Sustainable Finance or Financialization of Sustainability?

by

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Chapter 1

Introduction

Finance is everywhere. Over the past half a century, the role of finance has grown beyond the financial sector, influencing the economy through the financialization of non-financial corporations, as well as political and social life. Economies evolved from a system of industrial capitalism to one of financial capitalism. The outbreak of the 2008 financial crisis marked the culmination of the negative consequences of financialization, drawing increased public attention to the societal role and utility of finance. Today, the financial sector claims to be more responsible by contributing to solving societal challenges, such as climate change. Thus, the field of 'sustainable finance' emerged. In 2022, the total assets under management in sustainable funds reached USD 2.5 trillion (Morningstar, 2023). Non-financial corporations meanwhile pledge net zero targets and use sustainable financing instruments to signal their commitment and finance their sustainable transition. But how do fund managers define sustainability? How do corporations structure such sustainable securities? In this dissertation, entitled 'Sustainable Finance or Financialization of Sustainability?', I aim to provide different perspectives on this complex question with three empirical papers. The first essay sets the scene on the topic of financialization and how this process drove change within the financial sector and within non-financial corporations. It discusses the role of financial derivatives, as one example of financial innovation, and analyzes the link to the rise of income inequality. The second essay addresses the question of how fund managers define sustainable

investments using the regulatory context of the European Sustainable Finance Disclosure Regulation (SFDR). Finally, the third essay examines the phenomenon of sustainability-linked bonds (SLBs) and their pricing to understand who pays for sustainability improvements (the company or the investor). The aim of this introductory chapter is to provide the background and the foundation of my work, as well as a summary of the three essays.

Financialization is a complex process, and the definitions range from including 'everything finance' (Epstein, 2005) to more narrow descriptions of new 'financial market activities' (Stockhammer, 2004). The financialization literature can be broken down into four dimensions. The first dimension relates to the rising ascendancy of the financial sector and the associated emergence of financial innovation and growing complexity (Stockhammer, 2013). This development has spurred the emergence of non-bank financial institutions (such as investment funds, hedge funds and private equity funds), commonly referred to as the shadow banking system, which surpassed the size of the traditional banking sector (Pozsar and Singh, 2011). The second dimension represents the increasing participation of non-financial corporations (NFCs) in capital markets, and how they shifted from a 'retain and reinvest' to a 'downsize and distribute' model (Lazonick and O'Sullivan, 2000), inducing a reallocation of resources from the productive to the financial sector. Thus, this stream of research emphasizes the development of new corporate governance models based on maximizing shareholder value and financial profitability. The third dimension is the influence of finance on social life and the financialization of households (Van der Zwan, 2014). Finally, the last dimension relates to the financialization of the state, as state actors increasingly engage in financial market practices for purposes of sovereign debt and asset management (Fastenrath, Schwan, and Trampusch, 2017), as well as increased central bank activity (Walter and Wansleben, 2020). The 2008 global financial crisis shed light on the adverse effects of financialization, including short-termism, financial instability, and resource misallocation. In response, a substantial body of interdisciplinary literature emerged, discussing the detrimental social consequences, particularly in relation to inequality.

In the first essay of this thesis, co-authored with Marc Chesney, we contribute to this literature by discussing two channels within the financialization process that link financial derivatives to rising income inequality. The first channel is related to developments within the financial sector through the growth of financial innovation which led to increasing fee-generating revenues and rent extraction within the economy. The second channel is related to the financialization of NFCs, as we explain that the growing shareholder primacy led to the inclusion of stock options in executive compensation and hence the financialization, or 'optionalization', of the top income share. We therefore argue that there is a decoupling between top income compensation exposed to the growth of the derivatives market, as opposed to non-financialized wages linked to the real economy. Due to their structure, stock options promote the asymmetric effect of the financial cycle, as the top income share benefits disproportionally during boom phases, while being less exposed to losses in bust phases. Our essay also contributes to the empirical literature as it provides the first analysis using derivatives data. We test our hypothesis using a novel dataset of the aggregate volume of single stock options contracts traded across 14 OECD countries between 1990 and 2020. Our results suggest that single stock options have a statistically and economically significant correlation with the rise in the income share (top 10%, 1% and 0.1%). The correlation is strongest for the top 0.1% income share. This empirical finding aligns with both our argument and the existing literature, which consistently demonstrates a notable presence of NFC executives and high-earning finance professionals within the top 0.1% income share. Overall, this essay adds to the discussion on the social implications of financial innovation and increasing financial complexity.

As the negative repercussions of the financialization process reached their peak with the financial crisis, policymakers found themselves compelled to explore regulatory interventions to address the ensuing issues. In the EU, the Green Papers issued by the European Commission (2010, 2011) analyze the regulatory failures that led to the financial crisis and reach the conclusion that 'a comprehensive financial reform' is needed to address 'short-termism, poor risk management and a lack of responsibility of certain actors in the financial sector' (European Commission, 2010). In this

context, where financial institutions were increasingly under pressure, sustainable finance emerged as a reasonable and socially appealing alternative, which was actively presented as the 'antidote' to widespread financial irresponsibility (Ahlström and Monciardini, 2022). In the years following the financial crisis, sustainable finance was increasingly positioned as a solution to mitigate the negative consequences of the financialization process. For example, the European SRI study highlighted that most of the responsible investment strategies had proven more resilient than conventional strategies during the crisis (Eurosif, 2013). The argument that SRI strategies not only serve society but lead to superior financial performance was hence used to promote SRI policies to regulators (Ahlström and Monciardini, 2022). As a result, the SRI community was able to put forward sustainable finance as part of the solution to the crisis and gradually enter the EU policy discourse, as it supported the ideas of long-termism based on socially and environmentally responsible finance. As opposed to speculative 'casino capitalism' (Strange, 1997) leading to financial crises, sustainable finance embodied the new ideal of a more 'patient capitalism' supporting social prosperity and long-term growth.

While there were multiple factors driving the rise of sustainable finance, such as the increased public aversion to the financial sector after the financial crisis, cultural changes (Scholtens and Sievänen, 2013), institutional investor activism and financial returns (Nath, 2019), regulation played a significant role in the EU (Crifo, Durand, and Gond, 2019; Ahlström and Monciardini, 2022). A pivotal moment was the Paris Agreement in 2015, as it recognized the critical role of finance in redirecting resources and marked a commitment from the private sector to align financial flows toward low-carbon and climate-resilient development (United Nations, 2015). However, policymakers' attention shifted from broader sustainable finance to a narrower focus on climate finance after 2015. Central banks contributed to this shift by highlighting the impact of climate risks on financial stability, thus taking a financial approach to sustainability, and specifically climate, rather than a sustainable approach to finance (Campiglio et al., 2018). The influence of central banks is exemplified by the speech of Mark Carney, the Governor of the Bank of England and Chairman of the Financial Stability Board, discussing the 'tragedy of

the horizon' and the long-term monetary and financial stability policies required to manage climate-related risks (Bank of England, 2015). Climate change risks are distinct in finance due to their clear integration into financial analysis, facilitating risk management and product pricing (De Goede and Randalls, 2009). Unlike social or ecological impacts, climate risks align with the long-standing financial concept of rendering uncertainty calculable, enabling the creation of investment strategies, as well as insurance and debt products (Bracking, 2019). Despite the publication of Piketty's *Capital in the Twenty-First Century* in 2014 and the increased public attention on inequality, this social topic did not find a place in the sustainable finance debate. Between 2015 and 2019, the High-Level Expert Group on sustainable finance (HLEG)[1] made several suggestions on systemic changes related to short-termism and the need for financial markets to reflect societal values. However, the EU Commission's efforts were centered around supporting green finance markets and financial product development, contributing to the financialization of sustainability (Ahlström and Monciardini, 2022). As part of the EU's action plan, the EU Parliament and Council adopted the Sustainable Finance Disclosure Regulation (SFDR) in 2019 to improve transparency in the market for sustainable investment products, reduce information asymmetries and prevent greenwashing (Eurosif, 2022). Considering the large ambiguity within the sustainable finance space in terms of terminology, definitions, and strategies due to increasing institutionalization (Nath, 2019), the SFDR requires financial institutions to provide information on the level of sustainability integration in their financial products according to three types (Article 6, 8 and 9).

In the second essay of this thesis, co-authored with Marc Chesney, we examine the inclusion of companies into so-called 'dark green' funds disclosed as Article 9 under the SFDR. We analyze 290 public equity SFDR Article 9 fund holdings, comprising 4'463 global stocks. We develop a metric of a company's implied 'greenness' based

[1]The HLEG comprised 20 experts from the finance sector, academia, civil society and observers from European and international institutions. The group was mandated to provide the EU Commission with advice on how to steer public and private capital towards sustainable investments, identify steps to protect financial stability from environmental risks and deploy these policies on a pan-European scale.

on the inclusion frequency in our fund sample and analyze to what extent sustainability and financial characteristics drive this greenness score. Thus, this essay addresses the fundamental question of what constitutes a 'sustainable investment'. Our paper contributes to the sustainable finance literature, as it is the first empirical analysis using regulatory disclosure to provide insights into company-level characteristics driving inclusion frequency into sustainable funds. Our greenness score represents a novel measure of market perception, relying on fund managers' sustainability implementation, instead of a company's ESG rating. Our results provide two main findings. Firstly, a stock's greenness score is driven by sector exposures, climate targets and CSR efforts, such as human rights policies and ESG ratings. Net zero targets have a higher statistical significance than GHG intensity levels. UN Global Compact violations have no statistically significant effect. Secondly, we find differences in greenness score drivers between global and regional funds, suggesting different sustainability definitions due to investment universe and portfolio diversification considerations.

The findings of this essay provide empirical evidence to the literature's discussion on the regulatory-driven shift to climate finance and the contribution to increased financialization. Our findings show that companies with science-based net zero targets increase their inclusion frequency into sustainable funds, underscoring the financial sector's commitment to developing climate change-focused financial products. A substantial share of SFDR Article 9 funds comprises 'climate transition' strategies which have been designed to track a Paris-aligned benchmark (PAB) or Climate transition benchmark (CTB). These products showcase the financialization of sustainability by broadening climate change investment beyond thematic strategies (e.g., clean energy companies). Companies in these funds must have climate targets, a market standard for large public firms in recent years. Furthermore, the significant variety of SFDR Article 9 investment strategies demonstrates sustainable finance's mainstreaming, fostering financial innovation and new product development using sustainability. The growth in sustainable finance resulted in a diversity of managerial strategies to construct financial portfolios (Berry and Junkus, 2013; Capelle-Blancard and Monjon, 2014). Ambiguity in sustainable finance grew

with managerial discretion and financial institutions acting as intermediaries between individual investors and the market (Nath, 2019). The difference in ambition and sustainability definition across financial institutions, as well as the information asymmetry, gives rise to greenwashing risk. The findings of the second essay highlight this increased greenwashing risk as the definition of sustainable investment varies across funds and depending on the investment universe (i.e. global or regional funds). Furthermore, the strong correlation between the greenness score and ESG ratings indicates that fund managers rely heavily on ESG ratings to define 'sustainable investment'. These metrics, developed by third-party rating agencies, were intended to reduce ambiguity and increase transparency in assessing sustainability at firm and portfolio levels (Nath, 2019). However, the integration of ESG ratings into the traditional financial rating industry, described as institutional retrogression (Avetisyan and Hockerts, 2017), may risk diluting the original intention of the SRI movement. Critics argue that ESG ratings focus on how ESG risks affect the financial performance (i.e. financial materiality), instead of the impact materiality, promoting a financialized approach to sustainability. SFDR Article 9 funds should conceptually consider both financial and impact materiality (double materiality), but the findings suggest that many primarily rely on ESG ratings, emphasizing financial materiality. The current implementation of the regulation does therefore not solve the problem of ambiguity and suggests a financialized definition of sustainability in investment funds.

Beyond the investment fund industry, sustainability also fuels financial innovation in corporate finance to develop new instruments, notably in fixed income, which are increasingly issued by NFCs for financing purposes. Coincidentally, the first sustainable instruments were issued at the outbreak of the financial crisis. The European Investment Bank issued a climate awareness bond in 2007 and the World Bank the first green bond in 2008 (Bracking, 2019). As climate finance became more prevalent after the crisis, sustainable securities on capital markets emerged as a new fixed income asset class. In 2022, green, social and sustainability (GSS) bonds, as well as sustainability-linked bonds (SLBs) and transition bonds reached a cumulative volume of USD 3.7 trillion (CBI, 2023). GSS bonds have a 'use of proceeds'

clause stating that the financing will be used for dedicated investments (green, social or sustainable). Among these, green bonds constitute the largest share and are extensively studied in the field of sustainable finance. SLBs are distinct from green bonds, as the coupon is linked to the issuer achieving a predetermined sustainability performance target. Thus, SLBs promote sustainability mainstreaming by allowing companies to use capital proceeds for general corporate purposes, not restricted to green projects as with green bonds. While green bonds were used by companies to finance green projects and signal a sustainable commitment, SLBs are the first instruments incentivizing companies to achieve sustainability performance targets and linking the financial structure to the achievement. Companies are therefore held financially accountable for climate or other sustainability targets and integrate the risk of not achieving these targets by defining a financial penalty. While green bonds have a financial link through the 'greenium' of these securities at issue or on the secondary market, SLBs are unique in that they set a pre-determined price for sustainability. The majority of SLBs include GHG reduction targets, translating climate targets to financial risk and internal cost-benefit considerations for companies.

In the third essay of this thesis, co-authored with Julian Kölbel, we examine the pricing of SLBs. Our paper contributes to the sustainable finance literature, as it provides the first overview of the SLB market and empirical analysis of this novel phenomenon. We estimate the yield differential between SLBs and non-sustainable counterfactuals by matching bonds from the same issuer. Our results suggest that there was a statistically significant sustainability premium compared to conventional bonds until mid-2022, but this premium decreased over time. Furthermore, we find that a proportion of SLB issuers benefit from a 'free lunch', i.e. financial savings higher than the potential penalty. Finally, we show that the yield differential does not seem to be driven by an incentive mechanism, as there is no empirical relationship between the yield at issue and the coupon step-up.

While SLBs have the potential to be an instrument for finance to serve as a means to incentivize sustainable transformation, this requires SLBs to be structured according to an incentive mechanism with ambitious targets. However, the findings

of my third essay, especially the existence of the 'free lunch', raise questions on the incentive structure of SLBs. My results suggest that SLBs serve a signaling purpose, while also offering arbitrage opportunities for certain issuers. Policymakers and regulators have also discussed the mechanism and use of SLBs: While the European Central Bank accepted SLBs as a collateral (ECB, 2020), the UK's Financial Conduct Authority recently highlighted greenwashing concerns with respect to the ambitiousness of targets (FCA, 2023). Thus, more regulation and policymaker scrutiny on sustainability-linked instruments is expected in the future.

The three essays of this dissertation provide several discussion points on the current state of sustainable finance.

Firstly, the definition of sustainability is excessively influenced by financialization and requires greater transparency and examination. Despite policymakers' efforts to reorient capital flows towards sustainable investment and support double materiality, my findings suggest that sustainable investment funds largely base their inclusion criteria on ESG ratings, focusing on financial materiality instead of impact materiality. The current SFDR leaves fund managers too much discretion in their definition and disclosure of sustainability, which indeed reduces information asymmetry but requires higher sustainable finance literacy and scrutiny from investors. This dissertation explores sustainable finance from a primarily European perspective, analyzing regulations, such as SFDR, and focusing on the predominantly European phenomenon of SLBs. However, it is important to keep in mind that sustainability is characterized by regional and cultural differences. Recent social movements such as 'Fridays for Future' in Europe and 'Black Lives Matter' in the US have amplified these cultural variations in sustainability, placing greater pressure on stakeholders. These features are mirrored in regulatory developments and the financialization process. In Europe, policymakers and regulators promoted a shift of sustainable finance to climate finance. In the US, the social focus on diversity and inclusion contributed to the political backlash with critiques claiming that sustainable finance is a form of 'woke capitalism'. This tension underscores a more fundamental debate on the relationship between sustainability and finance.

Secondly, a critical examination of the interaction between finance and sustainability is essential to assess the role of sustainable finance. As a result of the financialization of capitalism, neo-classical economic thinking shaped profit maximization as a normative principle (Friedman, 1970; Ferraro, Pfeffer, and Sutton, 2005). This logic has outgrown the financial sector to other areas of the economy and society, including sustainability. While sustainable finance was aimed at fostering long-termism and responsible capitalism, the financial logic seems to prevail: the business and policymaker narrative is centered around treating sustainability as a commercial opportunity. The result is fund managers' myopic focus on financial materiality and the sustainability premium or 'greenium' of debt issuers. In academic research, this mindset is mirrored in the persistent assessment of the financial outperformance of green assets. The excessive prevalence of the financial logic may, however, impede the development of sustainability reforms and the achievement of sustainability goals (Wijen, 2014; Grodal and O'Mahony, 2017). While the EU sustainable finance agenda has so far limited effects on driving sustainability, it may paradoxically drive increased financialization through the promotion of sustainable financial products (Ahlström and Monciardini, 2022). Financial innovation can contribute to increasing the financial accountability of companies for their sustainability commitments. The findings of the second essay highlight the importance of climate targets for companies' sustainability perception, and the third essay discusses the incentive mechanism of SLBs as instruments holding companies accountable for these targets. The findings, however, point towards limitations in the incentive mechanism, since corporations can use SLBs for arbitrage purposes and gain financially without sustainable improvements. Thus, additional regulation and oversight of such instruments is necessary to prevent sustainability from merely fueling financial innovation. Policymakers and regulators should ensure that sustainability and finance do not inverse roles, whereby sustainability becomes a means to higher financial returns, rather than an end in itself. Sustainable finance should harness financial innovation to promote long-termism.

Chapter 2

Financialization and income inequality: The role of financial derivatives

Joint with Marc Chesney[1]

We discuss the role of financial derivatives within the financialization process and growing income inequality. We argue that financial derivatives contribute to the financialization of top income through two channels. First, within the financial sector the growth in the derivatives market is associated with the shift to fee-generating activities, higher financial market speculation, rent extraction and increased high-earners. Second, within non-financial corporations (NFCs) stock options contribute to the financialization, or 'optionalization', of executive compensation. Thus, there is a decoupling between top income compensation exposed to the growth of the derivatives market and non-financialized wages linked to the real economy. We test our hypothesis using a novel dataset of the aggregate volume of single stock options contracts traded across 14 OECD countries between 1990 and 2020. Our results suggest that single stock options have a statistically and economically significant correlation with the rise in the income share of the top 10%, top 1% and top 0.1%. The correlation is strongest for the top 0.1% income share, in line with the high representation of finance professionals and executives within this top income share.

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2.1 Introduction

In the introduction of the famous scholar book *Options, Futures and other Derivatives*, Hull (2014) highlights that derivatives play a 'key role in transferring a wide range of risks in the economy from one entity to another'. However, the use of derivatives goes beyond risk management, as these instruments are significantly used for arbitrage and speculation purposes, legitimized and defended by the argument of increased market liquidity and information efficiency (Chesney et al., 2022a). The financial derivatives market is therefore often cited as a measure of the proportions of the Keynesian idea of finance as a casino (Keynes, 1936), as derivatives have been and continue to play a significant role in speculative crises, market manipulations and frauds (Wigan, 2009). The notional volume of financial derivatives outstanding was USD 632 trillion in H2 2022 (BIS, 2023), representing more than six times world GDP. While there is a finite number of marketed assets (stocks, bonds) or 'primitives', there is a virtual infinity of 'derivative' assets generated by these primitives (Ross, 1976). This substantial growth and the use of instruments can be questioned given that the size of the financial derivatives market has outgrown any real economic requirement. The effects of financial derivatives are further amplified by the use of leverage of financial institutions and the high debt levels in the economy. In the 2022 annual report, for example, the Swiss bank Credit Suisse (2023) reported the total notional amount of derivative instruments at CHF 15 trillion, with a 1% share for hedging purposes and 99% for trading purposes. Credit Suisse's total amount of derivative instruments in 2022 was therefore more than 27 times the size of its balance sheet, and more than 18 times the size of Switzerland's GDP. Beyond the financial sector, the role of derivatives has also increased in non-financial corporations (NFCs) for financial market activities and in the form of stock options in executive compensation.

The growth of the financial derivatives market is a feature of the financialization process since the 1980s. Financialization can be referred to as interrelated processes through which finance has extended its influence beyond markets into other areas of the economy leading to the financialization of NFCs, as well as of social

and political life. While there is no universal definition of financialization (Van der Zwan, 2014), the literature commonly distinguishes between four channels: i) the development and complexification within the financial sector, ii) the financialization of NFCs, iii) of households iv) and of states. In this paper we focus on the first two channels. Within the financial sector, income-generating activities shifted away from traditional banking towards fee-generating business related to capital markets (Stockhammer, 2013), such as the trading of securities and corporate finance activities (mergers, acquisitions, and IPOs). Within NFCs, actors increasingly perceive themselves as financial institutions, manipulating their balance sheets as if they were managing a portfolio of assets and relying on the ability of trading in liquid assets (Stockhammer, 2013). The rise of these business areas was further reinforced and legitimized through the development of academic theories in the field of finance, which detached itself from the scientific discipline of economics, such as the Black-Scholes option pricing formula (Black and Scholes, 1973; Merton, 1973), or Jensen and Meckling's (1976) theory of the firm. These academic theories were seen as progress towards the mission of complete and perfect markets and therefore provided the scientific legitimization for the establishment of a financialized capitalism with a growing dominance of the financial sector[2], financial market instruments and the shareholder value principle.

In parallel to the financialization process, industrial nations experienced a significant rise in inequality over the past 50 years. Public awareness for this issue increased considerably with the publication of Piketty's (2014) *Capital in the Twenty-First Century*. A substantial body of literature on inequality emerged after the creation of the World Inequality Database, providing access to new data on income and wealth inequality, and published in the *World Inequality Report 2022* (Chancel et al., 2022). Over the past decades, one can observe that the income growth within the top 1% income share was higher than the rest of the income groups suggesting a significant upward redistribution, as shown for the US in Figure 2.1, leading to increasing income inequality across industrial nations (Figure 2.2). As a result of these two parallel developments, significant literature on the drivers of inequality and the

[2]Throughout the paper we refer to the financial sector to include companies in the traditional banking, shadow banking, securities and investment, insurance and real estate industry.

financialization-inequality nexus emerged. Kaplan and Rauh (2010), for example, show that top executives' and wall street's representation in the top end of the income distribution has significantly increased. Godechot (2016) decomposes the financial sector effect and argues that growing inequality was mainly driven by the growth of stocks traded and held in banks' balance sheets. He therefore interprets financialization as being a phenomenon of marketization, defined as the growing efforts devoted to the trade of financial instruments. Similarly, Huber, Petrova, and Stephens (2022) posit that the growing demand for financial professionals and the shareholder model of corporate governance are the two dimensions of financialization that drive up pre-tax income inequality.

The social implications of financial derivatives and their contribution to the rise in income inequality have received little attention in academic research so far. Wigan (2009) conceptually highlights the importance of derivatives in the financialization process and accords a central role in the dynamics of financialized accumulation. He argues that derivatives have instrumentalized risk as a novel form of ownership to promote financialized accumulation. The topic remains also largely unaddressed by the corporate world, despite the increasing importance of environmental, social and governance (ESG) or corporate social responsibility (CSR) considerations. In 2023, the report *Tackling inequality: An agenda for business action* by the Business Commission to Tackle Inequality (BCTI, 2023)[3] outlines that in recent decades wages of workers failed to keep pace with executive compensation. The report underlines that the average worker salary increased by 18% since 1978, while US CEO compensation increased by 1'460% over the same period. The report does not address stock options, although these have become an important component of executive compensation over the past decades. In 2009, equity-based compensation represented over 40% of executive pay in the US (Edmans, Gabaix, and Jenter, 2017). Within the financial sector, compensation levels reached unprecedented levels, as exemplified by the top twenty-five hedge fund managers earning more than all CEOs of the S&P 500 combined (Kaplan and Rauh, 2010).

[3]The BCTI is an organization convened and powered by the World Business Council for Sustainable Development (WBCSD).

The aim of our paper is to discuss and examine the role of financial derivatives within the financialization process and the link to income inequality. We argue that there are two channels within the financialization process through which financial derivatives are linked to income inequality. Firstly, within the financial sector, derivatives are a feature of the growth of financial innovation contributing to the shift to fee-generating activities, the sector's increase in rent extraction, and the resulting higher share of top income earners. Secondly, within NFCs derivatives have become an important component of executive compensation in the form of stock options and therefore contributed to the financialization, or 'optionalization', of top income compensation. Thus, through these two channels there has been an emergence of top income earners whose compensation was exposed to the exponential growth of the financial derivatives market, while non-financialized wages have had their income linked to the growth of the real economy. The decoupling of the derivatives market from the real economy could be exploited by the top income earners through the financialization of their compensation.

Our paper addresses this question empirically using a novel dataset of stock options at country level. We collect the aggregate volume of single stock options contracts traded at the stock exchange of 14 OECD countries between 1990 and 2020. While there exists a vast amount of empirical literature using financial development and stock market indicators, our paper moves beyond prior research by using the volume of single stock options as a proxy for financial market depth and financial innovation. In a first step, we compare our stock options variable to common financial market indicators used in the literature. We perform various econometric models and regressions on the top 1% pre-tax income share. In a second step, we analyze our explanatory variable across top income share measures (top 10%, 1%, 0.1%, 0.01%, and 0.001%) and test the robustness using different econometric specifications.

Our results provide two main findings. First, our results show that the volume of single stock options have a statistically and economically significant correlation to income inequality. Given that our stock options data has a significant correlation (0.46) to the IMF's Financial Development sub-index of financial market depth and thus represents an appropriate measure for financial innovation, this result suggests

that there are financial market dynamics beyond stock markets contributing to income inequality. Second, the correlation of the volume of single stock options is larger and statistically more significant for the top 0.1% income share than the top 10% or 1%. This result suggests that the top income earners are most exposed to the growth of the financial derivatives market. It is also in line with the finding of Efing et al. (2022) that less than 1% of employees are entitled to equity pay, as it is less common to grant stock options to employees below the executive level, as well as the argument of Kaplan and Rauh (2010) that wall street managers represent a higher proportion of the top income share. Thus, we argue that stock options are less relevant for income shares above the 0.1%, as stock options might be less relevant, or executives and finance professionals less represented in these income shares. Furthermore, the correlation is higher when controlling for stock market volatility, suggesting that higher stock market volatility has a positive correlation to the rise of the top income share. This can be explained by the amplifying effect of higher stock market volatility on stock option prices. Our empirical analysis confirms our hypothesis that the growth and relative size of the financial derivatives market in an economy is strongly correlated to the rising income share of high earners.

Our paper contributes to the financialization-inequality literature in two ways. First, we discuss two channels within the financialization process linking financial derivatives to income inequality. The first channel is related to the development within the financial sector through the growth of financial innovation which led to increasing fee-generating revenues and rent extraction within the economy. The second channel is related to the financialization of NFCs. The growing shareholder primacy has contributed to the inclusion of stock options in executive compensation and thus the financialization of the top income share. Second, we provide the first empirical analysis using country-level stock options data in the form of the volume of single stock options contracts traded. While the empirical literature uses a variety of stock market, bank balance sheet or lending data, as well as financial development indices, we are not aware of any empirical study analyzing the role of financial derivatives in the rise of the top income share.

The findings of our paper have important implications for the financialization and inequality debate, as well as for discussions related to ESG and sustainable finance. Policymakers and regulators should reflect on the integration of stock options in compensation given the impact on short-termism and risk taking. The general use of financial derivatives within the financial system should be assessed, as these instruments have largely outgrown their real economic and risk management purpose. Policies promoting transparency and limiting the disconnect between derivatives market and the real economy should be extended. Islamic finance can serve as an inspiration for future policymaking due to its principles on the prohibition of speculative transactions or the asset backing of financial contracts with real assets or economic activities (Kammer et al., 2015; Caporale and Helmi, 2018). In the sustainable finance space, the initiatives on climate change and social inequality are often addressed in siloes, with an implicit expectation that the latter would be tackled by policymakers instead of the private sector. However, the two topics are intertwined given the high emissions of the world's top 1% and the discussion around carbon inequality (Oxfam, 2021; Piketty and Chancel, 2015; Chancel, 2022).[4] Furthermore, at a company level, most corporations focus their attention on social initiatives related to diversity and inclusion or employee engagement. Both areas require no fundamental change to the status quo, and research highlights the positive effect on financial performance of improvements in these areas (Erhardt, Werbel, and Shrader, 2003; Campbell and Minguez-Vera, 2007). While these topics are important, the topic of executive compensation and widening income inequality should equally be part of the ESG, especially the social, evaluation of a corporation.

2.2 Literature review

This paper relates to three strands of the financialization and inequality literature.

[4] Piketty and Chancel (2015) show that income and CO2 emission inequalities within countries increased, and Chancel (2022) finds that the top 1% income share has been responsible for 23% of total greenhouse gas (GHG) emissions between 1990 and 2019.

Firstly, our paper relates to the research on the financialization process and the complexification within the financial sector by analyzing the role of financial derivatives. While there are various hypotheses on the determinants of financialization (Karwowski, Shabani, and Stockhammer, 2020) and the categories[5] of financial sector changes since the 1980s, the existing literature focuses mainly on the shift from a bank-based to a market-based financial structure as a distinctive feature of modern finance.[6] Libich and Lenten (2021) distinguish between traditional finance (retail banking, insurance, etc.) and modern finance (financial innovation and asset trading). Stockhammer (2013) emphasizes the growth of non-bank financial institutions, such as insurance firms, investment funds, money market funds, hedge funds and private equity funds as a major change within the financial sector. In addition to this important growth of the shadow banking system, which is now larger than the regular banking sector (Pozsar and Singh, 2011). Stockhammer (2013) describes the shift towards fee-generating business, rather than traditional banking which generates income based on the interest differential between deposits and loans. For example, Chesney et al. (2022b) show how banks strategically increase price complexity to mitigate competitive pressure. So far, only a few papers in the financialization literature have gone beyond the argument of the shift from bank-based to market-based economy and discussed the role of financial derivatives. Bryan and Rafferty (2006) and Wigan (2009) accord a central role to financial derivatives in defining the character and dynamics of financialized accumulation, as they have instrumentalized risk so that ownership and property take a novel form. Lindo (2018) discusses the political economy of derivatives markets and valuation models.

Secondly, our paper adds to the research on the financialization process within NFCs and the importance of stock options within executive compensation. The financialization of NFCs is characterized by the increasing participation of NFCs in capital markets with the development of new corporate governance models based on maximizing shareholder value and financial profitability in close association with

[5] Lagoarde-Segot (2017) breaks down financial sector changes into six categories: financial integration, transaction velocity, speculative trading, securitization / shadow banking, complex information networks and geopolitical finance.

[6] This shift is described in the literature on financialization (Aglietta and Breton, 2001; Lapavitsas, 2013) and of varieties of capitalism (Hall and Soskice, 2001).

the expansion of capital markets and institutional investors (Aglietta, 2020; Plihon, 2004; Stockhammer, 2004; Dallery, 2009; Lin and Tomaskovic-Devey, 2013). There is extensive literature on how the changes of financial structure contribute to the financialization of NFCs and changes to executive compensation. Schaberg (1999), for example, argues that the shift from bank-based to market-based financial institutions dampened investment activity by NFCs. The financialization of NFCs is described by Lazonick and O'Sullivan (2000) who explain how large corporations have shifted from a 'retain and reinvest' to a 'downsize and distribute' model, inducing a reallocation of resources from the productive to the financial sector. Stockhammer (2004), Jayadev and Epstein (2007), and Dünhaupt (2012) analyze how the rentier income share (interest, dividends and capital gains received by financial asset owners) has considerably increased in OECD economies during the past four decades. In order to reduce the agency problem and align the incentives of shareholders and executives, the compensation of executives has become increasingly equity-based over the past decades, combining options and stock grants (Murphy, 2013; Edmans, Gabaix, and Jenter, 2017). Recent research however points towards limitations of this approach as firm-level pay disparity leads to lower firm performance (Rouen, 2017).

Finally, our paper is associated with the empirical literature on the financialization-inequality nexus. Many studies focus on how the rise of different dimensions of the financial sector affects income inequality, with rather mixed evidence.[7] Furthermore, based on the Global Financial Development Database, an extensive dataset

[7] Greenwood and Jovanovic (1990) and Claessens and Perotti (2007) suggest that the benefits of more efficient financial markets will only be harnessed by wealthy individuals and established firms, whilst Beck, Demirgüç-Kunt, and Levine (2007) carry out a study on the impact of financial development on inequality for 72 countries spanning the period 1960-2005 and find that it reduces income inequality. Van Arnum and Naples (2013) study the relationship between financial sector growth and income inequality, and suggested that financialization has adversely affected employment creation and minimum wage and exacerbated income inequality as well. Delis, Hasan, and Kazakis (2014) find that financial liberalization has a negative effect on income (which turns insignificant when low-income countries are considered). Furthermore, Jaumotte, Lall, and Papageorgiou (2013) find that financial globalization might explain income dispersion whereas trade globalization reduces income inequality. Lin (2016) suggests that credit expansion adversely affects long-term investment activity and hence employment through the indirect channel of accumulation of corporate debt. Tomaskovic-Devey and Lin (2011) examine the institutional and income dynamics associated with financialization and offer a sociological explanation of the large shifts of income into the finance sector.

of financial system characteristics for 205 economies from 1960 to 2010, introduced by Cihak et al. (2012), there have been various empirical studies analyzing different sub-indices or proxies for financial market depth and their impact on inequality (Kus, 2013; Godechot, 2016; Jauch and Watzka, 2016; Makhlouf, Kellard, and Vinogradow, 2020; Cihak and Sahay, 2020; Alexiou, Trachanas, and Vogiazas, 2021). Godechot (2016) decomposes this financial sector effect and finds that the rise in inequality was mainly driven by the increase in the volume of stocks traded in national stock exchanges and by the volume of shares held as assets in banks' balance sheets, while the financialization of NFCs and of households does not play a substantial role. He therefore interprets financialization as being mainly a phenomenon of marketization, redefined as the growing amount of social energy devoted to the trade of financial instruments on financial markets. This growth is reflected in the increased demand for finance professionals, which translates to the higher earnings premium of workers in finance shown by Philippon and Reshef (2012). Additionally, Kneer (2013) analyzes the effects of the absorption of talent into finance and argues that policies fostering the development of the securities markets contribute to the brain-drain effect in non-financial sectors. Finally, Huber, Petrova, and Stephens (2022) summarize the two dimensions of financialization that drive up pre-tax income inequality as the increased demand for financial professionals and the shareholder primacy within NFCs, but argue that especially the latter benefits only the very top income earners.

The existing research combines econometric analysis on different channels of financialization and focuses on the volume of stocks traded as a proxy for financial markets depth. The empirical literature on the financialization-inequality nexus, however, lacks an analysis of the effects of financial derivatives markets on inequality. We aim to address this gap by diving deeper into the specific role of financial derivatives, which is an essential dimension of financial market depth.

2.3 The rise of derivatives and the financialization of top income

2.3.1 The rise of derivatives

Derivatives have a 4000-year history (Swan, 2000), which has been regularly punctuated by speculative excess, such as the seventeenth-century Dutch tulip mania or the 2008 'credit crunch', testifying to the destabilizing nature of derivative markets (Wigan, 2009). The history prior to the 20th century has remained widely unexplored given few historical records of derivative dealing and the absence of paper trail, given that these transactions were conducted through private agreements in the over-the-counter market (Weber, 2008). The late 1980s, however, marked a new era of large-scale derivatives markets with a rapid growth in volume and types of derivatives traded (Lindo, 2018). Financial market activities overall experienced significant growth, as reflected by the stock market turnover rise of 20% in 1975 to 215% in 2007 (French, 2008).[8] Among the drivers for the growth in trading were the introduction of negotiated brokerage commissions in 1975, the development of electronic trading networks, the decimalization of stock prices in 2000 and 2001, and the SEC's implementation of rules designed to increase market transparency and liquidity (French, 2008). The new era in the derivatives market was fueled by these developments, as well as the emergence of the topic of risk management. Mishkin (2014) argues that an increase in financial market volatility since the 1970s created a demand for hedging instruments used by financial institutions to manage risk. Due to the greater demand for risk reduction, the process of financial innovation produced new financial instruments to help financial actors manage risk better (Mishkin, 2014).

[8]The annual stock market turnover measured by French (2008) is the sum of 12 monthly estimates, which consist of the ratio of the total volume of shares (shares traded times the price) divided by the total market capitalization (both at the beginning of the month).

Academic theory contributed significantly to the topic of risk management and the growth of derivatives market, as the growing interest and demand for risk management required the formalization of these practices. While economic theory went through an intensive mathematization process after the Second World War (Debreu, 1991), the mathematization of the subdiscipline of finance resulted in the detachment from the economics discipline. Economic theories based on the principles of supply, demand and general equilibrium alone could no longer provide answers to the challenges faced by financial market participants, for example in asset pricing or portfolio theory. New financial market theories therefore emerged, such as the modern porfolio theory (Markowitz, 1952), the efficient market hypothesis (Fama, 1969), and the Black-Scholes option pricing formula (Black and Scholes, 1973; Merton, 1973). Based on these theories, a vast literature with new or extended models on risk management, asset pricing and valuation emerged. On derivatives pricing, successive research developed models which relaxed the assumptions or limitations of the Black-Scholes formula related to risk-free rates, transactions costs, dividends or non-constant volatility (Jankova, 2018). Such models emerged logically to tackle the large-scale trading obstacles of modern derivatives markets (Lindo, 2018). Wigan (2009) explains that the academic breakthrough meant that finance had discovered a valuation mechanism for assets with such precision that it could, in theory, fulfil its role in pricing and allocating capital with unprecedented efficiency and efficacy. These complex mathematical pricing models of financial instruments have since been criticized for their development by 'rocket scientists' (Stix, 1998).

While financial innovation has been justified as risk management and optimal capital allocation tools, it has transcended this role. Financial innovation has led to the creation of a large number of derivative instruments which appear to mirror extant volatility but have in reality rendered financial market volatility a traded asset (Wigan, 2009). Bryan and Rafferty (2006) argue that derivatives have a binding role as options and futures establish pricing relationships to 'bind' the future to the present, and a blending role as they establish pricing relationships between different forms of assets and allow for asset substitution. These two roles have contributed to derivatives having a central role in the global financial system since the 1980s as they

are not just seen as risk management tools, but as tools for the ongoing calculation of asset values by providing continuity and predictability in rates of conversion between different assets and serving as a source of information about the changing relative value of financial assets (Bryan and Rafferty, 2006). Chesney et al. (2022a) therefore argue that financial derivatives have outgrown their risk management and hedging purpose, legitimized by the argument of increased information efficiency and market liquidity, while they are increasingly used for arbitrage, speculation and market manipulation purposes.

2.3.2 The financialization of top income

The era of financialization has been characterized by the creation of what Foster and Holleman (2010) refer to as a 'financial power elite', deriving their wealth from financial profits, real estate and executive compensation. The rise in the imbalance in factor distribution of income between capital and labor since the 1980s has created a disjuncture between economic performance and its financial rewards, which have disproportionally accrued to high earners (Atkinson, 2009). Figure 2.1 shows how the income growth of the top 1% was significantly higher than for the other income groups, suggesting a redistribution from the bottom to high earners. There is a vast amount of literature proposing explanations for the increased skewness of the top income share distribution.[9] Kaplan and Rauh (2010) provide a synthesis of the different theories and suggest that their findings on top remunerations can be explained with the interaction of scale and technological change. The authors argue that technological change, especially in information and communication, might have benefited firms, in line with Gabaix and Landier (2008) findings, as well as skilled individuals, in line with Rosen's (1981) theory of economics of superstars. In the following we focus on the arguments related to the financialization process. According to Flaherty (2015) the connection between financialization and top income movements may be established through two channels: an abstract channel

[9]The explanations include globalization or trade theories (Hecksher, 1931; Ohlin, 1933; Stolper and Samuelson, 1941), the economics of superstars (Rosen, 1981), skill-biased technological change (Katz and Murphy, 1992), social norms (Piketty and Saez, 2003), managerial power (Bebchuk and Fried, 2004), and greater scale (Gabaix and Landier, 2008).

identified in the literature on the relative bargaining power of capital and labor, and a more direct way based on Thompson's (2013) disconnected capitalism theory. This theory suggests that top earners in financial sector related activities benefitted disproportionally as their pay was delinked from performance-related indicators and market-based compensation packages linked to stock options were established. The disjuncture's pace has been strongest in the financial sector, where top compensation surged more relative to other sectors since the 1980s (Kaplan and Rauh, 2010; Kus, 2013), suggesting successful rent-extraction from the non-financial sector (Tomaskovic-Devey and Lin, 2011). Between 1980 and 2008, the finance sector's[10] profits as a share of total US profits almost tripled from a postwar average of 15% to a peak of 45% (Tomaskovic-Devey and Lin, 2011). Godechot et al. (2022) argue that there is an asymmetry in the effect of the business cycle on earnings in finance, as rising income in the financial sector contributes to higher inequality in upswings, while inequality remains resilient in downswings. In addition to this income transfer into the finance sector, the financialization process has also restructured income dynamics within NFCs (Lin and Tomaskovic-Devey, 2013).

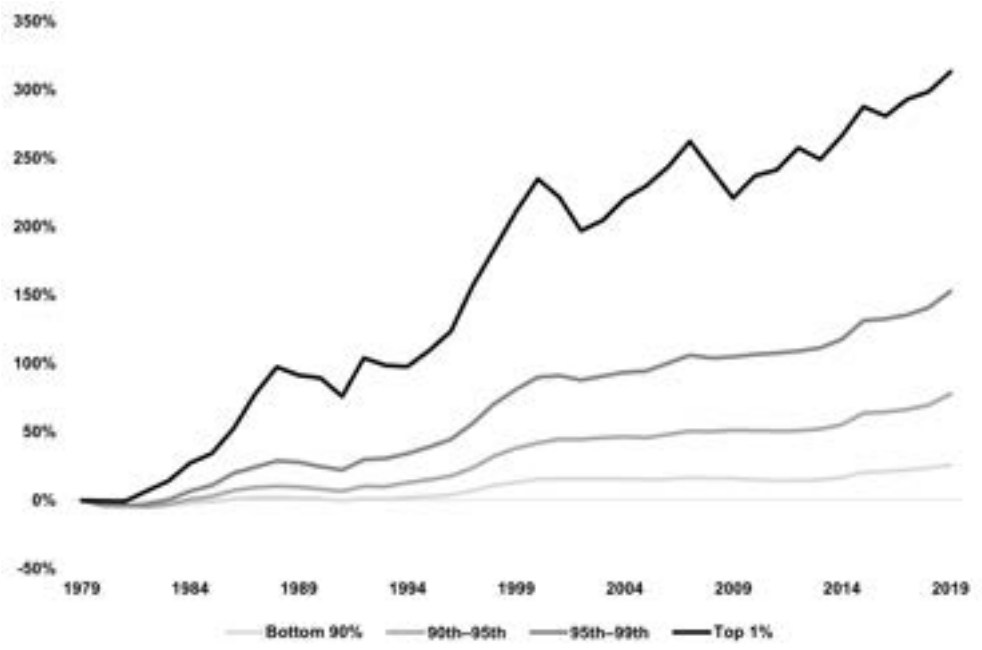
Our paper extends Flaherty's (2015) second channel based on Thompson's (2013) disconnected capitalism thesis and analyzes how the growth in financial innovation in the form of financial derivatives plays a significant role in the development of top income compensation. We argue that the disconnect between top income earners within both, the financial sector and NFCs, and the lower income groups is based on whether the activity or the compensation is exposed to the financial derivatives market. As Wigan (2009) argues, derivatives instrumentalize risk as a novel form of ownership to promote financialized accumulation, which does not represent a linear relationship to underlying processes of real wealth creation. In an equity derivatives contract, or a stock option, the owner has no claim on the company, but owns rather abstract features of a company's performance associated to the company's stock price volatility rather than its actual growth.[11] This feature is

[10] Tomaskovic-Devey and Lin (2011) include within the finance sector companies in the banking, securities and investment, insurance and real estate industry.

[11] Since the value of an option is a function of volatility, an option with a high strike price (above the spot price) has a higher value when the price of the underlying has a higher volatility.

fundamental to the asymmetry of profit taking of agents exposed to derivatives, as derivatives allow to profit despite of and based on increased financial market uncertainty. Pistor (2019) highlights how legal frameworks make derivatives more attractive for investors and capital holders. While Godechot et al. (2022) argue that the financial sector benefits from an asymmetric reward profile, which leads to rising inequality in upswings but not to inequality declines in downswings, we claim that this feature is not only inherent to the financial sector, but also to executives in NFCs. The decisive component for this feature is the exposure to the growth of the financial derivatives market.

FIGURE 2.1:
Cumulative percentage change in US real annual income by income group, 1979-2019



This figure shows the real income evolution of the bottom 90%, the 90-95th decile, the 95-99th decile, as well as the top 1% over the period 1979 until 2019. Source: Economic Policy Institute (2020) based of Kopczuk, Saez, and Song (2010) and Social Security Administration wage statistics.

Within the financial sector, the jobs exposed to the large-scale financial derivatives market increased exponentially since the late 1980s. The banking sector shifted its income-generating activities away from traditional banking towards fee-generating

business related to capital markets (Stockhammer, 2013). The main activities include asset and wealth management for private and institutional investors, financial markets trading and market-making of financial securities (stocks, bonds and derivatives) of investment banks, and corporate finance activities related to mergers, acquisitions and IPOs of corporations. The first two activities are most exposed to the growth of financial derivatives with the related fees mainly split into investment banks' 'transaction fees' for investors to trade and 'money manager fees' for mutual funds or hedge funds who manage assets of private and institutional investors.[12] French (2008) analyzes these fees during the period of 1980 to 2006 and estimates that investors spent on average 0.67% of the aggregate value of the securities market each year as cost of active investing. With the improvements in information technology and the increase in value of the securities markets, investment banks and asset managers grew to exploit these larger asset pools. The demand for finance professionals therefore increased significantly (Philippon and Reshef, 2012; Kneer, 2013), resulting in a rise in the number of managing directors at investment banking firms and a larger representation within the top 0.01% (Kaplan and Rauh, 2010). Additionally, Kaplan and Rauh (2010) show that in 2004 nine times as many wall street investors earned above USD 100 million as compared to US public companies, and that the top twenty-five hedge fund managers combined appeared to earn more than all CEOs of the S&P 500 combined. More specifically, on 'money manager fees' of hedge funds, the combination of fixed annual fee and a variable share of profits (typically 20%) implies that managers' compensation is strongly related to positive performance, but unrelated to poor performance. The compensation profile is therefore asymmetric, and the profit share acts like a call option (Kaplan and Rauh, 2010). Thus, these developments support the argument of Godechot et al. (2022) on the asymmetric reward profile and its link to income inequality.

Within NFCs, a driver of the financialization of income is the shareholder primacy

[12] French (2008) distinguishes between four categories of fees: the fees investors pay for mutual funds; the investment management costs of institutional investors; the fees investors pay for hedge funds; and the costs all investors pay to trade. For the purpose of our paper, we group these four categories into two.

and its implications for executive compensation. Jensen and Meckling (1976) provided the academic foundation legitimizing this process by arguing that agency problems can be alleviated through executive contracts aligning managers' interests with those of shareholders. A large part of the resulting corporate finance and managerial compensation literature addresses CEO incentives to increase share price and take equity risk. Edmans, Gabaix, and Jenter (2017) provide an extensive survey on the literature and empirical evidence of executive compensation. Gabaix and Landier (2008) show that the sixfold increase of US CEO pay between 1980 and 2003 can be fully attributed to the sixfold increase in market capitalization of large companies during that period. Frydman and Saks (2010) analyze the long-run trends in executive compensation of large firms from 1936 to 2005 and show that compensation was flat from the late 1940s to the 1970s, revealing a weak relationship between pay and aggregate firm growth. In line with Gabaix and Landier (2008), the authors show that this correlation was much stronger since the 1980s. Performance-sensitive pay for executives has surged since 1980, with most of this surge being in the form of stock options (Tomaskovic-Devey and Lin, 2011; Edmans, Gabaix, and Jenter, 2017), with some differences across regions.[13] In the 1990s, stock options were the largest component of executive compensation accounting for approximately 50% of the total compensation of S&P 500 CEOs by the end of the decade (Shue and Townsend, 2017). The practice of granting shares and stock options to employees below the executive level is less common and less than 1% of employees are entitled to equity pay (Efing et al., 2022). Following changes in the accounting treatment of options in 2005, the use of options declined.[14] Bettis et al. (2018) find that many firms have substituted option grants through performance-vesting stock grants, which have option-like payoffs (Shue and Townsend, 2017). However, stock options remain a major component of CEO pay, accounting for over 20% of

[13]There is inconclusive evidence on equity-based pay for executives in Europe. Fernandes et al. (2012) show that at the executive level equity-based pay in Europe is low compared to that in the United States. Jürgens, Naumann, and Rupp (2000), however, claim that even in countries where stock options are not very widely spread, such as Germany, stock options are increasingly offered to top management in large companies, especially those oriented towards the shareholder value principle.

[14]Until 2004, options benefited from favorable accounting treatment for US firms while they were replaced by performance-based equity grants as the most popular form of equity compensation after 2004.

total pay (Murphy, 2013; Edmans, Gabaix, and Jenter, 2017). The complexity of stock options creates considerable scope for rent extraction given the difficulty of determining their ex-ante values using accounting metrics, reducing transparency to the board and shareholders of companies about how much value is transferred to executives (Walker, 2016). Directors, shareholders and even executives systematically underestimate the cost of stock option compensation (Murphy, 2002; Hall and Murphy, 2003). In addition to this convexity effect, Ross (2004) shows that options can have a countervailing 'magnification effect' driven by the fact that options increase the sensitivity of an executive's wealth to the underlying stock price. Lazonick and O'Sullivan (2000) summarize the financialization process of NCFs by explaining that corporations have shifted from a 'retain and reinvest' to a 'downsize and distribute' model, inducing a reallocation of resources from the productive to the financial sector. Stock options incentivize the management of companies to such reallocation of resources in the form of share buybacks or higher dividend payments, at the expense of labour and reinvestment, in order to increase the stock price and the likelihood of the stock options being in-the-money.

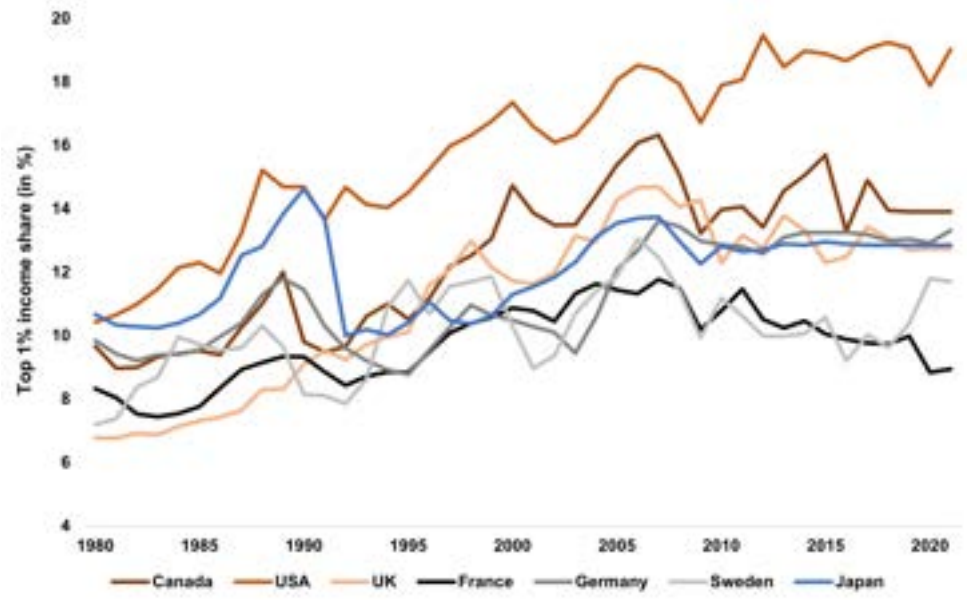
In summary, we claim that the rise of financial innovation and financial derivatives contributed to the financialization of top income and asymmetric compensation profiles. In the financial sector, jobs with wages linked to the derivatives market through the revenue generating activity increased in investment banking and asset management, while in NFCs executive compensation was financialized, or 'optionalized', through the inclusions of stock options. While there used to be a symmetry in the effect of crises on income across the income distribution, we argue that stock options contribute to the asymmetric effect of crises on inequality described by Godechot et al. (2022). Due to the exponential growth of the financial derivatives market, and its decoupling from the real economy, the income share of these jobs increased more strongly compared to jobs with wages linked to economic growth. We test this hypothesis empirically in the next section.

2.4 Data & empirical analysis

2.4.1 Data

Our dataset is based on macro-level country variables covering 14 OECD countries during the period of 1990-2020.[15] Table A.1 provides an overview of all variables used and the respective data sources.

FIGURE 2.2:
Top 1% income share across countries, 1980-2021



This figure shows the evolution of the top 1% income share between 1980 and 2021 across a selection of Anglo-Saxon economies (Canada, USA and UK), European economies (France, Germany and Sweden), and for Japan.

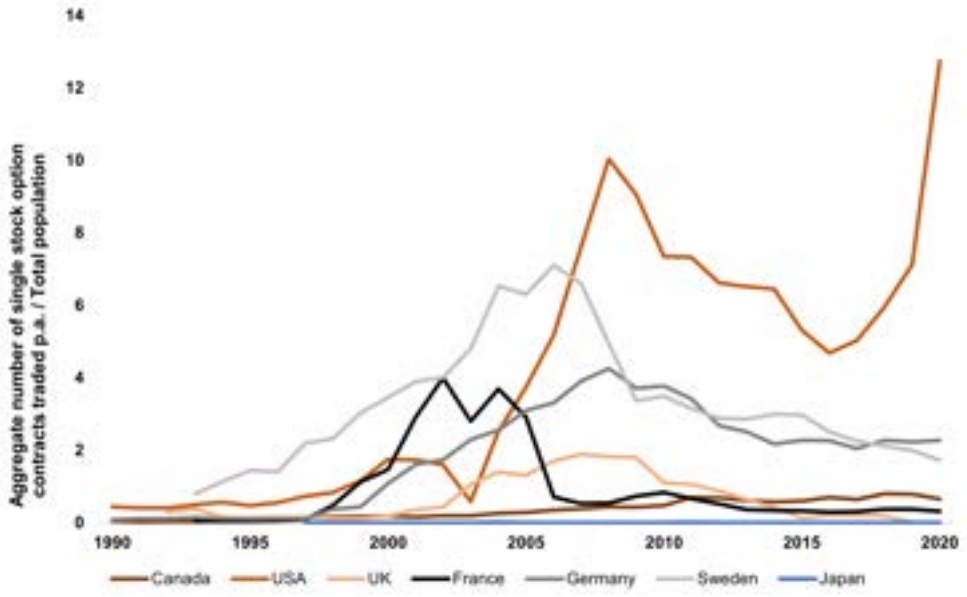
The dependent variable of our empirical analysis is income inequality. We focus on determinants of income inequality, as opposed to wealth inequality, given higher data availability and research showing that the income inequality is a key driver of wealth inequality.[16] Furthermore, the focus on income inequality also reduces

[15] The countries in our dataset are Australia, Austria, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, UK and USA. Note that the data for the annual volume of single stock options contracts traded is not consistently available for the full time period (1990-2020) across all countries.

[16] Lieberknecht and Vermeulen (2018) examine the joint evolution of income and wealth inequality and find that income inequality emerges as the key driver of wealth inequality in both short- and long-run. As the authors highlight, wealth inequality seems to be somewhat sticky, but depends on savings and tax rates in the long run.

endogeneity problems associated with differences in savings and tax rates across countries. We use the pre-tax income share of the top 10%, 1%, 0.1%, 0.01% and 0.001%, available on the World Inequality Database. Figure 2.2 shows the historical evolution of the top 1% income share across a set of countries in our sample. We can observe a consistent rise in income share of the top 1% across all countries, doubling in most cases during the period of 1980 to 2020.

FIGURE 2.3:
Evolution of the aggregate volume of single stock options contracts traded, 1990-2020



This figure represents the evolution of the ratio of the number of single stock option contracts traded per year divided by the respective total population between 1980 and 2020. The ratio is shown for a selection of Anglo-Saxon economies (Canada, USA and UK), European economies (France, Germany and Sweden), and for Japan.

The aim of our paper is to analyze the link between financial derivates and income inequality. Cihak et al. (2012) introduced the Global Financial Development Database (GFDD), which includes measures of financial development for 205 economies from 1960 to 2021. Based on these measures, the IMF developed a set of financial development indices and as sub-indices on the depth, access and efficiency of financial institutions and markets (Figure A.1). Our paper extends the IMF's financial development indices, especially the sub-index of financial market depth and common stock market indicators (stock market capitalization, stock market turnover, stocks traded and stock market return) by using a proxy for financial

market depth and financial innovation. We collect the aggregate volume of single stock options contracts traded at the stock exchange of 14 OECD countries between 1990 and 2020. This data has been collected and merged from multiple sources, including the World Federation of Exchanges, various national stock exchanges, as well as the data provider Euromoney Tradedata. Figure 2.3 shows the evolution of the aggregate volume of single stock option contracts traded as a ratio of total population across countries. Table A.2 shows the correlation between our stock options variable and the IMF's indices. The correlation is the highest (0.46) between stock options and the financial market depth sub-index, which suggests that our variable is a relevant indicator financial market innovation.

2.4.2 Empirical analysis

To address our research question and understand the link between financial derivatives and income inequality, we perform several econometric analyses.

In a first step, we compare different financialization measures with our financial derivatives proxy of single stock options using variations of OLS panel regressions with country and time fixed effects, and panel robust standard errors to account for time series autocorrelation (Beck and Katz, 1995). The empirical model takes the following form:

$$II_{i,t} = \beta_0 + \beta_1 \cdot F_{i,t} + \sum_k \beta_k \cdot x_{ki,t} + g_i + p_t + e_{i,t} \tag{2.1}$$

The dependent variable $II_{i,t}$ is the within-country income inequality represented by the pre-tax income share (top 10%, 1%, 0.1%, 0.01%, 0.001%). The main explanatory variable $F_{i,t}$ represents the financialization variable which differs across models, as we compare single stock options with indicators used in the literature (financial market depth, stocks traded, stock market capitalization, and stock returns). As control variables, we use indicators for which the financialization-inequality literature underlines their potential contribution, such as GDP per capita, unionization

rate, and import rate (Kus, 2013; Dünhaupt, 2012). g_i and p_t are the time-invariant country fixed effects and state-invariant time effect, respectively. The β_i for the k independent variables $x_{ki,t}$ therefore capture the effects of specific within-country variations in time in each country. Thus, our model measures the correlation of within-country financialization variation and within-country income inequality variation.

A key empirical limitation of fixed effects models outlined is that these regressions eliminate all time-invariant factors through the demeaning process. Bell and Jones (2015) therefore propose a 'hybrid' model between fixed effects and random effects models, thus combining random intercepts and slopes. The advantage of this approach is that it leverages the benefits of random effects models in that it treats each time-invariant factor as a separate intercept within the fixed effects regression and adds a dummy variable for each. Thus, the hybrid model allows to capture within-effects (i.e. variation within countries over time), as well as between-effects (i.e. variation across countries). In the context of our paper, this approach allows for different size effects of the volume of single stock options over time across our sample of countries, as the literature on financialization highlights divergences across regions. The hybrid model takes the following form, where β_1 captures the fixed effects estimators for the variation within countries over time (within-effect) and β_2 the variation across countries (between-effect):

$$II_{i,t} = \beta_0 + \beta_1 \cdot (F_{i,t} - \overline{F_i}) + \beta_2 \cdot \overline{F_i} + \sum_k \beta_k \cdot x_{ki,t} + g_i + p_t + e_{i,t} \tag{2.2}$$

In a final stage, we add further econometric features to test the correlation of the volume of single stock options to income inequality in the short and long term. The above fixed effects model is not robust to endogeneity problems, such as omitted variable bias, reverse causality or serial correlation. In order to address these endogeneity issues, we therefore also estimate error-correction models (ECM), which are applied in the literature (Lin and Tomaskovic-Devey, 2013; Godechot, 2016; Lieberknecht and Vermeulen, 2018). It is often referred to as a panel co-integration approach, which is suitable for the analysis of country panel data with a similar

number of countries N and time periods T. Equation (2.1) can be reparametrized to obtain the error-correction equation:

$$\Delta II_{i,t} = \Phi_{\mathrm{i}}[II_{i,t\text{-}1} - \theta_{\mathrm{i}} F_{i,t\text{-}1} - \sum\nolimits_{\mathrm{k}} \theta_{\mathrm{k}} x_{ki,t\text{-}1}] + \beta_1 \cdot F_i + \sum_k \beta_k \cdot x_{ki,t} + g_i + p_t + e_{i,t} \quad (2.3)$$

The dependent variable $\Delta II_{i,t}$ in this setting thus represents the change in income inequality. The parameter Φ_{i} is the error-correcting speed of adjustment. The vector θ_{k} captures the long-run relationship between the variables, while β_k captures the short-run relationship. In this third model, we are primarily interested in the long-run relationship between financialization and income inequality, thus the vector of coefficients θ_{k} will be of particular importance. If $\Phi_{\mathrm{i}} = 0$, there would, however, be no evidence for a long-run relationship. The decisive factor of the error-correction model is that it accounts for reverse causality, as an independent variable $x_{i,t\text{-}1}$ will not appear significantly tied to $II_{i,t}$ if it depends on $II_{i,t\text{-}1}$ or a previous lag, as well as for serial correlation, if $II_{i,t}$ is also correlated with its lag $II_{i,t\text{-}1}$.

2.5 Results

2.5.1 Comparing different financialization measures

In a first step we compare the financialization measures of financial development, financial market depth, stock market capitalization, stocks traded and the aggregate volume of single stock options contracts traded across fixed effects and hybrid regressions on the top 1% income share. For our regressions, we scale the stock options measure creating a ratio of volume of single stock options contracts traded over the size of a country's population. The results of the different regression specifications are summarized in Table 2.1.

The IMF indices for financial development and financial market depth are statistically significant across the hybrid model, but not in the time and country fixed effects model. Similarly, the variables related to the stock market capitalization and

TABLE 2.1:
Regression results comparing financialization measures

	Top 1% income share							
	Level-Level Model				**Log-Log Model**			
Explanatory variables	Fixed effects		Hybrid (random slopes)		Fixed effects		Hybrid (random slopes)	
Financial development	**0.02**	**-0.00**	**0.07*** **	**0.05*** **	**0.09**	**0.03**	**0.43*** **	**0.33*** **
N	*496*	*459*	*496*	*459*	*496*	*459*	*496*	*459*
R-squared	*0.4442*	*0.4872*	-	-	*0.4528*	*0.4875*	-	-
Financial market depth	**0.01**	**0.01**	**0.04*** **	**0.03*** **	**0.01**	**0.03**	**0.13*** **	**0.12*** **
N	*496*	*459*	*496*	*459*	*496*	*459*	*496*	*459*
R-squared	*0.4428*	*0.4902*	-	-	*0.4497*	*0.4899*	-	-
Stock market capitalization	**-0.00**	**0.00**	**0.02*** **	**0.01*** **	**-0.01**	**-0.00**	**0.04*** **	**0.02**
N	*459*	*430*	*459*	*430*	*459*	*430*	*459*	*430*
R-squared	*0.4270*	*0.4613*	-	-	*0.4402*	*0.4685*	-	-
Stocks traded	**0.00**	**0.00**	**0.02*** **	**0.01*** **	**0.01**	**0.01**	**0.08*** **	**0.06*** **
N	*449*	*420*	*449*	*420*	*449*	*420*	*449*	*420*
R-squared	*0.4418*	*0.4769*	-	-	*0.4451*	*0.4787*	-	-
Stock options	**0.17** **	**0.16** **	**1.68*** **	**0.52*** **	**0.03** **	**0.03** **	**0.06*** **	**0.04*** **
N	*395*	*365*	*395*	*365*	*384*	*354*	*384*	*354*
R-squared	*0.5351*	*0.5721*	-	-	*0.5476*	*0.5676*	-	-
Control variables	N	Y	N	Y	N	Y	N	Y

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the fixed effects and hybrid model regression results of the top 1% income share on different financialization measures. The dependent variable across all regressions is the top 1% income share. Each data point represents a separate regression. The first and third column show the results of simple level-level fixed effects and hybrid regression models, respectively, without any control variable. The second and fourth column show level-level fixed effects and hybrid regression models, respectively, when controlling for GDP per capita, import share and trade unions. The columns five to eight follow the same approach but with log-log regression models.

the stocks traded are statistically significant across the hybrid model, but not the fixed effects model. The stock options variable, however, is statistically significant across the fixed effects and random slope hybrid model. These findings are robust when adding GDP-per-capita, import share and trade union as control variables. The fixed effects model with the highest R-squared is the model with the stock options variable (0.6091).

In order to compare the economic significance of the different financialization variables and avoid the disadvantages of different scaling across variables, we perform the fixed effects and hybrid models using log-log regressions. In the fixed effects regressions the variables with the highest coefficients are financial development, financial market depth and stock options. The coefficient for stock options is between 0.03 and 0.06 in the log-log models, representing an increase of 0.03%-0.06% of the top 1% income share as the volume of single stock options contracts traded increases by 1%. While this coefficient might appear small, it needs to be put into perspective with the average total increase in stock options of 1376% over the period 1990-2020.

TABLE 2.2:
Comparing different top income share measures

Regression type	*Level-Level*					*Log-Log*				
Top income share	*10%*	*1%*	*0.1%*	*0.01%*	*0.001%*	*10%*	*1%*	*0.1%*	*0.01%*	*0.001%*
Stock options	0.29**	0.16**	0.09**	0.04*	0.02	0.01*	0.03**	0.03**	0.01	-0.03
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	365	365	365	365	365	354	354	354	354	354
R-squared	0.5753	0.5721	0.5266	0.4374	0.3803	0.6014	0.5676	0.4974	0.3867	0.2997

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the fixed effects regression results of the different top income share measures on single stock options. The dependent variable across all regressions is the volume of single stock option contracts traded and the control variables are GDP per capita, the import share and trade union density. Each column represents a separate regression with a different top income share measure.

2.5.2 Stock options and different measures of income inequality

In a second step, we analyze the link between the aggregate volume of single stock options contracts traded and different measures of income inequality when controlling for further financial market factors. We perform a series of fixed effects regressions as well as hybrid and error-correction models on different measures of income inequality.

Table 2.2 shows that the correlation between single stock options and the top 0.1% income share is the highest. The table provides an overview of time and country fixed effects regressions for different income share measures (top 10%, 1%, 0.1%, 0.01% 0.001%) on the stock options variable when controlling for GDP per capita, the import share and the trade union density. The regression models are performed in level-level form, as well as in log-log form. Table 2.2 suggests that single stock options have a statistically significant correlation with the top 10%, top 1%, top 0.1% and top 0.01% income share, but not with the top 0.001%. In terms of economic significance, the log-log specification shows that the correlation is the highest for the top 0.1% income share at 0.03. For the top 0.01% and top 0.001% the coefficients are smaller (even negative for the top 0.001%) and not statistically significant in the log-log model, suggesting that there are different income dynamics for these

income shares where stock options might be less relevant, or the representation of main street and wall street executives smaller.

Table 2.3 compares the time and country fixed effects regression results on the different income share variables while controlling for different stock market dimensions. The results confirm the statistical and economical robustness of the stock options coefficient. The addition of the different stock market variables does not reduce the statistical significance across any model, and the coefficient size remains largely the same. On the contrary, the inclusion of the stock market return variable increases the statistical significance of the stock options variable, and it represents the model specification with the highest R-squared for all income share variables (except the top 10%). Based on this result, Table 2.4 provides further regression models with lagged stock options and stock market return variables, as well as an interaction term between the two variables. The stock options coefficient remains robust when adding the interaction term (Model VI). The interaction term is also statistically significant across all model specifications suggesting that the correlation between the income share and stock options is higher as the annual stock market return increases. Model VI suggests that the correlation is similar when using lagged variables, as the statistical and economical significance remains the same. In Model VII the stock options coefficient is also statistically significant at the 10% level for the top 0.001% income share. The combination of stock options and its lagged variables in Model VIII reduces the coefficient size and statistical significance of the stock options variable. While it remains statistically significant at the 10% level for the top 10% and top 0.1% income share, it is statistically insignificant for the other income shares. Furthermore, the lagged stock options coefficient is not statistically significant across all income share measures. In terms of economic significance, the coefficient size across the models in Tables 2.2-2.4 remain robust across all income share measures.

Important features of the financialization process affecting the financial derivatives market are the increase in leverage and stock market volatility. In line with the four different domains of financialization, there are four different types of debt (financial sector, non-financial sector, household and government debt). Models IX and X

TABLE 2.3:
Regression results I

Income share	Top 10%				Top 1%				Top 0.1%				Top 0.01%				Top 0.001%			
Model	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Stock options	0.29**	0.26**	0.27**	0.28**	0.16*	0.16**	0.16**	0.17**	0.09**	0.09**	0.09**	0.09***	0.03	0.04*	0.04	0.04**	0.02	0.02	0.02	0.02
Fin. market depth	0.20				-0.61				-0.60				-0.52				-0.23			
Stocks traded		0.00				-0.00				-0.00				-0.00				0.00		
Stock market cap.			-0.00				-0.00				-0.00				-0.00				-0.00	
Stock return				0.01				0.00				0.00				0.00				0.00
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	365	330	340	355	365	330	340	355	365	330	340	355	365	330	340	355	365	330	340	355
R-squared	0.5754	0.6011	0.5888	0.5870	0.5733	0.5739	0.5643	0.5787	0.5296	0.5272	0.5197	0.5337	0.4444	0.4356	0.4307	0.4466	0.3872	0.3706	0.3614	0.3965

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the fixed effects regression results of the different top income share measures on single stock options. The main explanatory variable across all regressions is the volume of single stock option contracts traded. The financialization control variable differs acoss models between financial market depth (Model I), stocks traded (Model II), stock marekt capitalization (Model III) and annual stock returns (Model IV). Across all four models we additionally control for GDP per capita, import share and trade unions. Each column represents a separate regression with a different top income share measure.

in Table 2.5 show the time and country fixed effects regression across top income shares when also controlling for private sector debt and the interaction term. This variable represents the amount of private international debt securities (amounts outstanding) of all issuers (excluding the government) as a share of GDP, and includes bonds and money market notes issued from financial sector companies and NFCs. The coefficient for private sector debt is not statistically and economically significant. When including this control variable, the coefficient for stock options is no longer statistically significant either.

Given the asymmetric risk-reward profile of derivatives and the impact of stock market volatility on stock option prices, we perform the fixed effects regressions with stock market volatility as a control variable in the Models XI and XII in Table 2.5. Given the limited availability of national stock market volatility, we use the annual volatility of the S&P 500 as the control variable, as well as the CBOE Volatility Index (VIX) time series in Table A.3. This choice can be further justified by the fact that high volatility in the US stock market typically spreads across most world equity markets. The results show that our stock options variable remains highly statistically significant when controlling for the S&P 500 volatility or the

TABLE 2.4:
Regression results II

Income share	Top 10%				Top 1%				Top 0.1%				Top 0.01%				Top 0.001%			
Model	V	VI	VII	VIII	V	VI	VII	VIII	V	VI	VII	VIII	V	VI	VII	VIII	V	VI	VII	VIII
Stock options *(t)*	0.28*	0.27**		0.19*	0.17**	0.16**		0.11	0.09***	0.09**		0.08*	0.04**	0.04*		0.00	0.02	0.02		-0.01
Stock options *(t-1)*			0.29**	0.12			0.17**	0.07			0.08**	0.01			0.04*	0.04			0.02*	0.02
Stock return *(t)*	0.01	0.00		0.01	0.00	0.00		0.00	0.00	-0.00		0.00	0.00	-0.00		0.00	0.00	0.00		0.00
Stock return *(t-1)*			0.01	0.00			0.01	0.00			0.00	0.00			0.00	-0.00			0.00	0.00
Eq.d. x S.r. *(t)*		0.01***				0.00**				0.00**				0.00**				0.00**		
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	355	355	353	333	355	355	353	333	355	355	353	333	355	355	353	333	355	355	353	333
R-squared	0.5870	0.5962	0.5420	0.5842	0.5787	0.5873	0.5357	0.5824	0.5337	0.5437	0.4842	0.5441	0.4466	0.4564	0.4078	0.4645	0.3965	0.4090	0.3630	0.4250

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the fixed effects regression results of the different top income share measures on single stock options. The main explanatory variable across the regressions is the volume of single stock option contracts traded at time t (Models V and VI) and at time $t-1$ (Models VII and VIII). In Model V we control for annual stock returns. In Model VI we add an interaction term between stock options and stock returns. In Model VII we use the variables at time t and the lagged variables at time $t-1$. Across all four models we additionally control for GDP per capita, import share and trade unions. Each column represents a separate regression with a different top income share measure.

VIX. Additionally, the coefficient size for stock options increases significantly when including the interaction term between stock options and stock market volatility. However, the coefficient of the interaction term is negative, rendering the overall effect inconclusive. Furthermore, the S&P 500 volatility coefficient is statistically significant across most regression models, highlighting the high correlation of stock market volatility and top income share.

In Table 2.6, we control for differences in intercept and slopes across countries with hybrid regression models. Across all models and income shares, the fixed effect parameters are statistically significant at the 10% level, in some cases even at the 1% level. For level-level regressions the likelihood ratio (LR) test for random slope compared to only random intercept models is consistently statistically significant, while for log-log regressions it is only significant for the top 10% income share. The results show that the intercept (between-effect) is statistically significant across all level-level models, except for the top 0.1% income share. However, the slope (within-effect) is statistically significant at the 10% level for the top 0.1% income share and significant at the 1% for the top 0.001% income share. This suggests that the correlation of stock options with these top income shares differs across

TABLE 2.5:
Regression results with debt level and stock market volatility variables

Income share	Top 10%				Top 1%				Top 0.1%				Top 0.01%				Top 0.001%			
Model	IX	X	XI	XII	IX	X	XI	XII	IX	X	XI	XII	IX	X	XI	XII	IX	X	XI	XII
Stock options	0.27**	0.21	0.29**	0.50***	0.16*	0.09	0.16**	0.30***	0.08**	0.07	0.09**	0.16**	0.04	0.03	0.04*	0.08**	0.02	0.01	0.02	0.05*
Debt level																				
Private sector debt	-0.03	-0.03			-0.02*	-0.02			-0.01*	-0.01			-0.00	-0.00			-0.00**	-0.00		
Private sector debt x Stock options		0.00				0.00				0.00				0.00				0.00		
Stock market volatility																				
S&P 500			1.05	1.41**			0.92**	1.14***			0.57**	0.68***			0.41**	0.47***			0.17***	0.22***
S&P 500 x Stock options				-0.05***				-0.03**				-0.02*				-0.01*				-0.01**
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	352	352	365	365	352	352	365	365	352	352	365	365	352	352	365	365	352	352	365	365
R-squared	0.5868	0.5877	0.5753	0.5832	0.5863	0.5882	0.5721	0.5781	0.5339	0.5343	0.5266	0.5307	0.4297	0.4297	0.4374	0.4417	0.3741	0.3742	0.3803	0.3915

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the fixed effects regression results of the different top income share measures on single stock options when controlling for debt and stock market volatility. The main explanatory variable across the regressions is the volume of single stock option contracts traded. In Model IX we control for private sector debt. In Model X we add an interaction term between stock options and private sector debt. In Model XI we control for the annual S&P 500 volatility. In Model XII we add an interaction term between stock options and S&P 500 volatility. Across all four models we additionally control for GDP per capita, import share and trade unions. Each column represents a separate regression with a different top income share measure.

countries. Across the log-log models, the LR test indicates that the hybrid model is only significant for the top 10% income share. In terms of economic significance, the coefficient for stock options is larger in hybrid models than in fixed effects models illustrated in Tables 2.2-2.5. The coefficient size for the top 0.1% income share in the log-log model is 0.03 in Table 2.2 and 0.06 in Table 2.6, thus in line with the range of 0.03-0.06 in Table 2.1.

Finally, Table 2.7 analyzes the short- and long-run dimension with error-correction models performed in log-log form. Table A.4 shows the results in level-level form. Model XIII includes the stock options and control variables at time t, while Model XIV uses lagged variables. The results show that the long-run correlation between stock options and income inequality is only statistically significant for the top 0.1%, while it is significant for the top 10%, 1% and 0.1% when the variable is lagged. The coefficient is statistically significant across all income shares for the level-level models (Table A.3). In terms of economic significance, the coefficient size is the largest for the top 0.1% income share at 0.05 in Model XIII and 0.07 in Model XIV. This result is in line with the previous regression models, but the coefficient size is

TABLE 2.6:
Regression results for hybrid models

Regression type	*Level-Level*					*Log-Log*				
Top income share	*10%*	*1%*	*0.1%*	*0.01%*	*0.001%*	*10%*	*1%*	*0.1%*	*0.01%*	*0.001%*
Fixed effect parameters										
Stock options	0.59***	0.52***	0.35**	0.36*	0.10*	0.01***	0.04***	0.06***	0.08***	0.06**
Intercept	3.87***	2.41***	1.08	-1.86	-3.59**	3.87***	2.41***	1.08	-1.86	-3.59**
Random effect parameters										
Stock options	0.53	0.45	0.35*	0.65	0.17***	0.06***	0.00***	0.00***	0.00***	0.00***
Intercept	3.62***	1.94***	1.09	0.60**	0.26***	0.12***	0.21***	0.36***	0.58***	0.88
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	365	365	365	365	365	354	354	354	354	354
LR-Test	17.83	12.51	11.94	22.67	33.06	36.07	-0.00	-0.00	-0.00	-0.00
(p)	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(0.00)*	*(1.00)*	*(1.00)*	*(1.00)*	*(1.00)*

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the hybrid model regression results of the different top income share measures on single stock options. The dependent variable across all regressions is the volume of single stock option contracts traded and the control variables are GDP per capita, the import share and trade unions. Each column represents a separate regression with a different top income share measure.

TABLE 2.7:
Regression results for error-correction models

Income share	**Top 10%**		**Top 1%**		**Top 0.1%**		**Top 0.01%**		**Top 0.001%**	
Model	XIII	XIV	XIII	XIV	XIII	XIV	XIII	XIV	XIII	XIV
Long-run parameters										
Stock options (*t*)	0.010		0.029		0.054*		0.038		0.006	
Stock options (*t-1*)		0.026***		0.059***		0.074***		0.077		0.042
Short-run parameters										
Stock options (*D*)	0.003	0.010***	0.012	0.029***	0.020	0.042***	0.022	0.016	0.030	0.008
Adjustment term	0.210***	-0.302***	0.248***	-0.324***	0.323***	-0.366***	0.367***	-0.379***	0.564***	-0.570***
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	355	355	355	355	355	355	355	355	355	355

**p < 0.10, **p < 0.05, ***p < 0.01. The regressions are performed based on robust standard errors.*

This table reports the error-correction model regression results of the different top income share measures on single stock options. The dependent variable across all regressions is the volume of single stock option contracts traded and the control variables are GDP per capita, the import share and trade unions. Each column represents a separate regression with a different top income share measure. All regressions are in log-log form. The results in level-level form are shown in Table A.4.

slightly above the previous range of 0.03-0.06. In the short run, the lagged variables are again only statistically significant for the top 10%, 1% and 0.1%. The largest coefficient is also the correlation with the top 0.1% income share. The short-run parameter at time t is not statistically significant in any model.

In summary, our results suggest that the correlation between the aggregate volume of single stock options contracts traded and the income share of the top 10%, top 1% and top 0.1% is statistically significant. These results are robust across different econometric specifications. Furthermore, our results from log-log regression models suggest that the correlation is the largest with the top 0.1% income share with a coefficient size between 0.03 and 0.07. In terms of economic significance, a rise of 1% in the volume of single stock options contracts traded represents an increase of 0.03%-0.07% of the top 0.1% income share. This percentage change needs to be put into relation with the increase in volume of stock options of 1376% on average across all countries in our sample between 1990 and 2020. Finally, our results show limited or no statistical and economical significant correlation for the top 0.01% and 0.0001% income shares. Thus, this finding points to different income dynamics for these income shares where stock options might be less relevant, or executives and finance professionals less represented.

2.6 Discussion

The findings of our paper provide discussion points and implications for the financialization and inequality debate. While our analysis focuses on single stock options data and thus serves as a measure for equity derivatives and financial innovation, our research provides important insights on the rise of financial derivatives resulting from the financialization process and its correlation with income inequality.

Our paper makes two contributions to the financialization-inequality literature.

First, our paper provides an analysis of the role of financial derivatives in the rise of the top income share. We propose an explanation for the link between the growth of derivatives and income inequality by discussing two channels within the financialization process. The first channel is related to the development within the financial sector. Since the 1980s there has been a shift from traditional finance to modern finance, driven partly by financial innovation. Financial institutions shifted their

business activities to transaction-based and fee-generating revenues. This shift contributed to the rise in financial market activity and increased rent extraction from the financial sector within the economy, resulting in a higher share of financial sector employees within the top income share. The second channel is related to the financialization of NFCs. The financialization process has established the shareholder value principle within NFCs, as these shifted from a 'retain and reinvest' to a 'downsize and distribute' model (Lazonick and O'Sullivan, 2000). The consequences for corporate activity have been manyfold, including higher financial market activities, such as mergers, acquisitions and share buybacks, while real investments dropped (Schaberg, 1999). Executive compensation has also gone through changes with the aim of aligning the incentives of shareholders and executives. This shift contributed to the inclusion of stocks and more importantly stock options in executive compensation and thus the financialization of top income. Stock options have become an important component of executive compensation packages. We argue that this 'optionalization' of executive compensation contributed to the higher increase in executive compensation compared to average workers' salaries since the 1980s (Figure 2.1 and Figure A.2). Thus, the financialization of top income through the integration of stock options has not only increased the complexity and lowered the transparency of total executive compensation (Murphy, 2002; Hall and Murphy, 2003), but also contributed to this income share being disconnected from real economic fundamentals, in line with the financial derivatives market outgrowing the real economy. Our paper therefore extends Thompson's (2013) disconnected capitalism theory and Flaherty's (2015) argument on how the growth in financial innovation in the form of financial derivatives plays a significant role in the development of top income.

Second, our paper provides the first empirical analysis assessing the correlation of income inequality with a proxy for country-level stock options. The empirical literature uses a variety of stock market data and financial development indicators, such as the IMF indices developed and used by Cihak and Sahay (2020) to analyze the impact of financial structure and more specifically market-based finance on inequality. We are not aware of any empirical study analyzing the contribution of

financial derivatives to the rise in the top income share. Our paper goes beyond the standard market-based finance argument and focuses on the role of financial innovation as proxied by single stock options contracts across different economies. Based on a novel dataset of aggregate volume of single stock options contracts traded we show that the variation in derivatives markets is correlated with income inequality. Our results are statistically significant for the top 10%, 1% and 0.1% income share. Our empirical analysis tests the robustness of our results with hybrid models combining random intercepts and slopes to allow for different size effects of single stock options across countries, as well as short- and long-run dynamics with error-correction models. These models confirm our initial findings on the statistically significant correlation for the top 10%, 1% and 0.1% income share, and the economic significance for the top 0.1% income share. Our findings align with Efing et al.'s (2022) assertion that the allocation of stock options to employees below the executive level is relatively uncommon (i.e. less than 1%), as well as with Kaplan and Rauh's (2010) argument that wall street executives constitute a larger proportion of the top income share. Thus, we argue that there are different income dynamics for income shares above the 0.1%, as stock options might be less relevant, or executives and finance professionals less represented in these income shares.

Our paper also highlights the role of academic theory in the rise of financial derivatives and their inclusion in executive compensation. Lindo (2018) provides a political economy analysis of the mathematization of financial derivatives' valuation models. While the author argues that this professionalization is a natural result of increased demand for efficient pricing, the mathematization has contributed to the complexification of the financial sector highlighted by the financialization literature. This complexification spread to NFCs, as illustrated by the complexity of executive compensation and their use of compensation advisors for the calculation. The mechanics of executive compensation have been legitimized by corporate finance theory through Jensen and Meckling's (1976) agency theory proposing to alleviate the agency problem with executive contracts aligning managers and shareholder interests. Contrary to the financial theory argument, there is evidence on the association of excess executive compensation with firm underperformance (Brick,

Palmon, and Wald, 2006), as well as on the effect of stock options on increased risk taking of CEOs (Shue and Townsend, 2017; Chesney et al., 2020). While Figure 2.3 shows that single stock options reached their peak in 2008, the derivatives market still exceeds six times the world GDP. In Switzerland, the Swiss stock exchange publishes the total notional value of open positions of derivatives, which represented over 3'700 times the Swiss GDP in September 2023 (SIX, 2023).[17] Financial derivatives have a long history of speculative crises contributing to asymmetric effect on inequality, described by Godechot et al. (2022). Within financial institutions, research suggests that there is a positive association between total compensation and risk exposure (e.g. Cheng, Hong, and Scheinkman, 2015). In this context, the recent case of Credit Suisse should not have come as a surprise based on risk indicators published in their annual report, such as the volume of derivatives traded and their purpose.

Furthermore, our paper contributes to the interdisciplinary literature on inequality, financialization and finance. There is limited existing research combining research in sociology, political science, economics, finance, and management studies. As highlighted by Brou, Chatterjee, and Girardone (2021), due to the dominance of the agency theory within the financial research field, the finance or management literature on executive compensation has so far focused on financial or performance-based pay, while ignoring the effects related to income inequality. Thus, we wish to contribute to including the topic of social inequality in the current ESG debate in order to guide ESG efforts towards further social progress. While ESG factors have recently benefited from greater attention within academic research and the financial sector, the topic of social inequality remains largely unaddressed by financial market participants, as well as by firms in their corporate sustainability efforts. Currently, corporations focus on diversity and inclusion or employee engagement within the social dimension, as initiatives in this space do not require any fundamental change to their business model. More importantly, both are supposed to contribute to superior financial performance (Erhardt, Werbel, and Shrader, 2003; Campbell and

[17] The figures published by the Swiss stock exchange are significantly higher than the figures published by the BIS. Thus, this suggests that the BIS figures underestimate the size of the global derivatives market.

Minguez-Vera, 2007). While these topics are indisputably relevant, they should not be the sole focus in the social dimension of companies and be used to divert attention away from income inequality resulting from intra-company income divergences between low- and high-paid employees. On top of the moral dilemma that the growing income gap creates, there are also business reasons to take inequality into consideration. Benedetti and Chen (2018) show that high CEO-to-worker pay ratios negatively impact consumer and employee perceptions of companies.

Our paper provides reflection points on the use of financial derivatives within economies and potential actions for policymakers and market participants. Regulation should tackle the decoupling between the derivatives market and the real economy. In a first step transparency and disclosure on the use of derivatives should be increased, similar to recent regulatory developments in the sustainability space, such as the European Taxonomy to classify business activities or the Sustainable Finance Disclosure Regulation (SFDR) for financial products (see second essay). Disclosure regulations to promote transparency on the use of derivatives by financial institutions, as well as in compensation within NFCs should be extended. While the CEO-to-median-worker ratio is a mandatory disclosure for US public companies since 2018 (Section 953(b) of the Dodd-Frank Act), the executive-to-median-worker ratio should become a mandatory ESG disclosure in other countries and included in the assessment of the social dimension of companies. However, Knust and Oesch (2020) show that this disclosure regulation in the US did not yet reduce CEO compensation. The use of stock options in compensation and of derivatives within financial institutions should therefore be addressed beyond disclosure. The principles of islamic finance can serve as inspiration, such as the prohibition to engage into speculative transactions or the requirement of asset backing to ensure that financial transactions are underpinned by real assets or economic activities (Kammer et al., 2015; Caporale and Helmi, 2018). Such policies would tackle income inequality, as well as corporate decision-making and risk-taking linked to the exercise of stock options.

2.7 Further research

Given that financial derivates have not yet been largely addressed in the empirical financialization and sustainable finance literature, our paper offers a multitude of future research opportunities. First, we only considered single stock options across a set of OECD countries for the period of 1990 to 2020. As data for more types of derivatives and a larger number of countries becomes available, the association of different financial derivatives with income and wealth inequality should be analyzed. Second, more empirical research on stock options within executive compensation and their contribution to income inequality should be performed. Third, as a 'new economy' emerges with the exponential growth of start-ups, the contribution of their labor and remuneration practices (including stock options) should be evaluated. Finally, in the ESG debate, the association between ESG scores of companies and their intra-firm executive-to-median-worker ratio should be evaluated.

Chapter 3

How green is 'dark green'?
An analysis of SFDR Article 9 funds

Joint with Marc Chesney[1]

We develop a metric of a stock's implied 'greenness' based on the inclusion frequency in SFDR Article 9 funds and analyze to what extent sustainability and financial characteristics drive this greenness score. Our results provide two main findings on fund managers' sustainability preferences. Firstly, a stock's greenness score is driven by its sector exposure, climate targets and CSR efforts, such as human rights policies and ESG ratings. Net zero targets have a higher statistical significance than GHG intensity levels. UN Global Compact violations have no statistically significant effect. Secondly, we find differences in greenness score drivers between global and regional funds, suggesting different sustainability preferences due to investment universe and portfolio diversification considerations.

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3.1 Introduction

As the awareness of climate change and sustainability increases, there is a growing interest on the part of investors to contribute to the transition to a more sustainable planet by allocating their capital to 'sustainable' or 'green' investments. This ambition comes with the challenging question: What is a 'sustainable' or 'green' investment? While the fixed income space tries to provide a definition of sustainable investments through dedicated instruments such as green bonds (Flammer, 2021) or sustainability-linked bonds (see third essay), there is no comparable equivalent for equity investors. Fund managers typically rely on company ESG ratings for their stock selection, while end-investors rely on ESG fund labels for their fund selection. A common criticism by observers is that ESG ratings have no legal obligation or quality, since they do not capture a company's environmental or social impact (i.e. impact materiality) but reflect how ESG risks affect the financial performance of a company (i.e. financial materiality). The debate has been reinforced due to recent greenwashing cases, highlighting the fundamental problem of information asymmetry and the associated need for sustainability disclosure.

In 2019, the EU Parliament and Council adopted the Sustainable Finance Disclosure Regulation[2] (SFDR) to improve transparency in the market for sustainable investment products and prevent greenwashing. This regulation allows financial institutions to provide information on the level of sustainability integration in their financial products according to three types (Article 6, 8 and 9). While ESG labels have no legal obligation and quality, the SFDR disclosure has a legal definition and represents a regulatory commitment by the fund manager. While the majority of ESG-labelled funds apply one or a combination of responsible investment approaches, the novelty of SFDR is the distinction between financial products which promote environmental or social characteristics (Article 8) and those which have as

[2]Regulation 2019/2088 on sustainability-related disclosures adopted on 27 November 2019 is referred to as the Sustainable Finance Disclosure Regulation (SFDR).

an objective a positive environmental or social impact (Article 9). SFDR Article 9 financial products are commonly referred to as 'dark green', since they have sustainable investment as their objective. These funds should be conceptually different from ESG-labelled funds. The sustainable investment objective of SFDR Article 9 funds is required to be evidenced by investing in 'sustainable investments'.[3] SFDR Article 9 financial products are therefore considered the most ambitious and expected to take a holistic view on sustainability in the investment process (Eurosif, 2022). Numerous financial actors have disclosed their funds as SFDR Article 9. 1'080 funds, representing 4.3% of funds available for sale in the EU, were disclosed as SFDR Article 9 as of 30 September 2022 (Morningstar, 2022).[4] Due to the variety of sustainability terminology within the investment industry, the absence of legal obligation of ESG-labelled funds and the growing importance of regulatory disclosure, the SFDR provides an interesting identification context to assess fund managers' sustainability preferences and the market's implied greenness of stocks. While there is existing research on responsible investment approaches, as well as on the implications of regulation and disclosure, we are not aware of any study examining fund sustainability definition using regulatory disclosure.

The aim of our paper is to examine fund managers' sustainability preferences by analyzing stocks' inclusion frequency in SFDR Article 9 funds. While a large share of ESG-labelled funds focuses on financial materiality considerations based on screening or ESG integration approaches using ESG ratings, SFDR Article 9 funds are expected to surpass these approaches due to the disclosure requirement of investing into 'sustainable investments'. SFDR Article 9 funds are therefore supposed to

[3] A 'sustainable investment' is defined by the SFDR as an investment contributing to either an environmental or a social objective, while also requiring that it 'does not significantly harm' any of these objectives and that the investee companies follow good governance processes. Section 3.3.2 provides a discussion of this definition.

[4] Since Q4 2022, however, over 40% of SFDR Article 9 funds reclassified to Article 8 due to managers taking a more precautious approach given more clarity on the regulation (Morningstar, 2022). This precautionary approach and fund declassifications are expected to increase given regulators' stronger focus on greenwashing risk (Morningstar, 2022).

take into consideration the notion of double materiality combining financial materiality (i.e. how ESG risks affect the company) and impact materiality (i.e. the company's impact on society and the environment). In the responsible investment spectrum (Figure 3.1), this is typically the distinction between the ESG integration approach which considers the sustainability of a company's operations, including its decarbonization pathway, and thematic or impact investing which focuses on companies with products or services that have a positive environmental or social impact. We therefore aim to understand which materiality (financial or impact) and responsible investment approaches (i.e. screening, ESG integration, thematic or impact investment) drive stocks' inclusion frequency in SFDR Article 9 funds. Our greenness score thus represents a new sustainability measure which does not have the disadvantages of company ESG ratings or fund ESG labels.

Our paper addresses this question empirically using a sample of 290 public equity SFDR Article 9 funds. In a first step, we define an implied 'greenness score' representing the frequency a company is included in our sample of funds. To avoid our analysis being impacted by the choice of benchmarks or tracking-error considerations of funds, we focus on the simple inclusion of stocks rather than the percentage weight within funds. In contrast to ESG scores from rating agencies, this greenness score can be interpreted as the market's implied perception of a stock's sustainability profile. In a second step, we analyze to what extent this greenness score is driven by a company's sustainability characteristics as opposed to financial and business activity characteristics.

Our results provide two main findings. Firstly, our results show that sector exposures, climate targets and CSR efforts, such as human rights policies and higher ESG ratings, have a statistically and economically significant effect on the greenness score. While the GHG emission intensity is also statistically significant, the coefficient size suggests that the effect is smaller on the greenness score than companies'

net zero targets. These findings on the CSR efforts as well as the statistically significant revenue coefficient suggest a size bias favoring large companies. Furthermore, we find that UN Global Compact violations have no statistically or economically significant effect on the greenness score. Whether a company breaches these principles, does not affect the inclusion frequency in SFDR Article 9 funds (312 companies with UN Global Compact violations are included in our sample). This finding breaches negative screening or exclusion approaches and the SFDR principle of 'do no significant harm'. Secondly, we find significant differences in sector and CSR coefficients between global and regional SFDR Article 9 funds. While the renewable energy sector is widely acknowledged for its positive environmental impact and often serves as a straightforward proxy for 'sustainable investment,' it consistently exhibits a statistically and economically significant coefficient for global funds. However, this result does not hold true for regional funds. Regional funds have larger coefficients for ESG rating variables and climate commitments but different sector exposures. This finding suggests that regional funds focus more on financial materiality through ESG integration (e.g. high ESG ratings) and less on impact materiality through thematic investments (e.g. renewable energy companies). The different SRI focus could be explained by the more limited thematic investment universe for regional funds and the resulting lower diversification. Due to the expected lower share of sustainable investments, regional SFDR Article 9 funds should be more likely to be declassified to SFDR Article 8. Our analysis of declassified SFDR Article 9 funds confirms this prediction, as over 70% of regional funds within our sample are declassified, while the share is lower for global funds (35.7%). We also find that the greenness score is less driven by CSR efforts when excluding declassified funds.

Our paper contributes to the sustainable finance literature in two ways. First, our paper is the first paper assessing the sustainability preferences and implied greenness of stocks based on regulatory disclosure. The SFDR is the first regulation proposing official sustainability disclosure for financial products. As opposed to

ESG labels in fund names which have no legal obligation, the SFDR disclosure is based on a legal definition and represents a regulatory commitment from fund managers. It should therefore allow for a higher level of comparability and transparency across financial products. Our paper is the first empirical analysis using regulatory disclosure to provide insights into company-level characteristics driving inclusion frequency into sustainable funds. While most of the literature focuses on the fund perspective and therefore assesses fund characteristics to understand the level of ESG integration within funds, we take the company perspective and analyze characteristics that lead companies to be included more frequently in sustainable funds. Our greenness score represents a novel measure of the market's implied perception of a company's sustainability profile based on fund managers' sustainability preferences, rather than purely on third-party ESG ratings of a company. Second, our paper assesses sustainable fund types and strategies based on company-level characteristics. We highlight differences between global and regional sustainable funds in terms of sustainability coefficients and sector exposure, thus suggesting that regional funds' sustainability preferences are affected by investment universe and diversification considerations. Additionally, our paper offers potential explanations for regulatory disclosure decisions and SFDR fund declassifications.

The findings of our paper have important implications for the sustainable investing market, providing relevant insights into the implementation of regulatory disclosure, such as the SFDR Article 9 requirements, and serving as a basis for discussion on what should be seen as a 'sustainable investment'. Our results highlight the importance of science-based net zero targets. As companies increasingly commit to net zero targets and validate their targets by the science-based targets initiative (SBTi), the question arises of whether these companies should be considered as 'sustainable investments' based on their potential future decarbonization pathway. Criticism towards the fulfilment and reporting of science-based targets weakens this rationale (Bolton and Kacperczyk, 2021b). The argument of investing into 'transitioning

companies' increases the investable universe of companies for sustainable funds by allowing fund managers to be more flexible in their definition of a 'sustainable investment' and to construct more diversified portfolios. The resulting portfolios can thus include companies that violate the 'do no significant harm' principle, as evidenced by the number of companies with UN Global compact violations in our analysis. Furthermore, the high correlation of the greenness score with the MSCI ESG rating illustrates the strong reliance of fund managers on this ESG rating information. While the MSCI ESG rating is the most widely used ESG rating, it does not capture a company's environmental or social impact (i.e. impact materiality), but instead reflects how ESG risks affect the financial performance of a company (Berg, Heeb, and Kölbel, 2022). A high MSCI ESG rating should therefore not inevitably coincide with the definition of a 'sustainable investment'. If the inclusion frequency into sustainable funds is significantly driven by corporate sustainability efforts, which favor large corporations and lead to a size bias (Drempetic, Klein, and Zwergel, 2020), the holdings of SFDR Article 9 funds overlap strongly with more traditional funds, such as SFDR Article 8 funds, as evidenced by industry reports (Morningstar, 2022). The current implementation thus seems to be more process-oriented and less outcome-focused: Fund managers establish a 'sustainable investment' process for the selection of stocks with the aim of maintaining flexibility in their investment universe. This finding is especially pronounced for regional funds, which focus less on thematic approaches and more on ESG integration. It therefore raises greenwashing concerns as the integration of sustainability considerations and the investment process seems to be influenced by investment universe and portfolio diversification motivations, while neglecting the thematic and 'sustainable investment' objective. Based on these observations, we predict that regional, as well as climate transition funds are more likely to be declassified to SFDR Article 8 in the future. Our analysis of SFDR Article 9 declassifications supports this prediction, as the share of regional funds declassified within our sample is over 70% and significantly higher than for global funds (35.7%).

3.2 Literature review

This paper is motivated by and relates to three strands of the sustainable finance literature.

Firstly, our paper relates to the fundamental research on sustainability, socially responsible investment (SRI) approaches and fund characteristics. Since the development of SRI there has been a vast amount of discussion on the actual definition of SRI or the notion of sustainability in finance. Soppe (2004) discusses the underlying assumptions of financial theory against the background of sustainability. He claims that finance needs a multifaceted approach and defines the concept of sustainable corporate finance. This multifaceted and complex approach to integrating sustainability considerations into finance has given rise to a large heterogeneity in the sustainable finance field. Sandberg et al. (2009) discuss the heterogeneity of SRI on four levels (definitional, terminological, strategic and practical). While a large part of research examines the financial performance of green assets (Pastor, Stambaugh, and Taylor, 2022, 2021; Bolton and Kacperczyk, 2021a) and compares the characteristics SRI funds against conventional funds (Bauer, Koedijk, and Otten, 2005; Benson, Brailsford, and Humphrey, 2006; Kempf and Osthoff, 2008; Humphrey, Warren, and Boon, 2016; El Ghoul and Karoui, 2017), a number of studies assessing the various SRI approaches and investment styles have emerged, such as screening, ESG integration and thematic or impact investing. Berry and Junkus (2013) show that investors prefer to follow a best-in-class approach rather than negative screening. While Van Duuren, Plantinga, and Scholtens (2016) and Eccles, Kastrapeli, and Potter (2017) examine the motivation and use of ESG data, Amel-Zadeh and Serafeim (2018) identify the reasons and methods of integration of ESG considerations. More specifically within ESG integration, numerous recent studies assess the engagement process and outcomes (Bauer, Ruof, and Smeets, 2021; Azar et al., 2021; Chen, Dong, and Lin, 2020; Dyck et al., 2019; Dimson, Karakaş, and

Li, 2015). At last, Barber, Morse, and Yasuda (2021) and Chowdry, Davies, and Waters (2019) analyze the approach of impact investing.

Secondly, our paper is associated with the literature assessing and measuring the sustainability performance of portfolios and companies, as well as identifying investors' sustainability preferences. This research stream thus addresses the fundamental aspect of information asymmetry and principal-agent problem related to the implementation of sustainability considerations, as well as the issue of greenwashing. At the company level, recent research focuses on critically assessing the role of ESG ratings as company sustainability performance measures. Studies have shown that firms' ESG scores are more influenced by the existence of disclosure than the actual content of these disclosures (Drempetic, Klein, and Zwergel, 2020; Lopez-de Silanes, McCahery, and Pudschedl, 2019). Drempetic, Klein, and Zwergel (2020) find a significant positive correlation between firm size and ESG ratings which they explain by organizational legitimacy, suggesting that larger firms with more resources for ESG data provision seem advantaged. Pederson, Fitzgibbons, and Pomorski (2021) propose a theory in which each stock's ESG score plays two roles, namely providing information about firm fundamentals and affecting investor preferences. Berg, Kölbel, and Rigobon (2022) highlight the divergence across ESG rating agencies due to the scope (i.e. the criteria to evaluate ESG) and measurement (i.e. the metrics to determine ESG). Bams and van der Kroft (2022) argue that ESG ratings are inversely correlated to the sustainable performance of companies, and that portfolio optimization and divestment decisions according to ESG ratings create portfolios that are less sustainable than the market portfolio.

At the fund level, Joliet and Titova (2018) analyze US SRI fund holdings and show that these funds adjust the portfolio weights by considering companies' relative ESG performance with positive screening resulting in a higher weight of ESG best performers. Raghunandan and Rajgopal (2022) find that US ESG-labelled funds

hold portfolio firms with worse track records for compliance with labor and environmental laws, relative to portfolio firms held by non-ESG funds managed by the same financial institutions. Berg, Heeb, and Kölbel (2022) examine the impact of ESG ratings on mutual fund holdings and find that rating downgrades reduce ownership by mutual funds with a dedicated ESG strategy, while upgrades increase it. Focusing on impact funds, Scheitza, Busch, and Metzler (2022) analyze 185 funds with impact claims, including SFDR Article 9 funds, and find that only one third of the impact funds meet the outlined impact requirements, and that this share is equally low for SFDR Article 9 funds. More specifically on investor preferences, Nofsinger, Sulaeman, and Varma (2019) analyze the institutional ownership in firms with good and bad environmental and social performance and show that investors appear indifferent to the presence of positive environmental and social indicators, but underweight stocks with negative ES indicators. Bolton et al. (2020) estimate institutional investor preferences from proxy voting records, while Bubb and Catan (2022) investigate the structure of mutual funds' corporate governance preferences as revealed by how they vote their shares in portfolio companies.

Finally, a literature stream has emerged on the implications of regulation and disclosure. Krueger, Sautner, and Starks (2020) and Stroebel and Wurgler (2021) show that regulatory risks are regarded as the top climate risk to businesses and investors. Ilhan et al. (2023) provide systematic evidence that institutional investors value and demand climate risk disclosures. Raghunandan and Rajgopal (2022) show that ESG funds hold stocks that are more likely to voluntarily disclose carbon emissions performance but also stocks with higher carbon emissions, suggesting that these funds seem to value disclosure more than actual ESG performance of companies. More specifically on EU regulation, Bengo, Boni, and Sancino (2022) discuss the implications brought by the SFDR and build a conceptual link with social impact measurement practices. Becker, Martin, and Walter (2022) analyze the effect of

the SFDR on mutual funds and individual investors in the EU. Their study highlights that there are supply side effects illustrated by increasing ESG efforts and higher sustainability scores (based on Morningstar's sustainability scoring) of affected funds, as well as demand side effects reflected by higher inflows into these funds. Bassen et al. (2022) show that the EU Taxonomy Regulation and companies' alignment has affected realized returns. The authors show that the returns are higher when the sustainability assessment of investors as per EU Taxonomy Regulation alignment exceeds the companies' traditional ESG ratings, thus indicating a possible reallocation of capital by investors with sustainability preferences based on EU Taxonomy alignment, instead of ESG ratings.

Our paper extends the literature by providing an empirical study of fund managers' sustainability preferences and the implied greenness of stocks based on the SFDR Article 9 fund holdings. While prior literature assesses the sustainability at fund or company level, we address the intersection and analyze the factors driving the inclusion frequency of a stock into sustainable investment funds disclosed as SFDR Article 9. Our research ultimately feeds back to the fundamental debate on SRI heterogeneity, and how financial actors define 'sustainable investments' to translate this into sustainable investment portfolios.

3.3 What is green?

3.3.1 Different shades of green

The Global Sustainable Investment Alliance (GSIA) distinguishes between seven categories of responsible investment in its classification[5], while UNPRI (2013) summarizes the responsible investing and impact investing approaches into four broader

[5]The seven categories of the GSIA (2021) are: norms-based screening, negative screening, positive screening, ESG integration, corporate engagement and shareholder action, sustainability-themed investing, and impact investing.

categories, shown in Figure 3.1.

FIGURE 3.1:
The spectrum of responsible investment approaches

	Responsible investing				
Traditional	**Screening**	**ESG integration**	**Themed**	**Impact investing**	**Philanthropy**
Limited or no focus on ESG factors of underlying investments	Norms-based; Negative or exclusionary; positive or best-in-class	Use of qualitative and quantitative ESG information in investment processes, at the portfolio, stock, issuer or investee level	Selection of assets that contribute to addressing sustainability challenges	Environmental or social issues which create investment opportunities (with potentially some financial trade-off)	Focus on one or a cluster of issues where social and environmental need requires 100% trade-off

This figure summarizes the different responsible investment approaches as defined by UNPRI (2013). There are four overarching categories of responsible investment referred to as screening, ESG integration, themed and impact investing.

Screening. These approaches involve the screening and exclusion of investments based on their harmful industry classification (negative screening), their non-adherence to norms of business conduct (norm-based screening), as well as selecting companies that have the best ESG profiles within their industry (best-in-class or positive screening). There seems to be a predominant consensus within the financial industry on typically excluded companies.[6]

ESG integration. This approach includes the consideration of ESG factors in the investment process, such as the analysis of company ESG ratings. A key concept in ESG integration is materiality. There is the distinction between financial materiality, which refers to the financial importance of an ESG factor for a specific company, and impact materiality which describes a company's impact on the environment and society. Both notions together are referred to as double materiality. It is important to highlight that the former is often also referred to as sustainability risks and represents the major focus of ESG ratings. For example, the MSCI ESG rating is the most widely used ESG rating in the financial industry, but does not capture a company's environmental or social impact (i.e. impact materiality), but instead only reflects how ESG risks affect the financial performance of a company (Berg,

[6]Typically, investment funds with negative screening criteria exclude companies within the field of adult entertainment, alcohol, animal testing, gambling, genetically modified organism, nuclear power, tobacco and weapons (Lobe and Walkshäusl, 2016; Eurosif, 2019). Fossil-fuel and carbon intensive industries are also increasingly excluded due to growing climate concerns. There has however recently been a debate on natural gas and nuclear power, as both were classified as 'sustainable' under certain conditions within the EU Taxonomy.

Heeb, and Kölbel, 2022). The GSIA defines corporate engagement and shareholder action as a separate category, whereas this is included in UNPRI's category of ESG integration. It includes voting activities, meetings with management, as well as activism and public criticizing or threatening of divestment.

Sustainability-themed and impact investing. While ESG integration typically focuses on how sustainable the practices of a company are ('how'), sustainability-themed and impact investing strategies aim at investing in companies with sustainable products or services ('what'). Sustainability-themed investments focus on one or multiple issues related to sustainability, such as climate change, biodiversity or healthcare. Impact investors typically offer financial products with the dual mission of achieving environmental and social value while also generating financial returns. The essential pillars of impact investing are an investor's intentionality, additionality and the measurability of the impact achieved (GSIA, 2021). With the growing acceptance of the United Nations' Sustainable Development Goals (UN SDGs), impact investing strategies typically measure the positive impact of investments through the contribution to UN SDGs.

These approaches are not mutually exclusive and investment funds often apply several of these concepts in complementary ways. There is an increasing amount of research analyzing the impact of these different approaches, with mixed evidence.[7] Busch et al. (2021) trace these approaches historically and classify them into Sustainable Finance 1.0 (exclusion criteria due to ethical motivations), Sustainable Finance 2.0 (mainstreaming of sustainable investing and ESG to manage financial risks[8]), and Sustainable Finance 3.0 (investing with the aim of generating positive social or environmental impact). In line with the authors' chronological classification, there seems to be a consensus within the investment management industry

[7] Kölbel et al. (2020) provide a comprehensive literature review on the impact mechanism of different sustainable investing channels.

[8] Ahlström and Monciardini (2022) and Van Weeren (2022) discuss the financialization of sustainability in the context of mainstreaming of ESG.

that sustainability-themed and impact investing exceed screening approaches and ESG integration in terms of fulfilling investors' increasing sustainability preferences and motivations.

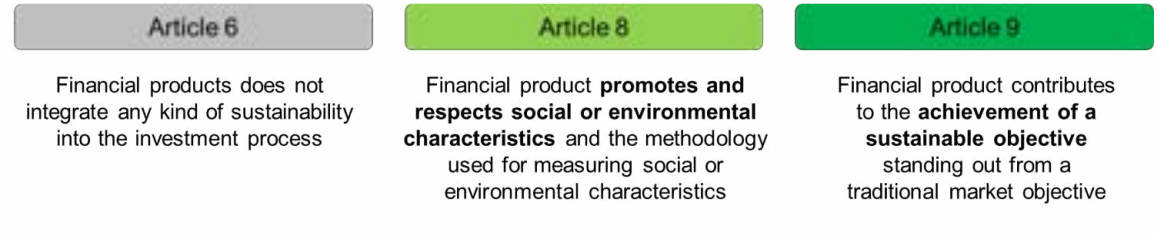
3.3.2 European regulatory framework

While the SFDR is complex and a full summary and discussion of its implementation are beyond the scope of this paper, we wish to highlight features of the regulation and their implications, which are essential for the understanding of our research and identification approach.

On 27 November 2019, the EU Parliament and Council adopted Regulation (EU) 2019/2088 on sustainability-related disclosures in the financial services sector, which is referred to as the 'Sustainable Finance Disclosure Regulation' (SFDR). The aim of the regulation is to reduce information asymmetries in principal-agent relationships with regard to the integration of sustainability risks, the consideration of adverse sustainability impacts, the promotion of environmental or social characteristics, and sustainable investment. It therefore requires financial market participants to make pre-contractual and ongoing disclosures and to provide information on the sustainability integration within their financial products according to Article 6, 8 and 9. The SFDR came into effect as of 10 March 2021. While in the years 2021 and 2022 the SFDR disclosure was solely based on financial market participants' self-proclamation, the regulator has been assessing the fund documentation and SFDR information since 2023. Figure 3.2 below provides an overview of the SFDR information.

Sustainable investment. The SFDR defines a 'sustainable investment' as an investment contributing to either an environmental or a social objective, while also requiring that it 'does not significantly harm' any of these objectives and that the

FIGURE 3.2:
Overview of the SFDR information



This figure summarizes the differences between the SFDR information provided by Article 6, 8 and 9. The intensity of the color indicates the sustainability level of the financial product. SFDR Article 8 financial products are referred to as 'light green', while SFDR Article 9 financial products are referred to as 'dark green'.

investee companies follow good governance processes.[9] The definition of sustainable investment by the SFDR leaves some flexibility for financial market participants to lay down their own definition[10], and is not based explicitly on the EU Taxonomy. Eurosif (2022) highlights the complexity brought about by having two frameworks (SFDR and EU Taxonomy) to define the notion of sustainability, thus rendering the uniform application and comparability across financial market participants challenging. At the time of the data collection (August 2022), the European Union had defined two out of six environmental objectives within the Green Taxonomy and was planning to finalize the social objectives within the Social Taxonomy by the end of 2023. Financial market participants could therefore only report on their

[9] Article 2(17) of SFDR defines a 'sustainable investment' as follows: *"An investment in an economic activity that contributes to an environmental objective, as measured, for example, by key resource efficiency indicators on the use of energy, renewable energy, raw materials, water and land, on the production of waste, and greenhouse gas emissions, or on its impact on biodiversity and the circular economy an investment in an economic activity that contributes to a social objective, in particular an investment that contributes to tackling inequality or that fosters social cohesion, social integration and labour relations, or an investment in human capital or economically or socially disadvantaged communities, provided that such investments do not significantly harm any of those objectives and that the investee companies follow good governance practices, in particular with respect to sound management structures, employee relations, remuneration of staff and tax compliance."*

[10] SFDR states in the introduction (17) that *"To ensure the coherent and consistent application of this Regulation, it is necessary to lay down a harmonised definition of 'sustainable investment' which provides that the investee companies follow good governance practices and the precautionary principle of 'do no significant harm' is ensured, so that neither the environmental nor the social objective is significantly harmed."*

alignment with the EU Taxonomy for a limited share of their investment portfolio. A further ambiguity is how to calculate which investments qualify as sustainable, as the SFDR does not define a within-company threshold level for economic activities to be classified as sustainable. Technically, an investment can be classified as a 'sustainable investment' in two ways: i) a revenue-based approach describing a percentage that its economic activities are sustainable in terms of their alignment with environmental or social objectives (e.g. 60% sustainable as 60% of its revenues contribute to an environmental objective); or ii) a binary approach based on a pre-defined threshold level by the financial market participant (e.g. all companies with more than 20% revenues aligned with an environmental objective are 'sustainable investments', while companies with aligned revenues below 20% are non-sustainable). In order to meet the requirement of holding only 'sustainable investments' and following ESMA's recent clarification, the binary approach has become the most commonly adopted according to Morningstar (2023).

Product-level threshold. As outlined in the European Commission's Q&A issued in July 2021, financial products with a sustainable investment objective (i.e. SFDR Article 9 funds) should only make 'sustainable investments'. The SFDR remains neutral in terms of the product design, investing styles, strategies or methodologies to be employed, but requires the product documentation to include information on how the given mix complies with the 'sustainable investment' objective and the 'do no significant harm' principle (ESMA, 2021). While an exact level for the percentage weight of sustainable investments within SFDR Article 9 funds has not been explicitly defined, the expectation is that it should be close to 100%.[11] In summary, as highlighted by Eurosif (2022), the interpretation of the share of sustainable investments is currently contingent on the interpretation by each financial market participant and therefore not fully comparable.

[11] The ESMA (2021) explains that SFDR Article 9 funds may also include investments for certain specific purposes such as hedging or liquidity, but which must meet minimum environmental or social safeguards.

The positioning of SFDR Article 9 thus goes beyond ESG performance by requiring highest ESG performance to be associated with the generation of positive impact on predetermined overarching sustainability objectives (Bengo, Boni, and Sancino, 2022). When setting the SFDR categories in the context of the spectrum of responsible investment approaches (Figures 3.1 and 3.2), it thus appears that SFDR Article 9 requires screening ('do no significant harm'), ESG integration ('good governance') and thematic or impact approaches ('sustainable investment'), while SFDR Article 8 requires screening and ESG integration. The key difference between the two is therefore that SFDR Article 9 funds are required to consider the concept of double materiality, so the impact of ESG risks on the company's financial performance (i.e. financial materiality), as well as the company's impact on the environment and society (i.e. impact materiality). SFDR Artilce 8 funds are expected to consider only financial materiality.

3.4 Data & empirical analysis

3.4.1 Data

Our sample of SFDR Article 9 funds is extracted from Bloomberg's database, covering all funds labelled as 'SFDR Article 9' as of August 10, 2022. The extraction results in a total of 772 SFDR Article 9 funds across all asset classes. It is important to note that the fund sample extracted from Bloomberg is not exhaustive and covers approximately 75% of the entire market, as there were 1'080 funds classified as SFDR Article 9 as of 30 September 2022 (Morningstar, 2022). The first step consists in removing all non-equity funds, which reduces the sample of funds to 382 equity funds. We focus on pure equity funds as we do not want our inclusion analysis to be affected by instrument considerations, such as green bonds or other

sustainable bonds. In order to guarantee the correctness of the SFDR fund information, we manually verify each fund's disclosure information in the fund prospectus or the website of the respective investment management company as of 30 September 2022.[12] After the category verification, and the verification of data availability of the funds' holdings, we obtain a sample of 315 equity funds classified as SFDR Article 9. The last step consists in keeping global funds, as well as European, US and Emerging Market funds, which leaves us with a final sample of 290 equity funds.[13] The company-level data and variables listed in Table B.3 are also extracted from Bloomberg.

As Table B.1 shows, our fund sample includes funds from a wide range of small and large fund managers. Table B.2 provides an overview of the regional focus and the different strategies of our sample of SFDR Article 9 funds. Within the global funds, 71% of the funds follow a thematic or impact strategy, while 22% are ESG/SRI funds and 7% are climate transition funds. Within the regional funds, 12% are thematic or impact funds, while 71% pursue an ESG/SRI strategy and 17% a climate transition strategy. Given that our fund sample represents approximately 40% of the SFDR Article 9 equity market[14] and has similar characteristics with the general SFDR Article 9 market as described in industry reports (e.g. Morningstar, 2022), our data can be considered as a representative sample of the general SFDR Article 9 equity fund market in several dimensions. As shown in section 3.5.4, 49.3% of our sample of SFDR Article 9 funds has been declassified to SFDR Article 8 as of 1 December 2023. This is in line with Morningstar (2023) highlighting that over 40% of SFDR Article 9 funds reclassified[15], and further reflects the representativeness of our fund

[12] There has been a wave of fund declassifications in H2 2022 from SFDR Article 9 to 8. We run all regressions with the fund classifications as of September 2022 but include an analysis of our results without declassified funds in section 3.5.4. For this analysis we manually verify each fund's information as of 1 December 2023.

[13] For regional funds we focus on European, US and Emerging Market strategies due to limited sample size of other regional or country-focused funds.

[14] According to Goldman Sachs (2023) there were 726 SFDR Article 9 equity funds as of 31 December 2022.

[15] As of 1 February 2023, 40.7% of our sample declassified from SFDR Article 9 to Article 8.

sample for the analysis of the SFDR Article 9 implementation.

3.4.2 Empirical analysis

To address our research question and understand the drivers of inclusion of stocks in SFDR Article 9 funds, we perform a two-step approach.

In a first step, we create a greenness score for each company that is included at least once in an SFDR Article 9 fund within our sample. The greenness score is therefore defined as the percentage inclusion of a company within our sample of SFDR Article 9 funds:

$$Greenness_i = \frac{\#Times\ included\ in\ SFDR\ Article\ 9\ funds}{Total\ sample\ of\ SFDR\ Article\ 9\ funds}$$

As described in section 3.4.1, our sample of SFDR Article 9 equity funds includes funds with a global focus, as well as funds with a regional focus. Therefore, our main analyses in section 3.5.1 and 3.5.2 focus on the greenness score for global funds. In section 3.5.3 we compare the findings between global and regional equity funds.

In a second step, we estimate an OLS regression to analyze the potential drivers of the greenness score. The dependent variable is therefore the greenness score $Greenness_i$ for every stock i. The OLS regression takes the following form:

$$\begin{aligned} Greenness_i = \beta_0 + \beta_j \cdot Sustainability\ characteristics\ \&\ ratings_{ji} + \beta_k \cdot Sector_{ki} \\ + \sum \beta_l \cdot Financial\ characteristics_{li} + \sum \beta_n \cdot Region_{ni} + u_i \end{aligned}$$

The independent variables are divided into four types. The first type of variables is linked to the sustainability characteristics and ratings of the company. These variables include the GHG emissions, the climate commitments in the form of net zero or science-based targets, the social and governance indicators, as well as ESG

ratings or risk scores. The second type of variables $Sector_{ki}$ is intended to capture the business activities of companies. The third group of explanatory variables includes financial variables, such as the revenues, EBITDA ratio, and price-to-book ratio. Finally, we control for the region of the company. Table B.3 provides a description of all variables.

In section 3.5.3, we compare whether regional SFDR Article 9 funds differ from global funds in terms of holdings and drivers of the greenness score.

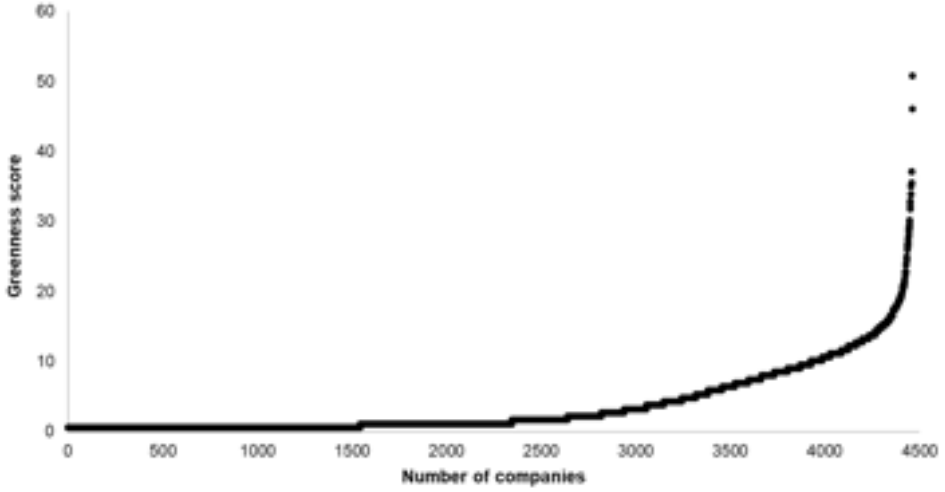
Finally, in section 3.5.4 we assess the recent wave of SFDR Article 9 fund declassifications to understand the typical characteristics and to what extent our analyses are affected when excluding these declassified funds from our sample.

3.5 Results

3.5.1 Stylized facts

Our greenness score calculation results in a sample of 4'463 companies included in 182 global equity SFDR Article 9 funds. Figure 3.3 shows the distribution in greenness score across the sample. 88.0% of the companies have a greenness score below 10 (3'926 companies), meaning that these companies are included in less than 10% of the global SFDR Article 9 funds within our sample. 10.8% of the companies within our sample have a greenness score between 10 and 20 (483 companies), 0.9% between 20 and 30 (39 companies), while 0.3% have a greenness score above 30 (15 companies). The average greenness score is 3.7, while the median lies at 1.1 due to the high number of companies being included only once in a global SFDR Article 9 fund and thus having a score of 0.55 (1'544 companies representing 34.6%). The maximum greenness score is 51.7.

FIGURE 3.3:
Distribution of the greenness score (global funds)



This figure shows the distribution of stocks' implied greenness scores for the 4'463 stocks included in the 182 global SFDR Article 9 fund sample. The x-axis represents the data point for each of the 4'463 stocks sorted in ascending order of greenness score. The y-axis shows the respective greenness score of each stock.

Looking closer at the sector distribution, Table 3.1 (and Figure B.1) shows that companies within the industrials, the financial services and TMT sectors are most represented across the entire sample, as well as the sub-samples including only companies with greenness scores above 10 and 20, respectively. The high representation of financial services companies is strongly pronounced in the sub-industry distribution, as shown in Table B.4. While banks represent the highest number of companies within our sample (5.7%), they have a low greenness score (1.9). Insurance companies, however, are less represented, but have a higher average greenness score (4.2 for life insurers and 4.4 for P&C insurers).

Within energy-related activities, our sample of SFDR Article 9 funds includes more oil & gas companies (98 representing 2.2%) than companies in the renewable energy space (72 representing 1.6%). Within the sub-samples of companies with greenness scores above 10 and 20, renewable energy is represented with 2.6% and 7.4% respectively. One reason for this low representation could lie in the small number

TABLE 3.1:
Summary statistics by sector (global funds)

Sector	Average greenness score	Min	Max	Standard deviation	# companies *(% of total sample)*	# with greenness score >10 *(% of total)*	# with greenness score >20 *(% of total)*
Consumer	3.2	0.53	27.5	4.2	588 *(13.2%)*	50 *(9.3%)*	4 *(7.4%)*
Financial Services	3.2	0.53	26.5	4.0	976 *(21.9%)*	97 *(18.1%)*	2 *(3.7%)*
Healthcare	4.0	0.53	35.4	5.6	495 *(11.1%)*	88 *(16.4%)*	8 *(14.8%)*
Industrials	3.9	0.53	50.8	5.4	1'031 *(23.1%)*	128 *(23.8%)*	18 *(33.3%)*
Oil & Gas	1.4	0.53	10.6	1.4	98 *(2.2%)*	1 *(0.2%)*	0 *(0.0%)*
Renewable Energy	6.1	0.53	46.0	8.3	72 *(1.6%)*	14 *(2.6%)*	4 *(7.4%)*
Retail	3.1	0.53	19.6	4.0	269 *(6.0%)*	27 *(5.0%)*	0 *(0.0%)*
TMT	4.2	0.53	37.0	5.3	797 *(17.9%)*	111 *(20.7%)*	15 *(27.8%)*
Utilities	4.9	0.53	33.9	6.0	137 *(3.1%)*	21 *(3.9%)*	3 *(5.6%)*
Total	**3.7**	**0.53**	**50.8**	**5.0**	**4'463 *(100%)***	**537 *(100%)***	**54 *(100%)***

This table shows the summary statistics of greenness scores by company sector for the 4'463 stocks included in the 182 global SFDR Article 9 fund sample. The first four columns show the average greenness score, the minimum greenness score within the sector, the maximum greenness score within the sector, and the standard deviation of greenness scores within the sector, respectively. The fifth column provides the number of companies represented by this sector in absolute number and as a percentage of the total of 4'463 stocks. The sixth column provides the number of companies with a greenness score above 10 in absolute and as a percentage of the total number of companies with a greenness score above 10. The seventh column provides the number of companies with a greenness score above 20 in absolute and as a percentage of the total number of companies with a greenness score above 20.

of renewable energy companies as a percentage of the total sample of companies. However, when considering the relative proportion of companies with greenness scores above 10 and 20 within the sectors (shown in Figure B.2), 19.4% of renewable energy companies have a greenness score above 10, and 5.6% above 20. Table B.4 shows that renewable energy equipment companies have the highest average greenness scores among all sub-industries (6.0).

Diving deeper into the sustainability leaders, Table B.5 shows the 20 companies with the highest greenness score. The French electrical power equipment company Schneider Electric is included in more than half of the global SFDR Article 9 funds within our sample. Industrials companies represent the largest sector followed by TMT companies. The top five companies have the highest MSCI ESG rating (AAA) and a low Sustainalytics risk category, as well as science-based net zero targets (except for Xylem). The remaining 15 companies are more diversified in terms of MSCI ESG rating, Sustainalytics risk categories and net zero targets.

In terms of ESG profiles, Table B.6 provides an overview of the distribution of MSCI

ESG rating and Sustainalytics risk categories across our sample of companies. The average greenness scores for companies with MSCI ESG ratings of AAA and AA is significantly higher than for companies with lower ratings. For Sustainalytics risk categories, the average greenness score differences are less pronounced among negligible, low and medium risk companies. This observation is confirmed by the lower correlation between the greenness scores and Sustainalytics risk scores (0.36), as compared to the higher correlation with the MSCI ESG rating (0.43).

Finally, Table B.7 shows the average greenness score by market capitalization and the overweight in mid and large cap companies. The average greenness score of large cap companies is more than double that of mid cap companies, while the greenness score distribution of small and micro cap companies is similar.

3.5.2 What drives the greenness score?

In a second step, we analyze the drivers of inclusion in SFDR Article 9 funds to determine the sustainability preferences for responsible investment approaches. We therefore assess to what extent the greenness score is affected by the companies' GHG emissions, net zero targets, other social or governance indicators, ESG scores, as well as sector classification. We perform a series of linear OLS regressions on the greenness score with different sets of control variables. The results of the different regression specifications are summarized in Table 3.2.

GHG emissions. As the absolute GHG emissions data is available for a significantly smaller number of companies within our sample, and the coefficients are comparable, we perform regression models with the GHG intensity variable (GHG emissions divided by the enterprise value). While the variable is statistically significant across all models, the coefficient is small and negative. Thus, an increase in the GHG intensity has a marginal negative effect on the greenness score.

TABLE 3.2:
Overview of regression results (global funds)

	Greenness				
	Model I	**Model II**	**Model III**	**Model IV**	**Model V**
Sustainability Characteristics & Ratings					
Decarbarbonization					
GHG Intensity	-0.07***	-0.16*	-0.11*	-0.14*	-0.09***
Net Zero Target	0.98***	0.61*	0.85***	0.33	0.78**
Science-Based Target	2.87***	2.50***	2.14***	1.48***	2.08***
Social & Governance Indicators					
Board Diversity	0.03**	-0.02	-0.01	-0.01	0.00
Human Rights Policy	1.76***	1.57***	1.27***	0.72*	2.10***
UN Global Compact	-0.14	0.09	0.39	-0.30	-0.91*
Weapon Exposure	-3.61***	-5.11***	-3.70***	-7.21***	-4.40***
ESG Ratings					
Sustainalytics Controversy Level		0.31**			
Sustainalytics Risk Score			-0.19***		
MSCI ESG				1.47***	
Bloomberg Environmental					0.65***
Bloomberg Social					-0.04
Bloomberg Governance					0.21
Sectors					
Financial Services	-0.58	0.51	-0.73	-0.57	-1.11
Healthcare	2.90***	3.53***	3.81***	2.97***	4.10***
Industrials	1.26***	1.46***	1.52***	1.31	0.70
Oil & Gas	-2.41***	-3.11***	-2.43***	-5.85***	-3.53***
Renewable Energy	8.03**	10.12**	10.60***	18.75***	6.42**
Retail	-0.49	-0.29	-0.96**	-0.57	-0.42
Technology, Media & Telecom	1.65***	1.78***	-0.80*	1.14**	1.88***
Utilities	2.03***	1.80**	2.06**	-0.61	0.49
Financial Characteristics					
Revenues	0.03***	0.02***	0.02***	0.01**	0.02***
EBITDA Ratio	0.00***	0.00***	0.00***	0.01**	0.00***
Price/Book	0.00***	0.00**	0.00*	0.00	0.00**
Other					
Region	Y	Y	Y	Y	Y
Constant	-0.15	0.83**	5.65***	-1.78**	-1.95
N	2'055	1'620	1'620	1'127	1'316
R-squared	0.1905	0.2188	0.2564	0.4184	0.2423

**p < 0.10, **p < 0.05, ***p < 0.01. The OLS regressions are performed based on robust standard errors.*

This table reports the OLS regression results of the stocks' greenness score on different inclusion drivers. The dependent variable across all regressions is the greenness score. In Model I, the explanatory variables are the decarbonization variables, such as the GHG intensity (GHG/Enterprise Value) and the climate commitments (NZT and SBT), the social and governance indicators, and the sector classifications. Furthermore, the companies' financial characteristics and region are used as control variables. In Model II, the additional explanatory variable is the Sustainalytics controversy level. In Model III, the additional explanatory variable is the Sustainalytics risk score. In Model IV, the additional explanatory variable is the MSCI ESG rating. In Model V, the additional explanatory variables are the individual Bloomberg ESG dimensions.

Climate targets. The variables related to net zero targets and science-based targets have a high statistical significance across all model specifications. Science-based targets imply net zero targets, and thus this represents a sub-set of companies with net zero targets. The economic significance of SBT_{i} is significantly larger than NZ_{i}. While the size of the coefficient varies across the model specifications between 0.3 and 1.0, the SBT_{i} coefficient is between 1.5 and 2.9. As science-based targets automatically imply net zero commitments, the sum of the two coefficients should be considered for the economic interpretation. Companies with science-based net zero targets increase their greenness score by more than two on average.

Social & governance indicators. The coefficients of the binary variables *Human rights policy*$_i$ and *Weapon exposure*$_i$ are both statistically significant across all model specifications. The existence of a human rights policy contributes to a greenness score increase of 0.7 to 2.1 on average. The coefficient related to the exposure to controversial weapons is the most negative coefficient across all variables, representing an effect of -3.6 to -7.2. *Board diversity*$_i$ is only statistically significant in Model I, but not in the other regression models when also including Sustainalytics risk measures or other ESG ratings. Furthermore, the sign is close to zero across all model specifications. The binary variable on the existence of UN Global Compact principles or OECD guidelines violations is not statistically significant across regression models, except for Model V where it is statistically significant at the 10% level. There are 312 companies with violations of the UN Global Compact principles or OECD guidelines for multinational enterprises within our sample of companies in SFDR Article 9 funds.

Sustainability ratings. In Models II-V we test various sustainability ratings. Both Sustainalytics measures, the controversy level and the risk score, and the MSCI ESG rating are statistically significant across all model specifications. While the coefficient size decreases for the Sustainalytics controversy level and the MSCI ESG

rating, as some of the effect seems to be captured by other sustainability characteristics (GHG emissions, SBT, social and governance indicators, sector classification), the coefficients of the Sustainalytics risk score remains robust when adding further variables. The MSCI ESG rating appears to be the most significant variable in terms of economic significance, as a one standard deviation increase in the MSCI ESG rating is associated with a rise of 2.2 in greenness score. This effect is significantly larger than both Sustainalytics measures. Model IV with the MSCI ESG rating also represents the model specification with the highest R-squared (0.4184). The high R-squared is in line with the finding of a high correlation between the greenness score and the MSCI ESG rating (as described in section 3.5.1). The Sustainalytics controversy level is statistically significant, but the coefficient is at 0.3. Thus, whether a company is categorized as medium or low risk increases the likelihood of inclusion into SFDR Article 9 funds by 0.3 percent. Similarly, the Sustainalytics risk score is highly statistically significant, and an increase in risk score by 1 point (the scale being between 0 and 50), reduces the greenness score by 0.2 on average. A one standard deviation increase in risk score reduces the greenness score by approximately 1 percent. This finding of a low economic significance of the Sustainalytics controversy and risk scores confirms the finding related to the UN Global Compact violations and the limited application of negative screening. Finally, when analyzing the different ESG dimensions separately using Bloomberg's environmental, social and governance scores, we find that the environmental dimension is the only statistically significant coefficient in Model V, while the social and governance dimensions are statistically insignificant.

Sector classification. The sector variable for renewable energy is consistently the coefficient with the highest economic significance, and statistically significant across all model specifications. In terms of coefficient size, the renewable energy sector is followed by the healthcare and utilities sector. In line with above stylized facts description, the financial services sector is highly represented, but companies within

this sector do not have a statistically significant higher greenness score. Companies within the oil & gas sector are the only sector that seem to have significantly lower greenness scores, which should not come as a surprise given their carbon intensity.

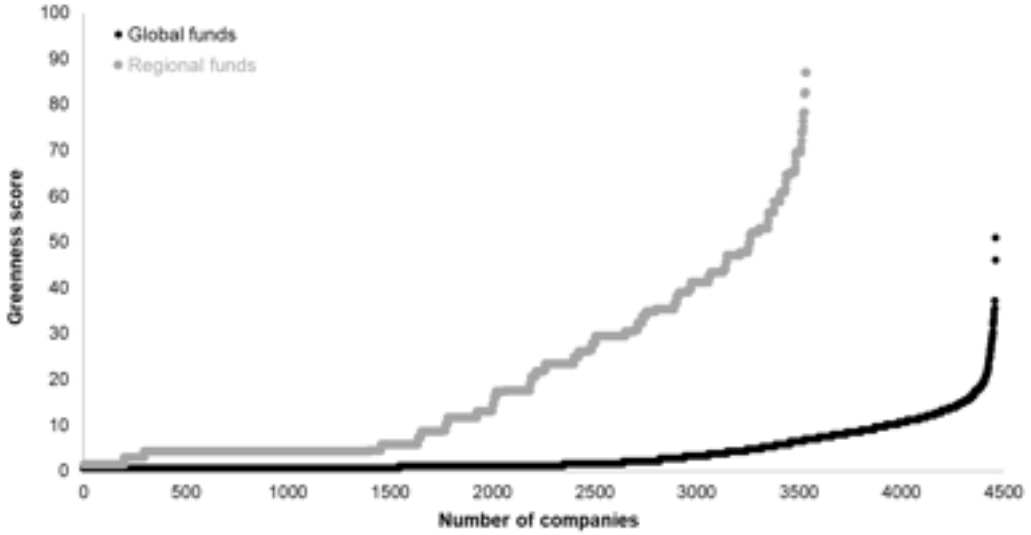
Financial characteristics. The revenue variable is statistically significant across all models and has the largest economic significance. The point estimate ranges from 0.01 to 0.05, which represents a coefficient size of 0.4 to 2.8 when multiplied by one standard deviation. This result suggests that there is a size effect, as the company size as proxied by its revenues has a positive effect on the greenness score. The EBITDA ratio and Price/Book variables are mostly statistically significant too, but consistently close to zero, and therefore economically less significant. As our regression focuses on the inclusion of a company into an SFDR Article 9 fund, rather than the portfolio weight, the financial characteristics serve as control variables.

3.5.3 Is there a difference between global and regional funds?

Tables B.8-B.9 provide summary statistics for the greenness score of regional funds. The total number of companies included in our sample of regional SFDR Article 9 funds is 3'534, which is lower than in our sample of global funds (4'463 companies). The distribution is also significantly different. 50.1% of the companies have a greenness score below 10 (88.0% for global funds), 11.8% between 10 and 20 (10.8% for global funds), 13.0% between 20 and 30 (0.9% for global funds), while 25.0% have a greenness score above 30 (0.3% for global funds). The average greenness score is 18.8 (3.7 for global funds), while the median lies at 8.8 (1.1 for global funds). The maximum greenness score is 87.0 (51.7 for global funds). Thus, the greenness scores for regional funds are significantly higher than for global funds, as shown by the distribution (Figure 3.4).

Table 3.3 shows the summary statistics by sector for regional SFDR Article 9 funds. In contrast to global funds, companies in the renewable energy sector do not have

FIGURE 3.4:
Distribution of the greenness score for global vs. regional funds



This figure compares the distribution of stocks' implied greenness scores for the 4'463 stocks included in the 182 global SFDR Article 9 fund sample and the 3'534 in the 108 regional SFDR Article 9 funds. The x-axis represents the data point for each stock sorted in ascending order of greenness score. The y-axis shows the respective greenness score of each stock.

the highest average greenness score in regional funds. The TMT (21.0), financial services (20.3), retail (19.9), healthcare (19.6) and consumer (18.5) sectors have higher average greenness scores than the renewable energy sector (16.8). While financial services companies are the most represented sector in the total sample of global and regional funds, they are also the most frequently represented companies in the sub-sample of greenness scores above 10 and 20 of regional funds. Furthermore, when looking at carbon-intensive companies, 14 companies within the oil & gas sector have a greenness score above 10 within regional funds (as opposed to one in global funds).

In order to test whether there are any differences in inclusion drivers between global and regional SFDR Article 9 funds, we run the same regressions (Model I-V) using the regional greenness score as dependent variable. The results are shown in Table 3.4.

TABLE 3.3:
Summary statistics by sector for global and regional funds

Sector	Regional funds				Global funds			
	Average greenness score	# companies *(% of total sample)*	# with greenness score >10 *(% of total)*	# with greenness score >20 *(% of total)*	Average greenness score	# companies *(% of total sample)*	# with greenness score >10 *(% of total)*	# with greenness score >20 *(% of total)*
Consumer	18.5	462 *(13.1%)*	237 *(13.4%)*	175 *(13.0%)*	3.2	588 *(13.2%)*	50 *(9.3%)*	4 *(7.4%)*
Financial Services	20.3	769 *(21.8%)*	400 *(22.7%)*	335 *(24.9%)*	3.2	976 *(21.9%)*	97 *(18.1%)*	2 *(3.7%)*
Healthcare	19.6	436 *(12.3%)*	193 *(10.9%)*	166 *(12.3%)*	4.0	495 *(11.1%)*	88 *(16.4%)*	8 *(14.8%)*
Industrials	16.4	772 *(21.8%)*	367 *(20.8%)*	252 *(18.7%)*	3.9	1'031 *(23.1%)*	128 *(23.8%)*	18 *(33.3%)*
Oil & Gas	6.8	68 *(1.9%)*	14 *(0.8%)*	1 *(0.1%)*	1.4	98 *(2.2%)*	1 *(0.2%)*	0 *(0.0%)*
Renewable Energy	16.8	65 *(1.8%)*	28 *(1.6%)*	19 *(1.4%)*	6.1	72 *(1.6%)*	14 *(2.6%)*	4 *(7.4%)*
Retail	19.9	202 *(5.7%)*	107 *(6.1%)*	84 *(6.2%)*	3.1	269 *(6.0%)*	27 *(5.0%)*	0 *(0.0%)*
TMT	21.0	651 *(18.4%)*	359 *(20.4%)*	275 *(20.4%)*	4.2	797 *(17.9%)*	111 *(20.7%)*	15 *(27.8%)*
Utilities	17.1	109 *(3.1%)*	59 *(3.3%)*	39 *(2.9%)*	4.9	137 *(3.1%)*	21 *(3.9%)*	3 *(5.6%)*
Total	**18.8**	**3'534** ***(100%)***	**1'764** ***(100%)***	**1'346** ***(100%)***	**3.7**	**4'463** ***(100%)***	**537** ***(100%)***	**54** ***(100%)***

This table compares the summary statistics of greenness scores by company sector for the stocks included in the 182 global funds and the stocks in the 108 regional funds. The first four column shows the average greenness score. The second column provides the number of companies represented by this sector in absolute number and as a percentage of the total of number of stocks. The third column provides the number of companies with a greenness score above 10 in absolute and as a percentage of the total number of companies with a greenness score above 10. The fourth column provides the number of companies with a greenness score above 20 in absolute and as a percentage of the total number of companies with a greenness score above 20.

In terms of statistical significance, the regression results for all sustainability characteristics and ratings are similar across global and regional funds, as shown in Table 3.4. However, there are large differences in the statistical significance of sector variables. While the coefficient for the renewable energy sector is highly statistically significant across all models for the global funds sample, the variable is only statistically significant in Models IV and V for regional funds. The coefficients of the healthcare and the oil & gas sector are statistically significant across all regressions, whereas the coefficients of the technology, media and telecom sector, as well as the utilities sector are statistically significant in some model specifications. These sector variables are thus less statistically significant for regional funds than for global funds and confirm the observation from Table 3.3 on the differences in sector exposures.

In terms of economic significance, one can notice at first sight that the magnitude of most coefficients appears to be significantly higher for regional funds than for global funds, which might be due to the higher average greenness scores for regional funds. However, the coefficient dispersion across models is larger, in line with the lower statistical significance and robustness of some variables for regional funds. When

TABLE 3.4:
Comparison of regression results for global vs. regional funds

	Greenness									
	Model I		**Model II**		**Model III**		**Model IV**		**Model V**	
	Global	Regional	Global	Regional	Global	Regional	Global	Regional	Global	Regional
Sustainability Characteristics & Ratings										
Decarbarbonization										
GHG Intensity	-0.07***	-0.42**	-0.16*	-0.82***	-0.11*	-0.65***	-0.14*	-0.68**	-0.09***	-0.69***
Net Zero Target	0.98***	4.23***	0.61*	3.11**	0.85***	4.02***	0.33	1.25	0.78**	3.40**
Science-Based Target	2.87***	7.60***	2.50***	5.22***	2.14***	4.96***	1.48**	1.78	2.08***	5.27***
Social & Governance Indicators										
Board Diversity	0.03**	0.08*	-0.02	0.04	-0.01	-0.02	-0.01	-0.00	0.00	0.05
Human Rights Policy	1.76***	6.24***	1.57***	4.37**	1.27***	3.78**	0.72*	0.96	2.10***	7.05***
UN Global Compact	-0.14	0.44	0.09	1.90	0.39	2.47	-0.30	-0.94	-0.91*	-1.62
Weapon Exposure	-3.61***	-10.92***	-5.11***	-17.66***	-3.70***	-12.45***	-7.21***	-21.53***	-4.40***	-12.82***
ESG Ratings										
Sustainalytics Controversy Level			0.31**	2.06***						
Sustainalytics Risk Score					-0.19***	-0.49***				
MSCI ESG							1.47***	4.29***		
Bloomberg Environmental									0.65***	2.05***
Bloomberg Social									-0.04	-0.03
Bloomberg Governance									0.21	-0.27
Sectors										
Financial services	-0.58	5.65**	0.51	5.81**	-0.73	2.40	-0.57	-0.56	-1.11	-5.20
Healthcare	2.90***	9.27***	3.53***	12.48***	3.81***	12.86***	2.97***	9.62***	4.10***	11.82***
Industrials	1.26***	0.07	1.46***	1.12	1.52***	0.77	1.31	-2.15	0.70	-2.24
Oil & Gas	-2.41***	-11.08***	-3.11***	-14.32***	-2.43***	-12.72***	-5.85***	-24.44***	-3.53***	-14.48***
Renewable Energy	8.03***	-2.29	10.12**	-1.74	10.60***	-0.99	18.75***	13.23***	6.42**	-17.85***
Retail	-0.49	-1.70	-0.29	-0.43	-0.96**	-2.40	-0.57	-3.41	-0.42	3.80
Tech., Media & Telecom	1.65***	4.64***	1.78***	6.12***	-0.80*	3.07*	1.14**	2.50	1.88***	4.63**
Utilities	2.03***	-0.85	1.80**	-0.96	2.06**	-1.21	-0.61	-11.57***	0.49	-7.06***
Financial Characteristics										
Revenues	0.03***	0.10***	0.02***	0.05**	0.02***	0.07***	0.01**	0.03**	0.02***	0.06***
EBITDA ratio	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.01**	0.05**	0.00***	0.00***
Price/Book	0.00***	0.02**	0.00**	0.01**	0.00*	0.01*	0.00	0.01*	0.00**	0.01***
Other										
Region	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-0.15	2.69	0.83**	6.07**	5.65***	19.94***	-1.78**	-4.89	-1.95	1.79
N	2'055	1'619	1'620	1'254	1'620	1'254	1'127	941	1'316	1'087
R-squared	0.1905	0.2114	0.2188	0.1878	0.2564	0.2033	0.4184	0.2694	0.2423	0.2595

**p < 0.10, **p < 0.05, ***p < 0.01. The OLS regressions are performed based on robust standard errors.*

This table reports the OLS regression results of the stocks' greenness score on different inclusion drivers and compares the results for global and regional SFDR Article 9 funds. The dependent variable across all regressions is the greenness score. In Model I, the explanatory variables are the decarbonization variables, such as the GHG intensity (GHG/Enterprise Value) and the climate commitments (NZT and SBT), the social and governance indicators, and the sector classifications. Furthermore, the companies' financial characteristics and region are used as control variables. In Model II, the additional explanatory variable is the Sustainalytics controversy level. In Model III, the additional explanatory variable is the Sustainalytics risk score. In Model IV, the additional explanatory variable is the MSCI ESG rating. In Model V, the additional explanatory variables are the individual Bloomberg ESG dimensions.

comparing the distribution across variables, some variables stand out as being more relevant for regional funds than for global funds. The coefficient size for climate related variables, such as the GHG intensity, the net zero and science-based targets are significantly larger for regional funds, as well as Bloomberg's environmental rating. The MSCI ESG rating coefficient is also larger, while the coefficient size of some sustainability ratings, such as the Sustainalytics risk score, remains unchanged and close to zero. The variables related to controversies, such as human rights, weapon exposure, Sustainalytics controversy level or the oil & gas sector, show significantly larger coefficient sizes for regional funds. The regression results for the sector variables show the largest differences between global and regional funds. The healthcare sector coefficient is significantly more positive for regional funds. The renewable energy sector, however, is negative across all models except for Model IV. Thus, renewable energy companies are less frequently included in regional funds than in global funds.

3.5.4 The great declassification

Since Q4 2022, there has been a wave of fund declassifications. Morningstar (2023) highlights that over 40% of SFDR Article 9 funds have been reclassified to SFDR Article 8 by end of January 2023. For this reason, we update the SFDR fund information of our sample as of 1 December 2023, and provide summary statistics, as well as regression results based on this modified data set as of 1 December 2023.

Declassified fund characteristics. 143 funds were declassified from SFDR Article 9 to Article 8 among our sample of 290 funds. This corresponds to 49.3%, which is in line with the market description of Morningstar (2023).[16] Table 3.5 shows the breakdown of declassifications by regional focus. 35.7% of global funds were

[16] As of 1 February 2023, 40.7% of our sample declassified from SFDR Article 9 to Article 8. Between February 2023 and December 2023 an additional 25 funds declassified bringing the total declassified funds to 143 as of 1 December 2023.

TABLE 3.5:
SFDR Article 9 fund declassifications in our sample

	ESG / SRI		Climate transition		Thematic / Impact		Overall sample	
	Total	Declass.	Total	Declass.	Total	Declass.	Total	Declass.
Global	41	20 *(48.8%)*	12	8 *(66.7%)*	129	34 *(26.4%)*	182	65 *(35.7%)*
Europe	46	29 *(63.0%)*	14	14 *(100.0%)*	8	5 *(62.5%)*	68	48 *(70.6%)*
USA	17	13 *(76.5%)*	2	2 *(100.0%)*	4	3 *(75.0%)*	23	18 *(78.3%)*
Emerging Markets	14	12 *(85.7%)*	2	2 *(100.0%)*	1	0 *(0.0%)*	17	12 *(70.6%)*
Total	118	72 *(61.0%)*	30	26 *(86.7%)*	142	42 *(29.6%)*	290	143 *(49.3%)*

This table provides an overview of all funds that changed SFDR disclosure from Article 9 to Article 8 between 30 September 2022 and 1 December 2023. The overview is split by regions and investment strategy. Per investment strategy, we show the total number of funds for each regional or global focus and the number of funds that were reclassified, as an absolute number and a percentage of the total share of funds within this investment strategy and region.

declassified, while the share of declassifications for regional funds is above 70%. In terms of fund strategies, 61.0% of ESG/SRI funds and 86.7% of climate transition funds were declassified.

Differences in greenness score. Figure B.3 compares the distribution of all global funds with the reduced sample excluding declassified funds. The average greenness score falls from 3.7 to 2.8 when excluding the declassified funds, as does the standard deviation from 5.0 to 3.9. There are 1'920 companies that have a greenness score of zero when excluding declassified SFDR Article 9 funds, which means that these companies were only included in funds that have been declassified to SFDR Article 8 as of December 2023. Out of these excluded companies, 67.0% (1'287 companies) had a greenness score of 0.55 (i.e. included only once in a global fund). 27.6% of the companies were included more than once and had a greenness score between 0 and 5, while 5.4% had a greenness score above 5, with the highest greenness score being 10.99.

TABLE 3.6:
Comparison of regression results for all global vs. global excluding declassified funds

	Greenness									
	Model I		**Model II**		**Model III**		**Model IV**		**Model V**	
	All global	ex. declassified	All global	ex. declassified	All global	ex. declassified	All global	ex. declassified	All global	ex. declassified
Sustainability Characteristics & Ratings										
Decarbarbonization										
GHG Intensity	-0.07***	-0.06***	-0.16*	-0.02	-0.11*	-0.07	-0.14*	-0.11**	-0.09***	-0.06***
Net Zero Target	0.98***	0.59**	0.61*	0.53	0.85***	0.59*	0.33	0.35	0.78**	0.56
Science-Based Target	2.87***	1.28***	2.50***	1.15***	2.14***	0.97***	1.48**	0.84*	2.08***	0.99**
Social & Governance Indicators										
Board Diversity	0.03**	0.00	-0.02	-0.00	-0.01	-0.01	-0.01	-0.02	0.00	-0.02
Human Rights Policy	1.76***	1.20***	1.57***	1.44***	1.27***	1.25***	0.72*	0.97***	2.10***	1.29***
UN Global Compact	-0.14	0.39	0.09	0.48	0.39	0.50	-0.30	-0.11	-0.91*	-0.27
Weapon Exposure	-3.61***	-	-5.11***	-	-3.70***	-2.23***	-7.21***	-	-4.40***	-
ESG Ratings										
Sustainalytics Controversy Level			0.31**	-0.02						
Sustainalytics Risk Score					-0.19***	-0.10***				
MSCI ESG							1.47***	0.73***		
Bloomberg Environmental									0.65***	0.26***
Bloomberg Social									-0.04	0.03
Bloomberg Governance									0.21	0.12
Sectors										
Financial Services	-0.58	-0.72**	0.51	-1.10***	-0.73	-1.50***	-0.57	-1.25***	-1.11	-0.30
Healthcare	2.90***	1.40***	3.53***	1.38***	3.81***	1.61***	2.97***	1.37***	4.10***	1.65***
Industrials	1.26***	1.55***	1.46***	1.61***	1.52***	1. 68***	1.31	1.68***	0.70	1.50***
Oil & Gas	-2.41***	-1.86***	-3.11***	-1.92***	-2.43***	-1.54***	-5.85***	-2.05***	-3.53***	-2.35***
Renewable Energy	8.03***	8.58***	10.12**	11.54***	10.60***	11.87***	18.75***	19.28**	6.42**	10.07***
Retail	-0.49	-0.66*	-0.29	-0.79**	-0.96**	-1.03***	-0.57	-0.88**	-0.42	-0.85*
Tech., Media & Telecom	1.65***	0.84**	1.78***	0.72*	-0.80*	0.37	1.14**	0.77	1.88***	0.97*
Utilities	2.03***	2.57***	1.80**	2.26***	2.06**	2.58***	-0.61	2.05*	0.49	1.58*
Financial characteristics										
Revenues	0.03***	0.00	0.02***	0.00	0.02***	0.00	0.01**	0.00	0.02***	0.00
EBITDA ratio	0.00***	0.01***	0.00***	0.02***	0.00***	0.01**	0.01**	0.01*	0.00***	0.01**
Price/Book	0.00***	0.00*	0.00**	0.00	0.00*	0.00	0.00	0.00	0.00**	0.00*
Other										
Region	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-0.15	0.85	0.83**	0.95	5.65***	3.35***	-1.78**	-1.11	-1.95	0.16
N	2'055	1'243	1'620	1'104	1'620	1'104	1'127	898	1'316	874
R-squared	0.1905	0.1529	0.2188	0.1764	0.2564	0.1925	0.4184	0.2263	0.2423	0.1468

**p < 0.10, **p < 0.05, ***p < 0.01. The OLS regressions are performed based on robust standard errors.*

This table reports the OLS regression results of the stocks' greenness score on different inclusion drivers and compares the results for all 182 global SFDR Article 9 funds and the 117 global SFDR Article 9 funds that did not declassify as of 1 December 2023. The dependent variable across all regressions is the greenness score. In Model I, the explanatory variables are the decarbonization variables, such as the GHG intensity (GHG/Enterprise Value) and the climate commitments (NZT and SBT), the social and governance indicators, and the sector classifications. Furthermore, the companies' financial characteristics and region are used as control variables. In Model II, the additional explanatory variable is the Sustainalytics controversy level. In Model III, the additional explanatory variable is the Sustainalytics risk score. In Model IV, the additional explanatory variable is the MSCI ESG rating. In Model V, the additional explanatory variables are the individual Bloomberg ESG dimensions.

In terms of sector classification, 24.5% of the excluded companies were in the financial services sector, 21.3% in the industrials and 16.7% in the technology, media and telecom sector. 4.3% were within the oil & gas sector. Finally, 144 companies with violations of the UN Global Compact principles or OECD guidelines for multinational enterprises (out of a total of 312 in our sample) have a greenness score of zero after excluding the declassified funds.

Regression coefficients. We run the same regression models as in section 3.5.2 for the greenness score of global funds but excluding the declassified funds. The results are shown in Table 3.6. The coefficient for science-based targets is significantly reduced. Furthermore, we find that the variables for board diversity and controversy level are no longer statistically significant. Model IV has a significantly lower R-squared when excluding declassified funds, suggesting that the relevance of the MSCI ESG rating is less pronounced for the funds that remained as SFDR Article 9. Finally, we find that the renewable energy sector is the only coefficient that increases in economic significance. Our findings indicate that the residual sample of SFDR Article 9 funds places greater emphasis on both business activity and the environmental impact of companies compared to the declassified funds. The latter appear to prioritize ESG ratings and corporate sustainability initiatives, which might explain the change in their fund disclosure to SFDR Article 8.

3.5.5 Robustness and limitations

We carry out robustness checks to address potential concerns regarding the company type and size effect, and discuss concerns related to excluded companies and sample bias.

Company type and size effect. Figure 3.3 shows the distribution of the greenness score across our sample of companies. 34.6% of the companies are included only once in our sample of global SFDR Article 9 funds. As these companies' inclusion

might have different drivers than for companies that are included more than once, we run the regression models for our company sample excluding the companies that appear only in one SFDR Article 9 fund. The results are shown in Table B.10. The statistical significance of the variables remains robust in this setting. Some variables have marginally smaller coefficients. Additionally, we run the regression models for the sample of companies that have a greenness score above 10. The results are shown in Table B.11. The net zero variable as well as the science-based target variable are no longer statistically significant. This indicates that for companies that have a greenness score above 10 climate targets do not contribute to a significantly higher greenness score anymore. Furthermore, the indicator for weapon exposure is omitted and the Sustainalytics controversy level variable is no longer statistically significant. The variable capturing the violations of the UN Global Compact principles or OECD guidelines for multinational enterprises remains statistically insignificant. The MSCI ESG rating remains highly statistically significant but has a lower coefficient size and the R-squared falls from 0.41 to 0.16. Furthermore, the Bloomberg environmental rating is statistically insignificant.

Excluded companies. Our sample of companies for the greenness score is limited to companies that have been included at least once in a SFDR Article 9 fund within our sample. The universe of companies in SFDR Article 9 funds could potentially be significantly better than the entire universe of listed companies (i.e. including companies that are not included in any SFDR Article 9 fund). However, our analysis focuses on the drivers of the greenness score, and therefore the factors increasing the frequency of inclusion. We argue that including all listed companies would distort the regression analysis, as we would include many companies with a greenness score of zero. Furthermore, this setting would be more suited for the analysis of what drives the binary inclusion of companies into SFDR Article 9 funds.

Sample bias. Our sample of funds includes 290 SFDR Article 9 public equity funds. and therefore represents approximately 40% of the SFDR Article 9 equity market.

We show in section 3.4.1 that our sample has similar characteristics with the general SFDR Article 9 market as described in industry reports (e.g. Morningstar (2022)). Furthermore, as shown in section 3.5.4, 40.7% of our sample of SFDR Article 9 funds has been declassified to SFDR Article 8 as of 1 February 2023. This is in line with Morningstar (2023) highlighting that over 40% of SFDR Article 9 funds reclassified. Thus, our sample of SFDR Article 9 funds can be considered as representative of the general SFDR Article 9 equity fund market and not influenced by selection bias.

3.6 Discussion

The findings of our paper provide discussion points and implications for the sustainable investing market. We are aware that at the time of data collection, the SFDR is still in its early phase and to a certain degree not finalized. There is some level of uncertainty on the criteria to disclose a financial product as SFDR Article 9. Nevertheless, our research provides important insights into fund managers' sustainability preferences and stocks' inclusion frequency based on sustainability disclosure, which should be taken into consideration and addressed by financial market participants.

Our paper makes two contributions to the sustainable finance literature. First, our paper is the first paper assessing the sustainability preferences and implied greenness of stocks based on regulatory disclosure. The SFDR is the first regulation providing official sustainability information for financial products. As opposed to ESG labels in fund names, the SFDR should in principle allow for a higher level of comparability across financial products and prevent greenwashing. While the SFDR is a European regulation, the implementation and implications of sustainability disclosure are a highly relevant topic outside the European Union, as many markets develop their sustainability disclosure regulation. Our paper provides the first empirical analysis using SFDR Article 9 funds to provide insights into company-level characteristics driving inclusion frequency. While most of the literature focuses on

the fund perspective and therefore assesses fund characteristics to understand the level of ESG integration within funds, we take the company-perspective and analyze the characteristics that drive companies' inclusion frequency in sustainable funds. Furthermore, our greenness score represents a novel measure of the market's implied perception of a firm's sustainability profile based on the legal definition of the SFDR, and thus avoids the disadvantages and lack of legal obligation of ESG ratings or ESG labels. Our research therefore contributes to the understanding of market participants' decision-making process in the sustainable investing space. Our results highlight that the inclusion frequency of a company is significantly driven by its sector exposure, climate targets and CSR efforts, such as human rights policies or ESG ratings. The consistently statistically significant company revenue coefficient indicates a size bias. Net zero targets have a higher statistical significance than GHG intensity levels. Furthermore, the non-statistical significance of violations of the UN Global Compact principles or OECD guidelines for multinational enterprises shows limitations in fund managers' screening and exclusion approaches.

Second, our paper assesses differences in sustainable fund types and strategies based on company-level characteristics. We highlight different sustainability coefficients and sector exposures between global and regional funds. This findings suggests that regional funds have different sustainability preferences driven more by the ESG integration approach and less by thematic or impact investment approaches, potentially due to investment universe and diversification considerations. From an SFDR perspective, regional funds might therefore have a lower share of 'sustainable investments'. Based on these findings our paper offers potential explanations for regulatory disclosure decisions, especially SFDR Article 9 fund declassifications.

Intuitively, from the interpretation of the regulation, one would expect SFDR Article 8 funds to combine screening approaches and ESG integration, while SFDR Article 9 funds would additionally also incorporate sustainability-themed or impact investing approaches, as described in section 3.3.2. Our results provide mixed evidence

for this implementation. While some variables related to controversial activities, such as human rights policy, weapon exposure and the Sustainalytics controversy level are statistically and economically significant, we find that violations of the UN Global Compact principles or OECD guidelines for multinational enterprises have no statistical effect on the greenness score. This finding raises doubts on the application of the negative or norms-based screening approaches, which is referred to as the 'do no significant harm' principle of the SFDR. Furthermore, we observe that the renewable energy sector, which benefits from a wide consensus on its positive environmental impact and can thus be used as a simple proxy for 'sustainable investment', is a statistically and economically significant driver for inclusion into SFDR Article 9 funds. However, this result applies to global funds, but less to regional funds. Our results suggest that regional SFDR Article 9 funds show different sector exposures than global funds. When considering the renewable energy sector, we find that in regional funds renewable energy companies have a lower average greenness score than other sectors. The science-based net zero targets and sustainability ratings, however, have a larger economic significance in driving the greenness score for regional funds. As shown in Table B.2, the share of ESG/SRI and climate transition funds is higher for regional funds, while global funds have a higher share of thematic and impact funds. One reason for this divergence in approaches might be the investable universe. A regional fund, focused on Europe for example, has a smaller number of companies within the renewable energy sector that it can invest in. However, despite this argument and the potential problem of portfolio diversification, it is surprising to see these large differences in sector exposures and sector coefficients in the regression models between regional and global funds.

Our results show that ESG ratings have a statistically significant effect on a company's greenness score. The effect is especially pronounced for the MSCI ESG rating, which has a correlation of 0.43 with the greenness score. This result confirms previous findings that the MSCI ESG rating is the most widely used ESG rating

(Berg, Heeb, and Kölbel, 2022). While ESG ratings are a measure of a company's efforts on improving the sustainability of its operations, they are not indicators of the positive environmental or social impact of a company and its products or services (i.e. impact materiality). On the contrary, MSCI ESG ratings measure the potential impact of ESG factors on the company and its shareholders (i.e. financial materiality). Furthermore, there is a significant positive correlation between ESG ratings and firm size, which can be explained by a company's available resources for providing ESG data and organizational legitimacy (Drempetic, Klein, and Zwergel, 2020). At the time of the data collection, the EU Taxonomy is not yet finalized, as the remaining environmental objectives of the Green Taxonomy and the Social Taxonomy need to be published. It can be argued that fund managers rely more heavily on ESG ratings due to the unfinalized EU Taxonomy and the absence of companies reporting on their revenue alignment. As the data becomes available over the next years, the correlation of the EU Taxonomy alignment and the greenness score will need to be assessed and compared to the ESG ratings. The findings of Bassen et al. (2022) indicate a possible reallocation of capital by investors based on EU Taxonomy alignment, instead of ESG ratings.

Our findings show that science-based net zero targets have a significant statistical and economic effect on a company's greenness score. While existing research shows the importance of climate disclosure for investors' sustainability preferences (Krueger, Sautner, and Starks, 2020; Raghunandan and Rajgopal, 2022), our paper highlights the importance of climate targets. This is in line with increased corporate climate commitments in recent years with the aim to transition to a low-carbon economy by 2050. Table B.2 shows that our sample of SFDR Article 9 funds includes 30 climate transition funds (12 global and 18 regional). A fundamental question to ask in this context is, however, whether a company should be seen as a 'sustainable investment' upon committing to net zero carbon emissions by 2050. Our

results show that the fact that these targets are verified by the SBTi has a significant statistical and economic effect. Fund managers seem to value science-based targets despite the criticism of recent years (Bolton and Kacperczyk, 2021b). The inclusion of these companies into SFDR Article 9 funds is therefore forward-looking and based on efforts for future improvement, as opposed to the existing sustainability profile. Additionally, companies with activities that currently have a negative environmental or social impact can commit to science-based net zero targets and thus increase their inclusion frequency in SFDR Article 9 funds, as they are seen as 'transitioning' investments. This could explain the high number of companies with violations of the UN Global Compact principles or OECD guidelines for multinational enterprises, and the fact that the variable is not statistically significant. A prominent finding is the high share of financial services company, and the fact that they represent the largest number of companies with a greenness score above 10 and 20 in regional funds. While companies in the financial services sector typically have low carbon emissions, there is some skepticism on classifying these companies as 'sustainable investments', especially given the high volume of financed emissions of some banking institutions or their financing of controversial companies. As shown in section 3.5.4, 87% of climate transition funds within our sample have been declassified to SFDR Article 8 as of 1 December 2023. The reasons for the declassifications can be manifold and potentially driven by the inclusion of companies breaching the 'do no significant harm' principle, and thus highlight the ambiguity of including 'transitioning' companies.

One of the objectives of the EU Action Plan is to reorient capital flows towards sustainable investment, and the SFDR serves the purpose of increasing sustainability transparency of financial products and preventing greenwashing due to the sustainability disclosure of funds. Industry reports, such as Morningstar (2022), highlight the high overlap between SFDR Article 8 and 9 funds. While we focus entirely on SFDR Article 9 funds and do not compare the holdings or greenness scores with

SFDR Article 8 funds, our results raise doubts on the adherence with the SFDR's legal definition and the principles of 'do no significant harm' and 'sustainable investments'. While the process description might be aligned with the SFDR definition, our results suggest that the implementation with a strong focus on ESG ratings seems to be more process-oriented and less outcome-focused, as shown by the low share of 'sustainable investments' (Morningstar, 2022). The investment and sustainability processes appear to be designed to maintain a broad investable universe, allowing for flexibility in the inclusion of companies from sectors that may not inherently contribute to positive environmental or social impacts. This includes sectors like financial services and, in some instances, even controversial sectors such as oil & gas and the weapons industry.

3.7 Further research

Given the novelty of sustainability regulation, such as the SFDR, and our focus on public equity funds, our paper offers a multitude of future research opportunities. First, as soon as the EU Taxonomy (Green Taxonomy and Social Taxonomy) is finalized, future research could analyze the EU Taxonomy alignment of companies' revenues within SFDR Article 9 funds in order to understand the activity threshold required for inclusion by financial market participants. Second, SFDR Article 9 funds of other asset classes, such as public fixed income or private market funds should be evaluated to compare the market dynamics across different market segments. Third, SFDR Article 8 and 9 funds should be compared in terms of inclusion criteria and exposures, as well as different responsible investment approaches applied by fund managers. Fourth, the flows of sustainable funds have also become an essential indicator for CFOs and investor relation departments. From a corporate finance and strategy perspective, it would therefore be interesting to analyze how corporate behavior of companies shift in order to increase public market investor

flows into sustainable funds. Finally, as more SFDR Article 9 funds are declassified, the fund holdings of funds that maintain their disclosure should be compared with funds that are declassified.

Chapter 4

Who pays for sustainability?

An analysis of sustainability-linked bonds

Joint with Julian Kölbel[1]

We examine the novel phenomenon of sustainability-linked bonds (SLBs). These bonds' coupon is contingent on the issuer achieving a predetermined sustainability performance target. We estimate the yield differential between SLBs and non-sustainable counterfactuals by matching bonds from the same issuer. Our results suggest that there was a statistically significant sustainability premium compared to conventional bonds until mid-2022, but this premium decreased over time. Furthermore, we find that a proportion of SLB issuers benefit from a 'free lunch', i.e. financial savings higher than the potential penalty. Finally, we show that the yield differential does not seem to be driven by an incentive mechanism, as there is no empirical relationship between the yield at issue and the coupon step-up.

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4.1 Introduction

As companies worldwide pledge to achieve net-zero emissions and other sustainability targets, a fundamental question arises: who pays for this shift to sustainability? A recent development in the field of corporate finance is the issuance of sustainability-linked bonds (SLBs).[2] The key characteristic of SLBs is that the coupon rate is contingent on the issuer's achievement of a sustainability performance objective. This sustainability performance target and the associated coupon step-up or step-down are contractually agreed upon in the bond prospectus. For example, in November 2020, the European cement company Holcim Group issued a EUR 850 million SLB with a coupon of 50 basis points (bps) maturing in 2031. This coupon will increase by 75 bps if the company fails to achieve its sustainability target of 475 kg net CO_2 per ton of cementitious material by 2030 (Holcim, 2020).

SLBs emerged as a major sustainable capital financing instrument for corporations. The first SLB was issued in December 2018. Since then, the value of outstanding SLBs has grown to over USD 200 billion in 2023. SLBs are distinct from green bonds, which have been studied in the literature. Green bonds have a 'use of proceeds' clause stating that the financing will be used for green corporate investments. SLBs do not determine the use of proceeds, the financing can be used for general corporate purposes. Instead, they create a financial incentive for issuers to achieve the specified sustainability performance target.

In this paper, we try to understand who pays for the sustainability improvement when an SLB is issued. To address this question, we analyze how SLBs are priced at issue in comparison to their non-sustainable counterpart and investigate how the sustainability target agreement affects the issuance price. A priori, one might expect that investors use SLBs to incentivize issuers to improve their sustainability

[2]SLBs are publicly listed bonds. There also exist sustainability-linked loans (SLLs) which are mostly non-listed loans provided by banks or other financial institutions. While the mechanism is identical for SLLs, the market dynamics and implications may vary.

performance. In this case, an SLB that specifies a coupon step-up for failing to reach the sustainability target should have a lower yield at issue compared to a conventional bond. However, it is also possible that companies use SLBs to signal that they are committed to reaching a sustainability target. In this case, an SLB with a coupon step-up could trade in line with conventional bonds.

Our paper addresses this question empirically in a three-step approach. First, we analyze whether SLBs are priced at a premium compared to non-sustainable counterfactual bonds. To this end, we match SLBs to a counterfactual bond from the same issuer and with the same seniority, maturity type, coupon type, and currency. We match to the bond with the closest issue date, bond maturity, and issue size. This matching results in 238 bond pairs, relying on all SLBs issued up until May 2023. Second, we perform a cost-benefit analysis from the perspective of the issuer, comparing the savings at issue to the potential penalty that firms pay in the event of failing to reach the sustainability performance targets. Third, we investigate which factors drive the magnitude of the yield differential at issue.

We obtain three main findings. First, we provide evidence that there was a statistically significant sustainability premium at issue for SLBs until mid-2022. However, we find that the economic and statistical significance of the premium varies over time: while the premium was statistically significant for SLB issues in 2021, the premium decreased since mid-2022. This may be due to the more volatile market environment in the aftermath of the Ukraine invasion and rising inflation and interest rates, or due to the SLB market maturing.

Second, our cost-benefit analysis suggests that over 40% of SLB issuers in our sample benefit from a 'free lunch'. For these SLBs, the financial savings at issue from the sustainability premium are larger than the maximum potential penalty they would face if they failed on all their sustainability performance targets. Thus, for some

companies, the issue of an SLB can be an arbitrage opportunity, instead of an incentive mechanism to improve their sustainability performance.

Third, we find that the magnitude of the potential penalty is not a driver of the SLB premium at issue, as there is no statistically significant relationship between the time-weighted coupon step-up and the yield differential. This suggests that the incentive mechanism does not seem to be a driver of the yield differential. Other factors, such as the issuer's ESG profile and the nature of the target, have no significant effect either.

Our interpretation is that SLBs serve as a signaling device for issuers. SLBs allow issuers to signal a commitment to achieving a certain sustainability target. This signal is costly since firms need to either bear the cost of realizing the target or pay a penalty when they do not reach the target. How costly (and thus credible) the signal is difficult to determine for outsiders due to information asymmetry on the cost of achieving the sustainability target. Nonetheless, an SLB target is more credible than a mere pledge to pursue a sustainability target, because it is contractually specified, includes a penalty, and invites scrutiny from outsiders. We believe it is this qualitative signal, rather than the details of the financial structure, that generates demand from ESG investors for SLBs. However, for arbitrage opportunities seem to exist some companies due to the presence of a 'free lunch'. Yet, it is crucial to acknowledge the potential risk of reputational loss should they fall short of sustainability performance targets in the future.

Our findings have important implications for the SLB market. First, issuers can in some cases benefit from a lower cost of capital by issuing SLBs. It is unclear whether this premium will exist in the future, given the market dynamics observed since 2022. Second, given that the average penalty associated with failing to reach a target is relatively small and in many cases smaller than the savings in the cost of debt, companies could issue SLBs purely for financial reasons without the intention

to reach the target. This is reflected by the fact that over 40% of SLBs in our sample benefit from a 'free lunch'. Finally, if demand for the category of SLBs drives the pricing, rather than an assessment of the contractual details, it may be necessary to specify minimum requirements for a bond to qualify as an SLB to avoid that SLBs are used as a greenwashing tool. This concerns in particular the ambitiousness of the target and the size of the penalty.

4.2 Literature review

Since the early 2000s there has been an interest in studying the relationship between firms' sustainability performance, especially environmental factors, and their respective credit instruments, as well as the associated bank lending behavior. Early research in the field highlighted that banks and bond investors integrate at best environmental risk in their credit risk assessment, but not in the further credit management process, such as the pricing of loans (Weber, Scholz, and Michalik, 2010). There has been a literature showing that better corporate social responsibility (CSR) performance is associated with lower yield spreads of bonds, but that some of the effect is absorbed by credit ratings Menz (2010); Ge and Liu (2015); Hasan et al. (2017); Magnanelli and Izzo (2017). Furthermore, CSR performance can also increase the investor base size.

With the emergence of green bonds, numerous studies analyze the pricing of green bonds to identify the potential presence of a green bond premium or so-called 'greenium'. Early studies pursue a multitude of approaches to analyze the greenium. Ehlers and Packer (2017) perform a simple comparison of 21 euro and USD bonds on the primary market and find a negative premium (-18 bps). Karpf and Mandel (2018) perform an Oaxaca-Blinder decomposition to analyze 1880 US municipal

bonds[3] on the secondary market. This approach separates the bond spread into an explained part (due to fundamental characteristics) and an unexplained part, which would potentially signal the existence of a greenium. When controlling for the bonds' liquidity based on the number of transactions within the past 30 days, Karpf and Mandel (2018) find a positive premium (8 bps). Finally, Baker et al. (2018) construct a framework featuring a subset of investors whose objective function includes nonpecuniary sources of utility, such as social responsibility from holding green bonds. They analyze 2083 municipal and corporate bonds on the primary bond market, using the issue amount as a proxy of the liquidity, and find a negative premium (-6 bps).

More recent studies base their analysis on matching procedures and a statistical analysis of the yield differential between green bonds and non-green counterfactuals. Hachenberg and Schiereck (2018) use a matching procedure and a panel regression to analyze 63 bonds aligned with the Green Bond Principles on the secondary market and find a minor negative premium (-1 bps). Gianfrate and Peri (2019) conduct a propensity score matching analysis with 121 European green bonds on the primary and secondary market, comparing the returns of these green bonds with conventional peers. Their results also indicate a statistically significant greenium of -18 bps. Similarly, Zerbib (2019) performs a direct matching method followed by a two-step regression procedure to estimate the yield differential between 1065 European and US green bonds and their counterfactual conventional bonds, and finds a small negative premium (-2 bps). Larcker and Watts (2020) focus on the municipal bond market comparing green bonds with conventional counterfactuals issued the same day by the same issuer. In contrast to previous work, their study based on 640 bond pairs indicates that the greenium is equal to zero. Larcker and Watts (2020) argue that the mixed evidence from prior studies result from misspecifications in the

[3]Note that some studies base their analysis on a less restrictive data framework than the alignment with the Green Bond Principles, and focus on bonds with a Bloomberg green flag, especially on the US municipal bond market.

methodological matching design which produce biased estimates. Applying Larcker and Watts (2020) methodology and in line with their results, Flammer (2021) finds no greenium for her sample of 152 corporate bond pairs. Thus, so far the empirical evidence for a greenium is mixed. Some studies seem to indicate the existence of a small greenium, especially in the municipal bond market. The more recent papers with tighter matching approaches however find no green bond premium (Larcker and Watts, 2020; Flammer, 2021)

Recently, a literature on sustainability-linked bonds and loans emerged. Berrada et al. (2022) offer a theoretical model of incentive compatibility for SLBs.[4] They emphasize the conditions under which an SLB contract is incentive compatible. We take a more empirical approach in our paper, covering a larger sample of existing SLBs. Pohl, Schüler, and Schiereck (2022) analyze the pricing dynamics of sustainability-linked loans. In addition, there are several papers providing commentary on the SLB concept or case studies of individual SLBs (e.g. Liberadzki, Jaworski, and Liberadzki, 2021). Furthermore, Barbalau and Zeni (2021) model how the choice between issuing an SLB versus a green bond depends on how much firms can manipulate the contracted outcomes. Dursun-de Neef, Ongena, and Tsonkova (2023) study the development of firms' ESG performance following the issuance of green loans versus sustainable loans. The authors find that the issuance of sustainable loans leads to subsequent improvements in firms' overall ESG performance. Finally, Kim et al. (2021) find that ESG scores deteriorate for companies with low-transparency sustainability-linked loans and that stock markets respond positively to high-transparency loan issues only. The authors thus point towards greenwashing risks and highlight the importance of transparency in ESG-contingent financing.

Our research extends the literature on sustainable debt instruments by analyzing the new phenomenon of SLBs. Our paper addresses the question of how SLBs are

[4]There is also a more practitioner-oriented approach to value SLBs using option pricing by Mielnik and Erlandsson (2022).

priced in comparison to their non-sustainable counterpart, and who pays for the sustainability (i.e. positive or negative premium).

4.3 Sustainability-linked bonds

As defined by the Sustainability-Linked Bond Principles (ICMA, 2020), an SLB is any type of bond instrument which incentivizes the issuer's achievement of predetermined sustainability performance objectives. The financial and/or structural characteristics of the bond can vary depending on the achievement of these objectives. Predefined sustainability performance targets (SPTs) are set for these objectives, measured using predefined key performance indicators (KPIs) and usually externally verified by an independent third party. These KPIs may include external ratings (ESG ratings) or metrics, a company's GHG emissions, or the number of female board members, for example. SLBs are fundamentally different from green bonds, as there is no 'use of proceeds' clause for the categorization of SLBs, and the funds are used for general corporate purposes in most cases.[5] The purpose of SLBs is therefore not the specific use of proceeds, but rather to improve the issuer's sustainability profile by aligning bond terms to the achievement of predetermined SPTs. The Sustainability-Linked Bond Principles (ICMA, 2020) further encourage issuers to select ambitious SPTs, and KPIs that are measurable and transparently defined. Furthermore, issuers should disclose the relevant information and appoint an external review to confirm the bond's alignment with the Sustainability-Linked Bond Principles (ICMA, 2020). The sustainability KPIs are thus included in the bond structuring documentation, tested on a regular basis, and used for coupon redetermination over the life of the SLB. The coupon adjustment typically works as follows: If the company fails to achieve the predetermined criteria, then the coupon increases by 25 bps. The SLB may in some cases be tied to several SPTs, and thus

[5]Note that in some instances a bond may be structured as both a green bond (aligned with the Green Bond Principles) and a sustainability-linked bond (ICMA, 2020).

have several coupon step-ups (e.g. 5 bps per SPT). As described in Section 4.4, the typical coupon step-up is 25 bps, but can be lower or higher for certain firms. In some cases, the coupon may also decrease by 25 bps in case of KPI attainment. Figure 4.1 below illustrates the typical mechanism of an SLB. The coupon step-down in Figure 4.1 is represented as a light-grey dashed line, since the most common case is to only include a penalty for failing to achieve the SPT (see Section 4.3).

Thus, SLBs can have an impact through two channels. First, SLBs create a clear financial incentive for firms to improve their sustainability performance to reach the SPT. If the firm does not meet the SPT, it leaves money on the table. Thus, unless the SPTs would have been reached anyways, SLBs give companies an incentive to change. Second, SLB issuers must commit to explicit sustainability goals, for which they will be held accountable and financially liable in the future. SLBs could, therefore, constitute a public commitment to sustainability that is costly to walk back beyond the financial penalty due to the risk of reputational loss.

FIGURE 4.1:
Typical mechanism of an SLB

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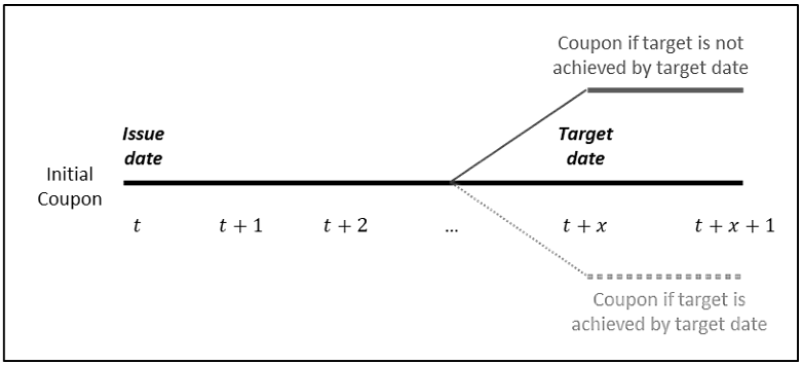


The figure shows the mechanism of SLBs with a coupon step-up and step-down, depending on whether the sustainability performance target has been achieved. The line for the coupon step-down is dashed as this is less common.

The impact of SLBs is therefore much more explicit than many other mechanisms in sustainable investing. For example, while an increasing volume of funds is managed

TABLE 4.1:
SLBs over time

Year	# SLBs	Amount (USD billion)	# SLBs in matched sample
2018	1	0.1	0
2019	4	4.3	1
2020	26	10.4	9
2021	263	117.5	96
2022	197	77.6	99
2023 May	60	29.7	33
Total	551	239.7	238

Summary statistics of annual issuance of overall SLB market.

according to ESG ratings, it is uncertain for firms what metrics they should improve and how substantial the market's reward will be. SLBs effectively put a price on specific improvements, giving firms a clear signal what they need to do, and what the reward will be.

4.4 Data and market overview

Our sample of (corporate) SLBs is extracted from Bloomberg's fixed income database, covering all bonds labeled as 'sustainability-linked bonds' as of May 31, 2023. Given the extent of the coverage of Bloomberg's fixed income database, we assume that the resulting data is likely to map closely the full universe of SLBs issued. The extraction results in a total of 551 SLBs issued by a total of 319 companies. For each bond, Bloomberg provides the standard bond characteristics (issue size, maturity, coupon, seniority, etc.) and a security description with information on the sustainability components. Bloomberg's security description contains details on the SPT, the target date and coupon adjustment for most SLBs. However, in some cases the security description does not provide complete information on the coupon step-up or the SPT. In these cases, we manually complete the data based on company press releases, publicly available investor relations materials or by contacting the investor relations of the respective company.

TABLE 4.2:
SLBs across regions

Region	# SLBs	Amount (USD billion)
Asia-Pacific	159	23.4
Europe	289	161.0
North America	46	36.8
Rest of World	57	18.5
Total	551	239.7

Summary statistics of regional breakdown of SLB market.

In Table 4.1, we provide a descriptive overview of the current market for SLBs as of May 31, 2023. For the sake of comparison, we convert all amounts into US dollars. While some media commonly attribute the world's first SLB in September 2019 to the Italian utility company Enel (Financial Times, 2021), Bloomberg data indicates that Beijing Infrastructure Investment Corporation Limited, the Chinese state-owned rail transportation company, issued an SLB in December 2018. The market for SLBs is growing strongly. In 2019, the total issuance of SLBs was USD 4.3 billion, it doubled the year after, and reached USD 117.5 billion in 2021. Since 2022, the sustainable bond issuance slowed down due to macroeconomic and geopolitical risk (Bloomberg, 2022).

In Tables 4.2 and 4.3 we provide a breakdown of SLBs by region and sector. Sectors are partitioned according to the GICS sector classification. The majority of SLB issuance is made up of European companies (USD 161.0 billion). With less than 10% of total bond issuance in North America by mid-2023, the phenomenon of SLBs has not yet been established in the US market and among the largest S&P 500 companies. In terms of sector breakdown, the industrials, energy and utilities sector issued the largest amount of SLBs. The leading SLB issuers are mainly from capital-intensive sectors which are most concerned by the transition to a more energy-efficient, low-emission economy. Furthermore, Table 4.3 also shows that many sectors, beyond capital-intensive companies, such as in healthcare or financials, started to issue SLBs.

TABLE 4.3:
SLBs across sectors

GICS Sector	# SLBs	Amount (USD billion)
Communication Services	25	9.6
Consumer Discretionary	40	20.6
Consumer Staples	42	17.7
Energy	72	27.3
Financials	43	10.5
Health Care	16	11.1
Industrials	135	47.6
Information Technology	21	10.5
Materials	61	25.7
Real Estate	30	6.9
Utilities	66	52.2
Total	551	239.7

Summary statistics of sector breakdown of SLB market.

Table 4.4 provides a breakdown of the SLB market by maturity type.[6] While 54% of the SLBs issued are at maturity (233 bonds), 66% of the SLB market volume consists of callable bonds (USD 127.9 billion). The use of callable corporate bonds has increased since the Great Financial Crisis to a share of over 60% in advanced economies due to the advantages for financing and liquidity optimization allowing issuers to redeem the bond due to changes in the interest rate or credit environment or for restructuring purposes (Çelik, Demirtaş, and Isaksson, 2019).

Despite the Sustainability-Linked Bond Principles and the efforts to create universal guidelines, there is a lot of diversity with respect to the SPTs and the concrete KPIs set by issuers. Table 4.5 summarizes the coupon margin adjustments across the entire sample of 551 SLBs based on the available Bloomberg data, company press releases, investor relations materials, as well as information provided by investor relations contacts. The most common SPTs are linked to a company's GHG emissions or energy efficiency measures followed by a target related to an ESG score or

[6]The plain vanilla maturity type for bonds is 'at maturity', meaning that the issuer must repay the bond at maturity. Callable bonds give the issuer the option to redeem the bond before maturity subject to time constraints or other special constraints (Çelik, Demirtaş, and Isaksson, 2019). Putable bonds offer the bondholders the right to demand early repayment of the principal from the issuer. Convertible bonds offer the possibility to convert the bond into a number of common stock or equity shares at a predetermined date. Sinkable bonds are bonds backed by a fund set aside by the issuer.

TABLE 4.4:
SLBs by maturity type

	# SLBs	$ Amount (billion)
At maturity	234	44.6
Callable	288	189.5
Callable / Perpetual	14	1.1
Callable / Sinkable	1	0.4
Convertible	3	1.6
Putable	5	0.2
Sinkable	5	1.5
Extendible	1	0.8
Total	551	239.7

Summary statistics of maturity type of SLB market.

TABLE 4.5:
SLB coupon step-up statistics

Coupon margin adjustment	# SLBs	$ Amount (billion)
Step-up: <25 bps	153	35.4
Step-up: 25 bps	171	108.9
Step-up: >25 bps	147	68.7
No step up or other penalty	23	3.4
No information	57	23.2

Summary statistics of coupon adjustments of SLB market

other sustainability rating. Some issuers have their SPT linked to diversity, water or waste management, or some company-specific renewable energy target. The coupon step-up, however, is comparable across companies. The most common feature of SLBs is a coupon step-up of 25 bps if the company fails to reach the predetermined SPT at the given date (USD 108.9 billion).

In summary, the SLB market as of May 2023 is still in the early stages. It is mainly a European phenomenon, dominated by the industrials, energy and utilities sectors. The variety in SPTs and coupon adjustment highlight the varying motivations and ambitions of issuers.

4.5 Matching methodology

To address our research question and test for the existence of a sustainability premium, we perform a matching approach at the bond-level. The aim of our matching procedure is to match bond pairs with an SLB and a non-sustainable bond by the same issuer, which is as similar as possible except for the sustainability features linked to it. This procedure allows us in a second step to compare and analyze the yield differential, as SLBs and conventional bonds of the same company are subject to the same financial risk once all their differences have been controlled for. Our matching procedure is similar to studies analyzing the greenium.[7]

Matching procedure. In the first step, we require that the issuer, bond seniority, maturity type, coupon type, and currency are identical for both the SLB and the counterfactual bond. In terms of maturity type, we focus on at-maturity and callable bond pairs and exclude putable and convertible bond pairs. Furthermore, for callable SLBs with a 'make-whole' call option[8] we require as a necessary condition that the counterfactual bond also includes a make-whole call option, while

[7]Studies analyzing the green bond premium are based on different matching approaches. Gianfrate and Peri (2019) apply three different propensity score matching techniques (nearest neighbours matching, kernel matching and radius matching) to predict the probability of bonds being green, using Logit and Probit functions. Hachenberg and Schiereck (2018) match each green bond with two comparable non-green bonds (one with a shorter and one with a longer maturity) from the same issuer with the closest maturity, same ranking, currency, rate structure (fixed or floating), secured/unsecured, and that are not structured (callable, etc.). Zerbib (2019) uses a matching method known as model-free or direct approach, which consists of matching a pair of instruments with the same properties except for this one green property. He thus matches every green bond with a conventional bond with the same currency, rating, bond structure, seniority, collateral, and coupon type (Zerbib, 2019). Larcker and Watts (2020) base their matching approach on the specific feature of the municipal bond market which consists in the fact that municipal issuers commonly price tranches of securities, including green and non-green bond in their case, on the same day with the similar maturities. Thus, this allows them to match green bonds with quasi-identical non-green bonds. Flammer (2021) applies Larcker and Watts (2020) methodology to the corporate green bond market, matching each green bond to the most comparable brown bond of the same issuer in two steps. Her first step requires the credit ratings to be the same, and the second step then picks the closest neighbor using the Mahalanobis distance based on four characteristics: log(issuance amount), maturity, coupon, and the number of days between the green and brown bond issuance (Flammer, 2021).

[8]Bonds with a 'make-whole' call option have a call price that is above the market price of the bond, making the investors 'whole' and reducing concerns about early redemptions (Çelik, Demirtaş, and Isaksson, 2019).

we accept differences in the make-whole spread.[9] While studies on green bonds use the bond rating as an additional matching criterion, we only take into consideration the bond seniority. Due to the early stage of the SLB market, many SLBs do not have a rating. Yet, none of the bond pairs differ in the bond rating, conditional on ratings being available. The bond seniority is therefore a reasonable matching requirement.

In the second step, we select the counterfactual bond with the closest issue date, maturity, and issue size based on the Euclidean distance.

Issue date. We limit the difference between issue dates for the bond pairs to a maximum of five years. In the robustness tests, we perform two tighter matchings with a three-year and one-year issue date difference.

Maturity. We limit the difference in maturity between SLBs and conventional bonds to five years. This maturity difference is marginally higher than in studies on green bonds.[10] In the robustness tests of section 4.6.1, we perform two tighter matchings with a three-year and one-year maturity difference.

Issue size. We limit the issue size ratio between the SLB and its counterfactual to a factor of 4 (i.e. not larger than four times the SLB's issue amount and not smaller than one-quarter). We do not set a constraint for the minimum issue size, as liquidity considerations do not affect our pricing analysis of the yield differential at issue.[11]

[9] The difference in the make-whole spread of the SLBs and the counterfactuals within our sample is, on average, 4.1 bps.

[10] Larcker and Watts (2020) limit the maturity differential to be within one year, as they argue that this restriction maximizes the number of securities for which they can obtain matches, while also minimizing the differences in the slope of the credit spread. Zerbib (2019) limits the maturity of the counterfactual bond to two years shorter or longer than the green bond's maturity.

[11] For liquidity reasons, some studies on green bonds have set constraints on the issue size. Hachenberg and Schiereck (2018) focus on bonds with a minimum issue size of USD 150 million, while Gianfrate and Peri (2019) set a minimum of EUR 200 million. Zerbib (2019) imposes the restriction of factor four on the issue size ratio between the green bond and the counterfactual.

TABLE 4.6:
Comparison of means

	SLB	N	Issue Date	Maturity	Size
Group 1	0	238	2020-12-29	6.70	2'764
Group 2	1	238	2022-02-17	7.12	3'112

This table compares the means between SLBs and their matched counterfactual bonds. The matching covariates are issue date, maturity and issue size.

While our sample is reduced by some missing values in the data, as Bloomberg does not provide yield for the complete SLB sample, we rely in some cases on the Refinitiv database to complete the data on yield at issue for some SLBs and counterfactuals.

Finally, our matching process results in 238 bond pairs from 158 issuers. There are 51 issuers with more than one bond pair (31 issuers with 2 bond pairs, 13 issuers with 3 bond pairs, and 7 issuers with more than 3 bond pairs). Table 4.6 provides summary statistics for the sample of bond pairs of SLBs and counterfactual bonds.

Our matching procedure results in a sample of bond pairs with a maturity difference of 0.42 years, and a similar issue size. The issue date difference within our bond pairs is on average 14 months. Table 4.6 does not include information on the bond seniority, as this was a necessary matching requirement, and thus identical for all bonds. In terms of bond seniority, most bonds are Senior Unsecured bonds (181 out of 238), while a minority are of higher seniority (5 out of 238) and lower seniority (52 out of 238).[12]

Overall, our sample reflects the general SLB market in several dimensions (see Table C.1 in the Appendix). First, our sample covers 43% of the total SLB market (238 out of 551 SLBs) and 50% of all issuers in the SLB market (158 out of 319). Second, in terms of maturity type, our sample has similar proportions of at maturity and callable SLBs as the overall market (137 at maturity and 101 callable). Third, the

[12] Among the bonds with higher seniority the breakdown is 2 First Lien and 2 Secured bonds. Among the bonds with lower seniority there are 51 Unsecured bonds and 1 Subordinated bond.

sector breakdown within our sample is comparable to the overall market. However, our sample of bond pairs has a higher share of SLBs from Asia-Pacific and a lower share from Europe, as compared to the overall SLB market.

4.6 Results

4.6.1 Is there a sustainability premium?

In a first step, we test whether there is a sustainability premium. We perform an OLS regression to test the statistical significance of the yield differential between the SLBs and the counterfactuals. The dependent variable is the yield at issue of every bond $Yield_{\mathrm{i}}$ and the OLS regression takes the following form:

$$Yield_{\mathrm{i}} \;=\; \beta_0 \;+\; \beta_1 \;\cdot\; SLB_{\mathrm{i}} \;+\; \beta_{\mathrm{j}} \;\cdot\; Bond\ pair_{\mathrm{j}} \;+\; \sum \beta_{\mathrm{k}} \;\cdot\; Control\ variables_{\mathrm{ki}}$$

The variable $Bond\ Pair_{\mathrm{i}}$ identifies bond pairs with one dummy variable for each of the 238 bond pairs. The variable SLB_{i} is a dummy variable indicating whether the bond is an SLB. As control variables we include changes in the market environment (interest rate and credit spreads), as well as matching differences (issue size and maturity).

The results are shown in Table 4.7. The unconditional yield differential in Model I is 29.3 bps between SLBs and the counterfactual bonds. The positive yield differential implies that the yield for SLBs is on average higher than for non-sustainable counterfactuals. However, when controlling for changes in the interest rate, credit spreads and matching differences in Models II, III and IV we obtain a negative yield differential (i.e. a sustainability premium). This negative yield differential is however not statistically significant. We perform robustness tests by running the

TABLE 4.7:
SLB yield at issue vs. counterfactual bonds

	Yield at issue			
Model	I	II	III	IV
SLB	29.30***	−5.27	−5.92	−7.71
Interest rate		0.97***	0.98***	0.98***
Credit spreads			0.44	0.52
Size				0.00
Maturity				3.84
Observations	476	476	476	476
R-squared	0.90	0.96	0.96	0.96

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Regression of the yield at issue for a sample of matched bond pairs. SLBs and counterfactual bonds are from the same issuer, and have identical seniority, maturity type (at the money or callable), coupon type (fixed or floating), and currency. The are matched to their nearest neighbour in terms of maturity, issue size, and issuance date. Model I estimates the effect of a dummy variable for SLB on yield at issue, controlling for each bond pair with a dummy. Model II adds the risk-free rate at the time of issue for each individual bond. Model III additionally adds the credit spreads at the time of issue for each individual bond. Model IV adds the matching variables size and maturity as additional control variables.

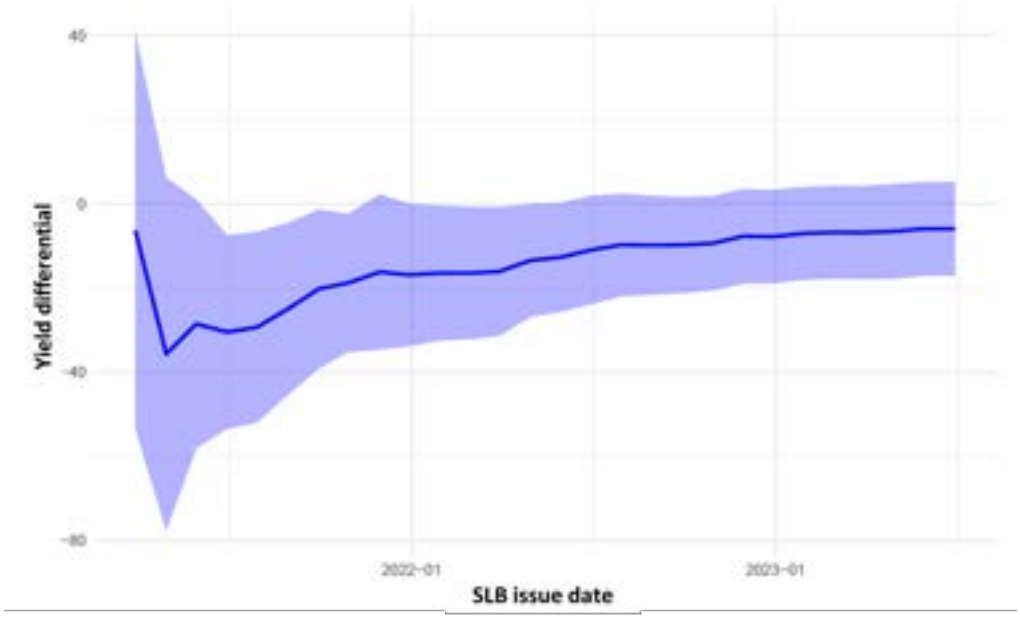
TABLE 4.8:
Yield at issue regressions over time

	Yield at issue				
	2021-06-30	2021-12-30	2022-06-30	2022-12-30	2023-05-31
SLB	−30.43**	−16.86*	−10.95*	−7.77	−5.92
Interest rate	0.87***	0.96***	1.01***	1.09***	0.98***
Credit spreads	−0.40	−0.41	0.07	0.27	0.44
Observations	96	212	326	410	476
R-squared	0.95	0.95	0.96	0.96	0.96

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Regression of the yield at issue for the sample of matched bond pairs over time. The regressions include bond pairs with SLBs issued up to the date in the header. The SLB dummy variable indicates the yield at issue differential. The regression models control for the risk-free rate and the credit spreads.

FIGURE 4.2:
The yield differential over time



This graph shows the coefficient on SLB for regressions akin to Model 3 Table 4.7. It is the illustration of Table 4.8, except that the regression is run with an increasing sample size each month (relevant date is the SLB issue date). The blue line shows the SLB coefficient over time, while the surface represents one standard deviation.

same analysis with tighter matching. In Table C.3 we apply a three-year limit to the issue date and maturity difference. The results are similar, except that in Model IV the sustainability premium of -12.2 bps is statistically significant at the 5% level. Furthermore, when limiting the issue date and maturity difference to one year in Table C.4, all four models result in a negative yield differential, and Model II shows a statistically significant sustainability premium of -16.3 bps. Thus, the results are inconclusive, but the evidence is in favor of a small sustainability premium.

Table 4.8 replicates Model III of Table 4.7 over time. The results show how the average yield differential evolves over time. There was a statistically significant sustainability premium until mid-2022. In the second half of 2022 the sustainability premium decreased and was no longer statistically significant, as shown by the models as of December 2022 and May 2023. Figure 4.2 illustrates this evolution over

TABLE 4.9:
SLB yield at issue vs. counterfactual bonds over time

	Yield at issue		
Model	V	VI	VII
SLB:2019	−107.10	−44.44	−28.83
SLB:2020	15.01	43.60	40.13
SLB:2021	−39.87***	−25.30***	−26.40***
SLB:2022	61.25***	8.85	7.50
SLB:2023	142.69***	1.57	−1.22
Interest rate		0.94***	0.95***
Credit spreads		0.70	0.76
Size			−0.00
Maturity			3.08
Observations	476	476	476
R-squared	0.919	0.966	0.966

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Regression of the yield at issue for a sample of matched bond pairs. This table is nearly equivalent to Table 4.7. The only difference is that the SLB dummy variable is interacted with the year in which the SLB was issued.

time by showing the regression coefficient and the standard deviation. The average sustainability premium decreased since early 2022. This finding is confirmed by the results in Table 4.9, where we estimate the SLB dummy separately for each year. These results are qualitatively similar with quarter fixed effects. It appears there was a premium for SLBs issued in 2021 in any model specification. However, SLBs issued in 2022 did not benefit from a statistically significant premium anymore. Thus, our results suggest that the SLB premium varies over time. The invasion of Ukraine and the rising inflation and interest rates, as well as developments in the SLB market, in terms of issuer type and market maturity, may have contributed to

this change.

In sum, we find that issuers benefited from a lower cost of debt when issuing SLBs until mid-2022. However, the magnitude and significance of the premium decreased over the sampling period, so that by mid-2023 there is no longer a statistically significant premium.

4.6.2 How large is the sustainability premium?

In order to analyze the incentive mechanism of SLBs, we perform a cost-benefit calculation of SLB issuance. We use the yield differential conditional on the interest rate between the issue dates of the SLB and the counterfactual (as used in Table 4.7). Thus, we subtract the changes in the interest rate from the yield differential to control for changes in the bonds' underlying risk-free rate. We compare the yield differential at the level of the bond pair to the maximum possible penalty over the period when the coupon step-up applies in case of failure to reach the SPTs. This is a rather aggressive estimate, as it represents the case in which the issuer fails to reach the SLB target with a probability of 1. The expected penalty is lower in reality, as issuers typically set several achievable targets, thus having a low likelihood of failure on all of them.

The results are shown in Table 4.10. The average yield differential varies over time. The average coupon step-up is 31.4 bps across the overall period, but shows a high diversity, as described in the market section in 4.4. While the coupon step-up appears to be large, it applies only over a fraction of the bond's lifetime: The average SLB has a maturity of 7.1 years, but the step-up applies only for 2.8 years, if it is triggered. The bottom two rows show the number of SLBs that benefit from a 'free lunch' (i.e. that have larger savings from the sustainability premium than the maximum potential penalty) and the percentage share in the respective years.

TABLE 4.10:
SLB cost-benefit analysis

	2019	2020	2021	2022	2023	Total
N	1	9	96	98	31	235
Yield differential (bps)	-40.7	45.3	-22.7	6.1	-2.5	-5.5
SLB coupon step-up (bps)	25.0	57.8	29.3	29.7	36.0	31.4
SLB maturity (years)	5.0	8.1	7.1	7.3	6.2	7.1
No coupon step-up until SPT date (years)	2.0	5.6	4.3	4.6	3.5	4.4
Coupon step-up after SPT date (years)	3.0	2.4	2.9	2.7	2.7	2.8
# SLBs with a 'free lunch' (savings > penalty)	1	2	49	37	12	101
% Share of SLBs with a 'free lunch'	100.0	22.2	51.0	37.8	38.7	43.0

Cost-benefit analysis of SLB issuance. The yield differential is conditional on interest rate changes between the issuance dates. The table states sample averages of the step-up rate in case of failing to reach the SLB target, the SLB maturity, and the time over which the step-up applies. The 'free lunch' applies when the savings are larger than the penalty.

Despite the aggressive maximum potential penalty (assuming a scenario where the issuer fails on all SPTs), our results show that 43% of SLBs in our sample benefit from a 'free lunch' (101 out of 235).[13] Since there was a significant sustainability premium in 2021, this year also represents the year with the highest number of SLBs with a 'free lunch'.

4.6.3 What drives the sustainability premium?

In a last step, we estimate an OLS regression to analyze the drivers of the sustainability premium. Hypothetically, we see two main drivers. The first driver is related to the financial structure and the incentive mechanism, so the option value of reaching the sustainability performance target priced by primary market investors based on the implicit probability of a coupon step-up. The second driver is sustainability signaling: by issuing an SLB, issuers can signal to investors that they are committed to reaching a certain sustainability target. Investors with sustainability preferences may prefer the securities of companies willing to demonstrate such a commitment.

[13] When relying on the unconditional estimate of the yield differential of Model I in Table 4.7, we find that over 20% of SLBs in our sample benefit from a 'free lunch'.

The signal value of issuing an SLB may be relevant for both, ESG leaders and laggards. ESG leaders could use SLBs as a reinforcement signal for their past commitments to sustainability, indicating that they are also prepared to be held financially accountable in case of missing sustainability targets. ESG laggards could use SLBs to signal that they aim to increase their commitment to sustainability.

Thus, we aim to determine the effect of the coupon step-up, other SLB characteristics, and issuer characteristics on the yield differential. The dependent variable is the yield differential at issue (in bps) between the SLB and its non-sustainable counterfactual Δ $Yield_{\mathrm{i}}$ for every bond pair i. The OLS regression takes the following form:

$$\begin{aligned}\Delta Yield_{\mathrm{i}} = \beta_0 + \beta_1 \cdot Step\text{-}up\ weighted_{\mathrm{i}} + \sum \beta_{\mathrm{j}} \cdot Sustainability\ characteristics_{\mathrm{ji}} \\ + \sum \beta_{\mathrm{k}} \cdot Matching\ differences_{\mathrm{ki}} + \sum \beta_{\mathrm{l}} \cdot Issuer\ characteristics_{\mathrm{li}} \\ + \sum \beta_{\mathrm{m}} \cdot Credit\ environment_{\mathrm{mi}} + u_i\end{aligned}$$

Table C.2 provides a detailed overview and description of all variables. The independent variables are divided into two groups and some control variables. The first group of variables is linked to the financial characteristics of the SLB: the time-weighted coupon step-up $Step\text{-}up\ weighted_{\mathrm{i}}$. This variable reflects what the company needs to pay to investors in case the target is not reached. If investors price these additional cash flows, they should have a negative effect on the yield differential (i.e. a larger yield differential).

The second group of variables is linked to the sustainability characteristics of the SLB and the issuer. At SLB level, we include a binary variable whether the SPT is related to environmental targets $Environmental\ SPT_{\mathrm{i}}$, such as GHG reduction or renewable energy installments. Furthermore, we include a binary variable whether it is the first SLB issued $First\ SLB_{\mathrm{i}}$. At issuer level, we include whether the issuer

is included in the Dow Jones Sustainability Indices[14], as well as a binary variable whether the issuer signed up to the science-based targets initiative (SBTi). These variables allow us to distinguish ESG leaders and laggards and indicate the strength of a signal that issuers may be able to send.

As controls, we include matching differences, issuer characteristics, and changes in the credit environment. $Matching\ differences_{\text{ki}}$ are intended to capture the differences between the SLB and the counterfactual bond due to our matching approach, and include the difference in issue size and maturity. $Issuer\ characteristics_{\text{mi}}$ include firm control variables, such as issuer credit rating changes, as well as country and industry fixed effects. Finally, we include credit environment variables, such as the change in the interest rate and credit spreads between the issue dates of the counterfactual bond and the SLB.[15] In addition, we include quarter fixed effects, given the previous finding that the yield differential seems to vary over time.

Table 4.11 shows the results for the regression on the drivers of the yield differential. We find no evidence that the yield differential responds to the penalty. The time-weighted step-up has no significant effect on the yield differential $\Delta Yield$ in any of the model specifications.

For the first SLB issue we estimate a significant negative coefficient in Model VIII, but not in the Models IX to XIII. Similarly, the coefficient for science-based targets is statistically significant in Model VIII, but not in the other model specifications. The other characteristics, such as environmental SPT and DJSI membership, have no statistically significant coefficients across any model.

[14]The DJSI constituents are available on the S&P website.

[15]To control for the interest rate change between the issuance of the counterfactual and the SLB, we use the change in the 5-year interest rate for bond pairs with a maturity below 7.5 years and the 10-year interest rate for bond pairs with a maturity above 7.5 years of the respective bond region, except for EUR-denominated bonds where we use the 10-year EURIBOR swap rate.

TABLE 4.11:
Drivers of the yield differential

	Δ *Yield*					
Model	VIII	IX	X	XI	XII	XIII
Step-up weighted	1.15	-0.02	0.06	0.02	0.04	-0.01
First SLB	-66.86***	-10.39	-10.96	-8.37	-9.08	5.52
Environmental SPT	26.94	1.19	2.19	9.78	18.21	32.79
DJSI member	9.07	8.07	5.90	10.97	4.94	-6.42
Science-based targets	75.70***	19.92	23.43	14.95	27.24	22.41
Interest rate		0.99***	1.00***	1.11***	1.10***	1.03***
Credit spreads		0.30	0.41	1.95	2.40*	1.62
Credit upgrade		-28.13	-27.45	-37.79	-12.25	-1.96
Credit downgrade		-21.44	-14.49	-34.59	-6.46	-6.77
Issue size			-0.00	-0.00	0.00	-0.00
Maturity			3.74	3.72	9.98***	11.31***
Issue date			-0.01	-0.01	0.01	0.01
Country FE	-	-	-	Yes	Yes	Yes
Industry FE	-	-	-	-	Yes	Yes
Quarter FE	-	-	-	-	-	Yes
Observations	230	230	230	230	230	230
R-squared	0.10	0.67	0.67	0.76	0.86	0.88

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Regressions of the yield differential Δ *Yield* between SLBs and their paired counterfactual bond. Time-weighted step-up is the SLB's step-up margin, weighted by the fraction of the bond's maturity over which the step-up applies. Further variables include a dummy whether an SLB is the the issuer's first, membership of the issuers in the DJSI, whether the SPT is an environmental target and whether the issuer is a signatory to the science-based targets initiative. Controls include changes in local credit risk and interest rate and the occurrence of credit rating up- or downgrades between the issue date of the SLB and the counterfactual bond, and remaining differences between the matched bond pairs. Fixed effects include industry, region and quarter of the SLB issue.

4.7 Discussion

In summary, our results provide evidence that SLB issuers benefitted from a sustainability premium until mid-2022. Since then, the size and statistical significance of the premium decreases, potentially due to macroeconomic developments or changes in the SLB market dynamics. Furthermore, we show that a proportion of SLB issuers benefits from a 'free lunch', as the potential penalty they face is lower than the cost savings at issue due to the sustainability premium. Finally, we find no statistical effect of the time-weighted coupon step-up on the magnitude of the yield

differential. Our results therefore suggest that the sustainability premium is not driven by the bonds' financial penalty structure or incentive mechanisms. This is consistent with the hypothesis that SLBs serve as a costly signaling device.

4.7.1 Contributions

Our results make several important contributions to the literature on green securities and to the understanding of the fast-growing SLB market. First, our paper provides the first overview and analysis of the SLB market. SLBs are a novel phenomenon and have gained significant traction since 2020. Due to the early stage of the SLB market, there is a diversity in SPTs and coupon step-up arrangements. Our results provide an overview of this diversity that may be helpful as the market matures.

Second, our paper provides evidence that until mid-2022 there was a significant sustainability premium. This finding implies that some issuers may have financial incentives to issue SLBs, as also reflected by our cost-benefit analysis suggesting that over 40% of SLBs benefit from a 'free lunch' (i.e. capital cost savings greater than the potential penalty faced when failing on the targets). The existence of the 'free lunch' calls into question, whether SLBs represent a well-structured incentive mechanism for issuers to pursue a sustainability target.

Third, we show that the coupon step-up does not affect the yield differential. This finding suggests that the yield differential is not driven by an incentive mechanism from the issuer's perspective, or arbitrage considerations from the investor's perspective. Thus, our result could suggest a signaling mechanism, where issuers use SLBs to convince investors that they are committed to pursue a sustainability target. Committing to a target and a penalty is a costly signal, as long as the target is not already achieved.[16] There are many ESG commitments by corporations these

[16] Tesco has been criticized for an SLB whose target was basically achieved when the bond was issued.

days, for example under the umbrella of the science-based targets initiative, where the question of credibility naturally arises (Bolton and Kacperczyk, 2021b). Issuing an SLB may thus serve as a credible and costly commitment ex ante and ex post. Thus, while some companies might benefit ex ante from a 'free lunch' at the time of issue of an SLB, this might be outweighed by the potential loss of reputation when failing on the target ex post.[17]

4.7.2 Limitations

Our study has some limitations. First, the market for SLB is still young, which constrains our sample size. We have taken care to create the largest possible sample and to our knowledge, this is the most comprehensive study of SLB pricing to date. As such, the findings of this article should be viewed as somewhat preliminary evidence. Nevertheless, given the fast growth of SLBs and their significant potential for investors with sustainability preferences, our study offers important insights that may help navigate the market for SLBs.

Second, we rely on a matching procedure that rests on the identifying assumption that matched bonds differ only with regard to the SLB feature. Given the nascent state of the market, we face a trade-off between sample size and matching tightness. We attempt to closely follow the existing literature with our methodology. In contrast to studies on green bonds, we allow for a slightly larger maturity difference, restricting the difference in maturity between SLBs and conventional bonds to five years. Larcker and Watts (2020) limit the maturity differential to be within one year, as they argue that this restriction maximizes the number of securities for which they can obtain matches, while also minimizing the differences in the slope of the credit spread. Zerbib (2019) limits the maturity of the counterfactual bond to two years shorter or longer than the green bond's maturity. The Achilles heel

[17] A recent literature emerged on the loss of reputation due to climate commitments (e.g. Cooper, Raman, and Yin, 2018; Guastella et al., 2022).

of our method is the temporal lag between the issue dates of the SLB and the counterfactual bond. We attempt to remedy this by controlling for changes in the credit environment as well as for credit rating changes of the issuer itself. We also include tighter matching approaches applying a limit of three year (Table C.3) and one year (Table C.4) to the issue and maturity date difference. These robustness tests confirm our results.

Third, the debt market changed over our sample period. The invasion of Ukraine and the increase in inflation and interest rates have considerably affected the credit environment. While we control for these changes by including variables for the interest rate and credit spreads, these macroeconomic developments may have affected the yield differential over time. Furthermore, the SLB market may have evolved in terms of SLB issuers or market standardization and investor scrutiny,

Fourth, we do not have any data on the probability that firms will reach their target. One could speculate that this is the reason why we do not find a relationship between the potential penalty and the sustainability premium. In theory, one might assume, that the pricing at issue reflects the probability-weighted value of the future cash flows caused by a step-up event. However, there are reasons to believe that including such a variable will not change much. It is inherently difficult to obtain an estimate of such a probability. There are second-party opinions on the ambitiousness of targets, which could be used as a proxy. Based on our own attempts, it is challenging to judge whether a target is ambitious, because the baseline is unclear (i.e. what the company would have done without setting this target). Furthermore, as our 'free lunch' finding shows, a proportion of SLBs are overpriced from a rational option pricing or incentive mechanism perspective since the sustainability premium exceeds the maximum penalty (i.e. a penalty with probability 1). Finally, we believe that issuers tend to set targets with a high likelihood of achievement so that the probability of receiving coupon step-up payments is close to zero in most cases.

To conclude, we cannot rule out that investors value the possibility of a coupon step-up, but we can conclude that it is not a significant driver of the pricing.

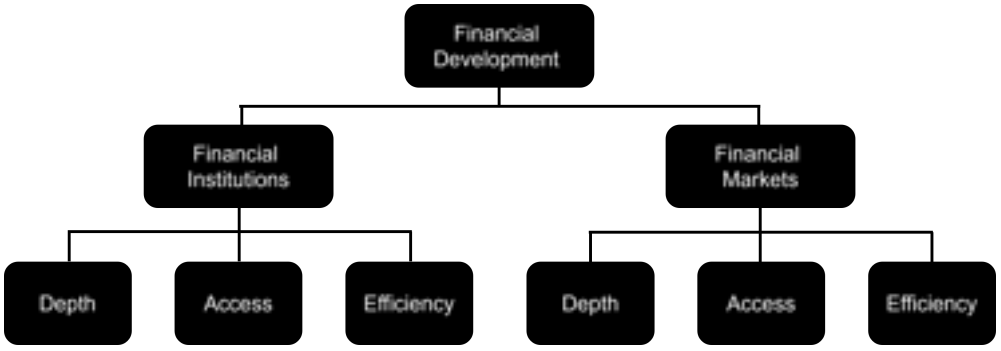
4.8 Further research

Since our paper is among the first studies addressing the new phenomenon of SLBs, it offers a multitude of future research opportunities. First, future research could analyze to what extent the sustainability targets set by companies are ambitious, and how the distance from the target impacts the sustainability premium of SLBs. Second, market dynamics should be considered. The demand for sustainable investments from institutional investors, especially in Europe, is high. Many company press releases describe the bond emissions as being oversubscribed. Further research could therefore analyze the impact of investor demand on the pricing of these SLBs on the primary and secondary bond market. Third, our paper focuses on the yield differential at bond issuance. Future research could analyze the development of SLBs on the secondary market, especially price movements, as the bond approaches its sustainability target date. Fourth, the actual impact of SLBs on companies' sustainability profiles could be analyzed. All these future research opportunities could be similarly addressed for (non-publicly listed) sustainability-linked loans. Research in the loan or private markets space could also offer interesting insights to disentangle the signaling and the financial motives, as non-listed companies are less driven by signaling purposes.

Appendix A

Appendix A: Financialization and Inequality

FIGURE A.1:
IMF's Financial Development indices and sub-indices



This figure shows the IMF's Financial Development indices and sub-indices. The overall aggregate index Financial Development is composed of two sub-indices for Financial Institutions and Financial Markets. Both these dimensions have sub-indices for depth, access and efficiency.

Table A.1:
Overview of variables and data sources

Variable	Description	Unit	Source
Income Inequality	Pre-tax income share of the top 10%, 1%, 0.1%, 0.001% and 0.0001%.	Percentage points	World Inequality Database (WID)
Financialization measures & control variables			
Stock options	Aggregate volume of single stock options contracts traded per country. The variable used in the regression is a ratio (in relation to the countries population).	Ratio (Number of contracts / population)	National stock exchanges, World Federation of Stock Exchanges (WFE), Euromoney Tradedata
Financial development	The index aims at capturing the multi-dimensional processes of financial markets and financial institutions, including their depth, access and efficiency. The data coverage is for the period 1990-2020 is complete for Australia, Canada, Germany, Spain and the USA. The other countries have an incomplete data coverage: Austria (1991-2014), Belgium (1993-2020), France (1993-2020), Italy (1996-2020), Japan (1997-2020), Netherlands (1993-2020), Norway (1990-2019), Sweden (1993-2020), UK (1992-2019),	Score (0-100)	Financial Development Index Database (IMF)
Financial market depth	The index captures the size of the stock market (capitalization, or the value of listed shares) and how active it is (stocks traded), the outstanding volume of international debt securities of sovereigns and international and domestic debt securities of financial and nonfinancial corporation	Score (0-100)	Financial Development Index Database (IMF)
Stock market capitalization	Total value of all listed shares in a stock market as a percentage of GDP.	Percentage points	Global Financial Development Database (GFDD)
Stocks traded	Total value of all traded shares in a stock market exchange as a percentage of GDP.	Percentage points	Global Financial Development Database (GFDD)
Private sector debt	Amount of private international debt securities (amounts outstanding) of all issuers (excluding the government) as a share of GDP	Percentage points	World Bank
S&P 500 volatility	Annual volatility based on monthly returns of the S&P 500 price development.	Percentage points	Online Data Robert Shiller
Economic control variables			
GDP-per-capita	GDP per capita is gross domestic product divided by midyear population.	US Dollars	World Bank
Import share	Imports of goods and services from the rest of the world as a percentage of GDP.	Percentage points	World Bank
Trade union	Trade union density is defined as the number of net union members (i.e excluding those who are not in the labour force, unemployed and self-employed) as a proportion of the number of employees.	Percentage points	OECD

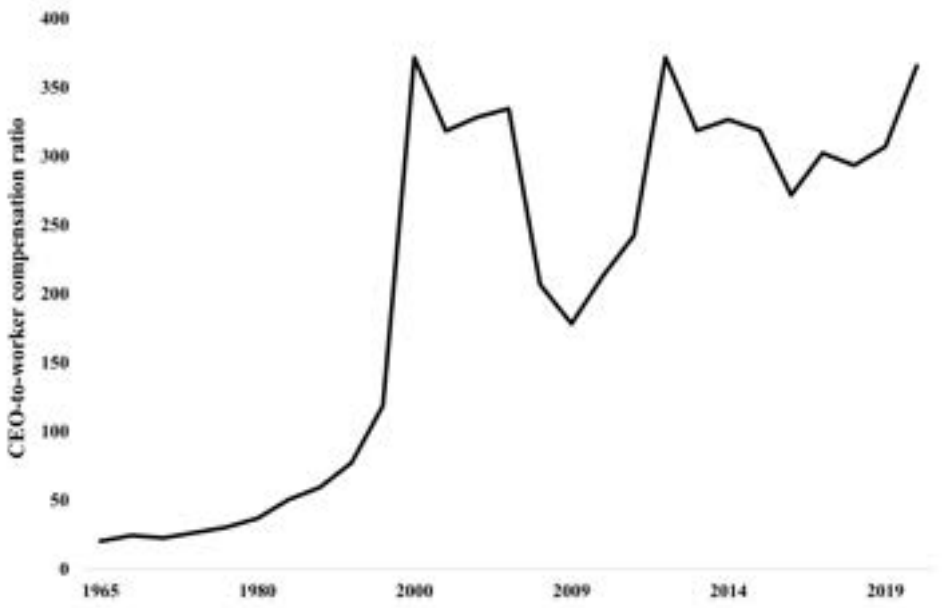
This table provides an overview and explanation of the dependent and all independent variables used in the regressions of section 2.5. The first column shows the variable name. The second column the variable description. The third column shows the unit of measure of the variable. Finally, the last column provides the source of data and information.

Table A.2:
Correlation of IMF Financial Development indices and single stock options

Indices & sub-indices	Correlation with single stock options
Financial Development	0.3705
Financial Insitutions	0.1650
Access	-0.0818
Efficiency	0.1241
Depth	0.3409
Financial Markets	0.4131
Access	0.0768
Efficiency	0.3358
Depth	0.4633

This table shows the correlation between the respective IMF financial development indices and single stock options.

FIGURE A.2:
Average U.S. CEO-to-worker compensation ratio of top 350 public companies, 1965-2020



This figure shows the average CEO-to-worker ratio for the top 350 publicly listed companies (ranked by sales) in the United States from 1965 to 2020. The CEO compensation includes salary, bonuses, restricted stock grants, options granted, and long-term incentive payouts. The worker salary is the annual average compensation of production and non-supervisory workers in the key industry of the respective firm. The source of the data is the Statista Research Department (2023).

TABLE A.3:
Regression results of error-correction models (level-level form)

Income share	Top 10%		Top 1%		Top 0.1%		Top 0.01%		Top 0.001%	
Model	XI	XII	XI	XII	XI	XII	XI	XII	XI	XII
Stock options	0.29**	0.55***	0.16**	0.33***	0.09**	0.18**	0.04*	0.09**	0.02	0.05*
VIX	-0.44**	-0.43**	-0.38***	-0.38***	-0.25***	-0.25***	-0.14***	-0.14**	0.05**	-0.04**
VIX x stock options		-0.01**		-0.01**		0.00		-0.00*		-0.00**
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	365	365	365	365	365	365	365	365	365	365
R-squared	0.5753	0.5821	0.5721	0.5774	0.5266	0.5305	0.4374	0.4413	0.3803	0.3908

This table reports the fixed effects regression results of the different top income share measures on single stock options when controlling for the CBOE Volatility index VIX. The Models XI and XII are the same as in Table 2.5 but replacing the S&P 500 volatility by the yearly average of the daily CBOE Volatility index VIX (provided by the St. Louis Federal Reserve). The main explanatory variable across the regressions is the volume of single stock option contracts traded. In Model XI we control for the VIX time series, while in Model XII we add an interaction term between stock options and the VIX. Across all models we additionally control for GDP per capita, import share and trade unions. Each column represents a separate regression with a different top income share.

TABLE A.4:
Regression results of error-correction models (level-level form)

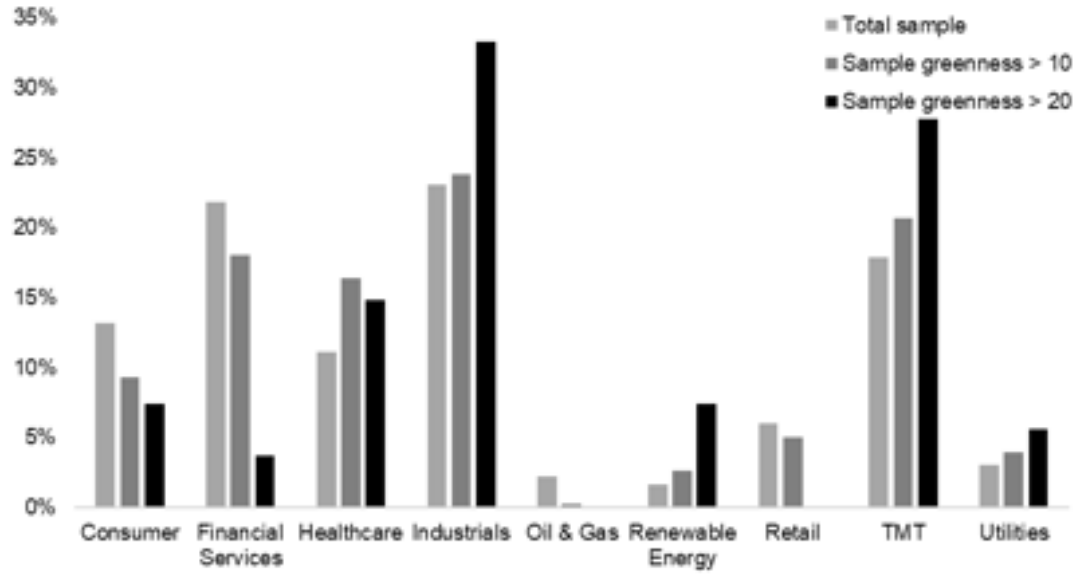
Income share	Top 10%		Top 1%		Top 0.1%		Top 0.01%		Top 0.001%	
Model	IX	X	IX	X	IX	X	IX	X	IX	X
Long-run parameters										
Stock options (*t*)	0.48**		0.35***		0.22***		0.11**		0.05**	
Stock options (*t-1*)		0.32**		0.21*		0.11		0.06		0.03*
Short-run parameters										
Stock options (*D*)	0.09	0.12	0.07	0.09	0.06	0.07	0.04	0.03	0.03**	0.02*
Adjustment term	0.20***	-0.24***	0.25***	-0.28***	0.29***	-0.30***	0.25***	-0.25***	0.28***	-0.30***
Control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	355	355	355	355	355	355	355	355	355	355

This table reports the error-correction model regression results of the different top income share measures on single stock options. The dependent variable across all regressions is the volume of single stock option contracts traded and the control variables are GDP per capita, the import share and trade unions. Each column represents a separate regression with a different top income share measure. All regressions are in level-level form. The results in log-log form are shown in Table 2.7.

Appendix B

Appendix B: SFDR

FIGURE B.1:
Distribution of greenness score by sector (global funds)



This figure shows the distribution of greenness scores by company sector for the 4'463 stocks included in the 182 global SFDR Article 9 fund sample. The light grey bars represent the distribution for the total sample of 4'463 stocks, while the dark grey bars represent the distribution for the sample of 537 stocks with a greenness score above 10. The black bars represent the distribution for the sample of 54 stocks with a greenness score above 20.

TABLE B.1:
List of fund managers within our sample of SFDR Article 9 funds

Frequency	Asset manager
18	Amundi
17	Blackrock
15	BNP Paribas
12	Pictet
11	AXA Investment Managers
8	Lyxor, RobecoSam
6	Candriam, CPR AM, LGIM, Storebrand, UBS
5	Actiam, Allianz, Dankse Invest, Handelsbanken, HSBC, Invesco, Schroders
4	Belfius (Candrium), Carmignac, DWS, Janus Henderson, M&G, Mirova / Natixis, Nordea, Oekoworld, Swisscanto
3	ABN Amro, Alliance Bernstein, DNB, Erste AM, Federated Hermes, Franklin Templeton, Lombard Odier, NN Investment Partners, Ofi AM, Swiss Life, UBP, Vontobel, Wellington
2	Asteria, Ecofi, Generali, iClima, J. Safra Sarasin, RIZE, Stewart Investors, Swedbank, Triodos
1	Aberdeen, Baillie Gifford, Berenberg, BFT IM, Cadmos, Caixa, Carnegie Fonder, CB Fonder, Coho Partners, Credit Suisse, Decalia, Delphi Fondene, Erik Penser Bank, Evangelische Bank, Financière Arbevel, Fondsfinans, Formue Pleje, FutureVest, GAM, Globalance, Guinness Global Investors, IFP, iM Global Partners, Impax AM, Liontrust, Lyrical AM, MACIF, Maeeschaert AM, Montanaro, Nykredit Invest, Oddo, Quaro Capital, Raiffeisen, RAM, VanEck, Warburg Invest

This table shows the number of global and regional SFDR Article 9 equity funds per fund manager within our sample of 290 SFDR Article 9 funds.

TABLE B.2:
Regional and strategy focus of our sample of SFDR Article 9 funds

	ESG / SRI	Climate Change / Transition	Thematic / Impact	**Total**
Global	41	12	129	182
Europe	46	14	8	68
USA	17	2	4	23
Emerging Markets	14	2	1	17
Total	118	30	142	290

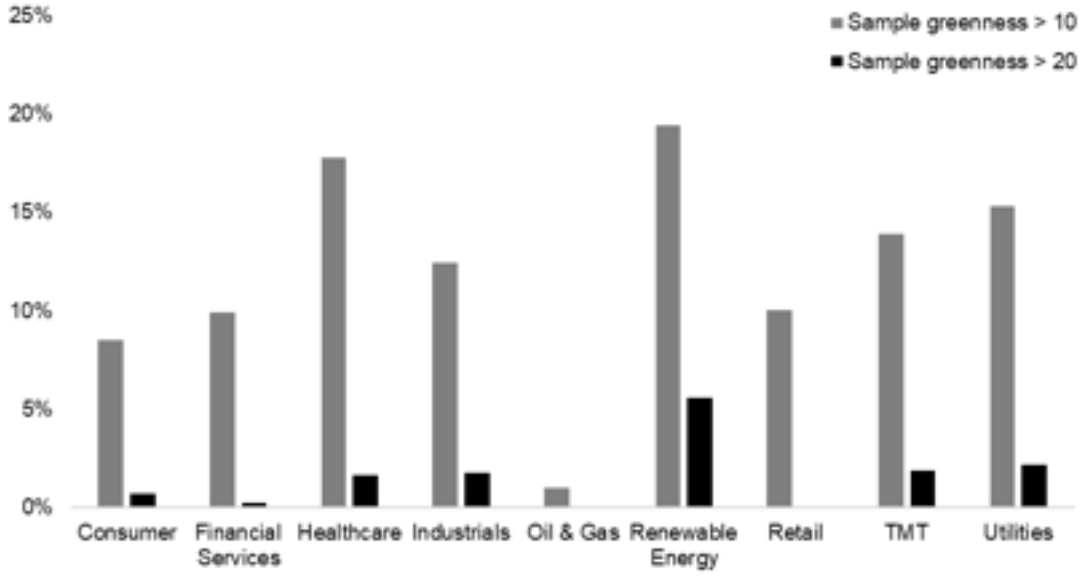
This table provides the breakdown of the 290 SFDR Article 9 equity funds by regional focus and investment strategy. The investment strategy is based on the label on Bloomberg. If the information is unavailable on Bloomberg, the categorization was based on information on the fund managers' website or fund factsheets.

TABLE B.3:
Overview and description of dependent and independent regression variables

Variable	Description	Type	Unit
Greenness	Number of times a company is included in an SFDR Article 9 fund divided by the total number of funds.	Quantitative	Score (0-100)
Sustainability Disclosure & Characteristics			
Decarbonization Variables			
GHG Emissions	Company's total GHG emissions (scope 1-3)	Quantitative	MT CO2e
GHG/Enterprise Value	Ratio of a company's total GHG emissions (scope 1-3) divided by the enterprise value including cash. For scale reasons the figure is divided by 1000.	Quantitative	MT CO2e / EVIC*1000
Net Zero Target	Company committed to a net zero target.	Qualitative	Binary (0 or 1)
Science-Based Target	Company is part of the science-based target initiative.	Qualitative	Binary (0 or 1)
Social & Governance Indicators			
Board Diversity	Percentage of board level diversity.	Quantitative	Percentage
Human Rights Policy	Company has a human rights policy.	Qualitative	Binary (0 or 1)
UN Global Compact	Company violated the UN Global Compact principles or the OECD guidelines for multinational enterprises.	Qualitative	Binary (0 or 1)
Weapon exposure	Company has exposure to controversial weapons.	Qualitative	Binary (0 or 1)
Sustainability ratings			
Sust. Controversy	Sustainalytics' controversy level.	Quantitative	Score (0-5)
Sust. Risk Score	Sustainalytics' risk score.	Quantitative	Points (0-50)
S&P ESG rank	A company's Standard & Poor's global ESG rank	Quantitative	Points (0-100)
MSCI ESG rating	MSCI ESG rating.	Quantitative	Score (0-10)
Bloomberg Environmental	Bloomberg Environmental score.	Quantitative	Score (0-10)
Bloomberg Social	Bloomberg Social score.	Quantitative	Score (0-10)
Bloomberg Governance	Bloomberg Governance score.	Quantitative	Score (0-7)
Sectors	Binary variables for company sector classification.	Qualitative	Binary (0 or 1)
Financial Characteristics			
Revenues	Company's revenues in 2021.	Quantitative	USD billion
EBITDA	EBITDA to revenue ratio.	Quantitative	Ratio
Price/Book	Price to book ratio.	Quantitative	Ratio
Region	Binary variables for company region.	Qualitative	Binary (0 or 1)

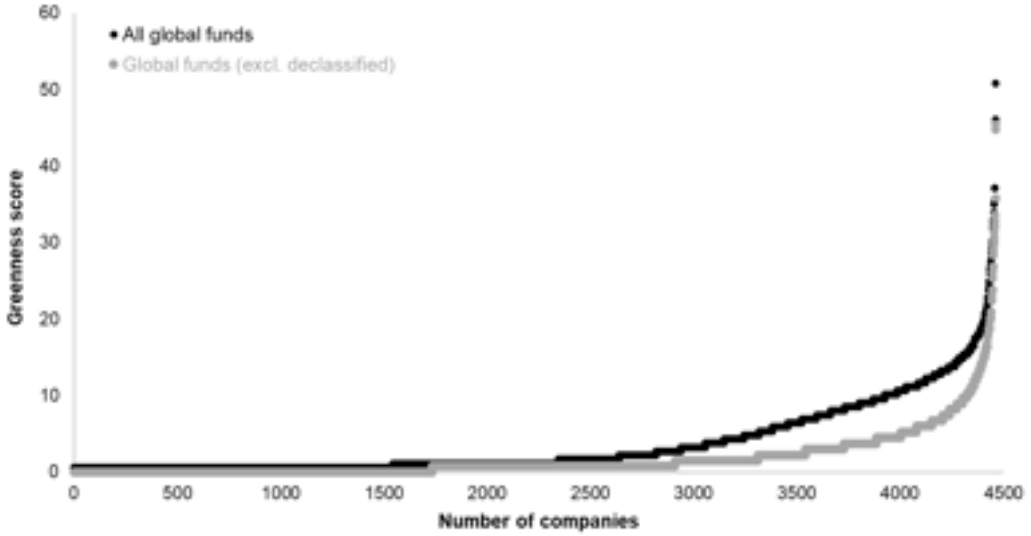
This table provides an overview and explanation of the dependent and all independent variables used in the regressions of section 3.5. The first column shows the variable name. The second column the variable description. The third column shows whether the indicator is a quantitative measure or a qualitative information. Finally, the last column shows the unit of measure.

FIGURE B.2:
Overview of intra-sectoral greenness score sample (global funds)



This figure shows the intra-sectoral distribution of greenness scores by company sector for the 182 global SFDR Article 9 fund sample. The y-axis represents the proportion of stocks from the total sector sample. The light grey bars represent the 537 stocks with a greenness score above 10 and the black bars the 54 stocks with a greenness score above 20. For example, for renewable energy stocks the share of stocks with a greenness score above 10 represents 19.4%.

FIGURE B.3:
Distribution of greenness score for all global vs. global excl. declassified funds



This figure compares the distribution of stocks' implied greenness scores for the stocks included in the 182 global SFDR Article 9 fund sample vs. in the 117 global SFDR Article 9 funds post-declassification wave. The x-axis represents the data point for each stock sorted in ascending order of greenness score. The y-axis shows the respective greenness score of each stock.

TABLE B.4:
Summary statistics of most frequent 20 sub-industries (global funds)

Sub-industry	Average greenness score	Min	Max	Standard deviation	# companies *(% of total sample)*	# with greenness score >10 *(% of total)*	# with greenness score >20 *(% of total)*
Banks	1.9	0.53	13.8	2.7	255 *(5.7%)*	9 *(1.7%)*	0 *(0.0%)*
Application Software	3.7	0.53	31.7	5.5	141 *(3.2%)*	17 *(3.2%)*	3 *(5.6%)*
Biotech	1.9	0.53	14.3	3.0	130 *(2.9%)*	7*(1.3%)*	0 *(0.0%)*
Specialty & Generic Pharma	2.2	0.53	12.2	2.9	86 *(1.9%)*	4 *(0.7%)*	0 *(0.0%)*
Packaged Food	2.7	0.53	21.2	3.9	82 *(1.8%)*	5 *(0.9%)*	1 *(1.9%)*
Specialty Chemicals	5.6	0.53	33.9	5.8	64 *(1.4%)*	14 *(2.6%)*	4 *(7.4%)*
Internet Media & Services	3.3	0.53	11.1	5.3	63 *(1.4%)*	3 *(0.6%)*	0 *(0.0%)*
Multi Asset Class Own & Develop	2.4	0.53	11.1	2.6	61 *(1.4%)*	2 *(0.4%)*	0 *(0.0%)*
Food & Drug Stores	3.1	0.53	13.8	3.4	60 *(1.3%)*	5 *(0.9%)*	0 *(0.0%)*
Power Generation	5.5	0.53	30.2	4.9	59 *(1.3%)*	10 *(1.9%)*	2 *(3.7%)*
IT Services	2.9	0.53	12.7	3.5	58 *(1.3%)*	5 *(0.9%)*	0 *(0.0%)*
Wireless Telecommunications	3.7	0.53	11.1	3.7	53 *(1.2%)*	4 *(0.7%)*	0 *(0.0%)*
Renewable Energy Equipment	6.0	0.53	46.0	7.8	51 *(1.1%)*	10 *(1.9%)*	2 *(3.7%)*
Basic & Diversified Chemicals	2.9	0.53	18.0	3.9	51 *(1.1%)*	3 *(0.6%)*	0 *(0.0%)*
Life Insurance	4.2	0.53	20.6	4.3	51 *(1.1%)*	3 *(0.6%)*	1 *(1.9%)*
P&C Insurance	4.4	0.53	15.9	4.7	50 *(1.1%)*	10 *(1.9%)*	0 *(0.0%)*
Auto Parts	2.8	0.53	14.3	3.2	49 *(1.1%)*	2 *(0.4%)*	0 *(0.0%)*
Semiconductor Devices	4.5	0.53	32.8	6.3	48 *(1.1%)*	7 *(1.3%)*	1 *(1.9%)*
Infrastructure Software	3.6	0.53	16.4	3.9	47 *(1.1%)*	3 *(0.6%)*	0 *(0.0%)*
Health Care Services	3.3	0.53	14.8	4.3	46 *(1.0%)*	6 *(1.1%)*	0 *(0.0%)*
Total	**3.7**	**0.53**	**33.9**	**5.0**	**1'505 *(33.7%)***	**537 *(24.0%)***	**54 *(25.9%)***

This table shows the summary statistics of greenness scores by company sub-industry for the 4'463 stocks included in the 182 global SFDR Article 9 fund sample. The first four columns show the average greenness score, the minimum greenness score, the maximum greenness score, and the standard deviation of greenness scores within the sub-industry, respectively. The fifth column provides the number of companies represented by this sub-industry in absolute number and as a percentage of the total of 4'463 stocks. The sixth column provides the number of companies with a greenness score above 10 in absolute and as a percentage of the total number of companies with a greenness score above 10. The seventh column provides the number of companies with a greenness score above 20 in absolute and as a percentage of the total number of companies with a greenness score above 20.

TABLE B.5:
Top 20 companies by greenness score (global funds)

Greenness	Company	Region	Sector	Sub-industry	MSCI ESG rating	Sustainalytics risk score	Sustainalytics risk category	Net zero targets / science-based	Market cap. (USDbn)
51.7	Schneider Electric	Europe	Industrials	Electrical Power Equipment	AAA	17.48	Low	Yes / Yes	87.7
46.7	Vestas Wind Systems	Europe	Renewable Energy	Renewable Energy Equipment	AAA	14.45	Low	Yes / Yes	27.5
38.5	Microsoft Corp	North America	TMT	Systems Software	AAA	15.24	Low	Yes / Yes	2'145.8
38.5	Xylem	North America	Industrials	Industrial Machinery	AAA	15.95	Low	Yes / No	18.0
37.4	ASML	Europe	TMT	Semiconductor Mfg	AAA	10.91	Low	Yes / Yes	255.9
37.4	SolarEdge Technologies	North America	Renewable Energy	Semiconductor Equipment	BBB	24.61	Medium	No / No	17.8
36.3	Thermo Fisher Scientific	North America	Healthcare	Life Sciences Tools & Services	BBB	13.52	Low	No / No	230.7
34.1	Ecolab	North America	Industrials	Specialty Chemicals	AAA	24.09	Medium	Yes / Yes	48.3
34.1	American Water Works	North America	Utilities	Water Utilities	A	27.76	Medium	No / No	28.2
33.0	Infineon Technologies	Europe	TMT	Semiconductor Devices	AA	17.89	Low	Yes / No	40.5
32.4	Autodesk	North America	TMT	Application Software	AA	16.07	Low	Yes / Yes	49.0
31.3	Danaher	North America	Healthcare	Life Sciences Tools & Services	A	11.73	Low	No / No	209.5
31.3	Koninklijke DSM	Europe	Industrials	Specialty Chemicals	AAA	19.94	Low	Yes / Yes	29.0
30.8	Waste Management	North America	Industrials	Waste Management	A	16.73	Low	No / No	70.7
30.8	EDP Renovaveis	Europe	Utilities	Power Generation	A	15.61	Low	No / No	27.9
29.1	Agilent Technologies	North America	Healthcare	Life Sciences Tools & Services	AA	15.33	Low	No / No	39.2
29.1	ANSYS	North America	TMT	Application Software	AA	13.05	Low	No / No	25.0
29.1	Aptiv	North America	Consumer	Auto Parts & Equipment	AA	11.68	Low	No / No	28.5
28.6	Trimble	North America	Industrials	Electronic Equipment & Instrum	AA	12.98	Low	No / No	17.3
28.0	Deere & Co	North America	Industrials	Agricultural & Farm Machinery	A	16.64	Low	Yes / Yes	108.0

This table shows the summary statistics of the 20 companies with the highest greenness scores across the 182 global SFDR Article 9 funds. The first column shows the greenness score and the second column the corresponding company. Columns three, four and five show the companies' region, sector and sub-industry, respectively. Columns six, seven and eight show the MSCI and Sustainalytics ESG ratings and risk categories. Columns nine shows whether the company has a net zero target, and whether this is approved by the science-based targets initiative. Column ten shows the market capitalization of the companies.

TABLE B.6:
Distribution of MSCI ESG and Sustainalytics risk categories (global funds)

MSCI ESG rating			
Scale	Number of companies	Average greenness score	Standard deviation
AAA	162	12.3	8.0
AA	501	8.7	5.8
A	531	6.9	5.5
BBB	419	5.3	5.0
BB	271	3.5	3.5
B	144	2.2	2.6
CCC	51	1.3	1.7
Total	**2'079**	**6.5**	**5.9**

Sustainalytics risk category			
Scale	Number of companies	Average greenness score	Standard deviation
Negligible	68	6.8	5.5
Low	1'212	6.1	6.5
Medium	1'312	4.7	5.0
High	420	2.5	2.8
Severe	88	1.2	1.1
N.S.	1'300	1.1	1.4
Total	**4'400**	**3.8**	**5.0**

This table provides an overview of the distribution of greenness scores for the MSCI ESG rating and Sustainalytics risk category for the stocks included in the 182 global SFDR Article 9 funds.

TABLE B.7:
Greenness score by company size (global funds)

Company size	Market cap. (USDbn)	Number of companies	Average greenness score	Standard deviation
Micro cap	< 0.3	55	2.00	4.31
Small cap	0.3 – 2.0	913	0.93	1.08
Mid cap	2.0 – 10.0	2'082	2.27	2.83
Large cap	> 10.0	1'381	7.92	6.37

This table provides an overview of the distribution of greenness scores by company size as defined by the market capitalization for the stocks included in the 182 global SFDR Article 9 funds.

TABLE B.8:
Distribution of MSCI ESG and Sustainalytics risk categories (regional funds)

MSCI ESG rating			
Scale	Number of companies	Average greenness score	Standard deviation
AAA	130	13.1	8.5
AA	405	8.8	6.3
A	432	7.1	6.0
BBB	356	5.2	5.2
BB	245	3.4	3.6
B	135	2.0	2.6
CCC	49	1.2	1.5
Total	**1'752**	**6.5**	**6.3**

Sustainalytics risk category			
Scale	Number of companies	Average greenness score	Standard deviation
Negligible	48	25.0	21.2
Low	975	26.9	20.5
Medium	1'077	24.0	18.4
High	319	21.0	15.0
Severe	74	17.2	10.0
N.S.	1'009	4.8	2.8
Total	**3'502**	**18.9**	**18.3**

This table provides an overview of the distribution of greenness scores by MSCI ESG rating and Sustainalytics risk category for the stocks included in the 108 regional SFDR Article 9 funds

TABLE B.9:
Greenness score by company size (regional funds)

Company size	Market cap. (USDbn)	Number of companies	Average greenness score	Standard deviation
Micro cap	< 0.3	32	2.80	5.53
Small cap	0.3 – 2.0	528	1.03	1.31
Mid cap	2.0 – 10.0	1'608	2.07	2.74
Large cap	> 10.0	1'195	8.13	6.63

This table provides an overview of the distribution of greenness scores by company size as defined by the market capitalization for the stocks included in the 108 regional SFDR Article 9 funds.

TABLE B.10:
Regression results for all companies vs. excluding those included once (global funds)

	Greenness									
	Model I		**Model II**		**Model III**		**Model IV**		**Model V**	
	All companies	Included >1x	All companies	Included >1x	All companies	Included >1x	All companies	Included >1x	All companies	Included >1x
Sustainability characteristics & ratings										
Decarbarbonization										
GHG/EVIC	-0.00***	-0.00***	-0.00*	-0.00*	-0.00*	-0.00*	-0.00*	-1.11*	-0.00***	-0.00***
NZT	0.99***	0.73**	0.62*	0.53	0.86***	0.82**	0.33	3.46***	0.80**	0.74*
SBT	2.88***	2.38***	2.51***	2.00***	2.15***	1.66***	1.49**	1.49***	2.11***	1.56***
Social & Governance PAIs								-3.31***		
Board diversity	0.02**	0.03**	-0.02	-0.02	-0.01	-0.02	-0.01	11.69***	0.00	0.00
Human rights policy	1.76***	1.77***	1.57***	1.73***	1.27***	1.37***	0.72*	-0.73	2.08***	2.05***
UNGC	-0.14	0.35	0.10	0.45	0.40	0.66	-0.30	-0.57	-0.91*	-0.52
Weapon exposure	-3.60***	-5.14***	-5.10***	-6.02***	-3.69***	-4.61***	-7.21***	1.09	-4.38***	-6.03***
ESG ratings										
Sustainalytics controversy level			0.32**	0.28*						
Sustainalytics risk score					-0.19***	-0.19***				
MSCI ESG							1.47***	1.48***		
BBG Environmental									0.64***	0.59***
BBG Social									-0.04	-0.07
BBG Governance									0.22	0.23
Sector										
Financial services	-0.58	0.16	0.51	-1.45	-0.73	-1.11*	-0.57	-0.51	-1.11	0.55
Healthcare	2.90***	3.05***	3.54***	3.17***	3.81***	3.46***	2.97***	3.12***	4.11***	3.72***
Industrials	1.25***	1.23***	1.45***	1.41***	1.52***	1.49***	1.31	1.46***	0.70	0.70
Oil & Gas	-2.41***	-3.61***	-3.11***	-4.06***	-2.42***	-3.31***	-5.85***	-5.79***	-3.53***	-4.74***
Renewable energy	8.03***	7.85**	10.13**	11.39**	10.61***	11.69***	18.75***	18.84***	6.44**	5.03*
Retail	-0.49	-0.13	-0.29	-0.22	-0.96**	-0.73	-0.57	-0.31	-0.43	-0.27
TMT	1.65***	1.40***	1.77***	1.45***	-0.78*	-0.57	1.14**	1.25***	1.87***	1.46***
Utilities	2.03***	0.78	1.80**	0.67**	2.07**	1.09	-0.61	-0.43	0.49	-0.65
Financial characteristics										
Revenues	0.03***	0.02***	0.02***	0.01**	0.02***	0.02***	0.01**	0.01*	0.02***	0.01**
EBITDA ratio	0.00***	0.02***	0.00***	0.02***	0.00***	0.02**	0.01**	0.01**	0.00***	0.01***
P/B	0.00***	0.00***	0.00**	0.00**	0.00*	0.00	0.00	0.00	0.00**	0.00**
Other										
Region	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-1.16	-1.23*	0.81**	1.61**	5.65***	6.49***	-1.78**	-1.98**	-2.03	-0.40
N	2'058	1'515	1'622	1'362	1'622	1'362	1'127	1'084	1'318	1'063
R-squared	0.1907	0.2027	0.2190	0.2403	0.2566	0.2737	0.4184	0.4004	0.2419	0.2406

**p < 0.10, **p < 0.05, ***p < 0.01. The OLS regressions are performed based on robust standard errors.*

This table reports the OLS regression results of the stocks' greenness score on different inclusion drivers for the stocks included the 182 global SFDR Article 9 funds and compares these results to the stocks that are included only once across the 182 global funds. The dependent variable across all regressions is the greenness score. In Model I, the explanatory variables are the decarbonization variables, suchs as the GHG intensity (GHG/Enterprise Value) and the climate commitments (NZT and SBT), the social & governance indicators, and the sector classifications. Furthermore, the companies' financial characteristics and region are used as control variables. In Model II, the additional explanatory variable is the Sustainalytics controversy level. In Model III, the additional explanatory variable is the Sustainalytics risk score. In Model IV, the additional explanatory variable is the MSCI ESG rating. In Model V, the additional explanatory variables are the individual Bloomberg ESG dimensions.

TABLE B.11:
Regression results for all companies vs. companies with greenness 10 (global funds)

	Greenness									
	Model I		**Model II**		**Model III**		**Model IV**		**Model V**	
	All companies	Greeness >10	All companies	Greeness >10	All companies	Greeness >10	All companies	Greeness >10	All companies	Greeness >10
Sustainability characteristics & ratings										
Decarbarbonization										
GHG/EVIC	-0.00***	-0.00***	-0.00*	-0.00***	-0.00*	-0.00***	-0.00*	-0.00*	-0.00***	-0.00***
NZT	0.99***	0.63	0.62*	0.67	0.86***	0.73	0.33	0.52	0.80**	0.52
SBT	2.88***	0.80	2.51***	0.87	2.15***	0.47	1.49**	0.63	2.11***	1.05
Social & Governance PAIs										
Board diversity	0.02**	-0.00	-0.02	-0.01	-0.01	-0.01	-0.01	-0.02	0.00	-0.02
Human rights policy	1.76***	1.85**	1.57***	2.00***	1.27***	1.65**	0.72*	1.59*	2.08***	2.25*
UNGC	-0.14	0.90	0.10	0.87	0.40	0.77	-0.30	0.25	-0.91*	-1.21
Weapon exposure	-3.60***	-	-5.10***	-	-3.69***	-	-7.21***	-	-4.38***	-
ESG ratings										
Sustainalytics controversy level			0.32**	-0.34						
Sustainalytics risk score					-0.19***	-0.16***				
MSCI ESG							1.47***	1.04***		
BBG Environmental									0.64***	0.10
BBG Social									-0.04	0.21
BBG Governance									0.22	0.18
Sector										
Financial services	-0.58	-2.30**	0.51	-2.42**	-0.73	-2.78***	-0.57	-2.61**	-1.11	-1.84
Healthcare	2.90***	0.58	3.54***	0.51	3.81***	0.80	2.97***	1.10	4.11***	1.07
Industrials	1.25***	1.82*	1.45***	1.68	1.52***	1.78*	1.31	2.09*	0.70	2.24*
Oil & Gas	-2.41***	-3.57***	-3.11***	-3.61***	-2.42***	-3.69***	-5.85***	-4.50***	-3.53***	-3.82**
Renewable energy	8.03***	8.15*	10.13**	8.08*	10.61***	8.19*	18.75***	14.50**	6.44**	1.73
Retail	-0.49	-1.56	-0.29	-1.67	-0.96**	-2.09**	-0.57	-1.45	-0.43	-1.41
TMT	1.65***	1.01	1.77***	0.84	-0.78*	-0.54	1.14**	1.30	1.87***	1.31
Utilities	2.03***	1.85	1.80**	1.60	2.07**	2.13	-0.61	2.11	0.49	0.35
Financial characteristics										
Revenues	0.03***	0.01	0.02***	0.01	0.02***	0.01	0.01**	0.01*	0.02***	0.01
EBITDA ratio	0.00***	0.01	0.00***	0.01	0.00***	0.01	0.01**	0.02*	0.00***	0.01
P/B	0.00***	0.00	0.00**	0.00	0.00*	0.00	0.00	0.00	0.00**	0.00
Other										
Region	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-1.16	-11.45*	0.81**	12.01***	5.65***	15.17***	-1.78**	5.61**	-2.03	9.23***
N	2'058	354	1'622	352	1'622	352	1'127	341	1'318	293
R-squared	0.1907	0.1093	0.2190	0.1131	0.2566	0.1292	0.4184	0.1561	0.2419	0.0946

**p < 0.10, **p < 0.05, ***p < 0.01. The OLS regressions are performed based on robust standard errors.*

This table reports the OLS regression results of the stocks' greenness score on different inclusion drivers for the stocks included the 182 global SFDR Article 9 funds and compares these results to the stocks with a greenness score above 10. The dependent variable across all regressions is the greenness score. In Model I, the explanatory variables are the decarbonization variables, suchs as the GHG intensity (GHG/Enterprise Value) and the climate commitments (NZT and SBT), the social & governance indicators, and the sector classifications. Furthermore, the companies' financial characteristics and region are used as control variables. In Model II, the additional explanatory variable is the Sustainalytics controversy level. In Model III, the additional explanatory variable is the Sustainalytics risk score. In Model IV, the additional explanatory variable is the MSCI ESG rating. In Model V, the additional explanatory variables are the individual Bloomberg ESG dimensions.

Appendix C

Appendix C: Sustainability-Linked Bonds

TABLE C.1:
Comparison of overall SLB market and our sample of bond pairs.

	SLB Market: # SLBs (% of market)			**Matched bond pairs sample: # SLBs (% of sample)**		
Total	551			238		
Region	• Asia-Pacific:	159	(29%)	• Asia-Pacific:	107	(45%)
	• Europe	289	(52%)	• Europe	89	(37%)
	• North America	46	(8%)	• North America	27	(11%)
	• Rest of World	57	(10%)	• Rest of World	15	(6%)
GICS Sector	• Com. Services	25	(5%)	• Com. Services	11	(5%)
	• Cons. Discretionary	40	(7%)	• Cons. Discretionary	10	(4%)
	• Consumer Staples	42	(8%)	• Consumer Staples	24	(10%)
	• Energy	72	(13%)	• Energy	40	(17%)
	• Financials	43	(8%)	• Financials	24	(10%)
	• Health Care	16	(3%)	• Health Care	10	(4%)
	• Industrials	135	(25%)	• Industrials	50	(21%)
	• IT	21	(4%)	• IT	11	(5%)
	• Materials:	61	(11%)	• Materials:	26	(11%)
	• Real Estate	30	(5%)	• Real Estate	21	(9%)
	• Utilities:	66	(12%)	• Utilities:	11	(5%)
Maturity type	• At maturity:	234	(43%)	• At maturity:	137	(58%)
	• Callable:	288	(52%)	• Callable:	101	(42%)
	• Callable / Perpetual:	14	(3%)	• Callable / Perpetual:	-	-
	• Callable / Sinkable:	1	(0%)	• Callable / Sinkable:	-	-
	• Convertible:	3	(1%)	• Convertible:	-	-
	• Extendible:	1	(0%)	• Extendible:	-	-
	• Putable:	5	(1%)	• Putable:	-	-
	• Sinkable:	5	(1%)	• Sinkable:	-	-

This table compares the overall SLB market with our sample resulting from the matching methodology.

TABLE C.2:
Description of variables

Variable	Description	Unit
Δ *Yield*	Yield at issue of the SLB minus the yield at issue of the the non-sustainable counterfactual.	Basis points
Financial characteristics		
Time-weighted step-up	Coupon step-up determined in the margin ratchet of the SLB multiplied by the fraction of the bond's maturity over which the step-up applies.	Basis points
Sustainability characteristics		
Environmental target	Binary variable equal to 1 if the SPT of the bond includes targets related to GHG emission reduction.	Binary (0 or 1)
First SLB issue	Binary variable for first SLB issued by this company.	Binary (0 or 1)
DJSI	Issuer was included in one of the Dow Jones Sustainability Indices at the time the SLB was issued.	Binary (0 or 1)
SBT	Binary variable equal to 1 if the issuer is a signatory to the science-based target initiative (SBTi).	Binary (0 or 1)
Matching differences		
Issue date diff.	Difference between issue dates of the sustainability-linked bond and the counterfactual bond.	Years
Maturity diff.	Difference between maturity of the sustainability-linked bond and the counterfactual bond.	Years
Issue size ratio	Ratio between the sustainability-linked bond and the counterfactual bond.	Ratio (0.25-4)
Issuer characteristics		
Credit rating change	Change in one of the issuer's credit ratings during the interval of the counterfactual and SLB issuance.	Binary (0 or 1)
Region	Binary variables for issuer region.	Binary (0 or 1)
Sector	Binary variables for issuer sector.	Binary (0 or 1)
Credit environment		
Interest rate change	Change in the Interest rate between the issue dates of the counterfactual and the SLB.	Basis points
Credit spreads	Change in the credits spreads between the issue dates of the counterfactual and the SLB.	Basis points

This table summarizes the variables used in the regressions of Table 4.7.

TABLE C.3:
SLB yield at issue vs. counterfactual bonds - 3 year matching

	Yield at issue			
Model	I	II	III	IV
SLB	23.41***	−5.91	−7.76	−12.21**
Interest rate		0.99***	1.02***	1.04***
Credit spreads			1.50	1.90*
Size				0.00
Maturity				12.82***
Observations	398	398	398	398
R-squared	0.91	0.96	0.96	0.97

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Regression of the yield at issue for a sample of matched bond pairs. This table is equivalent to Table 4.7, but uses a matching with a three-year limit on the issue date and maturity difference.

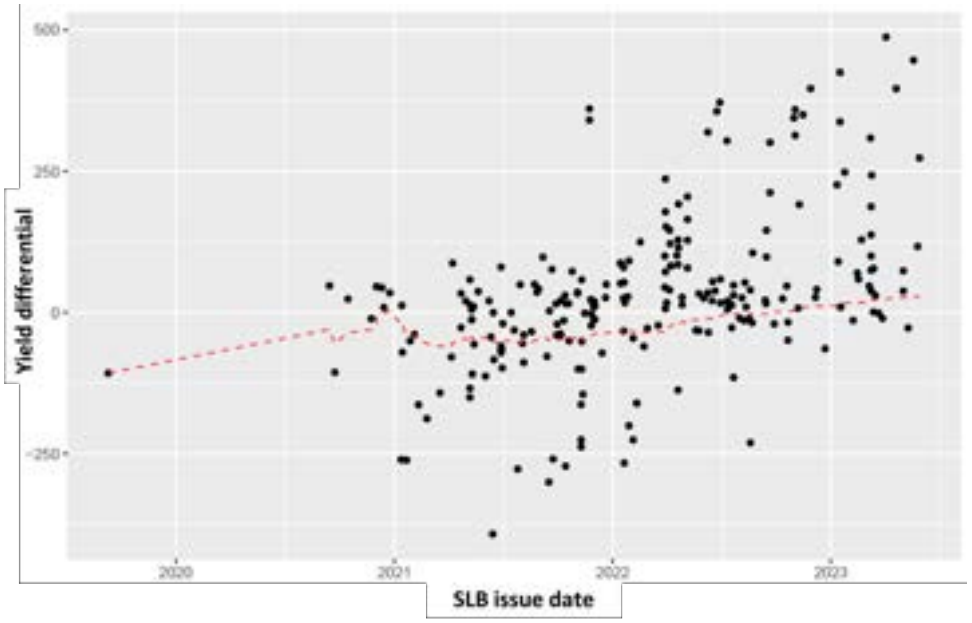
TABLE C.4:
SLB yield at issue vs. counterfactual bonds - 1 year matching

	Yield at issue			
Model	I	II	III	IV
SLB	−0.21	−16.30*	−13.42	−13.10
Interest rate		0.93***	0.87***	0.86***
Credit spreads			−5.22**	−5.32**
Size				−0.00
Maturity				−13.13
Observations	164	164	164	164
R-squared	0.92	0.96	0.96	0.96

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

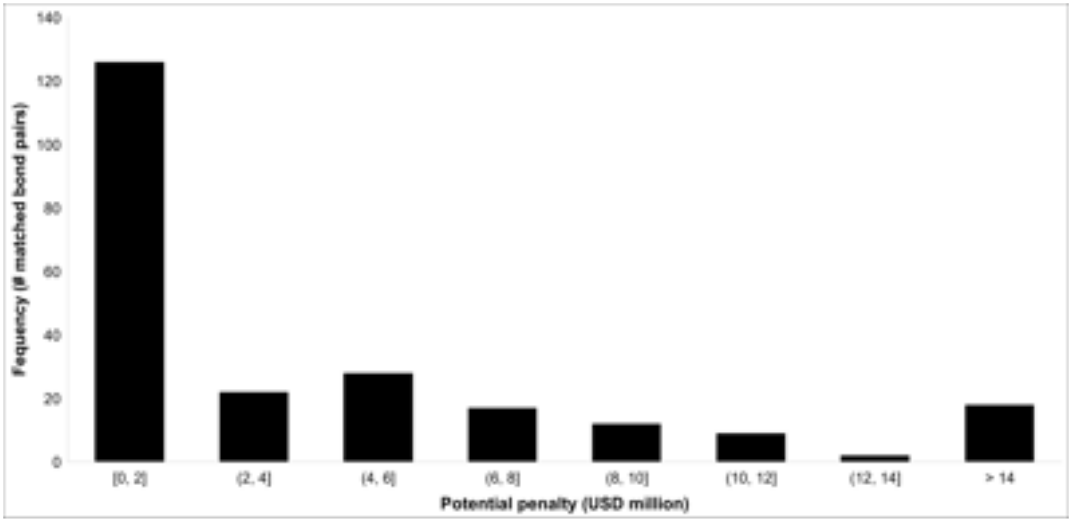
Regression of the yield at issue for a sample of matched bond pairs. This table is equivalent to Table 4.7, but uses a matching with a one-year limit on the issue date and maturity difference.

FIGURE C.1:
Distribution of yield differential within our bond pair sample



This graph shows the distribution of the yield differential between SLBs and counterfactuals over time. It is the result of our matching approach illustrated in Table 4.6.

FIGURE C.2:
Distribution of potential penalty for SLBs within our bond pair sample



This graph shows the distribution of the potential penalty in absolute amounts (USD millions) based on the issue size and the time-weighted coupon step-up within our sample.

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