, their CSR/ESG concerns remained about the same during the period analyzed. The authors concluded the prompt investment in CSR/ESG guaranteed the colluding firms smaller corporate fines and a less pronounced reduction in sales during the post collusion years.

Ferrés and Marcet (2021) also verified that colluding firms with high level of cash or cash flow from operations improve their CSR/ESG strengths during the post collusion period and larger and more visible cartel participants likely use CSR/ESG strategies following a cartel breakup. Iliev and Roth (2021) studied the transmission of reforms in sustainability regulations and disclosure requirements in foreign countries to U.S. firms, through international board connections and/or directors' exposure to such changes. They also observed that firms' financial health plays a crucial role in the adoption of sustainability policies. They noted that firms close to default are less likely to improve their environmental performance scores. Likewise, firms with greater R&D expenses and higher cash flow uncertainty invest less in improving their sustainability performance.

2.3.
Corporate Social Responsibility as a Real Option

Dixit and Pindyck (1994) argued that a firm with an opportunity to invest is in fact holding an "option" analogous to a financial call option, where the firm has the right, but not the obligation, to invest. Whenever the opportunity to invest is taken,

or the investment expenditure is made, or the option is exercised; the choice, along with any possibility to wait for more information to choose, ceases to exist.

A real option, in opposition to a financial option, has a real underlying asset. It can be to postpone, abandon, grow or expand a project or suspend, resume or replace inputs or outputs of production.

Taking into account most investment is irreversible and has uncertain future rewards, the ability to delay an investment decision should not be ignored. On the contrary, it is an opportunity cost to be included as part of the investment cost. The investment's expected revenues must not only exceed the investment's expected expenditures, but also the value of keeping the flexibility to invest or not, alive. This is observed when a firm do not invest until price rises substantially above long-run average cost and stay in business for a longer period while absorbing operating losses. As Dixit and Pindyck (1994) explains, the investment spending can only be explained once uncertainty, irreversibility and option value are accounted for. The firm exercises the option only in case of a favorable outcome. If conditions are not satisfied, the firm only loses what it spent to obtain the investment opportunity.

However, the discounted cash-flow (DCF) method, and its main indicator the net present value (NPV), fall short to incorporate daily statistics and so, fail to present the dynamic assessment required to calculate the option value (the value of the opportunity to invest) and the optimal investment decision rule (the trigger rule). For that, it is necessary a modern methodology for economic analysis of projects and investment decisions under uncertainty.

Because real options' calculation is more complex, it took many years of increasing processing capacity of computers, to disseminate. Today, real options are calculated in discrete or continuous time using models and methods, such as: no-risk portfolio, risk-neutral probability, binomial method, Brownian movement, mean reversion, jumps, Itô-Doeblin formula, Black-Scholes-Merton differential equation, Monte Carlo and finite difference approach. Also, real options can have numerical or analytical solution.

Besides replicating flexibilities and optimizing decisions under uncertainties, the real options methodology assist in exploring how investment opportunities are obtained. Dixit and Pindyck (1994) named patents, ownership of land or natural resources, reputation, managerial resources, market position and scale, along with technological knowledge as investment opportunities built up by firms over time.

Kogut (1991) explored the use of joint ventures as a mechanism to exploit and buffer uncertainty in new markets and new businesses. He explained that the

option is worth investing since committing to a risky project withdraws resources from other projects. He argued that the right to acquire the venture in favorable environments, meaning when industry condition or growth opportunities increase its valuation, is a real option to expand.

Husted (2005) developed the notion of corporate social responsibility (CSR) as a real option, based on his perception that CSR investing creates ‘‘opportunities to expand and grow in the future’’. He argued that CSR creates direct opportunities, as new products and services, or indirect opportunities, as the development of firm-specific assets that are valuable to the firm even though it requires further steps to have its rent potential captured. He explained that the CSR real option is the right to exploit the goodwill or trust created when investing in CSR. He added that the value of the CSR option depends on the resources it accesses (financial, human, or social capital) and the costs it avoids (penalties, liabilities, or reputational loss).

Some authors extended Husted (2005) notion by presenting CSR investing as a strategic flexibility to respond to possible risks and uncertainties associated to increasing environmental norms and social concerns in different stages of an asset life cycle (HITCH *et al*., 2014), and by regarding CSR investment as a preliminary project, or an European call on a future full project (BOSCH-BADIA *et al*., 2015).

Cassimon *et al*. (2016) extend Husted (2005) framework to include the opportunity cost of the investment. They analyzed three key moments in a case study to understand whether it was valuable to engage in CSR investment activity and when was the right time for a company to do so. They presented that the company exhibited the typical waiting behavior until different value drivers shifted (stakeholders reduced their support) and forced the company to invest in CSR (reduce its investments in a country criticized for human rights violation). Despite conceptualizing the long-term benefit of investing in CSR to increase or maintain stakeholders support, they concluded that the opportunity cost related to waiting disincentives the CSR option exercise.

Herath *at al*., (2019) developed a Bayesian real option model to extend the concept of “waiting” to include the opportunity to acquire additional information before making an irreversible investment decision, the “learning” real option. Lee (2018) applied a real option approach to derive the company valuation of CSR investments, CSR options value, and the optimal timing for implementing CSR. Lee (2019) compared CSR with non-CSR companies and showed empirical results suggesting a high percentage of the company value is attributed to real options.

It is pertinent to further extend Husted (2005) CSR/ESG real option notion. Options to invest and grow in the future are valuable and represent a substantial part of the market value of most firms (DIXIT; PINDYCK, 1994). The real options perspective enables us to observe actual investment behavior of firms, reflect on investment incentives and disincentives, and propose beneficial changes and consequently positive outcomes. As Cassimon *et al*., (2016) explained, the real options models could guide public policy makers towards the value drivers with more leverage on inducing companies to engage in CSR/ESG investments in specific contexts and areas.

3
Methodology

In this chapter, we present the various decisions carried out by this study that extend the CSR/ESG real option notion developed by Husted (2005).

First, we note that the CSR/ESG investment opportunity is equivalent to a perpetual real option, which has infinite expiration time. This is because a firm can decide at any given time to become socially responsible or to invest in social responsibility, facing, as a result, the trade-off between the stochastic benefits and the costs of CSR/ESG.

Second, we study the investment behavior of firms in relation to CSR/ESG, drawing on very recent empirical research articles on CSR/ESG to choose the best suited real options models to perform our analyses. We define the parameters for a base case and perform sensitivity analyses to better understand the relationship between the variables and how different values of a set of independent variables affect a specific dependent variable, under certain specific conditions.

3.1.
Empirical Research Articles

The empirical research articles we used, revealed some CSR/ESG investing dynamics in two separate moments: when the firm decides to become a socially responsible firm and when the already socially responsible firm decides to increase its investment in CSR/ESG in order to capture a goodwill. The empirical articles were detailed in items 2.2.1 and 2.2.2.

3.2.
Real Options Models

The value of the perpetual option has no time-related change and so, the irreversible investment decision must be taken when the investment payoff exceeds not only the investment cost, but also the value of keeping the flexibility to invest or not, alive. Perpetual options have simplified differential equations because its derivative in relation to time is zero and typically has an analytical

solution. Analytical solutions allow for more general conclusions and more general comparative statics than models that need to be solved numerically.

To explore the factors that influence the decision to invest in CSR/ESG, we use four different real perpetual option models to cover distinctive moments: the beginning, when a firm decides to become a socially responsible firm. The follow through, when the already socially responsible firm decides to additionally invest in CSR/ESG to capture a goodwill created by its CSR/ESG investing. By the end, when the socially responsible firm decides to stop investing in CSR/ESG. Lastly, is analyzed the case where CSR/ESG suddenly becomes valueless and the CSR/ESG firm loses its investment.

3.2.1. First Model: McDonald and Siegel (1986) Swap Option

The first model refers to a swap decision between two discounted expected cash flows and were presented in McDonald and Siegel (1986). In our example, the decision to become a socially responsible firm is indeed the exercise of a swap option between the firm's net present value of current assets (V) and net present value of added long-run benefits and costs of becoming a CSR/ESG firm (V_R). There is no required disbursement to exercise the swap option. Examples of the exercise are the signature of stakeholder-friendly and ESG commitments, the disclosure of the firm good-quality ESG data, and ESG self-labeling, referred to in item 2.2.1. The swap exercise implies that the CSR/ESG firms will continuously invest in CSR/ESG and receive its proceeds, as an open-ended project.

In this case, the expected net present value of the two streams of profits (or losses) can be computed in terms of underlying uncertainty. The uncertainty about both streams of cash flows is continuously resolved. Both V and V_R are stochastic and follows geometric Brownian motion of the form:

$$dV = \alpha_V V dt + \sigma_V V dz_V \tag{1}$$

$$dV_R = \alpha_{V_R} V_R dt + \sigma_{V_R} V dz_{V_R} \tag{2}$$

where α is the instantaneous drift rate, σ is the instantaneous volatility rate, and dz is the increment of a standard Wiener process; dz_V and dz_{VR} are correlated with coefficient ρ.

The degree one homogeneity of the perpetual real option to swap (F) with the two stochastic variables (V and V_R) allows the problem of dimensionality to be reduced by working with the ratio $v = V_R / V$, which is homogeneous of degree zero and depends only on α, σ and t, and not respectively on V and V_R.

Because the firm receives V_R - V when it swaps, the optimal decision is to maximize the time zero expected present value of the payoff. Having no time limit to the decision to swap, the maximization occurs when the payoff reaches the optimal investment boundary, subject to eq. (1) and eq. (2), that equals to v*, such that if $V_R / V \geq v^*$, the investment is undertaken, and deferred otherwise. The use of $v = V_R / V$ will lead to the use of the option by investment unit f(v) = F(V) / V.

Using the McDonald and Siegel (1986) model, as detailed by Dias (2015), the infinite time horizon option obeys the following partial differential equation:

$$\frac{1}{2}\left(\sigma_{V_R}{}^2 V_R{}^2 \frac{\partial^2 F}{\partial V_R{}^2} - 2\rho\,\sigma_{V_R}\sigma_V V_R V \frac{\partial^2 F}{\partial V_R \partial V} + \sigma_V{}^2 V^2 \frac{\partial^2 F}{\partial V^2}\right) +$$

$$\left(r - \delta_{V_R}\right) V_R \frac{\partial F}{\partial V_R} + \left(r - \delta_V\right) V \frac{\partial F}{\partial V} - r F = 0 \qquad (3)$$

where r is the risk-free rate, δ_{VR} and δ_V are the dividend yield of the CSR/ESG firm and the non-CSR/ESG firm, respectively.

The special feature of homogeneity helps to reduce the dimensionality of the problem and the chain rule can be used to differentiate composite functions, so the partial derivatives can be replaced by the following derivatives:

$\partial F / \partial V_R = F_{VR}(V_R, V) = f'(v)$

$\partial^2 F / \partial V_R{}^2 = F_{VR\,VR}(V_R, V) = f''(v) / V$

$\partial F / \partial V = F_V(V_R, V) = f(v) - v f'(v)$

$\partial^2 F / \partial V^2 = F_{V\,V}(V_R, V) = v2 f''(v) / V$

$\partial^2 F / \partial V_R \partial V = F_{VR\,V}(V_R, V) = - v f''(v) / V$

Replacing the derivatives in eq. (3) and grouping the terms, we have the following ordinary differential equation for the option by investment unit f(v) = F(V) / V:

$$\frac{1}{2}(\sigma_{V_R}{}^2 - 2\rho\,\sigma_{V_R}\sigma_V + \sigma_V{}^2)\; v^2 f\,''(v) \; +$$

$$(\delta_V - \delta_{V_R})\; v f\,'(v) \; - \; \delta_V f(v) = 0 \tag{4}$$

where $v = V_R / V$ and σ^2 = total volatility.

$$\sigma^2 = \sigma_{V_R}{}^2 - 2\rho\,\sigma_{V_R}\sigma_V + \sigma_V{}^2 \tag{5}$$

which substituting into eq. (4), are defined:

$$\frac{1}{2}\sigma^2 v^2 f\,''(v) + \left(\delta_V - \delta_{V_R}\right) v f\,'(v) - \delta_V f(v) = 0 \tag{6}$$

The value-matching condition (whenever the boundary is reached, the option value must equal the exercise value) is:

$$F(V_R{}^*, V) = V_R{}^* - V \;\; or \;\; F(V_R, V^*) = V_R - V^* \tag{7}$$

which considering that the exercise price equals to 1, because V / V = 1, would be:

$$f(v^*) = v^* - 1 \tag{8}$$

The smooth-passing condition (the graphs of f(v) and v meet tangentially at the boundary v*) is:

$$F_{V_R}(V_R{}^*, V) = 1 \;\; and \;\; F_V(V_R, V^*) = -1 \tag{9}$$

which written by investment unit, would be:

$$f\,'(v^*) = 1 \tag{10}$$

The ordinary differential equation eq. (4) has analytical solution of Av^{β}, which generates the following quadratic characteristic equation:

$$\frac{1}{2}\left(\sigma_{V_R}{}^2 - 2\rho\,\sigma_{V_R}\sigma_V + \sigma_V{}^2\right)\beta(\beta-1) + \left(\delta_V - \delta_{V_R}\right)\beta - \delta_V = 0 \tag{11}$$

whose two roots are $\beta 1 > 1$ and $\beta 2 < 0$.

Therefore, the ordinary differential equation eq. (4) solution is:

$$f(v) = A_1 v^{\beta_1} + A_2 v^{\beta_2} \tag{12}$$

The two roots are given by the following equations:

$$\beta_1 = \frac{1}{2} - \left(\frac{\delta_V - \delta_{V_R}}{\sigma^2}\right) + \sqrt{\left(\frac{\delta_V - \delta_{V_R}}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\delta_V}{\sigma^2}}$$

$$\beta_2 = \frac{1}{2} - \left(\frac{\delta_V - \delta_{V_R}}{\sigma^2}\right) - \sqrt{\left(\frac{\delta_V - \delta_{V_R}}{\sigma^2} - \frac{1}{2}\right)^2 + \frac{2\delta_V}{\sigma^2}} \tag{13}$$

Considering that, if v tends to zero, the option value must also tend to zero, and that, because $\beta_2 < 0$, $A_2 = 0$, otherwise the option value would tend to infinity, the eq. (12), when $v < v^*$, is simplified to:

$$f(v) = A_1 v^{\beta_1} \tag{14}$$

When v = v*, the value of waiting to exercise equals the present value of the exercise payoff. Bringing eq. (14) into the value matching condition eq. (8) and the smooth pasting condition eq. (10), we have:

$$f(v^*) = A_1 v^{*\beta_1} = v^* - 1 \tag{15}$$

$$f'(v^*) = A_1 \beta_1 v^{*\beta_1 - 1} = 1 \tag{16}$$

The system can be solved for A_1 and v*:

$$A_1 = \frac{v^* - 1}{v^{*\beta_1}} \tag{17}$$

$$v^* = \frac{\beta_1}{\beta_1 - 1} \tag{18}$$

The swap option investment trigger (v*) is a fixed number because it does not vary in relation to the calendar time nor to V_R and V). It is homogeneous of degree zero.

The swap option value is:

When v < v*:

$$f(v) = \left(\frac{v}{v^*}\right)^{\beta_1} (v^* - 1) \tag{19}$$

When v ≥ v*:

$$f(v) = (v^* - 1) \tag{20}$$

Because of homogeneity of degree one in V_R and V, the swap option value by investment unit can be multiplied by the scale factor V to give the swap option value.

3.2.2.
Second Model: Adkins and Paxson (2011) Renewal Option

The second model refers to the decision to restore the performance of an asset whose revenues and costs are uncertain and deteriorate with age and were presented in Adkins and Paxson (2011). In our example, a CSR/ESG firm that invests in CSR/ESG to burnish its reputation and protect its cash flows in case of potentially damaging event (reputational, environmental, or social), as detailed in 2.2.2, is in fact exercising a renewal option.

In this case, the CSR/ESG firm's revenues (R) and costs (C) are uncertain and follows geometric Brownian motion. But, because the one-time investment (K) is fixed, the problem of dimensionality cannot be reduced as in the first model. The solution to the problem entails maximizing the expected present value of the net cash flow stream, but the use of R − C combined is misleading. In response, the optimal investment threshold is defined by a function that represents the set of infinite paired values for the revenue (R) and cost (C) variables. For $X \in \{R, C\}$,

$$dX = \alpha_X X dt + \sigma_X X dz_X \tag{21}$$

where α is the instantaneous drift rate, σ is the instantaneous volatility rate, and dz is the increment of a standard Wiener process; the dependence between the two variables is given by:

$$Cov[dR, dC] = \rho \sigma_R \sigma_C RC dt \tag{22}$$

where $|\rho| \leq 1$.

The optimal investment threshold is determined by the set R*, C*, where R* and C* are correspondingly the optimal levels that, when attained simultaneously, triggers the additional investment. But because there is a trade-off between R* and C*, the set R*, C* is countless. The asset value includes the incumbent CSR/ESG asset and its embedded investment option, and depends on the prevailing revenue and cost levels, so F = F (R, C). As mentioned earlier, when the option is exercised or the investment is made, the incumbent CSR/ESG asset is enhanced and its new value includes a new CSR/ESG investment option, to be exercised whenever a new set R_1*, C_1* is attained simultaneously.

The problem has the following partial differential equation:

$$\frac{1}{2}\sigma_R{}^2 R^2 \frac{\partial^2 F}{\partial R^2} + \frac{1}{2}\sigma_C{}^2 C^2 \frac{\partial^2 F}{\partial C^2} + \rho\, \sigma_R \sigma_C\, R\, C\, \frac{\partial^2 F}{\partial R \partial C} +$$

$$\theta_R R \frac{\partial F}{\partial R} + \theta_C C \frac{\partial F}{\partial C} - r F + (R - C) = 0 \qquad (23)$$

where r is the risk-free rate, and θ_R and θ_C are the risk-adjusted drift rates for revenues and costs, respectively. The revenue risk-adjusted drift rate (θ_R) is the pace revenues decline over time and the cost risk-adjusted drift rate (θ_C) is the pace costs increase over time, under risk neutral measure. We assume $r - \theta_X > 0$ for $X \in \{R, C\}$ so that the R* and C* thresholds are finite. This is equivalent to assume that $\delta > 0$ (for details, see DIXIT; PINDYCK, 1994).

The partial differential equation eq. (23) has the following solution for its homogenous part:

$$F(R, C) = AR^{\beta}C^{\eta} \qquad (24)$$

where A is a constant to be determined.

The solution differentiates from McDonald and Siegel (1986) two-variable Cobb-Douglas power function because no conditions are imposed on the relative values of β and η (β + η ≠ 1), meaning non-homogeneity is allowed.

Substituting eq. (24) in the homogenous part of eq. (23), we will have the following ellipse equation:

$$Q(\beta, \eta) = \frac{1}{2}\sigma_R{}^2 \beta(\beta - 1) + \frac{1}{2}\sigma_C{}^2 \eta(\eta - 1) +$$

$$\rho\, \sigma_R \sigma_C \beta \eta + \theta_R \beta + \theta_C \eta - r = 0 \qquad (25)$$

which to be solved for β and η, when β + η ≠ 1, have to be intersect by the function H (β, η) = 0 that will result in four quadrants:

I: $\{\beta_1, \eta_1\}$ $\beta_1 \geq 0$, $\eta_1 \geq 0$,
II: $\{\beta_2, \eta_2\}$ $\beta_2 \geq 0$, $\eta_2 \leq 0$,
III: $\{\beta_3, \eta_3\}$ $\beta_3 \leq 0$, $\eta_3 \leq 0$,
IV: $\{\beta_4, \eta_4\}$ $\beta_4 \leq 0$, $\eta_4 \geq 0$,

and the equation:

$$F(R, C) = A_1 R^{\beta_1} C^{\eta_1} + A_2 R^{\beta_2} C^{\eta_2} + A_3 R^{\beta_3} C^{\eta_3} + A_4 R^{\beta_4} C^{\eta_4} \quad (26)$$

which, considering the following conditions:

lim $R \to \infty$ $(F_R | F) \to 0$,
lim $R \to 0$ $(F_R | F) \to \infty$,
lim $C \to \infty$ $(F_R | F) \to \infty$, and
lim $C \to 0$ $(F_R | F) \to 0$,

will be simplified to the quadrant IV, the only one that obeys all the above economic conditions:

$$F(R, C) = A_4 R^{\beta_4} C^{\eta_4} \quad (27)$$

The partial differential equation eq. (23) has the particular solution (cash flow perpetuity):

$$F = \frac{R}{r - \theta_R} - \frac{C}{r - \theta_C} \quad (28)$$

The sum of the particular and homogenous solutions, eq. (28) and eq. (24), respectively, produces the value of the asset and its renewal option:

$$F(R, C) = A_4 R^{\beta_4} C^{\eta_4} + \frac{R}{r - \theta_R} - \frac{C}{r - \theta_C} \quad (29)$$

The decision to invest is taken when R and C simultaneously attain their respective threshold levels R* and C*. The value-matching condition equals the incumbent CSR/ESG asset including its renewal option F*(R*, C*) to its enhanced CSR/ESG asset version including its new renewal option F_1*(R_1*, C_1*), less the investment cost K, or F* (R*, C*) = F_1 (R_1, C_1) – K. Note that R_1 > R* and C_1 < C*.

$$A_4 R^{*\beta_4} C^{*\eta_4} + \frac{R^*}{r-\theta_R} - \frac{C^*}{r-\theta_C} = A_4 R_1^{\beta_4} C_1^{\eta_4} + \frac{R_1}{r-\theta_R} - \frac{C_1}{r-\theta_C} - K \tag{30}$$

There are two associated smooth-pasting conditions, one for each factor:

$$\frac{\partial F}{\partial R}_{R=R^*,\ C=C^*} = 0 \tag{31}$$

$$\frac{\partial F}{\partial C}_{R=R^*,\ C=C^*} = 0 \tag{32}$$

Which help determine the constant A_4 when applied to eq. (30):

$$A_4 = \frac{R^*}{-\beta_4 (r - \theta_R)} \frac{1}{R^{\beta_4 *}\ C^{\eta_4 *}} = \frac{C^*}{\eta_4 (r - \theta_C)} \frac{1}{R^{\beta_4 *}\ C^{\eta_4 *}} \tag{33}$$

By substituting A_4 in F (R*, C*) and recognizing that F_1 (R_1, C_1) – K must be positive for the firm to invest, the CSR/ESG asset value including its renewal option F* at the renewal event is:

$$F^* = F(R^*, C^*) = \frac{R^*}{\beta_4 (r - \theta_R)} (\beta_4 + \eta_4 - 1) = \frac{C^*}{\eta_4 (r - \theta_C)} (1 - \beta_4 - \eta_4) > 0 \tag{34}$$

implying β4 + η4 < 1.

Simplifying eq. (33), we have that R* – C*^ can be negative and the renewal can occur for a negative prevailing net cash flow, exhibiting hysteresis, in contrast with the deterministic renewal models (for details, see ADKINS; PAXSON, 2011):

$$\frac{R^*}{-\beta_4 (r - \theta_R)} = \frac{C^*}{\eta_4 (r - \theta_C)} \tag{35}$$

Using eq. (33) to eliminate A_4, the value-matching relationship eq. (30) can be expressed as:

$$\frac{R^*}{r-\theta_R} - \frac{C^*}{r-\theta_C} + \frac{C^*}{\eta_4\left(r-\theta_C\right)}\left\{1 - \frac{{R_1}^{\beta_4}{C_1}^{\eta_4}}{{R^*}^{\beta_4}{C^*}^{\eta_4}}\right\} =$$

$$\frac{R_1}{r-\theta_R} - \frac{C_1}{r-\theta_C} - K \tag{36}$$

Substituting eq. (35) into eq. (36), we define:

$$H\left(\beta_4, \eta_4 \middle| C^*\right) =$$

$$\frac{C^*}{\eta_4\left(r-\theta_C\right)}\left(1-\beta_4-\eta_4-\frac{{R_1}^{\beta_4}{C_1}^{\eta_4}}{{C^*}^{\beta_4+\eta_4}}\left(\frac{-\beta_4\left(r-\theta_R\right)}{\eta_4\left(r-\theta_C\right)}\right)^{-\beta_4}\right) -$$

$$\frac{R_1}{r-\theta_R} + \frac{C_1}{r-\theta_C} + K = 0 \tag{37}$$

The threshold is determined by three equations: the characteristic root eq. (25), the reduced-form value-matching relationship eq. (37), and the reduced-form smooth-pasting condition eq. (35), that solve for unknowns R*, β_4, and η_4 after an initial value of C* is specified. Despite the constraint $\beta_4 + \eta_4 < 1$, the solution is not unique.

3.2.3.
Third Model: Adkins and Paxson (2011) Abandonment Option

The third model refers to the abandonment of the renewal option, detailed in item 3.2.2, and were presented in Adkins and Paxson (2011). In our example, adverse operating or market conditions could make it impossible or uneconomic for a CSR/ESG firm to capture a goodwill through CSR/ESG investing.

As Adkins and Paxson (2011) explain, the renewal of an asset is no longer justified when a sufficient decline in the initial revenue, or a sufficient increase in either the initial operating cost or the reinvestment cost, occurs. In this case, the CSR/ESG firm switch to the abandonment opportunity and no longer maintain the intangible asset at an unfavorable performance.

Due to the recency of the subject, there is no empirical research article on the abandonment of CSR/ESG investing, so, to simplify the study, we considered no residual asset value or costs of disposal.

The two stochastics variables renewal model implicitly assumes that every renewal event carries a future renewal opportunity. In case of abandonment, the number of future renewals cannot be infinite. Using the index J, where J = 0, 1, …., ∞ -1, to denote the number of remaining renewal opportunities, when there are no future renewal opportunities available, J = 0, and the abandonment option is given by F_0 (R, C). Because the valuation relationship satisfies the same partial differential equation, eq. (23), and the solution takes on a similar form as eq. (29), except for an abandonment option in place of a renewal option, we have:

$$F_0 = A_{04} R^{\beta_{04}} C^{\eta_{04}} + \frac{R}{r - \theta_R} - \frac{C}{r - \theta_C} \tag{38}$$

The value-matching condition equals F_0 (R*, C*) to zero:

$$F_0\left(R_0^*, C_0^*\right) = A_{04} {R_0^*}^{\beta_{04}} {C_0^*}^{\eta_{04}} + \frac{R_0^*}{r - \theta_R} - \frac{C_0^*}{r - \theta_C} = 0 \tag{39}$$

And the two smooth-pasting conditions, because the abandonment payoff is zero, can be expressed as:

$$A_{04} {R_0}^{*\beta_{04}} {C_0}^{*\eta_{04}} = \frac{R_0^*}{-\beta_{04}\left(r-\theta_R\right)} = \frac{C_0^*}{\eta_{04}\left(r-\theta_C\right)} \tag{40}$$

By combining eq. (39) and eq. (40), we obtain $\beta_{04} + \eta_{04} = 1$, with $\beta_{04} < 0$ and $\eta_{04} > 1$, so their solution values can be evaluated directly from eq. (25). Further, this implies that the renewal boundary is linear. The abandonment opportunity asset value is then given by:

$$F_0(R,C) = \frac{\left[-\beta_{04}\left(r-\theta_R\right)\right]^{\eta_{04}-1}}{\left[\eta_{04}\left(r-\theta_C\right)\right]^{\eta_{04}}} R^{\beta_{04}} C^{\eta_{04}} + \frac{R}{r-\theta_R} - \frac{C}{r-\theta_C} \tag{41}$$

3.2.4. Fourth Model: Dixit and Pindyck (1994) Jump to Zero Probability

The fourth model refers to the risk that an investment opportunity eventually become valueless and were presented in Dixit and Pindyck (1994) and detailed in Dias (2015). In our example, CSR/ESG investing can ultimately loses its shine, and, as a result, its long-run benefits to the CSR/ESG firm, vanish.

The present value of the expected future CSR/ESG cash flows could take a discrete jump to zero, what would transform the stochastic geometric Brownian motion process into a mixed Poisson-Wiener process. When the expected future CSR/ESG cash flow reaches zero, a natural absorbing barrier for the geometric Brownian motion process, the real option, or the investment opportunity, cease to have any value.

We name O_R the opportunity to be a CSR/ESG firm, or net present value of CSR/ESG's long-run benefits and costs for a CSR/ESG firm. We use the Merton (1976) model, mentioned in Dixit and Pindyck (1994, p. 172-173) and detailed in Dias (2015), to arrive at the following stochastic process for O_R:

$$\frac{dO_R}{O_R} = \left(\alpha_{O_R} + \lambda\,\phi\right) O_R\,dt + \sigma_{O_R} O_R\,dz - \phi\,dq \tag{42}$$

where α is the instantaneous drift rate, φ is the jump-down percentage (%) size, λ is the Poisson process frequency, σ is the instantaneous volatility rate, dz is the increment of a standard Wiener process, and dq is the Poisson process risk-effect, which is uncorrelated with the market portfolio and O_R. The jump-down percentage (%) size can take the values of 1 ("sudden death") or 0 (no jump).

We then transform the stochastic process for O_R into a risk-neutral process ("Q" measure) O_R^Q, subtracting the risk-premium (π) from the dt interval in eq. (42) (the risk-premium is calculated using the system: μ = α + δ and μ = r + π, where α + δ = r + π and π = - r + α + δ):

$$\frac{dO_R}{O_R} - \pi dt = \left(\alpha_{O_R} + \lambda\, \phi + r - \alpha_{O_R} - \delta_{O_R} \right) O_R\, dt +$$

$$\sigma_{O_R} O_R\, dz - \phi\, dq \tag{43}$$

$$\frac{dO_R^Q}{O_R} = \left(r - \delta_{O_R} + \lambda\, \phi \right) O_R\, dt + \sigma_{O_R} O_R\, dz^Q - \phi\, dq \tag{44}$$

As can be observed, the possibility of a discrete jump to zero affects the risk-neutral drift rate of the opportunity, which could be zero, and increases the process' variance (although it does not alter the risk-premium, since dq is uncorrelated with the market portfolio and O_R).

When we transform O_R into O_R^Q, or into a risk-neutral process ("Q" measure), we assume the option to invest in O_R^Q has a return that equals the risk-free rate:

$$r\, F\, dt = E^Q[dF] \tag{45}$$

Considering F is the perpetual option to invest in CSR/ESG, the expected function value for the risk-neutral process ("Q" measure) has the following partial differential equation, obtained by applying the Itô-Doeblin formula for jump diffusion processes (see Dias, 2015, for details):

$$E^Q[dF] = \left[(r - \delta_{O_R} + \lambda\, \phi)\, O_R \frac{\partial F}{\partial O_R} + \frac{1}{2} \sigma_{O_R}{}^2\, O_R{}^2 \frac{\partial^2 F}{\partial O_R{}^2} \right] dt +$$

$$\lambda \left[F\left(O_R - \phi O_R \right) - F\left(O_R \right) \right] dt \tag{46}$$

Substituting eq. (45) in eq. (46) and simplifying, we have:

$$\frac{1}{2}\sigma_{O_R}{}^2 O_R{}^2 \frac{\partial^2 F}{\partial O_R{}^2} + (r - \delta_{O_R} + \lambda\,\phi)\, O_R \frac{\partial F}{\partial O_R} - (r+\lambda)\, F +$$

$$\lambda\, F\left(O_R - \phi\, O_R\right) = 0 \qquad (47)$$

It is important to note that the ordinary differential equation eq. (47) has no inhomogeneous cash flow term, meaning the option refers to the additional value CSR/ESG brings to the firm. To calculate the value of the firm with the opportunity to invest in CSR/ESG, it is required to sum the current value of the firm to the option value.

The replacement of the analytical solution of AV^{β} in eq. (47) generates the following non-dependable on O_R and non-linear equation:

$$\frac{1}{2}\,\sigma_{O_R}{}^2\,\beta\,(\beta-1) + (r - \delta_{O_R} + \lambda\,\phi)\,\beta - (r+\lambda) +$$

$$\lambda(1-\phi)^{\beta} = 0 \qquad (48)$$

Considering the jump-down percentage size $\varphi \in [0,1]$, when there is no jump, or $\varphi = 0$, the equation is a regular quadratic characteristic equation, when there is a sudden death, or $\varphi = 1$, O_R equals zero and the quadratic characteristic equation is the following:

$$\frac{1}{2}\,\sigma_{O_R}{}^2\,\beta\,(\beta-1) + (r + \lambda - \delta)\,\beta - (r + \lambda) = 0 \qquad (49)$$

whose two roots are $\beta_1 > 1$ and $\beta_2 < 0$:

$$F(O_R) = A_1 O_R{}^{\beta_1} + A_2 O_R{}^{\beta_2} \qquad (50)$$

given by the following equations:

$$\beta_1 = \frac{1}{2} - \frac{(r+\lambda-\delta)}{\sigma^2} + \sqrt{\left[\frac{(r+\lambda-\delta)}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2(r+\lambda)}{\sigma^2}}$$

$$\beta_2 = \frac{1}{2} - \frac{(r+\lambda-\delta)}{\sigma^2} - \sqrt{\left[\frac{(r+\lambda-\delta)}{\sigma^2} - \frac{1}{2}\right]^2 + \frac{2(r+\lambda)}{\sigma^2}} \quad (51)$$

The option value, subject to the boundary condition of $A_2 = 0$, is given by the following equations:

When $O_R < O_R^*$:

$$F(O_R) = A_1 O_R^{\beta_1} \quad (52)$$

When $O_R \geq O_R^*$:

$$F(O_R) = O_R - I \quad (53)$$

The optimal investment boundary is:

$$O_R^* = \frac{\beta_1}{\beta_1 - 1} I \quad (54)$$

3.3. Sensitivity Analysis

Sensitivity analysis[7] is an important modeling tool used to better understand the relationship between dependent and independent variables. It tests how different values of a set of independent variables affect a specific dependent variable, under certain specific conditions. It permits the analyst to be flexible with the boundaries tested.

[7] https://corporatefinanceinstitute.com/resources/knowledge/modeling/what-is-sensitivity-analysis/

3.4.
Sensitivity Analysis Base Case

For our base case, we considered the general expectancy of higher cash flows and lower cost of capital for companies with more-sustainable business models. Theoretically, increased corporate reputation and long-term development potential are reflected in the market price (MATOS, 2020). But investors that are motivated by a non-financial component to their utility functions, are willing to pay a premium for high ESG quality securities and accept poorer risk-adjusted returns (LOPEZ-DE-SILANES *et al*., 2019). Thus, the equilibrium expected rate of return (μ) on the investment opportunity would be lower for CSR/ESG firms that for non-CSR/ESG firms:

$$\mu_{V_R} = \alpha_{V_R} + \delta_{V_R} \quad < \quad \mu_V = \alpha_V + \delta_V \tag{55}$$

where alpha (α) is the growth rate, or drift, and delta (δ) is the dividend yield or the premium for holding the investment.

It is not clear; however, whether a CSR/ESG firm has lower alpha or delta, or both, comparatively to a non-CSR/ESG firm. We assumed CSR/ESG firms are neither growth nor high yield companies. Instead, they are most likely a dividend growth firm[8]. A sound firm, that is less susceptible to crisis, has stable revenues and earnings, and can afford to regularly pay dividends and consistently increase the payments over the years. Attracting investors because of its status, they can afford a lower dividend yield, what, in perpetuity, increases their value. In addition, consistent with the empirical observation of lower cost of capital and lower market risk, it will be assumed that the market equilibrium total rate of return (μ) is lower for the CSR/ESG firm. Thus, we assumed no change in growth rate (α) and lower expected rate of return (μ) and dividend yield (δ) for CSR/ESG firms:

μ_{VR}	α_{VR}	δ_{VR}
7,00%	3,00%	4,00%

μ_V	α_V	δ_V
8,00%	3,00%	5,00%

Table 1 - Expected Rate of Return for V_R and V
Source: elaborated by the author

[8] https://www.dividendgrowthinvestor.com/2008/12/what-dividend-growth-investing-is-all.html

Complementary, Lopez-de-Silanes *et al*. (2019) found compelling evidence of a negative relationship between ESG and volatility, in line with other empirical studies on firm risk and ESG they referred. To compute the volatility of CSR/ESG and non-CSR/ESG firms, we assumed they are equivalent financial investments and accordingly have the same market price of risk.

We considered that the equilibrium expected rate of return (μ) can be written using the capital asset pricing model (CAPM), as following:

$$\mu_{V_R} = r + \beta_{V_R}\left(E[R_m] - r\right) \quad < \quad \mu_V = r + \beta_V\left(E[R_m] - r\right) \qquad (56)$$

where (r) is the risk-free rate and (β) the respective betas of CSR/ESG and non-CSR/ESG firms.

We considered the risk premium can also be expressed as the product of the market price of risk (λ) and volatility (σ), following Brandão and Saraiva (2008):

$$\mu_{V_R} - r = \lambda\,\sigma_{V_R} \quad < \quad \mu_V - r = \lambda\,\sigma_V \qquad (57)$$

We arbitrated the market price of risk and the risk-free rate, and arrived at the following volatilities for our numerical analysis:

r	**λ**	**σ_{VR}**	**σ_V**
5,00%	0,10	20,00%	30,00%

Table 2 - Computed Volatility for V_R and V
Source: elaborated by the author

To conduct the numerical analysis of the first model, detailed in item 3.2.1, because the difference between the two cash flows is the added long-run benefits and costs of becoming a CSR/ESG firm, we assumed a perfect correlation between the two streams, which gives a total volatility of:

ρ	**σ**
1,00	10,00%

Table 3 - Total Volatility
Source: elaborated by the author

To conduct the numerical analysis of the renewal and abandonment models, detailed in items 3.2.2 and 3.2.3, we used Adkins and Paxson (2011) parameters

for reestablished revenue and cost levels, as well as investment. We assumed the same deterioration pace for revenues and costs, the same volatility, and no correlation between them two. We maintained the same risk-free rate:

Parameters	Symbols	Values
Reestablished revenue level	R_I	80
Reestablished cost level	C_I	20
Investment cost	K	100
Revenue risk-neutral drift rate	θR	-2,0%
Cost risk-neutral drift rate	θC	2,0%
Risk-free rate	r	5,0%
Revenue volatility	σR	20%
Cost volatility	σC	20%
Revenue/cost correlation	ρ	0

Table 4 - Renewal and Abandonment Options Parameters
Source: elaborated by the author

To conduct the numerical analysis of "sudden death", detailed in item 3.2.4, we maintained the previous parameters for V_R and arbitrated on the following:

Asset Value ($V_R(0)$)	1,10	MM$
Investment (I)	1,00	MM$
Jump Frequency (λ)	1,00%	p.a.

Table 5 - Sudden Death Parameters
Source: elaborated by the author

3.5. Study Limitations (Method Limitations)

Real options framework carries assumptions such as flexibility, contingency and volatility, as well as considers business has appropriate information flow and opportunities to act.

The sensitivity analysis considers each variable individually when trying to determine the outcome. However, because variables are typically related to each other, the sensitivity analysis conclusion might be incomplete.

4
Analysis of the Investment Decision

4.1.
Becoming a Socially Responsible Firm: Swap Option

We proceed with the analysis of the first real option model, detailed in item 3.2.1, where a firm is faced with the mutually exclusive choice to commit to CSR/ESG, as detailed in item 2.2.1, and swap one discounted expected cash flow (V) for another (V_R).

First, we calculate the value of the swap option. Considering the base case detailed in item 3.4, the optimal ratio v* = V_R / V were calculated at 1.59, which means the net present value of the long-run benefits and costs of becoming a CSR/ESG firm (V_R) must surpass the net present value of the firm's current assets (V) by 59% to trigger the exercise. As displayed in Figure 1, the value of the swap option is zero when v* = 1 and reaches its maximum at the trigger (v*). The optimal ratio is fixed and determined by β1, but the option value is affected by the initial ratio (v0), as the more "in the money", the more valuable the option.

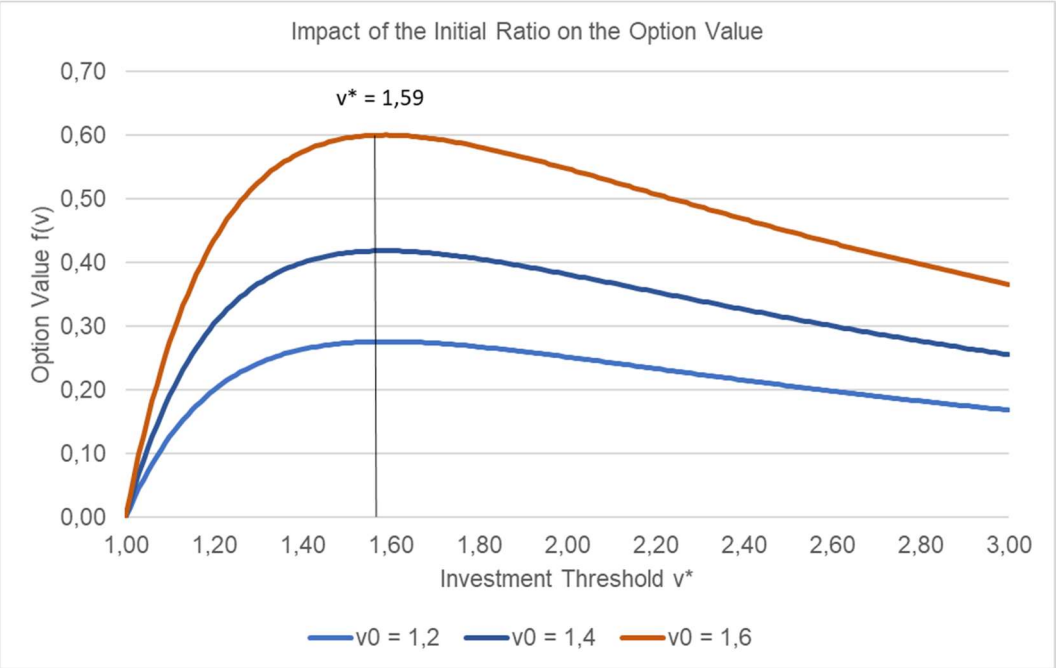

Figure 1 - Impact of the Initial Ratio on Trigger and Option Value

Second, we analyze the dividend yield impact on the investment threshold. As shown in Figure 2, the higher the incurrent dividend yield (δ_V), the greater the trigger, or the difference between the two cash flows streams. On the other hand, the higher the CSR/ESG firm's dividend yield (δ_{VR}), the trigger approaches one. It is very important to note that the option exercise requires VR – V > 0, and when the trigger v* = VR / V approaches one, VR – V approaches zero. This means that, although the investment looks attractive when a lower trigger is reached, the option is probable not exercisable.

Accordingly, the exercise should occur when the CSR/ESG firm net present value is substantially higher than the non-CSR/ESG firm net present value. Even if becoming a socially responsible firm might not increase growth and profit, the decrease in dividend yield following the status change, increases the firm value in perpetuity, in spite of unmodified cash flows. However, decreasing dividend yield might not be sufficient to trigger the exercise, since it spikes up the trigger. Thus, the large number of firms declaring to be socially responsible might be less of a rational decision than a response to market and financial pressure.

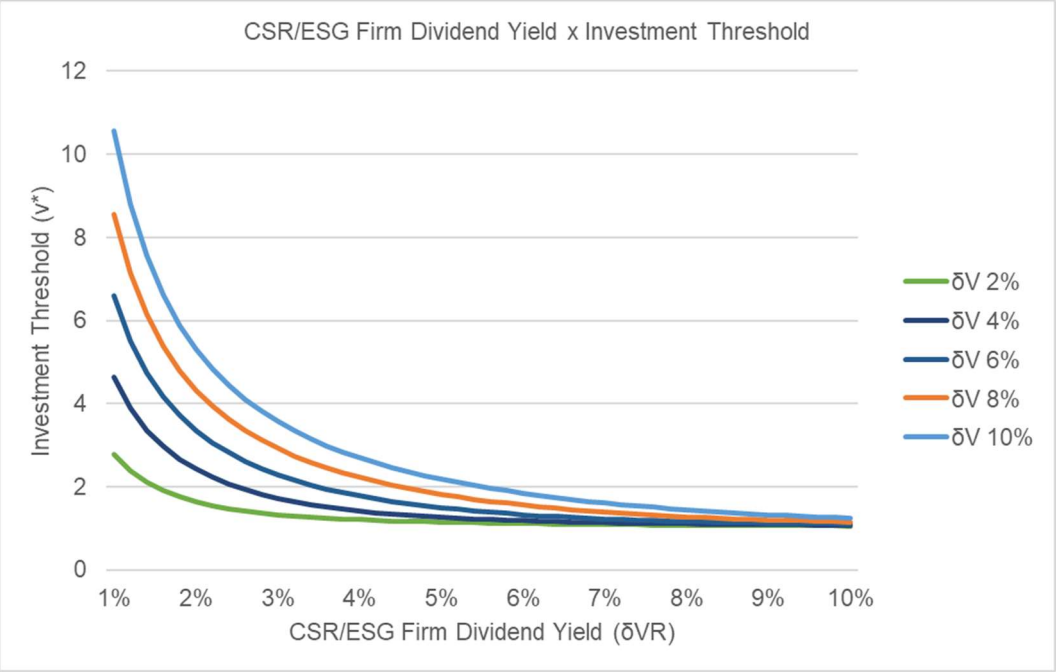

Figure 2 - CSR/ESG Firm Dividend Yield x Investment Threshold

We then analyze the impact of total volatility on the investment threshold. In Figure 3, maintaining the incurrent delta at 5%, we observe a stronger impact as the CSR/ESG firm delta decreases (δ_{VR}). In Figure 4, the impact of total volatility

is similar for different incurrent deltas (δ_V), maintaining the CSR/ESG firm delta at 4%.

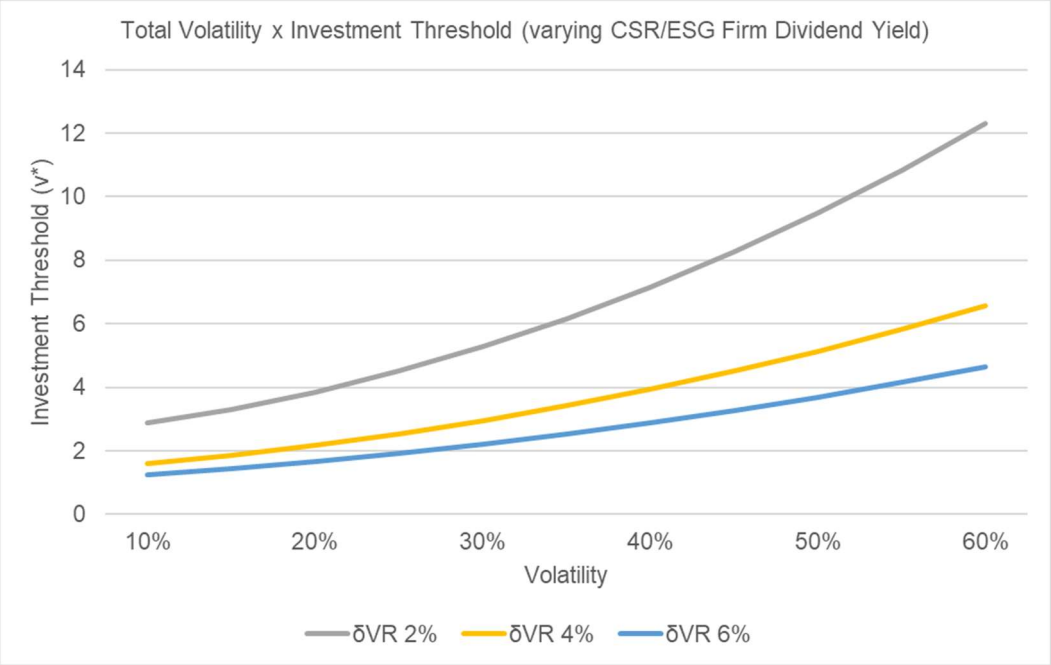

Figure 3 – Total Volatility x CSR/ESG Firm Dividend Yield

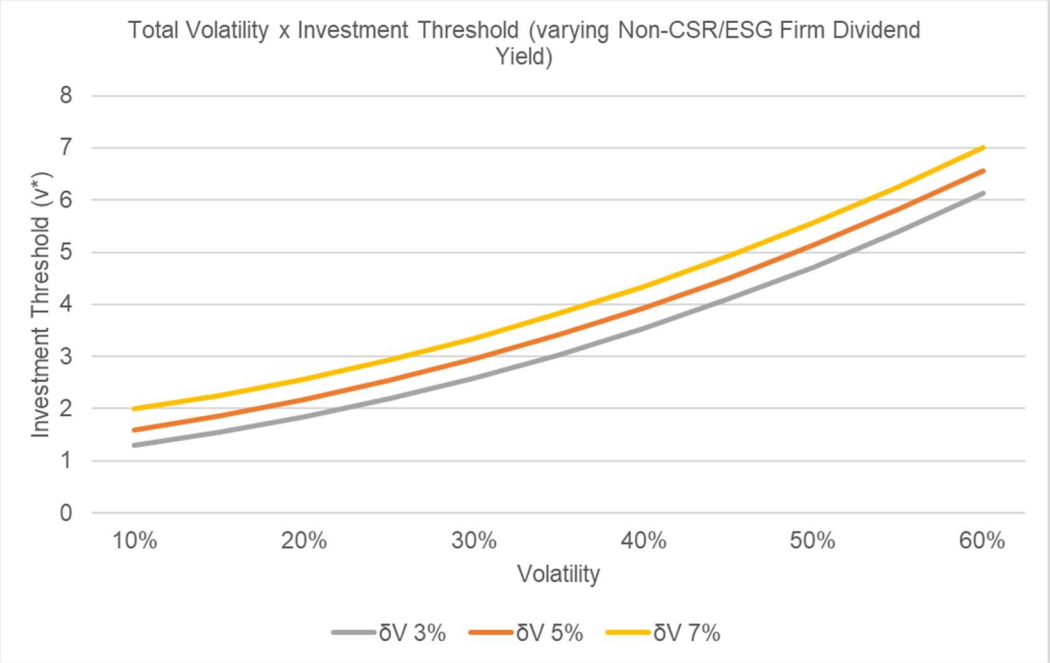

Figure 4 – Total Volatility x Non-CSR/ESG Firm Dividend Yield

An exercise of different total volatilities is presented in Table 6. Given the correlation between the two discounted cash flows, the total volatility is higher for

uncorrelated streams and lower for correlated streams, reaching zero when the two streams have the same volatility and are perfectly correlated.

	σ_{VR} 10%	σ_{VR} 20%	σ_{VR} 30%	σ_{VR} 40%	σ_{VR} 50%
ρ	σ	σ	σ	σ	σ
-1,00	40,00%	50,00%	60,00%	70,00%	80,00%
-0,75	38,08%	46,90%	56,12%	65,57%	75,17%
-0,50	36,06%	43,59%	51,96%	60,83%	70,00%
-0,25	33,91%	40,00%	47,43%	55,68%	64,42%
0,00	31,62%	36,06%	42,43%	50,00%	58,31%
0,25	29,15%	31,62%	36,74%	43,59%	51,48%
0,50	26,46%	26,46%	30,00%	36,06%	43,59%
0,75	23,45%	20,00%	21,21%	26,46%	33,91%
1,00	20,00%	10,00%	0,00%	10,00%	20,00%

Table 6 - Total Volatility considering ρ and σV 30%
Source: elaborated by the author

Complementing the analysis of reduced dividend yield for CSR/ESG firms, it is important to note that the added long-run benefits and costs of becoming a CSR/ESG firm should not differentiate much from the firm's current cash flows, otherwise they will increase total volatility and the investment trigger, precluding the exercise. Thus, since the investment in CSR/ESG is continuous, it must also be moderate and not change much the firm's activities over time.

Finally, we analyze the timing of the investment. As explained in 3.2.1, the optimal decision is to maximize the expected present value (t = 0) of the exercise payoff. The maximization occurs when the payoff reaches the optimal investment boundary $V_R/ V \geq v^*$ at time t*. To bring the exercise payoff at time t* to present (t = 0) we use the expected discount factor $E^Q [e^{-r t^*}]$. The discount factor is calculated considering the initial ratio (v_0) and the optimal ratio (v*), $E^Q [e^{-r t^*}] = (v_0/v^*)^{\beta 1}$. In Figure 5, it is shown the trade-off between waiting and exercising the swap option. At the same time a higher optimal ratio postpones the exercise, a longer period of waiting decreases the present value of the exercise payoff. In the same way, a lower optimal ratio anticipates the exercise, but the exercise payoff is lower.

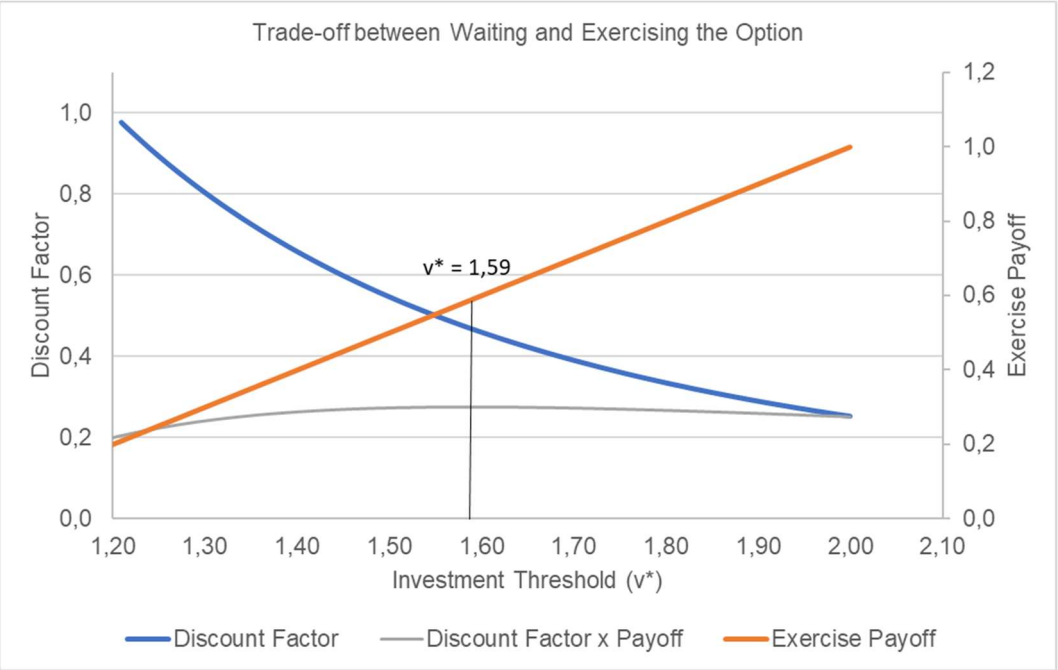

Figure 5 - Trade-off between Waiting and Exercising the Option

4.2.
Capturing the Firm's CSR/ESG Goodwill: Renewal Option

Following we analyze the second real option model, detailed in item 3.2.2, where a CSR/ESG firm has the alternative to substantially invest in CSR/ESG to reverse eroding revenues (R) and escalating costs (C) during a crisis, as detailed in item 2.2.2.

We used the parameters set in item 3.4 and Table 4 and Excel Solver solution to perform the sensibility analysis.

First, we analyze the set R*, C*; the optimal levels of revenues and costs required to be attained simultaneously to trigger the option exercise. In Figure 6, we can see the optimal exercise boundary and the renewal region right below. When costs escalate, which include sanctions and fines, the required decline in revenues to trigger the investment aimed to reestablish the initial levels, is minor. The same goes for revenues, in the event of a sharp decline, the required cost increase to trigger the investment, is not far from its initial level. The two triggers compensate each other.

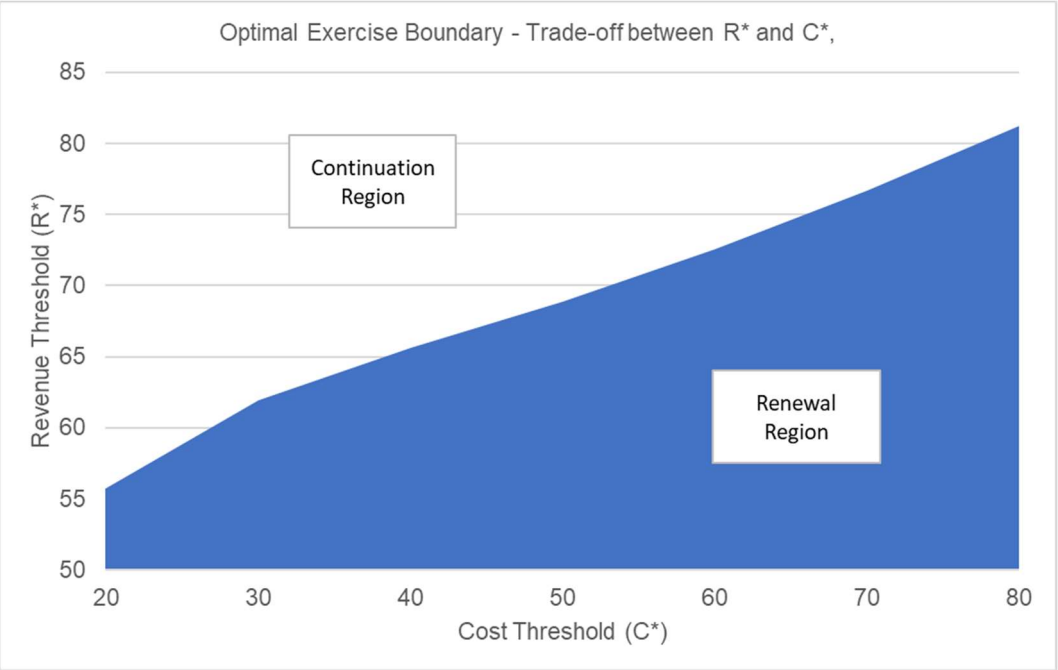

Figure 6 - Optimal Exercise Boundary: Trade-off between R* and C*

It is important to highlight that the set R*, C* has multiple solutions, despite the constraint $\beta 4 + \eta 4 < 1$ in Eq. (37). Accordingly, economically unsound solutions, like a revenue threshold level exceeding its reestablished level, can be eliminated from the evaluation.

Second, we analyze the effect the investment cost (K) has on the optimal exercise boundary. As shown in Figure 7, when the necessary investment for the exercise increases, the optimal exercise boundary moves downward. This means that, for the same cost level, current revenues must decline more to trigger the exercise. Thus, higher investment cost postpones the exercise.

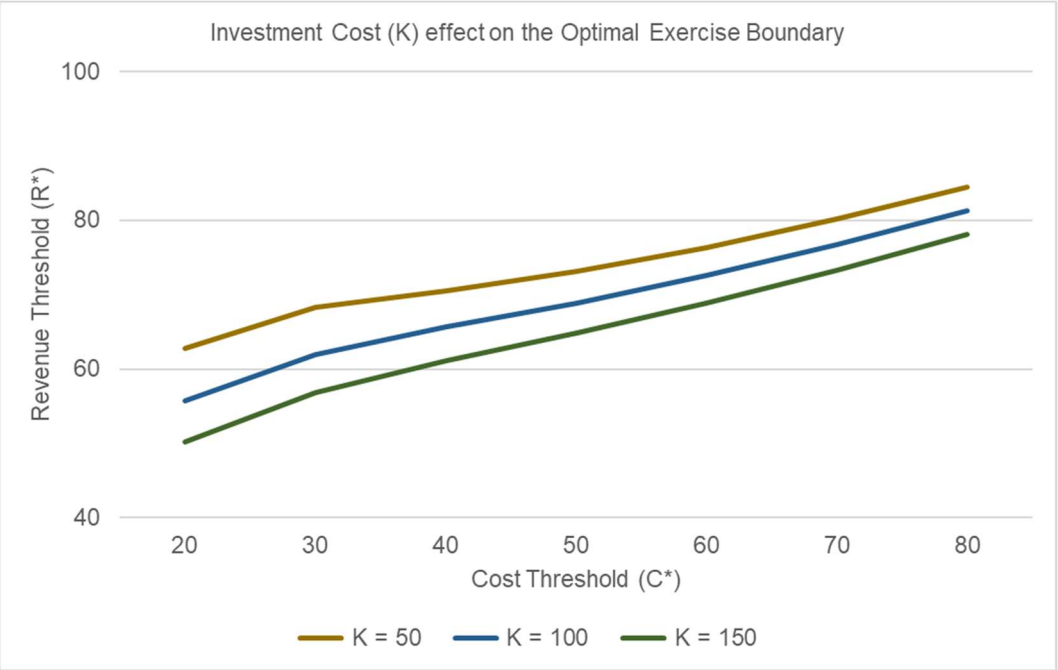

Figure 7 - Investment Cost (K) effect on Exercise

Third, we analyze the effect the initial levels (RI, CI) have on the optimal exercise boundary. The initial level is the level revenues and costs return to, after the renewal. It is also referred to as reestablished level. As shown in Figure 8, the optimal exercise boundary moves upward when we increase the asset's initial revenue level (RI). The opposite goes for the initial cost level (CI). In Figure 9, the optimal exercise boundary moves downward when we increase the asset's initial cost level. Meaning the exercise is more attractive when the reestablished levels are more favorable, or the investment will largely increase revenues or decrease costs.

As can be observed in Figure 7, Figure 8, and Figure 9, changes in the initial revenue level (RI) have a greater relative impact on the optimal renewal boundary than changes in investment cost (K) or initial cost level (CI).

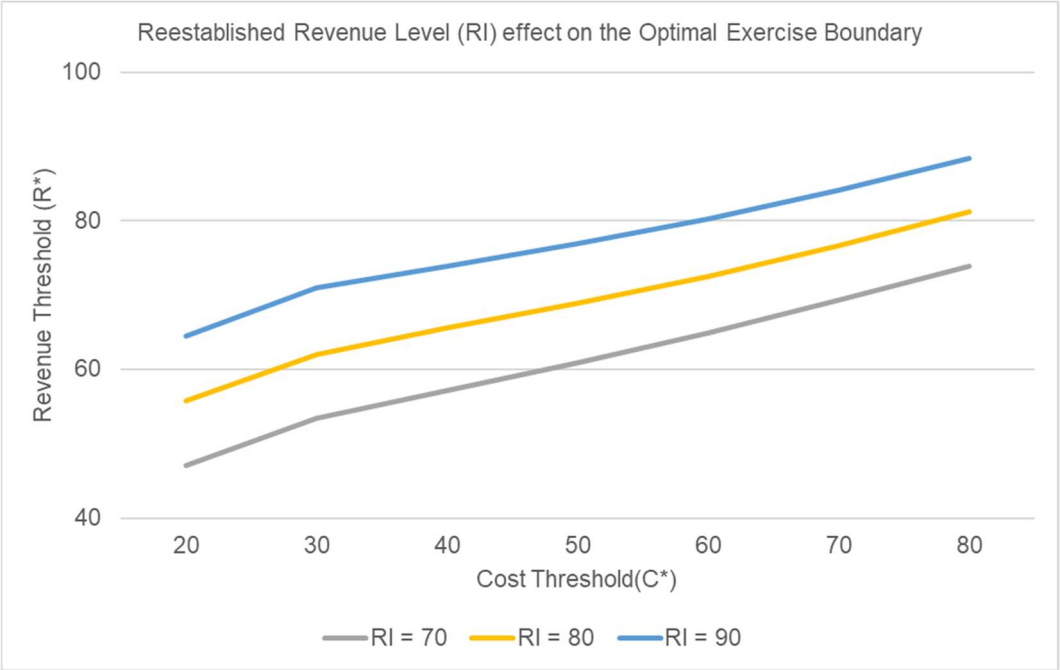

Figure 8 - Reestablished Revenue Level (RI) effect on Exercise

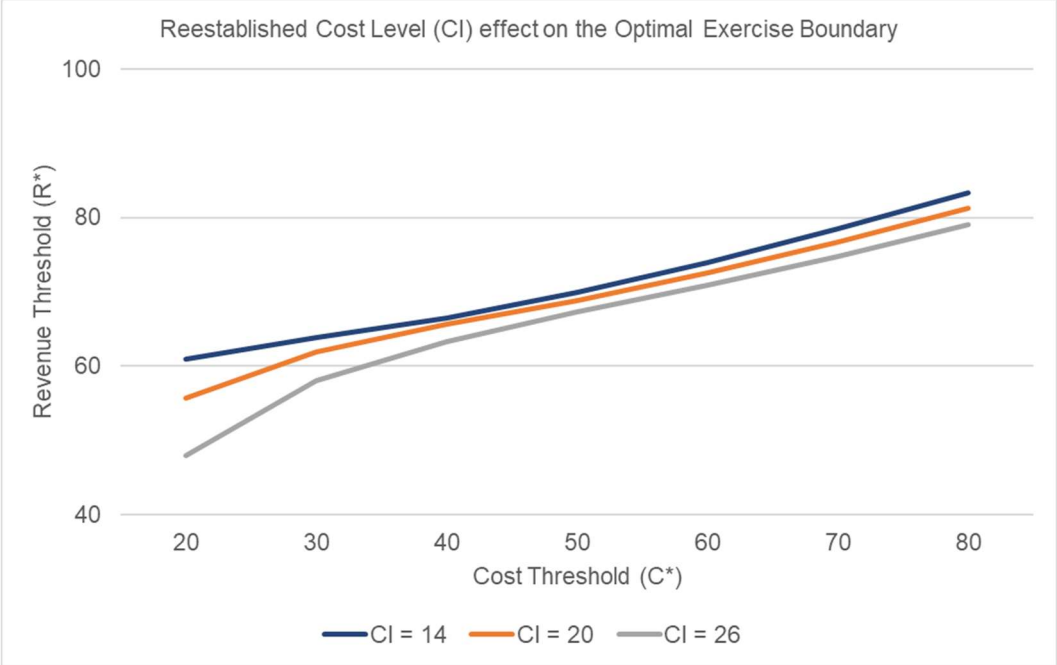

Figure 9 - Reestablished Cost Level (CI) effect on Exercise

Fourth, we analyze the risk-neutral drift rate and risk-free rate effects on the optimal exercise boundary. The risk-neutral drift rate is the pace revenues decrease and costs increase over time. As shown in Figure 10, the optimal exercise boundary moves downward as the revenue risk-neutral drift rate (θ_R), or the revenues decrease pace, becomes more negative. In the case of cost risk-neutral drift rate (θ_C), the effect is ambiguous.

Adkins and Paxson (2011) commented on the impossibility of defining the sign of the effect of the three variables on the renewal boundary. They explained; however, that when R* is significantly less than RI, a more negative revenue risk-neutral drift rate (θ_R) moves the renewal boundary vertically downwards. It is less attractive to invest in an asset whose revenues rapidly decline, demanding a new investment shortly after. When C* is significantly more than CI, a more positive cost risk-neutral drift rate (θ_C) moves the renewal boundary upward. This mean a lower decline in revenues will be required to trigger the exercise, anticipating it. Also, for a set of C* not significantly high, increases in the risk-free rate move the renewal boundary vertically downward, because of the cost of capital impact on the investment.

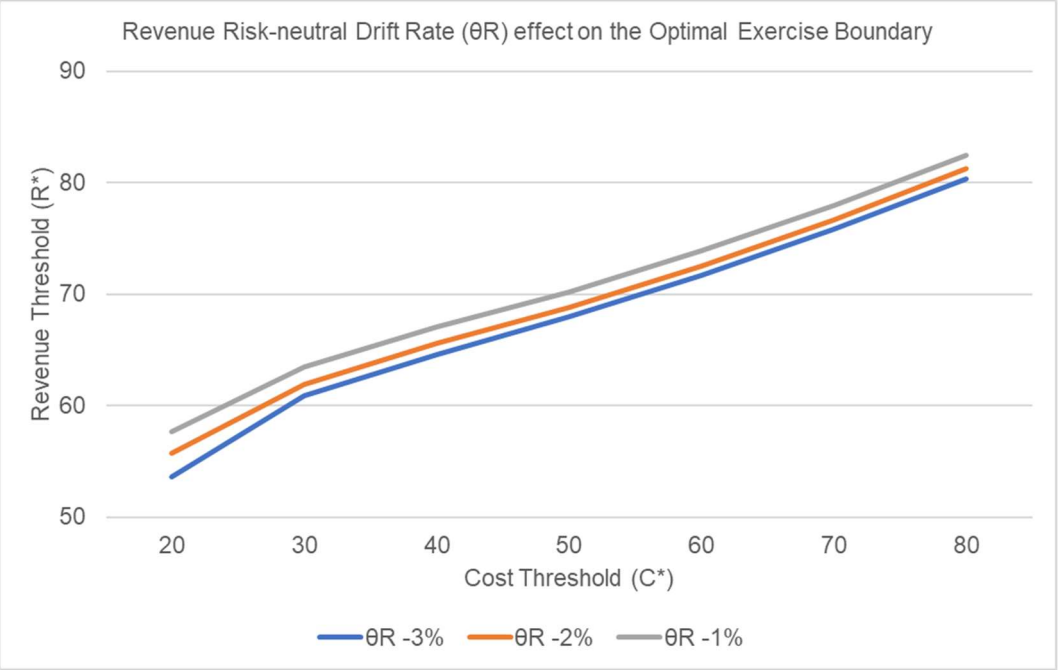

Figure 10 - Revenue Risk-neutral Drift Rate (θ_R) effect on Exercise

In Figure 11, we can see that the effect of a higher cost risk-neutral drift rate (θ_C) at a lower cost trigger (C*) is the opposite of its effect at a higher cost trigger.

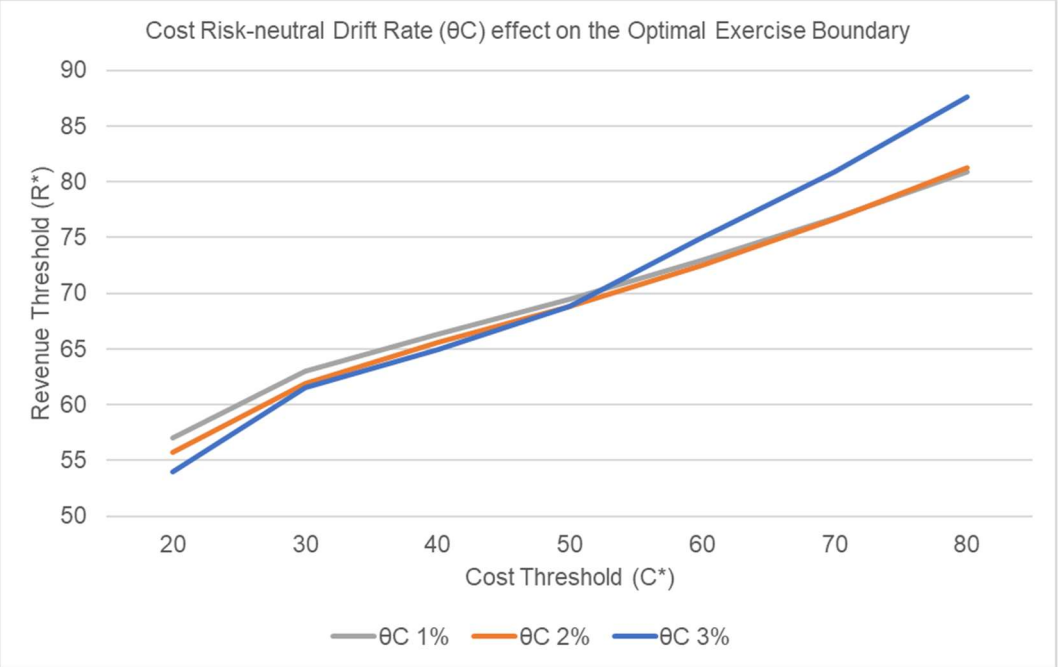

Figure 11 - Cost Risk-neutral Drift Rate (θ_C) effect on Exercise

The same goes for the risk-free rate. The effect of the risk-free rate at a lower cost trigger (C*) is the opposite of its effect at a higher cost trigger (Figure 12).

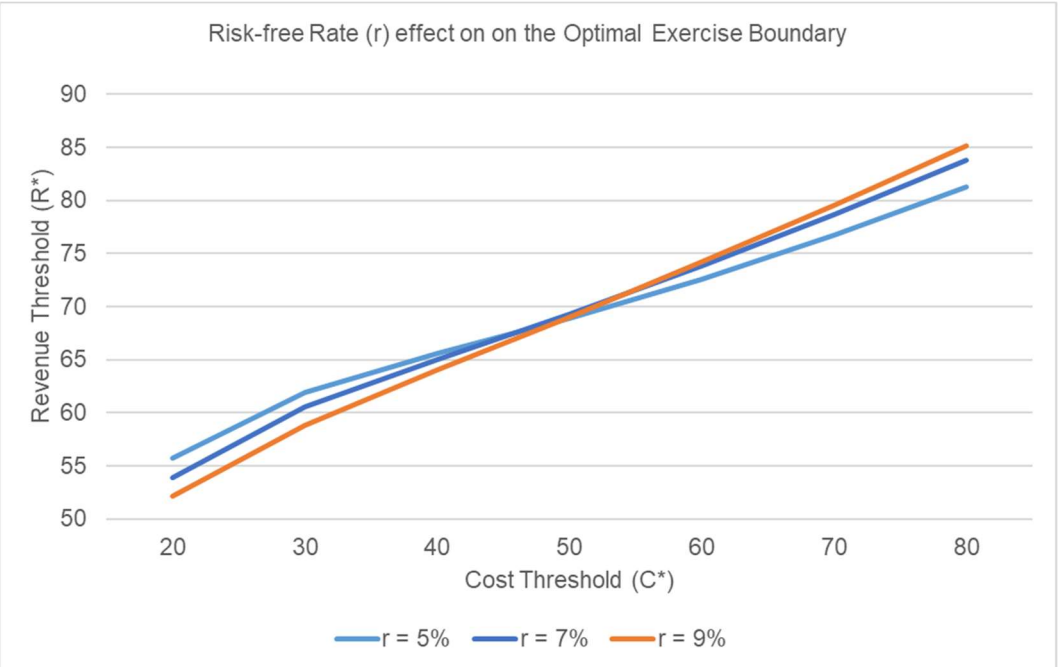

Figure 12 - Risk-free Rate (r) effect on Exercise

Additionally, we analyze the effect of both revenues and costs volatilities on the optimal exercise boundary. As shown in Figure 13, maintaining cost volatility at 20%, the optimal exercise boundary moves downward with increased revenue volatility, meaning that a worst performance is required to trigger the exercise. In Figure 14, the movement is less clear for higher cost volatilities.

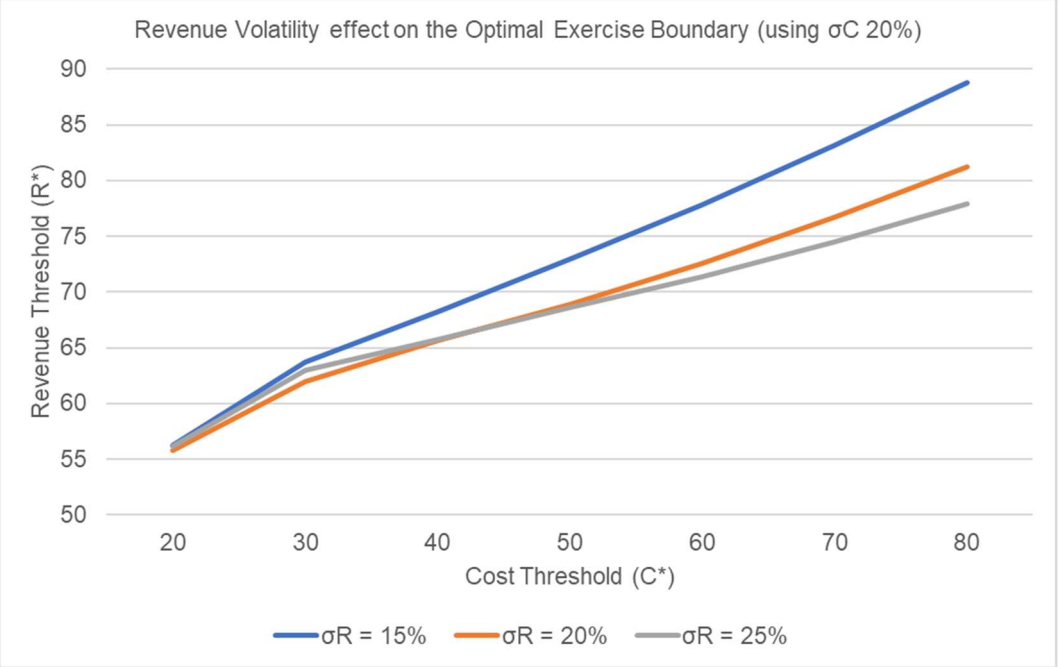

Figure 13 - Revenue Volatility effect (using σ_C 20%) on Exercise

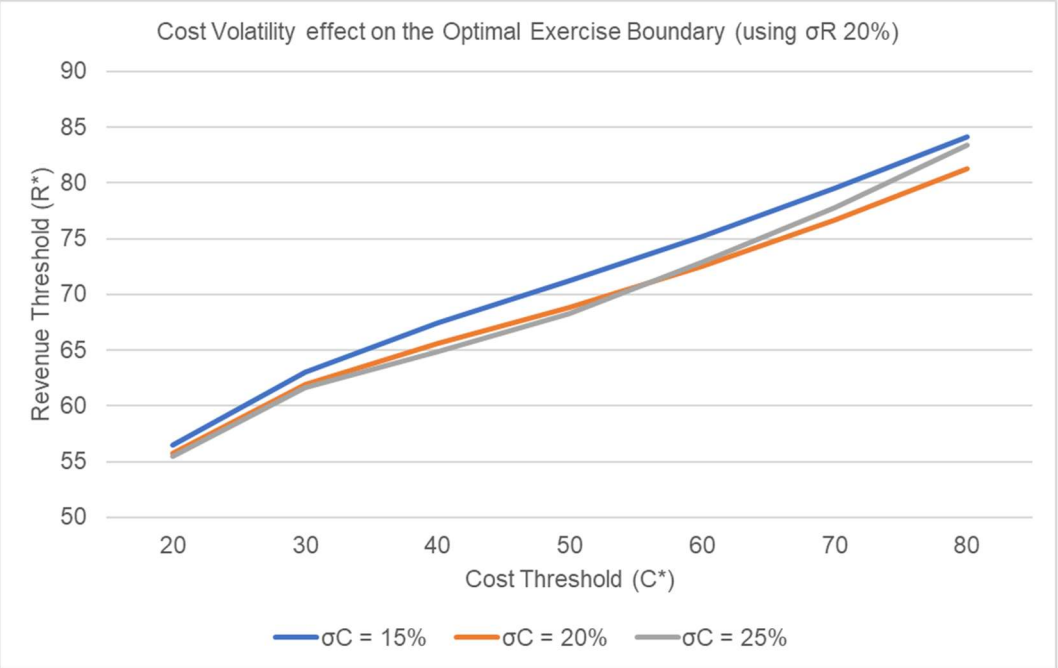

Figure 14 - Cost Volatility effect (using σ_R 20%) on Exercise

Finally, we analyze the correlation coefficient effect on the optimal exercise boundary. As shown in the Figure 15, because the threshold level represents the positive trade-off between revenues and costs along the renewal boundary, its slope attains a maximum value when the two variables are perfectly positively correlated. The importance of correlation between the two variables reinforces the need to treat them separately.

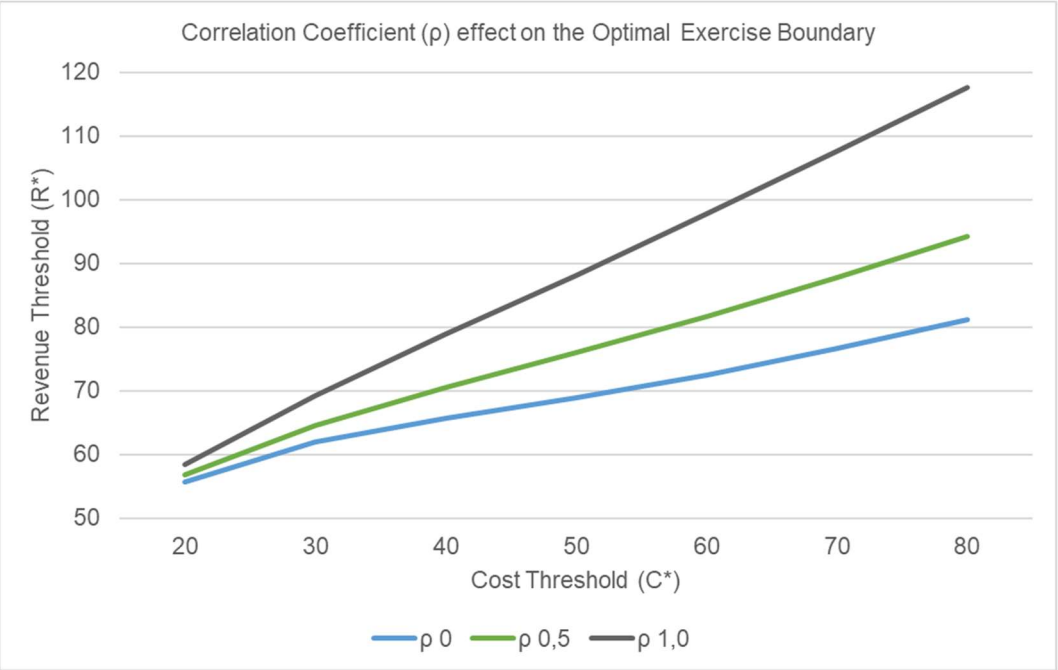

Figure 15 - Correlation Coefficient (ρ) effect on Exercise

4.3.
Stop Investing in CSR/ESG: Abandonment Option

Following we analyze the CSR/ESG abandonment option, detailed in item 3.2.3. In this case, it is neither possible nor appropriate for a CSR/ESG firm to invest in CSR/ESG to reverse its eroding revenues (R) and escalating costs (C). A sufficient decline in benefits or a sufficient increase in either reestablished cost level or investment cost could trigger the switch to the abandonment opportunity.

The decline in benefits might come from the unwillingness of investors to pay a premium for CSR/ESG firms, increasing their cost of capital, or from low returns on a poor-quality projects' portfolio built with prior excessive available capital. Higher costs might come from increasing CSR/ESG restrictions that hamper access to resources, suppliers and markets or from added requirements to capture CSR/ESG goodwill.

First, we compare the optimal exercise boundary for the multiple renewal opportunity, as detailed in 3.2.2, with the one for the abandonment opportunity. We used the parameters set in item 3.4 and Table 4. In Figure 16, for the same cost trigger (C*), the revenue trigger for the abandonment opportunity (R_0*) is much lower than for the multiple renewal opportunity (R*), meaning a sharper decline in revenues is needed to exercise the abandonment opportunity. The abandonment option is the opportunity to cease recurring negative cash flows. At the same time, it limits the renewal region, it allows more flexibility to the investment decision.

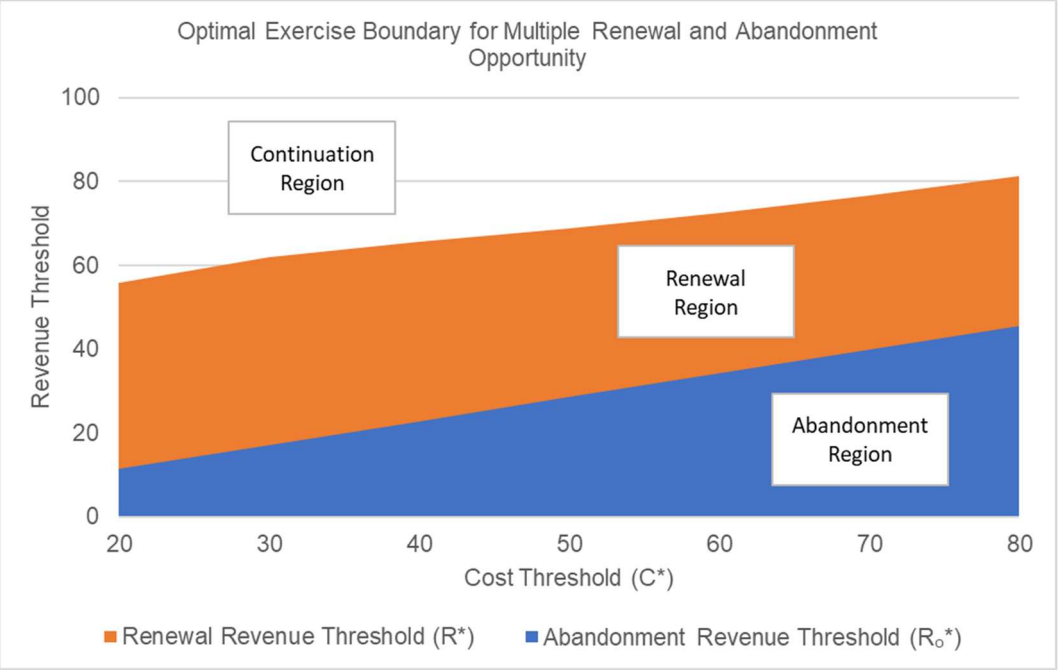

Figure 16 - Multiple Renewal and Abandonment Opportunity

Second, we analyze the risk-neutral drift rate impact on the asset value when an abandonment opportunity is included. The risk-neutral drift rate is the pace revenues decrease and costs increase over time. As shown in Figure 17, a more negative revenue risk-neutral drift rate (θ_R), or a greater revenue decrease pace, lowers the asset value carrying the abandonment opportunity. The same goes for the cost risk-neutral drift rate. As shown in Figure 18, a more positive cost risk-neutral drift rate (θ_C), or a greater cost increase pace, lowers the asset value. An accelerated pace of revenues decrease (or costs increase) over time reduces the number of possible renewals and increases the chance of abandonment. When discontinuation is more likely, the asset value decreases and the abandonment option value increases.

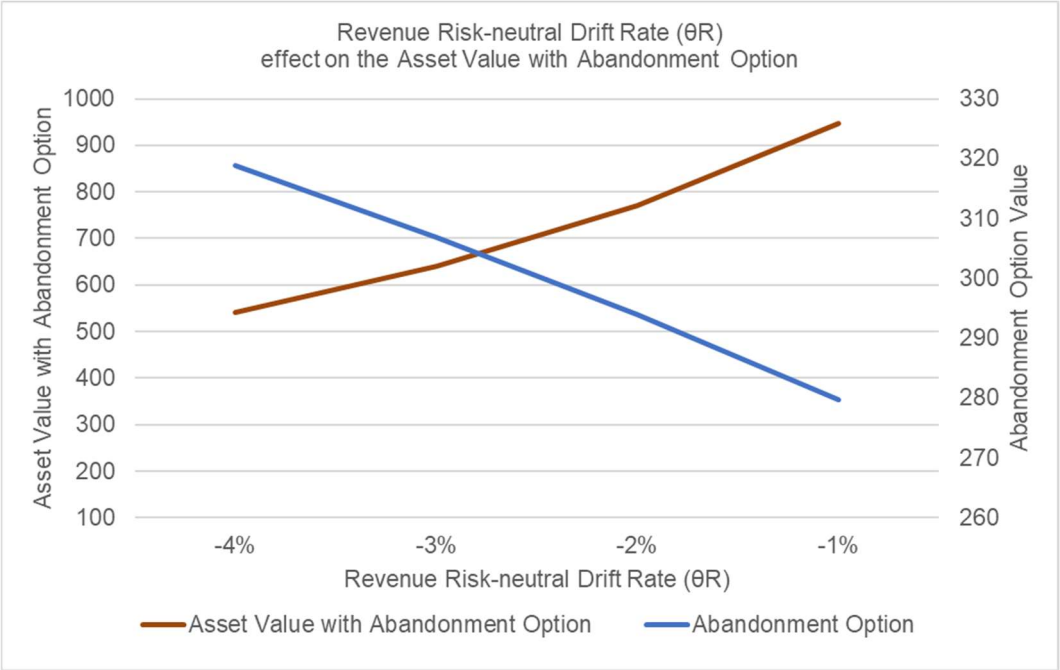

Figure 17 - Revenue Risk-neutral Drift Rate (θ_R) effect on Asset Value

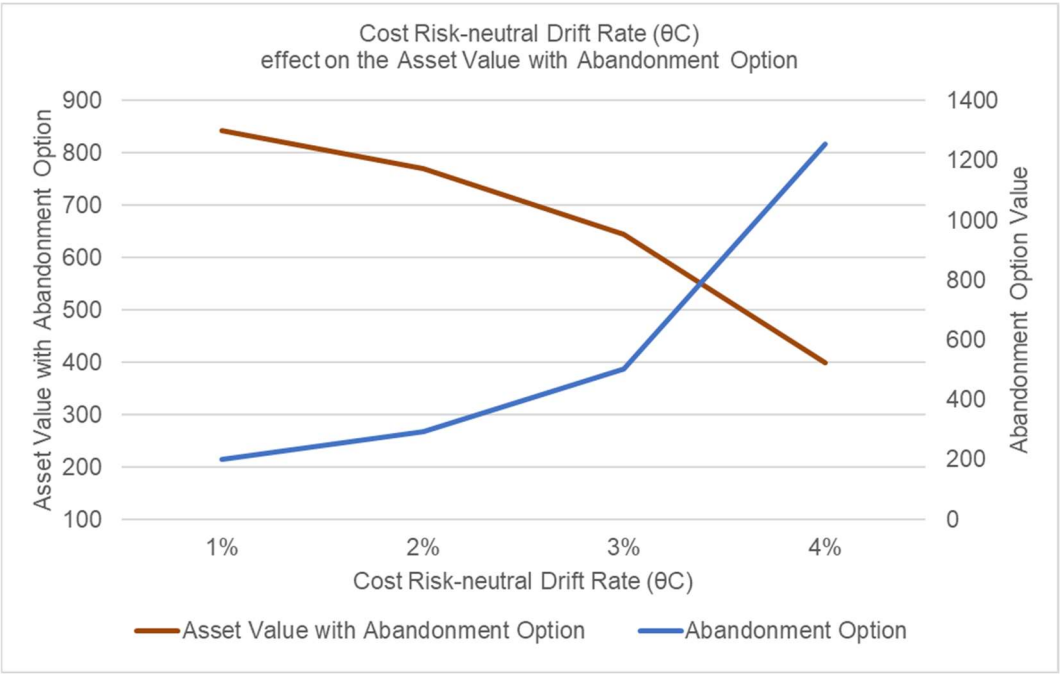

Figure 18 - Cost Risk-neutral Drift Rate (θ_C) effect on Asset Value

Third, we analyze the effect the initial revenue and cost levels has on the abandonment opportunity. As observed in Figure 19 and Figure 20, unfavorable changes in the initial conditions can increase the abandonment probability and value, since an asset with either low revenues or high costs reduces its chances of renewal.

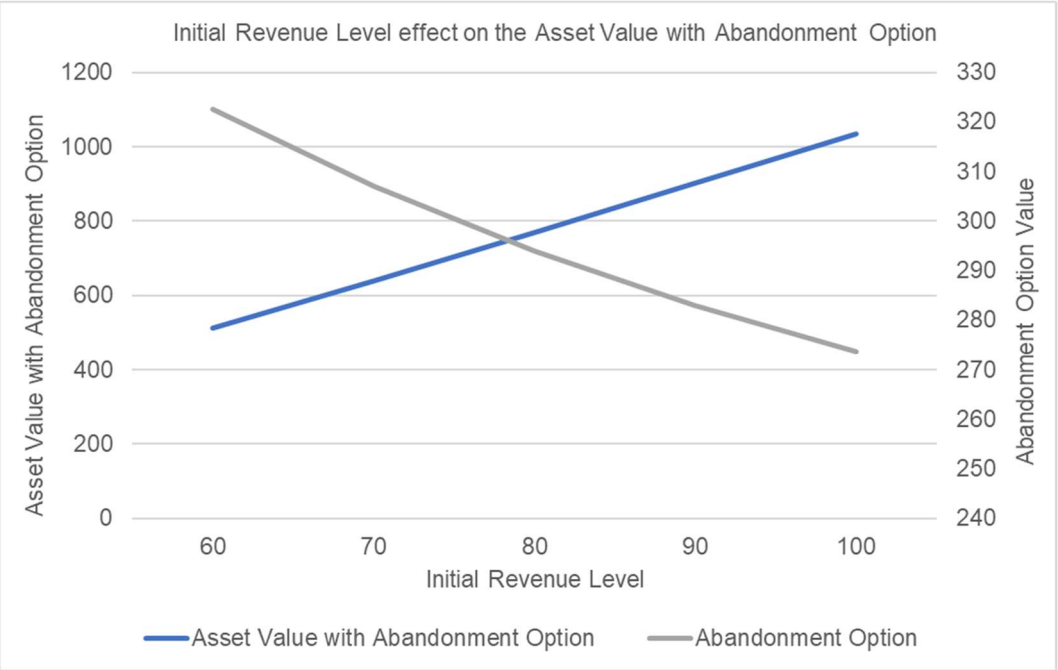

Figure 19 - Initial Revenue Level Effect on Asset Value

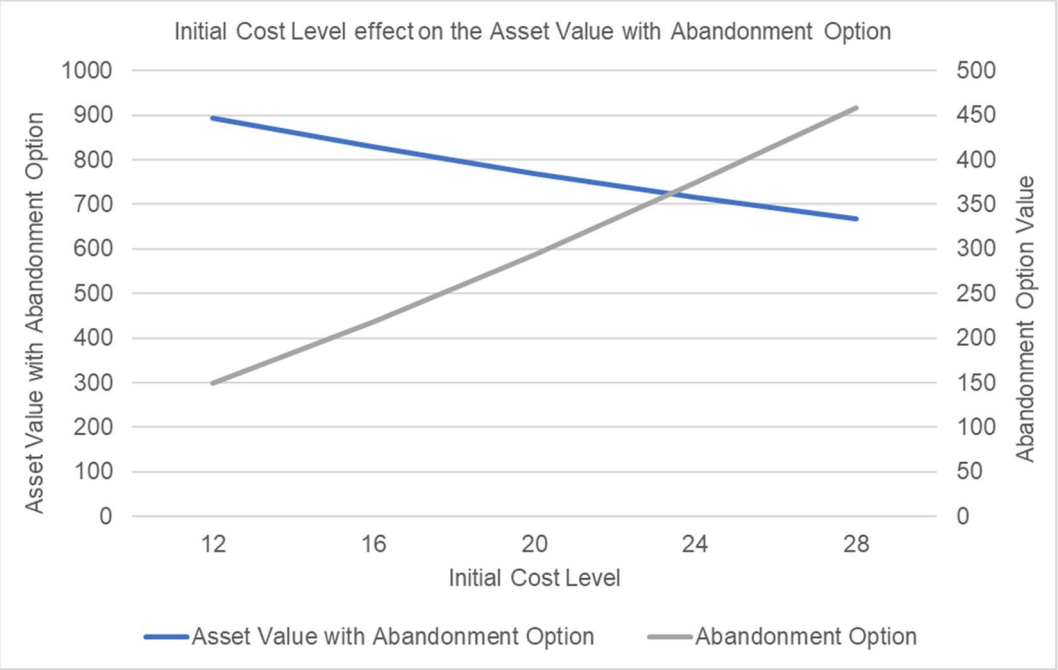

Figure 20 - Initial Cost Level Effect on Asset Value

Fourth, we analyze the volatility effect on the abandonment opportunity. As observed in Figure 21 and Figure 22, higher volatilities reduce the abandonment region, or require the asset to have a worst performance to trigger the exercise. Higher volatility regularly postpones the decision.

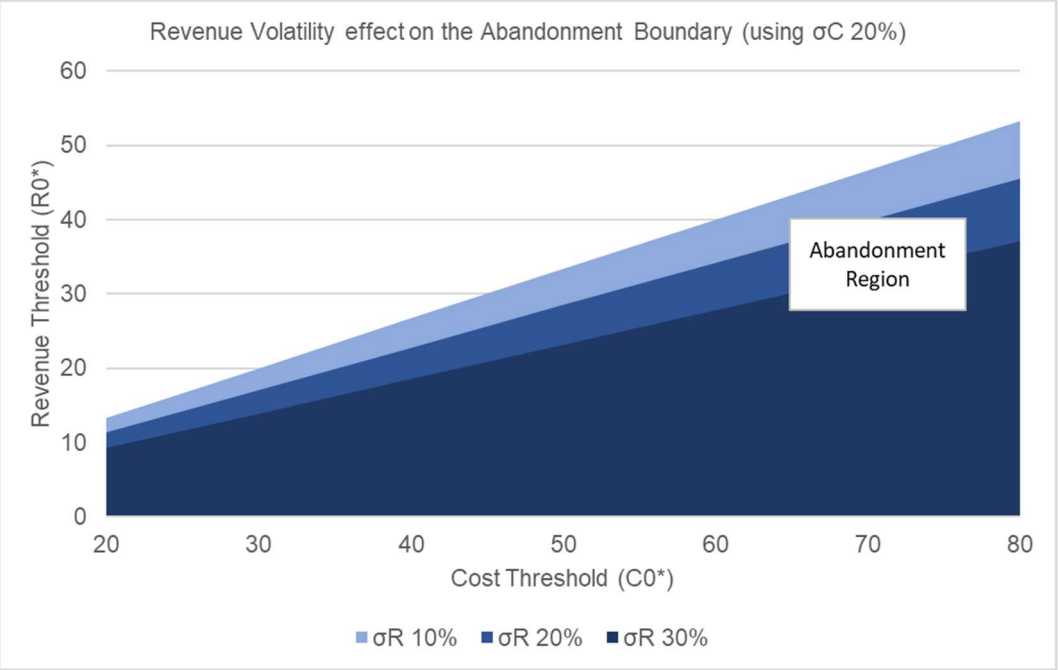

Figure 21 - Revenue Volatility effect (using σ_C 20%) on Exercise

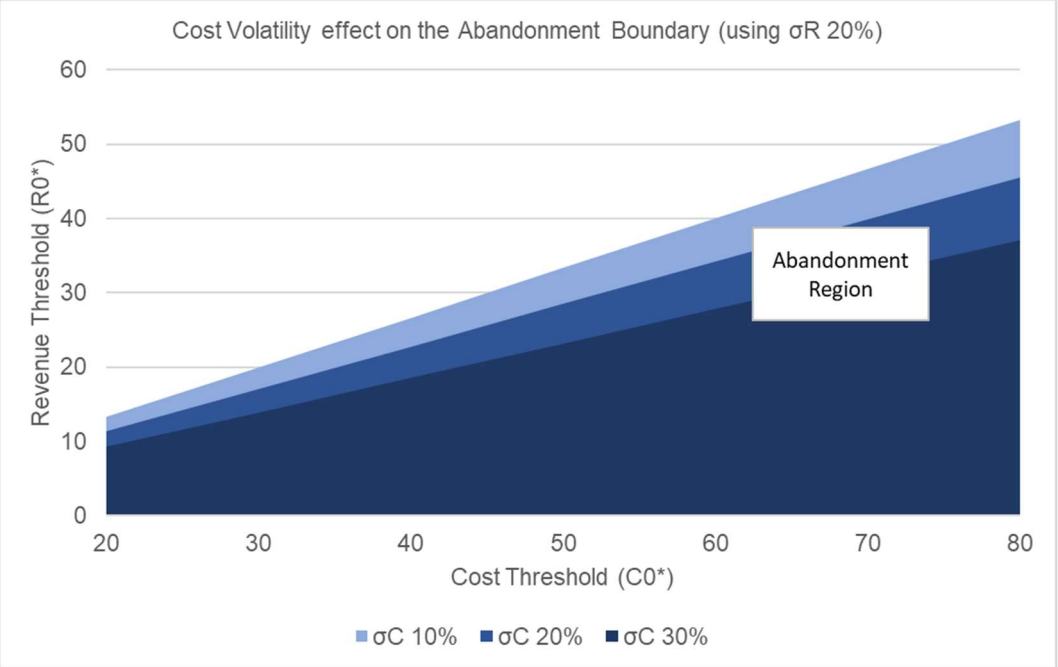

Figure 22 - Cost Volatility effect (using σ_R 20%) on Exercise

4.4.
CSR/ESG Fade Out: Jump to Zero Probability

Following we analyze the effect of the jump to zero probability, or the risk CSR/ESG loses its shine and its long-run benefits to the firm became valueless, as detailed in item 3.2.4. We considered the parameters for V_R detailed in item 3.4 and Table 5 to perform a sensitivity analysis.

First, we analyze the impact of the jump frequency on the investment boundary (V_R*) and the option value ($F(V_R)$). As shown in Figure 23, the increase in frequency, increases the investment boundary and the option value, as the risk of a 'sudden death', or of $V_R(0)$ losing its value, becomes higher.

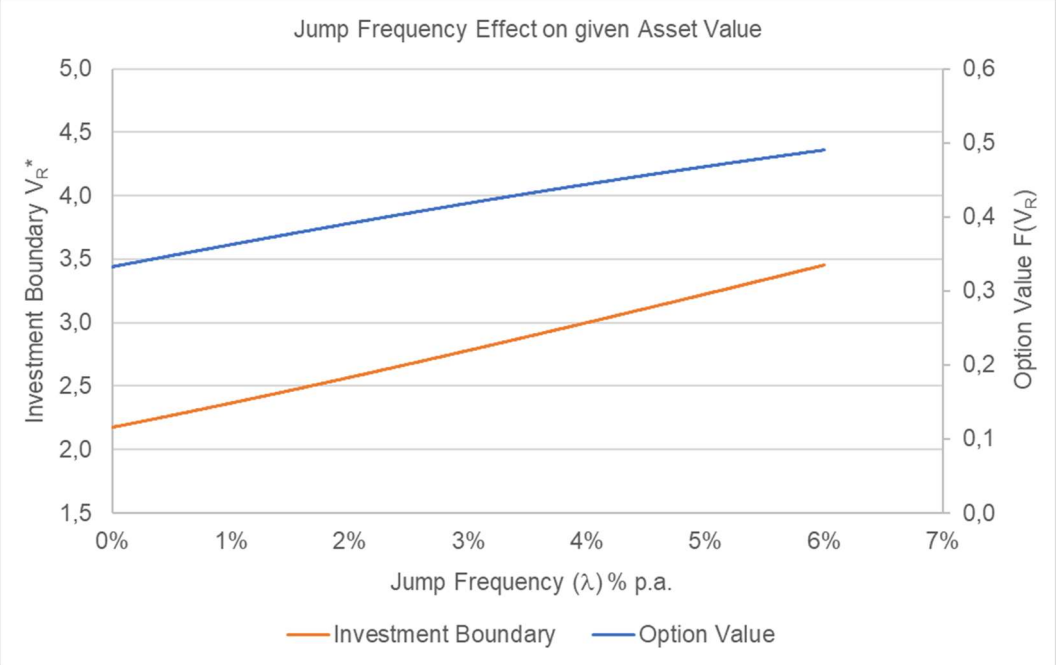

Figure 23 - Jump Frequency Effect on given Asset Value

We add the impact of volatility to the analysis. As shown in Figure 24, the investment boundary moves upward when volatility increases, as volatility turns the investment riskier.

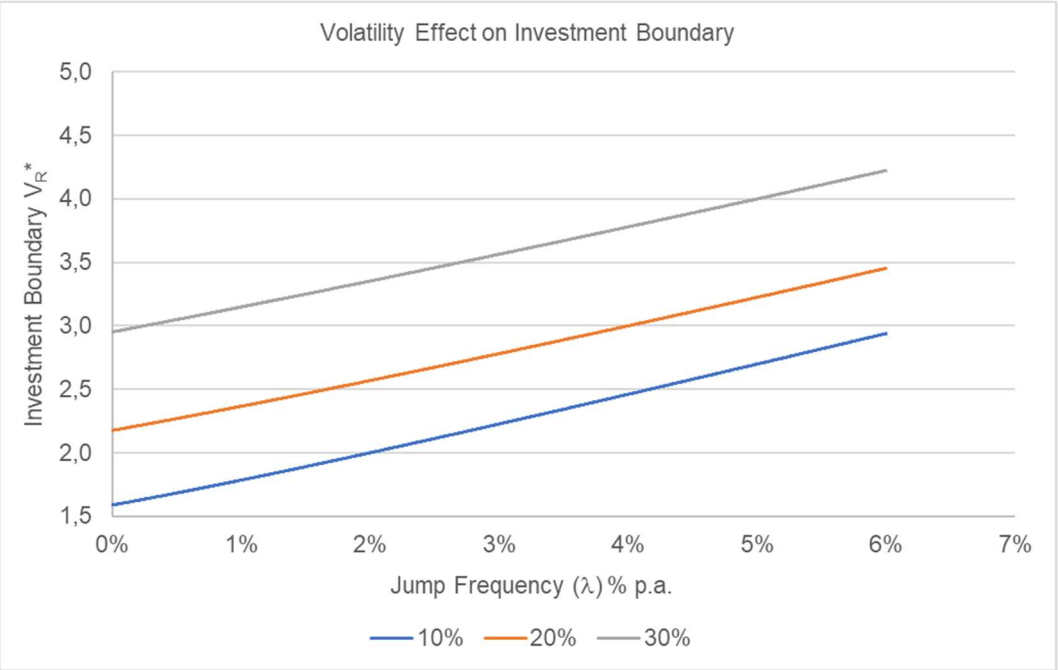

Figure 24 - Volatility Effect on Investment Boundary

Second, following Dias (2015), we show the impact of the jump frequency on the asset value taking into account that the asset value should reflect the positive probability of a discrete jump to zero. To calculate the possible valueless asset ($V_R(\lambda)$), we add the jump frequency (λ) to the risk-free rate (r). Considering the asset value is its future cash flows in perpetuity, we have:

$$V_R = \frac{FCF}{r} \Rightarrow FCF = V_R \ r \tag{58}$$

$$V_R(\lambda) = \frac{V_R \ r}{r + \lambda} \tag{59}$$

As shown in Figure 25, a higher jump frequency decreases the value of the asset as it increases the probability the asset will turn valueless at some point.

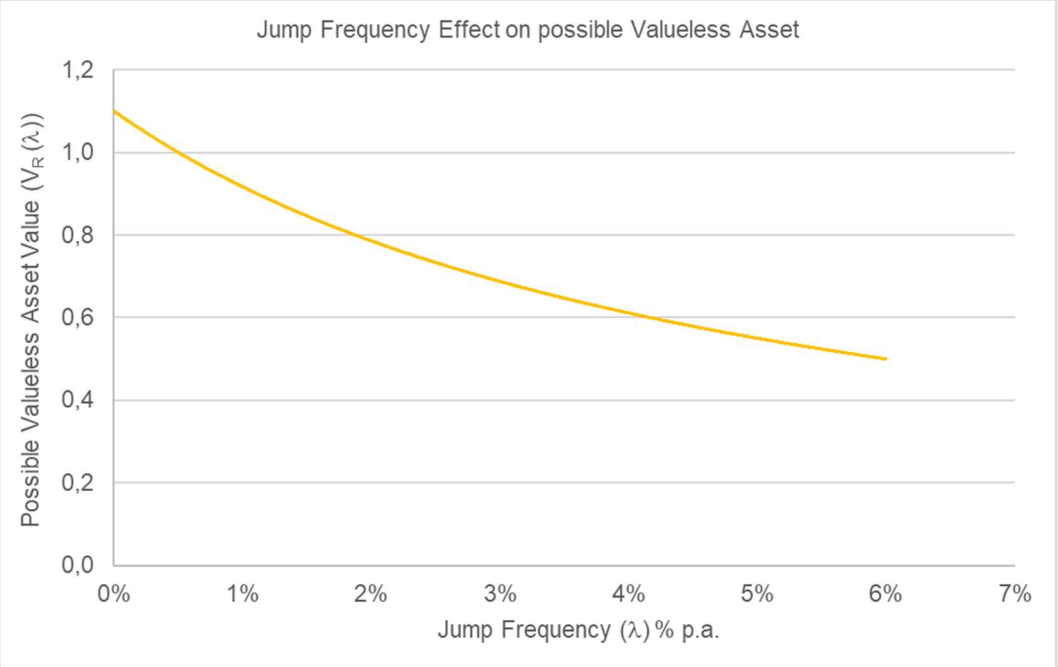

Figure 25 - Jump Frequency Effect on possible Valueless Asset

Third, we analyze the impact of the jump frequency on the investment boundary (V_R^*) and the option value $F(V_R(\lambda))$, this time considering that the asset value should reflect the positive probability of a discrete jump to zero. As showed in Figure 26, the value of the opportunity to invest in a possible valueless asset decreases as the jump frequency increases. However, because the investment boundary does not depend on the asset value, it continuous to increase with higher jump frequency.

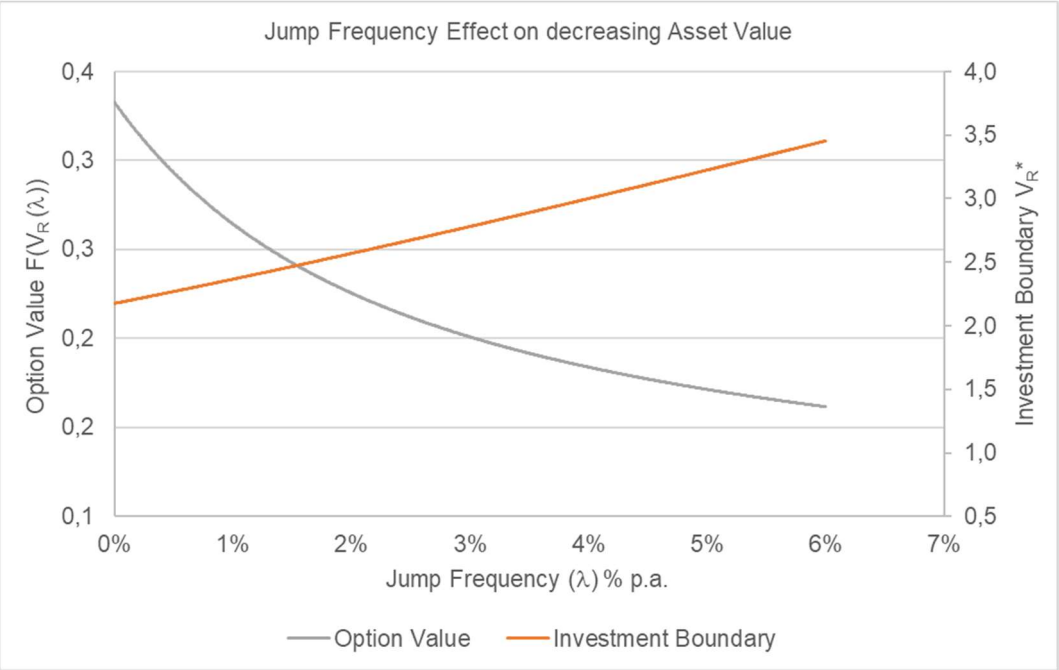

Figure 26 - Jump Frequency Effect on decreasing Asset Value

The analysis has shown that CSR/ESG investment opportunity depends on the investors' constant attention. Data standardization and comparability, as well as new regulatory policies, might help against greenwash at the same time might commoditize CSR/ESG initiatives and make firms undifferentiated. Accordingly, once investors stop paying attention to CSR/ESG and the buzz starts to fade out, increasing the jump frequency, the investment opportunity could simply vanish. To keep the option alive, it is understandable that organizations, consultants, bankers and investment managers, whether conscious or unaware, continuously cheer the concept.

5
Results

In this chapter, we discuss the results of our models and sensitivity analyses and shed light on the rationales of embracing or rejecting CSR/ESG investing.

From our first model, a firm should decide to become a socially responsible firm, and exercise its swap option, only when the difference between its CSR/ESG and non-CSR/ESG net present cash flows is substantial.

The status change, even if allowing for a decrease in dividend yield –which increases the CSR/ESG firm value in perpetuity– might not be sufficient to trigger the exercise. The lower the CSR/ESG firm's dividend yield, the higher the optimal investment boundary. Since the results about CSR/ESG additional value remains inconclusive, the large number of firms declaring to be socially responsible seem to be less of a rational decision than a response to market and financial pressure.

Besides, the cash flows swap must not represent a great change to the firm's activities. From our sensitivity analysis, when the two streams are poorly correlated and have different volatilities, the total volatility increases and rises the investment trigger. The contraposition between becoming a socially responsible firm, releasing several sustainability or corporate responsibility reports, but not altering corporate activities, might be interpreted as greenwashing, camouflage, false signaling, and, more generally, unethical practices concealed behind the adoption of presumed sound ethical management initiatives (ZERBINI, 2017),

Nonetheless, CSR/ESG firms are facing a learning curve. Which CSR/ESG initiatives should they prioritize? Should they invest on CSR and ethics programs, corporate disclosures, certifications and memberships or social and environmental performance? Which initiative captures higher benefits? Amel-Zadeh and Serafeim (2018) highlighted that, even though ESG information is considered to be material to investment performance, if corruption is more material than water pollution, or climate change is more material than violations of human rights, will probably vary among countries, industries and even company strategies. Every initiative has a cost and an impact that may be different than anticipated and will only be known as the project proceeds. Dixit and Pindyck (1994) explained that, in the case of technical uncertainty, the investment has a shadow value beyond its direct

contribution to the completion of the project, that is to reveal information about cost and impact, and thus about the expected net payoff from investing further. However, since the investment in CSR/ESG is continuous, it is expected that firms will keep them within reasonable limits to do not exceed its potential long-run benefits.

Another possible reason for a large number of firms to exercise the swap option is the prospect of protecting their cash flows during unfavorable situations. From our second model, a relevant event that provokes a sharp decline in revenues or soaring costs might trigger a CSR/ESG firm to substantially invest in CSR/ESG to enhance its position in the market and when facing regulators in order to minimize its sales loss and potentially reduce its corporate fines and sanctions. Our results are in line with Ferrés and Marcet (2021) that colluding firms use CSR investing to reduce fines and reputational backlash, Hong *et al*. (2019) that CSR/ESG firms prosecuted under FCPA receive lower sanctions, and Hindkjaer and Slettan (2020) that CSR/ESG performance have an insurance-like effect on firm value.

According to our sensitivity analyses, a higher investment cost, interest rate, revenue drift rate (revenue decline pace over time), as well as a limited gain (lower reestablished level of revenue or higher reestablished level of cost), disincentivize the exercise.

Complementary to the decision to invest in CSR/ESG an infinite number of times to reestablish levels of revenues and costs, a CSR/ESG firm can decide to stop investing in CSR/ESG. An accelerated pace of revenues decrease (or costs increase) over time reduces the number of possible investments and increases the chance of abandonment. In the CSR/ESG case, the pace could be increased by mounting business restrictions (more expensive suppliers and processes, higher salaries, restricted markets). Also, unfavorable reestablishment conditions reduce the number of possible renewal investments. An asset with low revenues and high costs has more chances to be abandoned. This means that if the upside in revenues or the downside in costs are limited, and performance will not change substantially following the investment, it would be better for the firm to abandon the CSR/ESG project. Dixit and Pindyck (1994) explained that a firm generally gets an option to invest together with an option to abandon and that the two options must be priced simultaneously to resolve the optimal policies for investment and abandonment. If the cost of abandonment is too high, a firm would take a more cautious approach when deciding to invest, and vice versa.

Our fourth model shows the impact of the possibility of a ‘sudden death’ of the opportunity, or the possibility of CSR/ESG losing its long-run benefits to the firm value. An increase in the probability of a ‘sudden death’ decreases the value of a CSR/ESG firm and therefore the opportunity value to invest in it.

Cornell and Damodaran (2020) perceived impression that market players push for the concept, may be justified as a necessary effort to maintain the renewal option alive. Many projects need to be kept in operation to preserve its tangible or intangible capital —mines flood, machines rust, teams of skilled workers disband, and brand recognition is lost. Otherwise, the firm will have to reinvest in all these assets to restart (DIXIT; PINDYCK, 1994).

The investment opportunity depends on the constant attention of the market: investors, investment managers, consultants, banks etc. The moment the attention received ends, neither consumers will consider in their purchases the investments of a company in CSR/ESG, nor will the authorities take these investments into account when imposing sanctions and fines. The attention may fade away due to standardization of data and regulations that accommodate initiatives and make companies undifferentiated.

6
Conclusion

The results of our study suggest that CSR/ESG investing is valuable, but not for the reasons commonly presented. CSR/ESG investing creates an opportunity for the firm to limit its losses in a moment of crisis. While the use of this opportunity has no guaranteed positive outcome, the option is an undeniably advantage.

The time of this option exercise cannot be anticipated, as a moment of crisis cannot be predicted with high precision. Reason for which the firm must keep the option alive by constantly investing in CSR/ESG initiatives. Considering CSR/ESG is an open-ended project, the firm must manage its costs to not surpass its benefits over the years, as well as introduce a sufficient number of valued novelties bound to have a positive impact on the market and among regulators when necessary.

Despite being logical in terms of investment decision, is this “insurance” beneficial to society? Does it provide the “positive change” so many call for?

CSR/ESG initiatives include the publication of ethical codes, the employment of ethics officers, training and incentive programs, the use of CSR/ESG and ethics committees, the adoption of certifying systems, product awards and independent authorities’ reviews, membership of sustainability rating systems, and the use of corporate disclosures (ZERBINI, 2017). Nevertheless, as Aguilera *et al*. (2008) explained, carrying out different practices impose systemic costs of compliance that are reflected in the firm’s balance sheet and other accounting documentation, as well as less explicit opportunity costs, as directors’ time spent on the initiatives instead of business strategy or changes in managerial risk preferences. Even though new regulations and enhanced CSR/ESG standards are beneficial, the implementation of increasingly required CSR/ESG initiatives may harm small and medium-sized firms. In line with some studies, a firm’s size and financial health is decisive for the investment (FERRÉS; MARCET, 2021; ILIEV; ROTH, 2021), and a firm unable to cope with CSR/ESG necessary corporate structure, data collection systems and documents reporting might be disregarded by the financial market investment screening.

The expansion of required CSR/ESG initiatives, besides potentially harming smaller firms, keep alive an option that will most probably be exercised by larger

firms. Larger and stronger firms have the resources to invest, are more exposed to adverse events and have more money at stake (penalties and decline in revenues) to trigger the investment. At the same time, larger and stronger firms can retain consultants, bear different practices, market their initiatives, pay for and participate in CSR/ESG conferences and seminars for investors and stakeholders. This process feeds on itself: larger and stronger firms promote the CSR/ESG concept and benefit from it. A cycle that might foreclose the market to small and medium-sized firms, whose investments would comparatively seem trivial.

Doesn't strengthening large companies contradicts "shared prosperity"?

Also, the opportunity to limit losses in a moment of crisis may propel firms to engage in a reckless behavior that can led to reputational, environmental, or social damaging events. A reckless or an unethical behavior, considering greenwashing, camouflage, impression management and false signaling (ZERBINI, 2017).

It is significant that massive "too big to fail" corporations will always have possible systematic risk as bailout argument (SORKIN, 2010). Although their ruin will affect all stakeholders, to safeguard them might be an incentive to malpractice or unethical behavior. As Sorkin (2010) points out, should those corporations have implicit or even explicit guarantee to continuously take irresponsible risks and profit enormously from it? We ask whether it is contradictory to strengthen larger and stronger firms and call for "shared prosperity". As well as, to demand a "positive change" and give an "insurance" to be used in case of corporate wrongdoing.

Some say Milton Friedman's "there is one and only one social responsibility of business- to use its resources and engage in activities designed to increase its profits" quote is obsolete. However, the second part of the quote "so long as it stays within the rules of the game, which is to say, engages in open and free competition, without deception or fraud" (FRIEDMAN, 1962, p.133) is very often omitted. The suppression served the narrative of demonizing profits, but a sustainable economy depends more on ethical behavior than on sacrificing profits. On our view, the full quote remains valid up to the current days.

For future research, we suggest exploring the effect that the strategic interaction between competing firms in the market has on accelerating the investments in CSR/ESG. In this case, an extension is to combine real options and game theory models. Game theory can also quantify the signaling effect of firms that become socially responsible firms and verify whether or not the signaling is credible in terms of Bayesian equilibrium. We suggest addressing the apparent

inconsistency between adopting CSR/ESG initiatives and behaving unethically, as well as exploring the effect of disclosure standardization and regulatory constrain.

7
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