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FINANCIAL ECONOMICS WITH PREFERENCES AND FRICTIONS

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Andreas Brøgger

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Financial Economics with Preferences and Frictions

Andreas Brøgger

A thesis presented for the degree of
Doctor of Philosophy

Primary supervisor: Jens Dick-Nielsen
Secondary supervisor: David Lando
CBS PhD School
Copenhagen Business School

Andreas Brøgger
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Abstract

This thesis represents the final product of my PhD studies at the Department of Finance and the Center for Financial Frictions at Copenhagen Business School. The thesis consists of three chapters which document how individuals' preferences interact with financial markets to produce both financial and real outcomes in often surprising ways. The chapters are self-contained and can be read independently.

The first chapter, "Skills and Sentiment in Sustainable Investing," won the best paper in finance award at the 2020 conference on behavioral research in finance, governance, and accounting and has been invited to submit to the Review of Financial Studies. The chapter documents that flexible investors, such as hedge funds, have outperformed more socially constrained investors, such as pension funds, in their sustainable investments.

The second chapter, "The Future of Emissions," proposes to introduce a new financial asset named "Emission Futures". Emission futures would allow us to make objective forward-looking ESG ratings, which would make impact investing more impactful by decreasing ratings' inaccuracies and making them less prone to greenwashing.

The third chapter, "Corporate Asset Pricing," discovers the new fact that idiosyncratic volatility significantly predicts the convenience yield. This fact poses a puzzle with current safe asset theories and explains why these theories have been unable to match the convenience yield since the financial crisis.

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In the process of writing this thesis, I have been fortunate to benefit from the advice, feedback, and support from many more people than I can possibly mention here. This long list of people, however, includes some who deserve special recognition.

First of all, I am grateful to my advisor Jens Dick-Nielsen. Jens dedicated more time and effort than I could have imagined any supervisor would. He also helped me sharpen my thinking, prioritize, and believed in me at critical points when it was most needed. Without him this thesis would surely not have been written.

Secondly, I am thankful for my secondary supervisor, David Lando, who is the personification of rigorous scientific curiosity. His passion for research is a beacon, illuminating not only me but also reaching researchers around the globe. I am grateful to have been in this inspiring light, and I hope to pass it on in my own academic career.

Thirdly, I am thankful for the connections I made during my PhD, including my research stays at Wharton and Luxembourg. Many struggles and victories have been shared with Alexander Kronies, a co-PhD, co-author, roommate, and confidant. I am grateful to Itay Goldstein for generously sponsoring my stay at Wharton and donating his time. I thank Juan Imbet, Alejandro Lopez-Lira, and Max Miller, who not only welcomed me as a part of their own, but also made our uncountable hours of discussion extremely fun! Today, I see them all as great friends. I am deeply indebted to my co-author, Jules Hans van Binsbergen, who taught me critical thinking. Without his encouragement, I would not be where I am today. In Luxembourg, Roberto Steri welcomed me and advised me on the job market. There, I also met François Koulischer and Michael Halling, whom I thank for great co-authorship and support during the last year.

Finally, Louise deserves special thanks. Her endless encouragement and support of my academic career made it possible to be where I am today. I am also grateful to my friends and family for bearing with me in stressful times and to my grandparents and parents for always believing in me. This thesis is dedicated to the memory of my grandparents.

Andreas Brøgger

Copenhagen, April 2023

Introduction and Summaries

This thesis starts from the central idea that market outcomes - such as prices, investments, and emissions - are determined both by investors' preferences as well as frictions that distort markets in a certain way from the friction-free benchmark. Such preferences could be aversion to risk or personal benefits from sustainable investments, and frictions could be tax deduction of debt. The importance of these two ideas are exemplified by the following Nobel winning papers. In the first Sharpe (1964) shows that investors' risk aversions determines the return of the stock market, and in the second Modigliani and Miller (1958) shows that tax deductions lead to higher debt issuance than in a world without this tax deduction.

All three chapters in this thesis document new findings on how individuals' preferences *interact* with frictions to produce, often surprising, financial and real outcomes. Chapter 1 shows that asymmetry in investor mandates and asymmetric information lead to the profit-seeking investor investing in stocks that increase more in their ESG scores than investors with stronger ESG mandates. Chapter 2 shows that the structure of current ESG scores can also mean that when sustainable investors invest into stocks with a high ESG score it leads to higher future emissions, rather than lower. And Chapter 3 shows that the structure of a firm and its inherent agency conflicts leading to increased demand for safe assets such as treasuries and increasing their convenience yield.

In these following chapters, after issues are documented, solutions are often suggested, that can help make a real difference to our society. Such as the introduction of a new financial asset, Emission Futures, to improve the impact of impact investing. The next pages provide summaries of the individual papers in English and Danish. These summaries clarify the individual papers' contribution.

Summaries in English

Skills and Sentiment in Sustainable Finance

In my first paper, "**Skills and Sentiment in Sustainable Investing**," we explore how the rise of ESG investing has affected investors' sustainable investment returns. We find that investors' mandates are important in explaining these outcomes. Specifically, flexible mandate investors earn 3.1% higher returns by investing into stocks that afterwards increase their ESG scores and are sold to strict mandate investors. This channel is validated by the finding that increases of ESG scores lead to positive abnormal returns in the cross-section of stock returns.

The finding that flexible investors outperform on their sustainable investments cannot be explained by current theories such as Pedersen, Fitzgibbons and Pomorski (2021a) and Pástor, Stambaugh and Taylor (2021a) which is why we extend the latter theory to incorporate that some investors can predict ESG scores. We calibrate my structural model and find that our proposed channel explains half of the return difference. Furthermore, using exogenous variation in investors' holdings arising from exclusions from the leading ESG indices, we show that the effect is due to prediction, not activism.

I provide a new climate sentiment measure, which shows that the performance gap is higher when accompanied by rising sentiment. I conclude that using a forward-based, instead of a backward-based, ESG measure would allow the strict investor to directly invest in the sustainable firms improving capital allocation and halving the wealth transfer from strict to flexible investors.

The Future of Emissions

In my second paper, "**The Future of Emissions**,", joint with Jules van Binsbergen, we propose such a forward-based ESG measure. We show both empirically and theoretically that backward-looking subjective ratings are limited to the extent that they fail to capture future reductions in emissions. We show evidence that although lower emissions have predicted higher E ratings, higher E ratings have predicted higher, not lower, emissions. This also means that investors, by following these ratings, have inadvertently allocated their money to firms that pollute more, not less.

Another problem with the subjective backward-based ratings is that it leads to cheap talk. In fact, we show that firm mentions of 'Sustainability' improves their E score, but does not decrease emissions. While deriving our theoretical results on capital misallocation and impact we develop an easily extendable framework for value-maximisation that nests both standard firm-maximisation and sustainable investing.

We conclude that if sustainable investing is to have an impact the current subjective backward-looking ratings need to be replaced by objective forward-looking measures, hence generalizing the policy recommendation of my first paper. In this paper we propose such a measure. Our measure makes real impact easily observable and transparent. As a consequence, evaluating the sustainability of asset managers becomes straightforward and cheap talk can be avoided simply by linking managerial pay to our measure. Our proposed measure is easily extendible to other observable variables related to an externality (positive or negative) such as social and governance factors.

Corporate Asset Pricing

In my third paper "**Corporate Asset Pricing**," I show the new fact that idiosyncratic volatility significantly predicts the convenience yield. This fact poses a puzzle with current safe asset theories both because idiosyncratic volatility should not be priced Ross (1976), but also because the theories of Krishnamurthy and Vissing-Jorgensen (2012) and Nagel (2016) have been unable to match the convenience yield since the financial crisis.

I develop a new theory that reconciles this puzzle - a theory I label Corporate Asset Pricing (CAP). CAP explains 29% of future convenience yield variation and is verified in the cross-section of firm treasury holdings. I show theoretically that when managers are exposed to moral hazard, corporate investors' required returns will be determined by their idiosyncratic risk. When this is combined with a market segmentation between the risk-free bond and a risk-free alternative from derivatives only available to advanced intermediaries, the corporates will be willing to accept a lower return for the risk-free asset than the traded return in the advanced derivates market. I isolate the demand-based effect from confounders by using exogenous cross-sectional variation from corporate size and industry exposures. The results provide support for the importance of corporates as an investor group in determining asset prices.

In summary, this theory has the potential of uniting expected returns across several assets at the same time as explaining why idiosyncratic volatility appears to be prized.

Resuméer på dansk

Færdigheder og Sentimentalitet i Bæredygtig Investering

I mit første papir, "**Skills and Sentiment in Sustainable Investing**," undersøger jeg, hvordan udbredelsen af ESG-investering har påvirket investorers bæredygtige investeringsafkast. Jeg finder at investorers mandater er vigtige for at forklare disse resultater. Specifikt tjener investorer med fleksible mandater 3,1% højere afkast ved at investere i aktier, der efterfølgende øger deres ESG-scorer og sælges til investorer med strenge mandater. Denne kanal valideres ved fundet af at stigninger i ESG-scorer fører til positive unormale afkast i tværsnittet af aktieafkast.

Fundet af at fleksible investorer præsterer bedre på deres bæredygtige investeringer kan ikke forklares af nuværende teorier såsom Pedersen, Fitzgibbons og Pomorski (2021) og Pástor, Stambaugh og Taylor (2021a), hvorfor jeg udvider sidstnævnte teori til at inkorporere at nogle investorer kan forudsige ESG-scorer. Jeg kalibrerer min strukturelle model og finder at min foreslåede kanal forklarer halvdelen af afkastforskellen. Desuden viser jeg ved hjælp af eksogen variation i investorers beholdninger, der opstår fra eksklusioner fra de førende ESG-indekser, at effekten skyldes forudsigelse, ikke aktivisme. Jeg præsenterer et nyt klimasentimentmål, som viser at præstationsforskellen er højere når den ledsages af stigende sentiment.

Jeg konkluderer at brugen af et fremadskuende, i stedet for et bagudskuende, ESG-mål ville gøre det muligt for den strenge investor at investere direkte i de bæredygtige virksomheder, der forbedrer kapitalallokeringen og halverer formueoverførslen fra strenge til fleksible investorer.

Fremtiden for Udledninger

I mit andet papir, "**The Future of Emissions**," skrevet med Jules van Binsbergen, foreslår vi et sådant fremadskuende ESG-mål. Vi viser både empirisk og teoretisk, at tilbageskuende subjektive vurderinger er begrænsede i den udstrækning, at de ikke formår at fange fremtidige reduktioner i emissioner. Vi viser beviser for, at selvom lavere emissioner har forudsagt højere E-vurderinger, har højere E-vurderinger forudsagt højere, ikke lavere, emissioner. Det betyder også, at investorer, ved at følge disse vurderinger, utilsigtet har allokeret deres penge til virksomheder, der forurener mere, ikke mindre.

Et andet problem med de subjektive bagudskuende vurderinger er, at det fører til "billig snak". Faktisk viser vi, at virksomheders omtale af "Bæredygtighed" forbedrer deres E-score, men reducerer ikke deres emissioner. Mens vi udleder vores teoretiske resultater om kapitalmisallokering og indvirkning, udvikler vi en let udvidelig ramme for værdimaksimering, der indeholder både standard virksomhedsmaksimering og bæredygtig investering.

Vi konkluderer, at hvis bæredygtig investering skal have en effekt, skal de nuværende subjektive bagudskuende vurderinger erstattes af objektive fremadskuende målinger, hvilket generaliserer politikanbefalingen i mit første papir. I dette papir foreslår vi et sådant mål. Vores mål gør reel indvirkning let observerbar og gennemsigtig. Som en konsekvens bliver det ligetil og billigt at vurdere bæredygtigheden af kapitalforvaltere, og billige snak kan undgås simpelthen ved at koble ledelsens løn til vores mål. Vores foreslåede mål er let udvideligt til andre observerbare variable relateret til en eksternalitet (positiv eller negativ), såsom sociale og ledelsesmæssige faktorer.

Virksomheders inflydelse på Prissætning

I mit tredje papir "**Corporate Asset Pricing**," viser jeg den nye kendsgerning, at idiosynkratisk volatilitet signifikant forudsiger bekvemmelighedsudbyttet. Dette er en gåde for de nuværende teorier både fordi idiosynkratisk volatilitet ikke bør prissættes Ross (1976), men også fordi teorierne fra Krishnamurthy og Vissing-Jørgensen (2021) og Nagel (2016) ikke har formået at matche bekvemmelighedsudbyttet siden finanskrisen.

Jeg udvikler en ny teori, der forener denne gåde - en teori, jeg kalder Corporate Asset Pricing (CAP). CAP forklarer 29% af fremtidige bekvemmelighedsudbyttevariationer og verificeres i tværsnittet af virksomheders statskassebeholdninger. Jeg viser teoretisk, at når ledere udsættes for moralske dilemmaer, vil kravene til virksomhedsinvestorers afkast blive bestemt af deres idiosynkratiske risiko. Når dette kombineres med en markedssegmentering mellem den risikofrie obligation og et risikofrit alternativ fra derivater, der kun er tilgængelige for avancerede mellemhandlere, vil virksomhederne være villige til at acceptere et lavere afkast for den risikofrie aktiv end den omsatte afkast på det avancerede derivatmarked. Jeg isolerer efterspørgselseffekten fra alternative faktorer ved hjælp af eksogen tværsnitsvariation fra virksomhedsstørrelse og branchepåvirkninger. Resultaterne støtter vigtigheden af virksomheder som en investorgruppe i at bestemme aktivpriser.

Afslutningsvis har denne teori potentiale til at forene forventede afkast på tværs af flere aktiver, samtidig med at den forklarer, hvorfor idiosynkratisk volatilitet synes at blive værdsat.

Contents

Chapter 1

Skills and Sentiment in Sustainable Investing

with Alexander Kronies

Abstract

We document a significant difference in the returns to sustainable investing across investor types. Investors with strict ESG mandates earn 3.1% less than flexible investors. The mechanism is that flexible investors are able to react on expected ESG improvements. Without engaging in activism, flexible investors buy stocks that subsequently experience ESG score increases. After ESG improvements have realized, demand from strict mandate investors pushes up stock prices, resulting in positive returns for flexible investors. A new climate sentiment measure shows that the performance gap is higher when accompanied by rising sentiment, as seen during the 2010s. Our channel accounts for 51% of the return difference between strict and flexible ESG investment mandates. Hence, going from backward to forward-looking ESG ratings could reduce both capital misallocation and wealth transfer from strict investors, such as pension funds, to more flexible investors, such as hedge funds.

We thank Ken L. Bechmann, Jens Dick-Nielsen, Peter Feldhütter, Benjamin Holcblat, Harrison Hong (discussant), Franҫis Koulischer, David Lando, Francesco Nicolai (discussant), Lasse Pedersen, Loriana Pelizzon, Fabricius Somogyi, Robert Stambaugh, Roberto Steri, Jiajun Tao (discussant), Lucian Taylor, Zacharias Sautner (discussant), Kaustia Markku (discussant), Ryan Williams (discussant), Farshid Abdi (discussant) and participants of the 2019 European Finance Association Doctoral Workshop, the 2020 Macro Finance Research Program Summer Session for Young Scholars, the 19th International Conference on Credit Risk Evaluation, the 32nd Annual Northern Finance Association Conference, the 2020 Behavioral Research in Finance, Governance, and Accounting Conference (BFGA), the 2020 Nordic Finance Network Young Scholars Finance Workshop, the 2021 Annual Meeting of the Central Bank Research Association (CEBRA), the 2022 University of Oklahoma Energy and Climate Finance Research Conference, FRIC Final Event, 6th Finance PhD Workshop at HEC Paris, 1st YSBC Sustainable Finance Conference at Università di Bologna, the 2022 Young Scholars Nordic Finance Workshop, as well as seminar participants at the Wharton School at University of Pennsylvania, Copenhagen Business School, University of Luxembourg, T. Rowe Price, Rotterdam School of Management at Erasmus University, Universidad Carlos III de Madrid, Tilburg University, IESE Business School, École Supérieure de Commerce de Paris Europe, and Stockholm

1.1 Introduction

The consequences of the sustainable investment transition are not yet well understood. Fundamentally, general equilibrium theory would tell us that a higher demand of sustainable stocks today should lead to low returns going forward (as in Pástor, Stambaugh and Taylor 2021b). On the other hand, Baker and Wurgler (2006) would argue that exactly because there is a high demand, this sentiment will yield high returns in the short term. Finally, a third view is that high returns could arise if environmental, social and governance (ESG) metrics are a hidden quality signal (Pedersen, Fitzgibbons and Pomorski 2021b).

This paper documents a significant difference in the returns of sustainable investing across investor types. To reconcile this difference with current theories, we develop a new channel. The channel is that if some investors are under strict ESG mandates, other investors can use their flexibility to invest in stocks with expected ESG improvements. When the improvements materialise, demand for sustainable investments then leads to high returns for flexible investors.

Institutional investors have experienced an unprecedented shift in their clients' capital allocation towards assets with an ESG focus.[1] Because of this sudden inflow to ESG investing, institutional investors have had to integrate sustainable investments into their portfolios. However, as institutional investors typically vary in the strictness of their mandates, it has created heterogeneity across institutional investors' sustainable investment portfolios.[2]

We show that the inflow to ESG investing has been accompanied by an increased

School of Economics, for helpful comments and suggestions. We thank the 2020 BFGA committee for awarding us the Best Finance Paper Prize. The ESG and Climate factors are available upon request, as well as the Climate Sentiment Measure. Parts of this study were conducted at the Wharton School of University of Pennsylvania. All mistakes are ours. Andreas Brøgger gratefully acknowledges support from the Center for Financial Frictions (FRIC), grant no. DNRF102, and Alexander Kronies from Innovationsfonden and the Pension Research Center.

[1] The capital invested in ESG funds more than doubled in 2020 (Morningstar's 2020 Sustainable Funds Landscape Report). Additionally, new ESG investments of $51.1 billion make up nearly one fourth of the total inflows into U.S. funds. Over a longer horizon, from 2002 the amount of assets incorporating ESG principles has risen from just under $ 2 trillion to $ 10 trillion by the end of 2017 (Forum for Sustainable and Responsible Investment in the USA's 2018 Report). Figure 1.8 in Appendix 1.D shows this evolution over time at the global level.

[2] One might think that investors with a flexible mandate would not care to incorporate sustainable preferences into their investment strategy, but that is in fact not the case. For example, BlackRock has committed to take sustainability concerns into consideration to capture the opportunities presented by the net zero transition (BlackRock's letter to CEO's 2020).

Additionally, there is evidence that hedge funds short firms that they believe have bad ESG prospects and enter as activist investors. See Activist hedge funds prefer to fight ESG stars, Global Capital, 27th August 2020, and DesJardine and Durand (2020), DesJardine, Marti and Durand (2020).

climate sentiment. During this period, the investors with flexible mandates act as skilled investors: They purchase stocks, which they expect will experience future ESG score increases. We see that they capitalise on this, as they later sell their stocks to strict mandate investors. Hence, strict investors' demand for sustainable investments leads to high returns for those stocks, which have realised a higher ESG score.[3] This means that the flexible investors' sustainable investments yields an ESG premium. In summary, this paper documents the effects of skills and sentiment in sustainable investing.

To explain these findings, we introduce skills and sustainability sentiment to the standard capital asset pricing model (CAPM). We do so by allowing flexible investors to be able to exploit their prediction of future ESG score increases, an addition to the model of sustainable investments by Pástor, Stambaugh and Taylor (2021b). This flexibility leads to positive abnormal returns as the prediction materialises.

Earlier models fall short in explaining our findings. For example, we see a negative general ESG premium, whose size varies with sustainability sentiment (as in Pástor, Stambaugh and Taylor 2021b), and that it can occasionally yield positive returns, as in Pedersen, Fitzgibbons and Pomorski (2021b) where ESG serves as a hidden quality factor. However, neither model can explain the difference in sustainable investing returns across investors.

To empirically tease out the effects of skill from a general ESG premium, we separate our investors into two groups following Hong and Kacperczyk (2009). We refer to the first group of investors as flexible investors, as they tend to be have more flexible investment mandates (these include mutual fund managers, hedge funds, and other investment companies and independent investment advisors). Correspondingly, the group of investors with stricter investment mandates is referred to as strict mandate investors (they include university endowments, pension plans, employee ownership plans, banks, and insurance companies). By distinguishing between these two types of investors, we document how mandates affect the investors' returns to sustainable investing.

We see ESG investing yielding negative excess returns on average. However, when separating our investors, we find that flexible investors' ESG stocks have yielded large positive returns over recent years. Interestingly, this positive sustainable investment return does not exist for strict mandate investors' stocks. Hence, despite the observation that sustainable investing generally yields negative expected excess returns, a significant

[3]Hartzmark and Sussman (2019) show that investors value sustainability and chase sustainable stocks. Investor sentiment for funds with high sustainability ratings resulted in net inflows of more than $24 billion, whereas funds regarded as less sustainable experienced net outflows of $12 billion dollar, after Morningstar first published sustainability ratings in March 2016.

positive abnormal return can be achieved by investing sustainably in a smart way.

We go on to explore what may be driving the difference in returns to sustainable investing across the two groups. First, we consider whether there is a difference in the two investors' behavior. Specifically, we see how the investments' ESG scores develop after the purchase by either type. Here, we find that flexible investor ownership predicts future ESG score increases, whereas strict mandate ownership does not. The effect does not seem to be arising from a general skill of the flexible investor, as we only see abnormal returns amongst their ESG stocks, and not stocks in general.

Second, we consider whether strict mandate investors indeed buy the flexible investors' stocks after their higher scores materialise. In line with our model, we see that strict investors have purchased high ESG stocks most prominently from flexible investors. Specifically, strict investors excess purchase from flexible investors during the 2010s amount to close to half of the outstanding high ESG shares.

Third, we test whether strict mandate investors' purchases of high ESG stocks have led to positive abnormal returns for the flexible investors. We test this by running a Fama MacBeth regression of returns on changes in ESG scores whilst controlling for risk factors. In line with our hypothesis, we find that ESG scores changes are associated with higher returns.

We use the findings to calibrate our model. When we do, we see that the ESG prediction channel explains 51% of the return differential across strict mandate and flexible investors' sustainable investment returns. That is, an investor's ability to use their skill in ESG performance prediction is economically meaningful.

We extend our analysis by exploring how climate sentiment has affected the difference in returns to sustainable investing. To measure sentiment, we retrieve climate sentiment shocks from Google search volumes on the term *Climate change*. Our sentiment measure shows that the 2010s have been associated with a rising climate sentiment, a trend that is matched by inflows into ESG funds.

Using our measure in a regression setup, we see that when climate sentiment rises, it increases the difference in returns to sustainable investing between the two investor types. Additionally, sentiment also gives positive abnormal returns to sustainable investments in general. Finally, we see that climate sentiment tends to be negatively correlated with economic sentiment as measured by Baker and Wurgler (2006), making it a potential recessionary hedge.

We conclude by contrasting the costs with the benefits of sustainable investing. Sustainable investors incur a cost due to their strict mandate, however they incentivize firms to become greener, which describes the welfare channel of Pástor, Stambaugh and Taylor (2021b). For the cost estimate we use the difference in returns between strict and flexible investors, and for the benefit measure we use the improvements in carbon emissions for the firms owned by flexible investors. Comparing the two, we find that sustainable investing has been a promising, yet somewhat inefficient, channel for decreasing emissions, as investors have incurred a cost of USD 424 billion to reduce annual carbon emissions by 1.34 billion tons CO_2. This amount equates to USD 9 to 69 billion in the carbon credit market.

The welfare channel's relative inefficiency can be improved by introducing the right policy. Specifically, a policy which replaces backward-looking ESG ratings with forward-looking ESG ratings doubles the sustainable investments' welfare effects. The new ESG ratings would reduce the costs without affecting the benefits, as it would allow strict investors to invest directly into the firms which reduce emissions. This is in line with Oehmke and Opp (2020) and Green and Roth (2021), who propose that for investors to have an impact on firm behaviour they need to have broad mandates and invest in line with a new ESG metric that takes into account the changes in emissions of the firm from the investments itself.

This paper's central contribution is to document a difference in the returns to sustainable investing across investors. Specifically, our paper is the first to consider why returns to sustainable investing vary across investors. The closest papers to ours is Cao et al. (2019) and Hwang, Titman and Wang (2021), who in the first paper document that the investments of ESG investors are more prone to overpricing, and that this mispricing gets corrected to a lesser extend, leading these investments to exhibit lower abnormal returns, and in the second, that CSR investor ownership increases predict increases in firms CSR ratings, lowering returns, which they assume is due to the cost of improving such ratings. In addition to considering general investments and not sustainable investments, Cao et al. (2019) and Hwang, Titman and Wang (2021) follow a different identification strategy through their revealed preference approach, in the latter case controlling for institutional type, making their classification orthogonal to our classification. Our classification circumvents potential issues that may arise from defining groups by the output variable, as we separate investors into strict mandate and flexible investors following Hong and Kacperczyk (2009), which means whether the institutional investor is under public pressure to follow strict mandates. It is therefore not surprisng that we, in contrast to Cao et al.

(2019) and Hwang, Titman and Wang (2021), find that high ESG stocks held by flexible investors yield *high* abnormal returns, suggesting that the skill channel of our flexible investors seems to be dominating the general ESG sentiment channel.

Our findings differ from the seminal work on ‘Sin’ stocks by Hong and Kacperczyk (2009), as our main result originates in the top quartile of ESG scores rather than the bottom. Furthermore, our results are present within each industry, rather than comparing ‘Sin’ industries to the rest. Hence, the results cannot be driven by ‘Sin’ stocks, and are instead driven by investors’ opportunities to utilize skill within high ESG stocks. While we see insignificant but negative returns for a general ESG strategy, our results also show that flexible investors manage to achieve positive abnormal returns for their ESG strategy, illustrating the importance of skill, and not just sustainability preferences. These findings are interesting, as they show the cost to investors’ strict mandates in sustainable investment.[4]

This paper’s secondary contribution is to help explain why some find that sustainable investing leads to higher abnormal returns and some find that it lowers them. Our answer is that it depends to which degree assets are held by which type of investor. Moreover, we show that it can be difficult to measure the sign of the expected ESG premium, as there have been positive realizations due to the increasing climate sentiment in the 2010s.[5]

Previous papers have looked at the general returns to ESG investing. Friede, Busch and Bassen (2015) conducts a meta study of over 2000 studies from 1970’s to 2015 and find that a large majority of studies report a positive relationship between ESG and financial performance. Over 90% report a non-negative relationship. Specific papers that investigate the relationship between social responsibility and stock performance include Dimson, Karakaş and Li (2015), Eccles, Ioannou and Serafeim (2014), Fatemi, Fooladi and Tehranian (2015), Ge and Liu (2015), Krüger (2015), Porter and Kramer (2006), who argue that there is a positive relationship between an increase in sustainability efforts and returns. Furthermore, Greening and Turban (2000), Porter and Van der Linde (1995), Xie (2014) argue that there are additional benefits as improved resource productivity, motivated employees, or more customer satisfaction (as cited in Fatemi, Glaum and Kaiser 2018). On the other hand, others argue that there is no causal relationship between returns

[4]Narrow mandates may be optimal when there are costs to broad mandates such as in He and Xiong (2013). However, it is then important to realize this trade-off and possibly redefine your mandate to take advantage of expected ESG score improvements.

[5]Engle et al. (2020) also construct a text-based climate measure, which is based on an advanced high-dimensional multi-stage textual model of *Climate* news coverage in the Wall Street Journal. Instead we see our the simplicity and transparency of our measure as a virtue, as it gives a complementary and intuitive interpretation.

and sustainabaility efforts (e.g. Alexander and Buchholz 1978, Bauer, Koedijk and Otten 2005, Hamilton, Jo and Statman 1993, McWilliams and Siegel 2000, Renneboog, Ter Horst and Zhang 2008). Finally, there is also evidence for a negative relationship as provided by, for example, Boyle, Higgins and Rhee (1997), El Ghoul and Karoui (2017), Fisher-Vanden and Thorburn (2011).

The remainder of this paper is structured as follows. Section 1.2 describes the data used, as well as how we construct our climate sentiment measure. Section 1.3 documents the difference in returns across investor types. Section 1.4 lays out the theoretical framework of skills and sentiment and defines empirical tests of the theory's capacity to explain the difference in returns. Section 1.5 tests the framework's predictions in terms of predicing ESG scores, whether ESG stocks are demanded and whether increases in ESG scores are priced. Section 1.6 estimates the importance of our results in explaining the difference to sustainable investing. Section 1.7 compares the costs to the benefits achieved by sustainable investing. Section 1.8 concludes the paper.

1.2 Data

This section outlines the data sources and places them within our analysis.

Returns. The objective of the analysis requires us to combine data on equity returns and sustainability. First, we obtain monthly stock returns from the Center for Research in Security Prices (CRSP). We also obatin monthly data points on the number of stocks and their share price to compute market values. We follow Fama and French (1993) and only include stocks that are listed on NYSE, AMEX, or NASDAQ and have a CRSP share code of 10 or 11.

ESG. We utilize a unique ESG dataset to tackle the research question. Specifically, we download yearly ESG score data from Thomson Reuters, referred to as ASSET4. This data depicts equally-weighted ratings on the metrics of companies' economic, environmental, social and corporate governance performance. In particular, the ESG score is a measure from 0 to 100. A low score suggests that a given company behaves poorly with regards to overall sustainability, and vice versa. The higher a company's score, the more sustainable it is with regards to the pillars mentioned above.

We address the usual issues of using ESG scores. The ASSET4 database experienced an update of scores in the year of 2020, however, we use scores downloaded in 2018.[6] These

[6] Other studies having used the same data include, for example, Breuer et al. (2018), Dyck et al. (2019), Stellner, Klein and Zwergel (2015).

'original' scores, as Berg, Fabisik and Sautner (2023) put it, have not been backfilled, meaning that there would not be an assignment of scores for any other than the most recent year. For example, if Thomson Reuters did not assign a score for the year 2005 due to insufficient information but then receives valuable insights in 2008 for the year of 2005, they would not go back in time and assign a score for the year of 2005.[7] This is important because our analysis makes the implicit assumption that investors had the relevant ESG score information for the previous year available at the time. Furthermore, Berg, Fabisik and Sautner (2023) point out that the update of scores in 2020 is systematic and related to past performance. It seems as if firms that have outperformed others in a given year have received higher ex-ante scores in the update. The updated data would therefore distort our results and it is hence important for us to use the 'original' data instead as we analyze the skill to invest sustainably with information at the time. Finally, although Berg, Kölbel and Rigobon (2022) find that the ASSET4 data is not perfectly correlated with other widely used sustainability assessment data, it still displays a strong positive correlation. For example, the correlation between ASSET4 and Sustainalytics and Vigeo Eiris is 0.67 and 0.69, respectively. The facts that scores have been available to investors at the time, high correlations to other data providers, and a long time horizon are the deciding factors for us to use the ASSET4 database in our study.

Thomson Reuters computes the scores themselves and follows a strict methodology when doing so. For every firm, they consider a total of 750 questions, which they attempt to gather information for. Data are collected from multiple sources, including: a) company reports; b) company filings; c) company websites; d) NGO websites; e) CSR Reports; and f) reputable media outlets. Thomson Reuters writes that every data point goes through a multi-step verification process, including a series of data entry checks, automated quality rules, and historical comparisons. These data points reflect more than 280 key performance indicators and are rated as both a normalized score (0 to 100, with 50 as the industry mean) and the actual computed value. The equally-weighted average is normalized by ASSET4 so that each firm is given a score relative to the performance of all firms in the same industry around the world; in other words, the ratings are industry-benchmarked.

We merge the return data from CRSP with the ESG data according to their CUSIP codes. ESG data points are available on a yearly basis, whereas returns are available at a monthly frequency. This means that the individual firm's ESG score is the same throughout a given year, i.e. for every monthly return observation. ESG scores are

[7] We gathered this information from an interview with the persons responsible for the ESG data bank at Thomson Reuters.

available from 2002 until 2016, which defines our sample period. This is a longer time period than most other data providers can offer, which additionally encourages us to use the ASSET4 scores.[8] Figure 1.1 displays the data availability over time.

[Figure 1.1 about here]

Investigating the ESG data set in greater detail, Table 1.I16 exhibits distribution statistics and developments in ESG scores over time. In the first year of the sample period, 2002, a total number of 624 firms in the sample were assigned an ESG score. This number significantly increases to a maximum of 2,992 firms in the final year of 2016. The distribution of ESG scores over time remains relatively stable. We see scores on both the low and the high end of the scale.

For the empirical analysis in the next section, the entire universe of ESG score firms are taken into account. The total number of firms is thereby identical to the number of firms in Table 1.I16. This also implies that the cross-section's total number of firms in later performance analysis rises over time.

Risk factors. To control for risk factors we use the risk-free rate and factor-returns of the Fama and French (1993) three factor model as well as the momentum factor from Ken French's website. We test our hypotheses against the CAPM, Fama-French three factor model and Carhart four-factor model.

Business cycles. We use the NBER Business Cycle Reference Dates to identify recessions and use these to define good and bad economic times. We use these bad times as a proxy to investigate how ESG returns perform during periods of high risk and low consumption. In a later analysis, we further utilize price-dividend ratios (PD) as a measure for the state of the stock market. The PD data is gathered from Shiller's website.

Ownership. We obtain quarterly institutional holding data (13F) from Thomson Reuters. According to the SEC, all institutional investors with assets under management over $100 million need to report their holdings to the commission.The data includes the number of shares held by every institutional investor. We use this number to calculate the relative holding of a firm by each institutional investor. Specifically, each investors' number of shares divided by the total number of shares outstanding depicts the holdings of a given firm. Sometimes, the data does not adjust for stock splits or repurchases and the relative share might increase above one, in which case we exclude it from the data.

[8] The MSCI KLD data is available for a slightly longer time horizon, however, their dataset experienced significant updates in between. These updates violate our binding constraint that investors need to be ensured to have had access to the very scores we use in our analysis.

We further follow standard asset pricing literature and exclude stale data, whenever there are several filing dates ($fdate$) for the same report date ($rdate$). In such a case, we only keep the data points of the report date with the earliest filing date.[9]

The institutional ownership data (13F) exhibits five different types of owners which we categorize into strict and flexible investors as in Hong and Kacperczyk (2009) (they refer to strict investors as norm-constrained). Strict owners are banks (Type 1), insurance companies (Type 2) as well as all other other institutions, which includes universities, pension plans, and employee ownership plans (Type 5). Flexible owners are investment companies (Type 3) and independent investment advisors (Type 4), which also includes hedge funds. We aggregate holding data for these two groups and merge it with returns.

We explore each investor types' ESG investments in Appendix 1.D. Here we show that responsible investing has evolved from excluding sin stocks to incorporating ESG principles in a broader sense. Responsible investors include UN PRI signatories. UN PRI practice involves excluding low ESG and over-weighing high ESG companies. We go on to show that strict investors are more likely to have signed the UN PRI. Additionally, when comparing strict and flexible signatories, strict investors also sign earlier. We also see that strict investors are more likely to overweight and exclude stocks in their high ESG portfolio compared to flexible investors. Strict investor flow is also more sensitive to ESG score, in the sense that they allocate more capital based on ESG scores, than flexible investors do. Lastly, UN PRI have grown tremendously over the last 10 years and assets invested under UN PRI principles now make up a large fraction of total invested assets.

Climate sentiment. We test for climate sentiment by using the search interest of 'Climate change' on Google, which we retrieve from Google Trends. Figure 1.2 shows how our sentiment time series is constructed. The general hits measure is the search volume in the United States expressed relative to the maximum search volume in percent (top left). As it is clearly seasonally affected, we show the difference to the same month a year ago in the top right panel. The bottom left panel shows the innovations from fitting an AR(1) model on the seasonally adjusted hits, which serves as our sentiment measure. The bottom right shows the cumulated hit innovations. The shaded area denotes recession. We notice a general fall in sentiment in the recession, a sharp peak between the recession and the European debt crisis, and a steep rise since 2014.

[Figure 1.2 about here]

[9] For similar applications, see, for example, Brunnermeier and Nagel (2004) or Blume, Keim et al. (2017).

We compare results from our climate sentiment measure to the economic sentiment measure of Baker and Wurgler (2006), which is the principal component of five sentiment proxies (*perp*). As a robustness test we also compare our results to using the Engle et al. (2020) text-based climate measure, which is based on text coverage of *Climate* in the Wall Street Journal. They have two measures. One for general coverage (*wsj*) and one for negative coverage (*chneg*).

One might be concerned that our measure is overly simplistic or that climate deniers account for a significant fraction of the time series' movements. We argue that climate change deniers only represent a negligible fraction of the population and that their search intensity is relatively constant over time, whereas the worry of climate change has varied over the last decades with an overall rising trend. Hence, by using the variation of search volumes, we believe to capture climate change worries to a large degree. However, we show that more complicated text-based sentiment measures, such as (Engle et al. 2020), which is constructed from a high-dimensional dataset, are qualitatively similar. So in fact, we see the simplicity and transparency of our measure as a virtue.

1.3 Results

Returns to sustainable investing across investor types

In this section, we compare the returns to sustainable investing for flexible and strict mandate investors. Meaning what return the investors get when they invest into stocks with a high ESG score.

Before doing so, however, we test for a general ESG premium in the market, meaning under no consideration of ownership. We create the ESG premium from a long-short portfolio (LS), which goes long in the top decile ESG firms and shorts the lowest decile of ESG firms. Table 1.1 shows the results. We see that there does not seem to be a general ESG premium after adjusting for risk, which confirms the findings by Berg, Fabisik and Sautner (2023). We find partial evidence that the firms in the lowest decile portfolio earn a positive abnormal return, though not at a significant level. These results suggest that the market, in general, pays neither a positive nor negative premium for investing sustainably.

[Table 1.1 about here]

We shift our focus to ESG investing across ownership types and evaluate if either one earns a premium for investing sustainably. We construct the results by doing two sets of double-sorted portfolios. First, we sort stocks according to their lagged ESG scores in a total of four portfolios.[10] In the second step, we do one set of double-sorted portfolios where we conditionally sort stocks according to their previous quarter's flexible institutional ownership, and a second set where we conditionally sort by strict institutional ownership share and assign them into another four portfolios, yielding two sets of 16 portfolios in total. We value-weight each portfolio and risk-adjust returns.

To test the effect of investor ownership on sustainable investing returns we focus on the portfolios with the top quartile of either flexible or strict institutional ownership (two sets of four portfolios) and show the abnormal returns from these portfolios in Table 1.2.[11] Comparing flexible and strict investors' returns under the Carhart 4-factor model, we find that flexible investors earn a significant ESG premium of 30 bp, whereas strict investors do not. This result is driven by the high returns in the long leg. The long leg, which is the high ESG and high flexible ownership portfolio, earns an abnormal return of 39 bp. The difference between the investor types' returns to high ESG investing is 26 bp per month adding up to 3.15% on an annual basis. We further find a positive and significant differences in the second and third ESG quartiles from flexible to strict investor returns across all risk models. These results provide evidence that flexible investors outperforman strict mandate investors when investing into stocks with a certain ESG score level.

[Table 1.2 about here]

Before exploring what may be driving the difference in returns to sustainable investing across investor types in Section 1.5, we conduct a wide array of robustness tests for this result. We start by confirming our results by using all risk factor models to document alphas of the long-short equity strategy held to a large and small degree by flexible investors in Table 1.I3 in Appendix 1.IA.[12] The robustness check further documents that the premium loads on the market itself as well as the small minus big and momentum factors. The fact that risk cannot explain returns under any model serves as a motivation for us

[10] We form portfolios in the standard way of Fama and French (1992). More details on sorting can be found in Appendix 1.IG.

[11] In Table 1.I1 in Internet Appendix 1.IA, we show the same table but with a total number of ten portfolios across the ESG score. And in Table 1.I2, we show the same table but with for all levels of institutional ownership for both investor types, meaning two sets of all 16 portfolios.

[12] Table 1.I2 in Internet Appendix 1.IF shows results for all 16 portfolios as well as for four long-short portfolio within each ownership quantile. This is shown for the flexible investor under both the Carhart and CAPM risk models. Table 1.I22 in Appendix 1.IF shows results for the same portfolios, but for both the flexible and the strict investor as well as for the future holdings. The results are also robust to first sorting according to ownership and secondly to ESG. Table 1.I5 in Appendix 1.IF shows results for the same portfolios, but using a more precise, but smaller coverage, of investor classifications by (Bushee 2001), updated up to date, with no substantial difference. We additionally show that the outperformance is driven by independent investment advisors in both classifications.

to explore whether less risk-based factors may be driving these returns as, for example, sentiment. An alternative research design at the fund level using panel regressions based on their portfolio weights is considered in Internet Appendix 1.IB. Here we find that the results carry through with similar magnitudes when linearly controlling for the ESG score instead of by portfolios.

We continue by showing results for other sustainability metrics. We download scores from Sustainalytics, another ESG data provider, as well as data points on firms' CO_2 emissions per dollar of revenue. The latter is used by both ASSET4 and Sustainalytics as part of their scoring approach. Table 1.3 shows the results for portfolios under high flexible ownership and high scores under the alternative metrics (for CO_2 per revenue, the 'sustainable' portfolio is that of firms with lowest emissions). We see that our results are robust under the application of these different sustainability metrics. Furthermore, we show that the results under alternative ESG metrics also hold when using different risk models in Table 1.I4 in Appendix 1.IA. For the flexible investor, investing in firms with high sustainability scores (or low emission scores) pays high returns.

[Table 1.3 about here]

We similarly use these alternative ESG metrics to explore the robustness of the long-short ESG portfolio under high flexible ownership (instead of purely the long leg in Table 1.3). Table 1.4 shows the results. We observe a significant sustainability premium under the Sustainalytics Environment (S:E) and the CO_2 scoring models. For the general Sustainalytics scores, we document positive abnormal returns, though not at a significant level under the Carhart 4-factor model. This seems to be because the social and governance aspects of the Sustainalytics score (S:S and S:G) are less related to positive returns than the environment aspect (S:E).[13] These results confirm our main result and suggest that the ESG premium for flexible investment strategies is driven by environmentally-related scores.

[Table 1.4 about here]

We finish by additionally examining the performance of stock holdings by flexible and strict investors as if they were bought one period earlier. For example, if an investor held 10% of Stock A in Q2 2015, we assume that investor held 10% of Stock A in Q1 2015 (which we refer to as sorted on *future* holdings). This gives us a way to consider the

[13]However, the premium from using the general Sustainalytics scores is significant to a p-value of below 5% under the CAPM and the Fama-French 3-factor model.

performance of stocks that the two investor types are demanding. We follow our double-sort methodology and sort stocks on ESG scores as well as future holdings. Table 1.5 shows results on value-weighted and risk-adjusted returns on the high flexible and strict future ownership portfolios, the long-short portfolios as well as the differences.

[Table 1.5 about here]

This additional test shows that high ESG stocks held by both investor types in the next quarter yield positive and significant abnormal returns. Based on the Carhart four-factor model, flexible investors earn 42 bp per month and strict investors earn 33 bp per month. This suggests that ESG demand pushes up the price for ESG stocks. This implies that there has been a larger increase in ESG demand than there has been for other stocks, or that the price elasticity is lower. However, as we observe a difference between the two types of investors in their returns to sustainable investing using actual holdings, it suggests that only some investors can use their flexibility to increase their returns to ESG investing.

In the next section we consider theoretically what may be driving the difference in returns to sustainable investing across the two investor types.

1.4 A Theory of Sustainable Investing with Skill

To understand why both sustainable investment mandates and skill are necessary to explain the returns to sustainable investing across investor types, we consider first the case only with mandates.

Mandates in sustainable investing

Here, we have one type of investors who have a standard negative exponential utility function increasing in their future wealth W_{1i}, where i denotes a specific investor, and they all have an absolute risk aversion given by a:

$$U[W_{1i}, \boldsymbol{X}_i] = -e^{-aW_{1i}}. \tag{1.1}$$

There are two periods 0 and 1. The wealth evolves as $W_{1i} = W_{0i}(1 + r_f + \boldsymbol{X}_i'\boldsymbol{r}^e)$, where W_{0i} is wealth at period 0, $\boldsymbol{X}_i$ is a vector of stock weights and $\boldsymbol{r}^e$ is a vector of returns in excess of the risk-free rate r^f. The risk $\boldsymbol{\epsilon}$ is distributed as $N(\boldsymbol{0}, \boldsymbol{\Sigma})$ and excess returns will be determined in equilibrium as

$$\boldsymbol{r}^e = \boldsymbol{\mu} + \boldsymbol{\epsilon}, \tag{1.2}$$

where $\boldsymbol{\mu}$ are expected excess returns.

In addition, the investors have mandates of varying strictness. More precisely, let the strictness of a mandate be determined by the ESG threshold $\underline{g_i}$, which the investor is required to aim for. Let $\boldsymbol{g}$ be a vector of stocks' ESG scores. If they invest in a stock with an ESG score below this threshold they will incur costs $\boldsymbol{C}$ per dollar invested from their stakeholders in forms of protests and legal action, which is proportional to how far they are from their agreed goal for each stock. Similarly if they go for a higher ESG score they will incur goodwill. Together, this is captured by the vector of costs $\boldsymbol{C} = c(\underline{g_i} - \boldsymbol{g})$. Hence return after cost becomes $\tilde{\boldsymbol{\mu}} = \boldsymbol{\mu} - \boldsymbol{C}$, where $\tilde{\boldsymbol{\mu}}$ is the return per stock after costs. Furthermore, let these mandates $\underline{g_i}$ be uniformly distributed between ESG scores 0 and 1. ESG scores also range from 0 to 1 with an average value of 0.5. As a consequence, the number of investors that have mandates that make them bear a cost to invest in a particular stock n will be decreasing in the stock's ESG score g_n, as an example both the investor with a threshold of 0.5 and the one with 0.9 can invest into a stock with an ESG score of 0.9 without a cost, but only one can invest into a stock with an ESG score of 0.5 without a cost. Given γ as the relative risk aversion coefficient, the investor's optimal portfolio weights will be

$$\boldsymbol{X}_i = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - c(\underline{g_i} - \boldsymbol{g})]. \tag{1.3}$$

Proof in Appendix 1.A. ■

We set the risk-free asset to be zero net supply and consequently market clearing requires that the market weights $\boldsymbol{w_m}$ of stocks equals the total stock demand by investors. Introducing ω_i as the wealth share of investor i we get that

$$\begin{aligned}\boldsymbol{w_m} &= \int_i \omega_i \boldsymbol{X}_i di \\ &= \int_i \omega_i \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - c(\underline{g_i} - \boldsymbol{g})]di \\ &= \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - c(\frac{1}{2} - \boldsymbol{g})] \\ &= \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} + c\tilde{\boldsymbol{g}}], \end{aligned} \tag{1.4}$$

where 0.5 arrives because it is the average of a uniform distribution from 0 to 1, and $\tilde{\boldsymbol{g}}$ is the stocks' ESG score minus the investors' average threshold value. The expected excess returns are then given in equilibrium by Equation (1.4) as

$$\boldsymbol{\mu} = \gamma \boldsymbol{\Sigma} \boldsymbol{w_m} - c\tilde{\boldsymbol{g}}. \tag{1.5}$$

By pre-multiplying by the market weights $\boldsymbol{w'_m}$ we see that the market expected excess return μ_m equals

$$\boldsymbol{w'_m}\boldsymbol{\mu} = \gamma \boldsymbol{w'_m} \boldsymbol{\Sigma} \boldsymbol{w_m} - c\boldsymbol{w'_m}\tilde{\boldsymbol{g}}. \tag{1.6}$$

As both ESG scores and thresholds are centered around 0.5, the market-weighted ESG tilt from thresholds $\tilde{\boldsymbol{g}}$ is zero. Additionally, as $\mu_m = \boldsymbol{w'_m}\boldsymbol{\mu}$ we get by introducing σ_m^2 as the market variance that

$$\mu_m = \gamma \sigma_m^2. \tag{1.7}$$

Rewriting the return to a specific stock by solving Equation (1.7) and inserting it in Equation (1.5) we get

$$\boldsymbol{\mu} = \mu_m \boldsymbol{\beta_m} - c\tilde{\boldsymbol{g}}, \tag{1.8}$$

Equation (1.8) displays the result that the expected return on stocks are determined by their market beta and their ESG score. This is equivalent to the theory of Pástor, Stambaugh and Taylor (2021b) with $c = \frac{\bar{b}}{\gamma}$, where $\bar{b}$ is the market-weighted ESG benefit that investors receive from investing in stocks that a higher ESG score than the average. Pedersen, Fitzgibbons and Pomorski (2021b) equivalently have $-c = \lambda$, where λ can be both negative, zero, or positive depending on whether investors are ESG motivated in the sense that they derive utility from their ESG investments, ESG aware that ESG scores are correlated with higher dividends, or ESG-unaware that ESG scores are correlated with higher dividends. Hence, none of these theories can explain how two stocks with the same ESG score can have different expected returns after controlling for their market betas.

Strict and flexible investors

The next step in explaining our empirical results is incorporating the fact that another group of investors are not constrained and make up a sizable fraction, so called flexible investors f. Specifically, let a fraction θ of investors be under ESG mandates, so called strict investors, and hence a fraction $1 - \theta$ are flexible investors. As flexible investors do not have a cost to invest in low ESG scores their demand $\boldsymbol{X}_i^f$ is given from Equation (1.3) with c set to zero:

$$\boldsymbol{X}_i^f = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu}. \tag{1.9}$$

And the strict mandate investors are still given by Equation 1.3. Using $\mathbb{1}_{i=f}$ and $\mathbb{1}_{i=s}$ as indicator functions for whether investor i is flexible or strict respectively, we can rewrite the demand for any investor i as

$$\boldsymbol{X}_i = \mathbb{1}_{i=f}\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} + \mathbb{1}_{i=s}\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - c(\underline{g_i} - \boldsymbol{g})]. \tag{1.10}$$

Having both flexible and strict mandate investors leads the expected return to be given in equilibrium as

$$\boldsymbol{\mu} = \mu_m\boldsymbol{\beta_m} - \theta c\tilde{\boldsymbol{g}}. \tag{1.11}$$

Proof of Equation (1.11) in Appendix 1.A. ■

Equation (1.11) shows that the return is still given by the market beta and the ESG score, however the return after controlling for risk, the abnormal return, decreases the smaller the share of strict investors is. Furthermore if the fraction of strict mandate investors is 1, $\theta = 1$, we recover Equation (1.8) and if all investors are flexible we get the classical CAPM result. However, even two types of investors cannot explain how two stocks with the same ESG score can have different returns.

Backward looking ESG scores

Having seen that two types of investors cannot explain our empirical results, we additionally introduce backward looking ESG scores. As the ESG scores are backward looking, they can be predicted by skilled investors who have the information for which the ESG scores are based on. The investors with this information we label skilled. To illustrate the benefit from this information we introduce an additional second period. Period 1 is now inhabited by generation 1 investors who live between time 0 and 1 and trade at time 1 with generation 2 investors who have the same wealth and mandates $\underline{g}_2$ as the average mandate of period 1 investors $\underline{g}_{1,i}$, meaning $\underline{g}_2 = \int \underline{g}_{1,i} di$, which gives generation 2 investors finite utility given the lack of uncertainty and leverage constraints. Period 1 remains the same, which in particular means that generation 1 investors still trade between themselves at time 0. We model the uncertainty of stock payoffs per dollar invested as $\tilde{\boldsymbol{u}}$, which resolve at time 1 as $\boldsymbol{u}$ and is realised at time 2. Hence the strict investors still bear a cost per dollar invested in the second period if they own low ESG stocks. Centrally, we allow the

ESG score to be updated at time 1 based on information known to skilled investors. The value for investors at time 1 will be determined by the resolved payoffs $\boldsymbol{u}$, plus an investor-specific cost due to their mandates in the second period $c(\underline{g_2} - \boldsymbol{g}_2) = -\theta c\tilde{\boldsymbol{g}}_2$, therefore the equilibrium price at time 1 per dollar invested at time 0, $\boldsymbol{p_1}$, will be such that benefits equal costs:

$$\boldsymbol{u} = \boldsymbol{p_1} - \theta c\tilde{\boldsymbol{g}}_2 \iff \boldsymbol{p_1} = \boldsymbol{u} + \theta c\tilde{\boldsymbol{g}}_2 = \boldsymbol{u} + \theta c\tilde{\boldsymbol{g}}_1 + \theta c\Delta\boldsymbol{g}, \tag{1.12}$$

where $\Delta\boldsymbol{g}$ is the change in ESG scores from period 1 to period 2.

Due to difference in information, the expected payoff differs between skilled and unskilled investors. Specifically, skilled investors ς know the exact demand (and price) at time 1 and hence maximise due to the correct payoff expectation, which uses both the current and future ESG scores $E_0^{\varsigma}[p_1] = E[p_1|g_1, g_2]$. However, as unskilled investors only know the current ESG score they form payoff expectations as if they remain their current ESG scores $E_0^{-\varsigma}[p_1] = E[p_1|g_1]$. Specifically,

$$E_0^{\varsigma}[\boldsymbol{p_1}] = E_0[\boldsymbol{p_1}] = E_0[\tilde{\boldsymbol{u}}] + \theta c\tilde{\boldsymbol{g}}_1 W_{0i} + \theta c\Delta\boldsymbol{g} W_{0i}. \tag{1.13}$$

As unskilled investors $-\varsigma$ do not know $\Delta\boldsymbol{g}$ they have the following expectation of $\boldsymbol{p_1}$

$$E_0^{-\varsigma}[\boldsymbol{p_1}] = E_0[\tilde{\boldsymbol{u}}] + \theta c\tilde{\boldsymbol{g}}_1 W_{0i}. \tag{1.14}$$

Hence, $\boldsymbol{p_1} - E_0^{-\varsigma}[\boldsymbol{p_1}]$ is the vector of unexpected payoffs for the unskilled investors at time 1. Accordingly they deviate from the correct expected payoff by

$$E_0^{-\varsigma}[\boldsymbol{p_1}] - E_0[\boldsymbol{p_1}] = -\theta c\Delta\boldsymbol{g}. \tag{1.15}$$

Deviations in payoff expectations equate to deviations in gross return expectations $E[\boldsymbol{\mu}+1]$ as they are deviations per dollar invested at time 0, hence we get that the unskilled investors deviate from the correct expected return by

$$E_0^{-\varsigma}[\boldsymbol{\mu}] - E_0[\boldsymbol{\mu}] = -\theta c\Delta\boldsymbol{g}, \tag{1.16}$$

and invest accordingly.

To illustrate the effects of introducing backward-looking ESG scores to the sentiment in sustainable investing we here make the simplifying assumption that strict mandate investors s cannot predict ESG scores, but flexible investors f are skilled and hence able to predict ESG scores. Accordingly, their demands at time 0 are given by

$$\boldsymbol{X}_i = \mathbb{1}_{i=f}\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu}] + \mathbb{1}_{i=s}\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - \theta c\Delta\boldsymbol{g} - c(g_i - \boldsymbol{g}_1)]. \tag{1.17}$$

Proof in Appendix 1.A. ■

The expected excess returns are then determined in equilibrium as

$$\boldsymbol{\mu} = \mu_m\boldsymbol{\beta_m} - \theta c\tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2 c\Delta\boldsymbol{g}. \tag{1.18}$$

Proof in Appendix 1.A. ■

Equation (1.18) provides several intuitive results. First, if all investors are strict, $\theta = 1$, then everyone are surprised by the change in ESG scores leading them to the full return effect of $c\Delta\boldsymbol{g}$ in addition to their expectation of $\mu_m\beta_m - \theta c\tilde{\boldsymbol{g}}_{\mathbf{0}}$. On the other hand if everyone are flexible, $\theta = 0$, then there are no unexpected returns and the change is fully priced in. Additionally, due to the absence of investors with mandates the returns simply become $\mu_m\beta_m$. Therefore when going from a small amount of flexible investors to a larger share the return to prediction decreases quadratically due to both more investors trading on the information and the information becoming less valuable. Importantly, now having ESG preferences and skill we can see that in contrast to the Pástor, Stambaugh and Taylor (2021b) and Pedersen, Fitzgibbons and Pomorski (2021b) models two stocks with the same ESG score $\boldsymbol{g}$ may have different expected returns $\boldsymbol{\mu_0}$ dependent on whether the stock is expected to rise in its ESG score in the future or not ($\Delta\boldsymbol{g}$).

Furthermore, using the equilibrium returns leads to the holdings for each type as

$$\boldsymbol{X}_i^f = \boldsymbol{w_m} - \theta\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\Delta\boldsymbol{g} \tag{1.19}$$

$$\boldsymbol{X}_i^s = \boldsymbol{w_m} + (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\tilde{\boldsymbol{g}}_{\mathbf{1}} - (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\theta c\Delta\boldsymbol{g} \tag{1.20}$$

Proof in Appendix 1.A. ■

Equations (1.19) and (1.20) show that flexible investors deviate from the market weights $\boldsymbol{w_m}$ by tilting towards stocks with lower ESG scores and those stocks that they expect to increase in their ESG scores.

This means we can now calculate the expected excess returns to each type as $E(r_i) = \boldsymbol{X}_i'\boldsymbol{\mu}$ giving

$$E(r_i^{e,f}) = \mu_m + \theta^4 c^2\frac{1}{\gamma}\Delta\boldsymbol{g}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g} + \theta^2 c^2\frac{1}{\gamma}\tilde{\boldsymbol{g}}_{\mathbf{1}}'\boldsymbol{\Sigma}^{-1}\tilde{\boldsymbol{g}}_{\mathbf{1}} - 2\theta^3 c^2\frac{1}{\gamma}\tilde{\boldsymbol{g}}_{\mathbf{1}}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g}, \tag{1.21}$$

$$E(r_i^{e,s}) = \mu_m - (1-\theta)\theta c^2 \frac{1}{\gamma}\tilde{\boldsymbol{g}}_{\boldsymbol{1}}{}'\boldsymbol{\Sigma}^{-1}\tilde{\boldsymbol{g}}_{\boldsymbol{1}} - (1-\theta)\theta^3 c^2 \frac{1}{\gamma}\Delta\boldsymbol{g}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g} + 2(1-\theta)\theta^2 c^2 \frac{1}{\gamma}\tilde{\boldsymbol{g}}_{\boldsymbol{1}}{}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g}. \tag{1.22}$$

Proof in Appendix 1.A. ■

Equations (1.21) and (1.22) show that strict investors earn less because of 1) their stricter mandates (second term) but also 2) being less skilled (third term) and 3) because changes may be negatively correlated with ESG scores (forth term).

Costs of strict mandates

The combination of mandates and backward-looking ESG scores lead to two costs for the strict investor. First, the transfer in wealth from strict to flexible due flexible investors buying stocks, which go on to increase in ESG scores, and are then sold to strict mandate investors. Second, the backward looking ESG scores lead to strict mandate investors allocating capital to stocks that on average go on to have lower ESG scores in the future, as we will show in this subsection. Specifically,

1. The lower return for strict mandate investors due to the backward-looking ESG scores is

$$E(r_i^{e,s}) - E(r_i^{e,s})_{\boldsymbol{g_1}=\boldsymbol{g_2}} = -(1-\theta)\theta^3 c^2 \frac{1}{\gamma}\Delta\boldsymbol{g}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g} + 2(1-\theta)\theta^2 c^2 \frac{1}{\gamma}\tilde{\boldsymbol{g}}_{\boldsymbol{1}}{}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g}. \tag{1.23}$$

2. The capital misallocation for strict mandate investors due to the backward-looking ESG scores is

$$\begin{aligned}
[\boldsymbol{X}_i^s]'[\boldsymbol{g_2} - E[\boldsymbol{g_2}]] &= [\boldsymbol{X}_i^s]'[\boldsymbol{g_2} - \boldsymbol{g_1}] = [\boldsymbol{X}_i^s]'[\Delta\boldsymbol{g}] \\
&= [\boldsymbol{w_m} + (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\tilde{\boldsymbol{g}}_{\boldsymbol{1}} - (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\theta c\Delta\boldsymbol{g}]'[\Delta\boldsymbol{g}] \\
&= (1-\theta)c\frac{1}{\gamma}\tilde{\boldsymbol{g}}_{\boldsymbol{1}}{}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g} - (1-\theta)\theta c\frac{1}{\gamma}\Delta\boldsymbol{g}'\boldsymbol{\Sigma}^{-1}\Delta\boldsymbol{g}.
\end{aligned} \tag{1.24}$$

Policy. How could these two costs to strict mandates be reduced? On one hand doing away with the strict mandates would remove these costs, but this may not be an attractive solution. Specifically, the mandates are there to protect investors money, such that they get invested in the way agreed to by the investor. Furthermore, investors are often forced to place their money at these institutional investors, such as the companies pension plan, and do not have the option to withdraw and place them at a different investment manager, as would be the case for money at mutual funds or hedge funds. Therefore a more promising solution would be to go from backward to forward looking ESG scores. What this would do is that it would **1**) remove the informational advantage of the skilled investor ensuring that the strict investor can purchase the stock with a higher forward looking ESG score directly, and **2**) ensure that when the strict mandate investor purchases a high ESG stock it is the stock that is expected to remain a high ESG stock in future, and hence they are supporting the correct stocks. Hence going from backward to forward looking ESG scores would be a way to removing the two costs to strict mandate investing under backward looking ESG scores.

Empirical predictions

On top of explaining our main empirical finding, our theory leads to three additional empirical predictions, which we summarize below.

1. We get from Equation (1.19) that skilled investors tilt their holdings towards stocks that increase in their ESG scores, meaning that their holdings predict ESG score increases:

$$\Delta \boldsymbol{g} = \boldsymbol{\alpha} + \boldsymbol{\beta} \boldsymbol{X}_i^f, \tag{P1-1}$$

where $\boldsymbol{\alpha}$ is given by $[\tilde{\boldsymbol{g}}_{\mathbf{1}} - \gamma/(\theta^2 c)\boldsymbol{\Sigma}\boldsymbol{w_m}]$ and $\boldsymbol{\beta}$ is given by $\gamma/(\theta^2 c)\boldsymbol{\Sigma}$.[14]

Conversely, from Equation (1.20) we get that unskilled ownership predicts ESG score worsening:

$$\Delta \boldsymbol{g} = \boldsymbol{\alpha} - \boldsymbol{\beta} \boldsymbol{X}_i^s, \tag{P1-2}$$

where $\boldsymbol{\alpha}$ is given by $[\tilde{\boldsymbol{g}}_{\mathbf{1}} - \gamma/((1-\theta)\theta c)\boldsymbol{\Sigma}\boldsymbol{w_m}]$ and $\boldsymbol{\beta}$ is given by $\gamma/((1-\theta)\theta c)\boldsymbol{\Sigma}$.

2. We get from Equation (1.20) that strict mandate investors tilt their holdings towards stocks with a high ESG score. So taking holdings in period 1 and subtracting holdings in period 0 we get combined with empirical prediction **1** that strict mandate investors should increase their holdings of high ESG score stocks previously held by the flexible investor.

$$\Delta \boldsymbol{X}_i^s = (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1} c \Delta \boldsymbol{g}.$$

[14]The vectors $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are then used to estimate $\hat{\alpha}$ and $\hat{\beta}$ such that

$$\hat{\alpha} = \frac{1}{NT}\sum_{t=1}^{T} \mathbf{1}'\boldsymbol{\alpha}, \tag{1.25}$$

$$\hat{\beta} = \frac{1}{NT}\sum_{t=1}^{T} \mathbf{1}'\boldsymbol{\beta}, \tag{1.26}$$

where $\mathbf{1}$ is a unit vector of dimension N, N is the number of stocks and T the number of time periods.

$$= (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c[\boldsymbol{\alpha} + \boldsymbol{\beta}\boldsymbol{X}_i^f].$$

$$= \boldsymbol{\alpha}' + \boldsymbol{\beta}'\boldsymbol{X}_i^f, \tag{P2}$$

where $\boldsymbol{\alpha}'$ is given by $(1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\boldsymbol{\alpha}$ and $\boldsymbol{\beta}'$ by $(1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\boldsymbol{\beta}$.[15]

3. We see from Equation (1.18) that increases in ESG scores should be associated with a positive abnormal return.

$$\boldsymbol{\mu} = \boldsymbol{\alpha} + \boldsymbol{\beta}_1\Delta\boldsymbol{g} + \boldsymbol{\beta}_2\boldsymbol{\beta_m}, \tag{P3}$$

where $\boldsymbol{\beta}_1$ is given by θc, $\boldsymbol{\beta}_2$ by μ_m and $\boldsymbol{\alpha}_1$ by $-\theta c\tilde{\boldsymbol{g}}_{\mathbf{1}}$.

Additionally, we see by comparing Equation (1.21) to (1.22) that the outperformance of flexible investors is increasing in the strength of ESG mandates c, meaning it is larger at periods of high ESG sentiment.

1.5 Testing the Empirical Predictions

In order to test whether the strict mandates and backward looking ESG score may be driving the outperformance of flexible investors in their sustainable investing, we test in this section the empirical predictions developed from the explanation in Section 1.4. First, we investigate whether the flexible investor's holdings predict ESG score improvements (Equation (P1-1)) and whether strict holdings predict ESG score worsening (Equation (P1-2)). Second, we test whether strict mandate investors purchase high ESG score stocks from flexible investors (Equation (P2)). Thirdly, we test whether investors are compensated for predicting ESG scores (Equation (P3)). Additionally, we examine in Subsection 1.5.4 whether climate sentiment has increased abnormal returns of green stocks and the outperformance by the flexible investor, and in Subsection 1.5.5 whether the increases in ESG scores have been from prediction or activism by the skilled investor.

1.5.1 ESG score changes across investor types' holdings

Section 1.3 showed that flexible investors earn an ESG premium, whereas strict investors do not. We build on this finding and give an explanation as to where flexible investors' abnormal returns to sustainable investing come from. In this subsection, we test our first empirical prediction, that flexible investor ownership should predict ESG scores improvements (Equation (P1-1) in Section 1.4).

[15] Assuming that Δ is the same across periods.

We test whether flexible investors are better at predicting changes in firms' ESG scores. We test this by estimating

$$\Delta ESG_{i,t,t+N} = \alpha + \beta^I O^I_{i,t} + \epsilon_{i,t}, \tag{1.27}$$

where $\Delta ESG_{i,t,t+N}$ is the cumulative ESG score difference between the ESG score lagged by one year in year t and $t+N$ years ahead.[16] The variable $O^I_{i,t}$ is the relative institutional ownership of firm i at time t held by flexible or strict investors $I = \{F, S\}$. Additionally, we allow for heteroskedastic standard errors and control for industry-year effects. The results are displayed in Figure 1.3.

[Figure 1.3 about here]

Figure 1.3a shows that an increase in ownership by flexible investors leads to future increases in the ESG score of the stock. We see that, if a stock is bought by a flexible investor, the stock experiences positive changes every year for three years in a row. The most significant yearly change is between year one and two, where it rises about 17 ESG points or half a standard deviation. This makes sense as ESG scores can be updated from January to December, the second year will be the first time, that the change reflects a whole year of ownership prior to the change. Instead, had the stock remained in the hands of a strict investor, see Figure 1.3b, its ESG score would decrease on average, though a little less than the increase for a flexible investor.

This stylized fact indicates that flexible investors are better able to detect ESG firms with the potential of increases in their sustainability score. Flexible investors therefore seem to have superior skill in detecting future ESG scores, which may be explained by these firms spending a lot on fundamental analysis of companies, which they hope pays off through higher returns. Alternatively, it may be due to strict investors' mandates preventing them from purchasing these promising stocks because of the backward looking ESG score.

This finding can help explain why flexible firms earn superior returns when they invest in ESG firms. A firm with a low ESG score could be of value for investors once a higher score materializes and the market prices in this new publicly available information. This would lead to price appreciation, which current holders would yield abnormal returns from,

[16]We lag the ESG score to ensure that we use the score before investor ownership as we do not know when in the year the ESG is released and hence could be released in December even though the investor owned the stock in March.

see Equation (1.18) in Section 1.4. If this is true, then ESG score increases should lead to abnormal returns. We test this in the next subsection.

Before doing so, we conduct a robustness check to our findings in Figure 1.3. An alternative explanation to flexible investors being able to predict future ESG score increases could be that ESG score changes correlate with future cash flows as in Pedersen, Fitzgibbons and Pomorski (2021b). This would mean that flexible investors are really able to predict future cash flow changes rather than changing ESG scores. We test this by exchanging deltas in ESG scores by deltas in dividend yields and re-estimate Equation (1.27). Figure 1.I1 in Appendix 1.IA shows these results. We find that even though dividend yields tend to increase in the future when flexible ownership goes up, this effect is not significant. When strict ownership increases, dividend yields decrease significantly. However, the magnitude in either case is minor. Specifically, we estimate this effect to be 0.2 bp and -0.5 bp per p.p. of ownership under flexible and strict mandates, respectively. We therefore conclude that changes in ESG scores depict a skill by flexible investors that is unlikely to be explained by changes in dividend yields.

1.5.2 Strict investors' purchases of high ESG stocks from flexible investors

As a second step, we provide evidence on how flexible investors profit from sustainable investing. Our previous results show that flexible investors buy stocks, which later experience an increase in their ESG scores. Whilst we see for both types of investors that high ESG stocks rise in value when purchased, the strict investors' returns are not sustained. This suggests that flexible investors benefit from finding ESG firms which later increase in their score and by then selling them off, perhaps to the strict managers, which may be subject to a mandate to only invest in stocks with some of the highest ESG scores. To test this formally, we check whether strict investors indeed purchase high ESG firms from strict investors (Equation (P2) in Section 1.4). This also serves as a test of where the ESG demand arises from.

To do so we compare the change in strict ownership of two types of stocks. Specifically, we test if strict investors purchase more high ESG stocks from stocks mainly held by flexible investors versus high ESG stocks mainly held by other investors. In other words, we compute

$$Purchase_t^S = \Delta Ownership_t^{C^{HESG,HF}} - \Delta Ownership_t^{C^{HESG,LF}}, \tag{1.28}$$

where $\Delta Ownership_t^{SHESG,HF}$ represents the quarterly change in strict ownership share in the high ESG and high flexible ownership portfolio, and similarly for $\Delta Ownership_t^{SHESG,LF}$, but with low flexible ownership. Hence, $Purchase_t^S$ documents whether strict owners increase their ownership of high ESG stocks more in stocks previously held by flexible investors relative to other investors.

We plot the time series of results in Figure 1.4. The results show that strict investors demand and purchase high ESG score stocks held by the flexible investors. They have increased their purchases since the onset of the financial crisis, and over time build up a significant positive cumulated ownership share.

[Figure 1.4 about here]

1.5.3 Returns to ESG score changes

The previous sections show that flexible investors are able to predict ESG score increases and that strict investors purchase stocks with high ESG scores from flexible investors. We build on these findings and test how changes in ESG scores affect returns, or put differently, whether additional demand due to higher scores increases returns. We test this by regressing returns onto ESG score changes, whilst controlling for risk (Equation (P3) in Section 1.4).

As a standard panel-regression restricts each firm to have the same β, we also include a Fama and MacBeth (1973) specification, allowing the β estimates to vary at the firm level. We run

$$r_i^e = \gamma_0 + \gamma_{mkt}\hat{\beta}_{i,mkt} + \gamma_{smb}\hat{\beta}_{i,smb} + \gamma_{hml}\hat{\beta}_{i,hml} + \gamma_{mom}\hat{\beta}_{i,mom} + \gamma_{\Delta ESG_t}\Delta ESG_{i,t} + \epsilon_i \;, \tag{1.29}$$

where $\hat{\beta}_{i,f}$ are firm-specific β estimates onto the factor f. The change in ESG scores from the previous year to the current year t is denoted by $\Delta ESG_{i,t}$, where we have added a time subscript as we also use $\Delta ESG_{i,t-1}$ in the analysis, which in turn is the change from two years ago to the previous year $t-1$. The variables of r_i^e and ϵ_i are the excess and unexplained return for firm i. Table 1.6 shows the results.

[Table 1.6 about here]

We find that changes in ESG scores in the current year lead to positive excess returns, see Columns (1) and (3). If a firm, for example, has an ESG score of 30, but gets a higher score during the current year of 80, our results indicate that the excess return increases by

40 bp, or equivalently 10 bp for a standard deviation move in the ESG score. We do not observe any effect for lagged ESG score changes (Columns (2) and (4)), suggesting that the returns are realised as the new score gets published.

One might be worried that returns could be confounded by dividend changes. That is, if dividend increases are associated with both a positive return and ESG changes, ESG changes could be picking up the return effect from the increase to cash flows. We control for this in Table 1.7. To be able to control for dividends we consider returns purely coming from price changes, so they do not include returns coming mechanically from dividend payments. Columns (1) and (2) show that the results for the total excess return and excess return excluding dividends are very similar; the ESG effect increases a little when excluding dividend returns. In Column (3) we see that changes in the dividend return from a year ago are associated with a negative return. This is similar when considering just the dividend return as in Column (4). Finally, in Column (5) we include both and see that the ESG effect remains constant. Table 1.I6 in the Appendix shows the same results but for total returns. These robustness results are very similar to our baseline results, except that the dividend effect is not significant. Our findings show that cash flow changes are not a confounding factor for returns arising from changes to ESG scores.

[Table 1.7 about here]

These findings shed light on how flexible investors profit from sustainable investing. In a nutshell, flexible investors are able to predict positive ESG score changes (Figure 1.3) and later sell higher ESG score firms to strict investors (Figure 1.4). The additional demand due to higher scores leads to higher returns (Table 1.6), which the flexible investors capitalize on (Table 1.2).

1.5.4 Sentiment in sustainable investing

We go on to test whether the ESG premium can be influenced by climate sentiment, an indicator for the relevance of environmental concerns in the market. As documented in Equation (1.18) in the theory section, when sustainability sentiment is higher it may lead to a higher cost for strict mandate investors to deviate from their ESG mandate increasing the return to predicting ESG score increases. This can help explain the positive returns earned by flexible investors' sustainable investments. Additionally, Pástor, Stambaugh and Taylor (2021b) show that unexpected increases in sustainability sentiment can lead to a positive ESG return even though the unconditional ESG premium is negative.

To test for the effects of climate sentiment, we consider the returns of a long-short equity portfolio, which goes long in high ESG firms and short in low ESG firms. The climate sentiment measure is developed from Google searches for 'Climate change' and is explained in Section 1.2. When conducting our analysis, we compute

$$LS_t^I = r_t^{HESG,I} - r_t^{LESG,I} = \alpha + \gamma \ Sentiment_t + Controls_t + \epsilon_t \ , \tag{1.30}$$

where $r_t^{HESG,I}$ ($r_t^{LESG,I}$) depicts the high (low) ESG portfolio return of investor type I at time t, where I can be either flexible F or strict S. The abnormal return is denoted by α. The climate sentiment at time t and γ, the loading on this proxy, are depicted by $\gamma \ Sentiment_t$. Moreover, the controls always include the factors f_j together with their loadings β_j for all J factors, and sometimes a crisis indicator $\beta_{\mathbb{1}} \mathbb{1}_{NBER}$, which equals 1 in a crisis and 0 otherwise. Finally, ϵ_t is the unexplained return.

This is our empirical specification of Equation (1.18), where α is the abnormal return due to the difference in ESG scores of the firms in the long and short portfolio. The notation of $\gamma Sentiment$ is the return from the preference shock, which also scales with the greenness of the firm. Hence, we expect γ to vary according to the greenness of the firm, and be especially pronounced in our long minus short portfolio (ESG factor) as we capture the difference in greenness of the high ESG and low ESG firms.

Table 1.8 shows the results. Indeed, the results confirm that climate sentiment positively affects the returns to sustainable investing of the flexible investor (Columns (1) to (3)), as well as for the general investor (Columns (4) to (6)).

[Table 1.8 about here]

In terms of magnitude, we see that a standard deviation shock to *Climate sentiment* is associated with a realized abnormal return from sustainable investing of 6 bp and 4 bp for the ESG factor in general. These estimates remain the same if we control for the crisis effects, however different investors performed quite differently during the crisis, as the estimates rise for the flexible investors, but fall for the general factor.

As for robustness, we see that the results are not driven by the crisis, as it is equally strong outside the crisis, as seen by the $Climate : NBER_{false}$ interaction term. The results are consistent across the different asset pricing models: CAPM, Fama-French, and Carhart. The results are also robust to creating the factor based on searches on 'Climate' and to using just the Google searches coming from the news part. Lastly, the results are robust to using the changes in *Climate sentiment* instead of the AR(1) residual, as well as a non-seasonally adjusted time series.

Additionally, Table 1.I7 in Appendix 1.IF confirms that *Climate sentiment* increases the difference in the returns earned by sustainable investing across the two investor types. It does so, as we see in line with theory that *Climate sentiment* drives the returns to sustainable investing for the strict investor less.

These results strengthen the idea that climate sentiment is a force that affects ESG stock valuations. Doing so, it helps explain the difference in returns to sustainable investing returns across the two investor types. Additionally, the results suggest that the value of predicting ESG scores might be higher in a period of high noise and uncertainty as, for example, the financial crisis.

As robustness, we test the general ESG factor against other sentiment measures, including the highly complex Engle et al. (2020) climate change news measure, the Baker and Wurgler (2006) economic sentiment indicator, and the price dividend ratio as an index of optimism in the economy. The results are shown in Appendix 1.IE. First, we see in that the Engle et al. (2020) climate change news associates with 80 bp of abnormal returns in periods of more than average amounts of negaive news. Second, returns on the ESG factor are higher outside of high sentiment periods under the Baker and Wurgler (2006) measure, indicating that sustainability sentiment is not correlated with general business sentiment and especially strong in recessions. Third, we find that a falling price dividend ratio increases the returns on the ESG factor and thereby confirm that sustainability sentiment seems negatively correlated with general business sentiment.

1.5.5 Stock holder prediction versus activism

To test whether the outperformance of flexible investors is due to a prediction ability or extra monitoring I use exogenous variation in investor holdings arising from stock exclusions from the leading ESG indices. The idea behind this approach, which we will label as Instrumented Portfolios, is simple. In asset pricing we are interested in how accounting variables of a firm affects its cost of capital. However, these variables are endogenously decided by the firm and the analysis is prone to the case that there may be a third, potentially unobserved, variable that affects both the accounting variable and the cost of capital, such as financial frictions like illiquidity drying up certain markets making firms invest less and raising their cost of equity. This is where Instrumented Portfolios comes in as by using an exogenous change to a specific firm variable we circumvent worries of confounding third variables. Intrumented Portfolios then sorts portfolios on these exogenous changes and considers the difference in the resulting cost of equity. Another benefit of this method is that it can be extended beyond expected returns to other firm variables of interest, as for example changes in ESG scores.

The reason why we can use Instrumented Portfolios to test for monitoring or prediction is that purchases done by the flexible investor out of liquidity provision is different to purchases done because the investor believes the firm's ESG score to increase. In contrast, no matter the reason of purchase an investor can still pursue its monitoring efforts. Hence, if we still see the same effects from our Instrumented Portfolios relative to our original Portfolios, the effect is likely to be from monitoring, and alternatively from prediction.

A test of prediction or monitoring. Specifically, we are interested in how investor type ownership affects returns and ESG scores, and as an instrument we will use exclusions of a stock from an ESG Index. In this case either the MSCI USA ESG Screened Index or the FTSE4Good index, where we get the holdings of the primary ETFs who follow these indeces (iShares MSCI USA ESG Screened and Vanguard FTSE Social Index Fund) from the S12 mutual fund holdings dataset. These two funds represents the two largest ESG index funds.

We use these exclusions to instrument for fund holdings. Hence, for each firm we compute the changes in their holdings happening at the same time as the index exclusion. Using our categorization of flexible and strict investors we summarize the purchases of flexible and strict investors and then use this group purchase measure to split the stocks into four portfolios for each investor type dependent on their ownership share. We always lag the firm variable, holdings in this case, before regressing an outcome variable on the portfolios. In the baseline case we keep their previous purchases up to time $t-1$, as would be normally done, however our coming results are robust to just considering the outcome variables for purchases in the previous period.

Doing this exercise for both flexible and strict investors, and comparing the difference, allows us to control for the fact that firms that are excluded from the ESG index may be trying to re-enter the index by increasing their ESG score, because this effect would impact firms owned by the strict and flexible investors equally.

Validity of social index exclusions as an instrument. The initial step in IP is to ensure instrument validity. This first of all requires the instrument to satisfy the exclusion restriction, meaning that the instrument does not effect the outcome variable directly, but only through the firm variable, which in our case is investor type ownership. And secondly, we need to ensure that the instrument is not weak, which we do below in Table 1.9. Here we see in Panel A that strict investors tend to sell stocks, which leave the social indices. Where our baseline measure is giving in column (1) where we take the changes in share numbers multiplied by the value of those shares in the previous period to not have any effects coming directly from price changes. Column (2) shows the effects purely for the share changes, and column (3) is similar to column (1) but allowing the prices to update. As our F-statistics in column (1) to (2) are 23 and 29 respectively we can reject that the instruments are weak and we can proceed to the next step. Panel B shows the effect for both strict and flexible investors separately and we see that each group generally sells, but the strict investor group sells the most.

[Table 1.9 about here]

Instrumented portfolio results. We display the IP results for returns in Table 1.10 and changes to ESG scores in Table 1.11. Here we see that the returns of the flexible investor tends to be lower than for the strict investor, especially considering the spread between the high and low portfolios. This is also the case for the CAPM alpha, Carhart alpha, and controlling for the changes to the ESG score. This suggests that the original results do not derive from monitoring, however we additionally test for changes to ESG scores in the next table. Note that each cell is a different regression and hence the number of observations and R^2 differs across each and is not given for ease of clarity.

[Table 1.10 about here]
[Table 1.11 about here]

Table 1.11 displays the changes in ESG to the same stocks as before. As the portfolios always are lagged, we first see how ESG score develops over the first year in the top row and the second year in the bottom row as robustness, and we find that they evolve very similarly across the two investor types for this kind of forced purchases.

1.6 Interpretation of Magnitudes

We can now get a sense of magnitudes from the returns to sustainable investing with skill. First, we can get a sense of how important skills are in explaining the returns to sustainable investing for the flexible investor. We isolate the skill effect by evaluating Equation (1.18) from Section 1.4 using parameters estimated in Section 1.3, and compare it to the total returns achieved by the flexible investors sustainable investments. Additionally, we conduct a similar exercise for the difference between returns for different investor types.

We start off by quantifying the skill channel. Using that the realised return is the expected return given by Equation (1.18) for a specific stock n plus a random shock and subtracting the returns from the risk factors we get the abnormal return to sustainable investing is

$$\alpha_n = \mu_g \beta_{g,n} + \mu_{\Delta g} \Delta g_n + \epsilon, \tag{1.31}$$

where μ_g is given by $-\theta c$, the average ESG mandate strength, $\beta_{g,n}$ is $\tilde{\boldsymbol{g}}_{\mathbf{1}}$, the deviation of stock n's ESG score from the average mandate target value, and $\mu_{\Delta g}$ is given by $\theta^2 c$, the compensation for ESG score improvements.

The first term is proportional to the return arising from the long-short ESG strategy. To see its effect we turn to Table 1.1 in Section 1.3. There, we see that we cannot reject that these returns are zero, and hence we use this estimate for the rest of the section. The second term is the returns from predicting the ESG score. We estimate this from how well the investors predict ESG scores Δg_n (Figure 1.3) multiplied by the returns to increases in ESG scores $\mu_{\Delta g}$ (Table 1.6).[17] Hence, we get from our estimates that the alpha achieved from ESG skill (E) for the flexible investor is

$$\alpha_E^F = \mu_g \beta_{g,n} + \mu_{\Delta g} \Delta g_n + \epsilon = 0 + 17 \Delta ESG \times 0.8 \frac{\text{bp}}{\Delta ESG} = 13.6 \text{ bp}.$$

When comparing this to the total abnormal return achieved by the flexible investor α_T^F (Table 1.2), we see that skill makes up 35%. The residual return is due to channels such as sentiment and other sources of skill than predicting ESG scores.

One way to control for the sentiment effect is to consider the difference in returns to sustainable investing for the two types. Here, we see that skill explains 51% of the difference. In summary, these results suggest that the skill of predicting ESG scores is economically an important driver for the differing returns to sustainable investing, especially when controlling for sentiment.

[17] To be able to do so, we make the implicit assumption that the investors own 100% of the stocks they invest in. This is of course a simplifying assumption. If we look at the ownership figure in the internet appendix we can see that they own 20% of all the ESG stocks. So the actual average ownership percentage of the ESG stocks they invest in, will be somewhere from 20 to 100%, however it is likely to be closer to 100 than 20% as there are many stocks they do not invest in.

1.6.1 Discussion of difference in magnitudes

In terms of magnitude we find that the flexible investors earn 26 bp per month higher returns from sustainable investments than their strict mandate counterparts. This size seems reasonable as Hong and Kacperczyk (2009) find in their study that Sin stocks earn the same 26 bp higher returns relative to comparable stocks in their specification with the same risk model as ours. Where as our returns vary from 26 to 28 bp dependent on the model, theirs vary between 25 and 30 bp.

Another way to think about the magnitude is to consider what size of demand and price elasticity is needed to achieve this effect. United Nations Principles for Responsible Investing (UNPRI) write in their report that the amount of assets invested under responsible investing principles exceeded USD 25 trillion in 2021. As this corresponds to 25% of the global asset management industry, it is a significant fraction.[18]

To get the total impact on returns we lastly need elasticity estimates. Estimates that are least likely to suffer from bias are from the index-inclusion literature such as Chang, Hong and Liskovich (2015). They find that price elasticity, meaning how much the price is affected by demand in percentage terms, is around 1. Specifically, they find a price elasticity between 0.39 and 1.46, depending on whether you take passive assets following the index or all assets benchmarked to the index. With an estimate of 1 we would only need a demand change of 3.1% to get an annual return difference of 3.1%, which is equal to 26 bp per month. Or 5% to 1.2% demand change for Chang, Hong and Liskovich (2015)'s two individual estimates. However, this also means that if occurring continuously throughout the year, for example every month, then the demand increase has to be even lower. Specifically in this example a 12th of the conservative 5% is 0.4%.

Additionally, we argue that indeed only 51% of the difference to sustainable investing between investment mandates is due to the ESG improvement strategy and hence the demand needed is only 1.6%. These results are further supported by Koijen and Yogo (2019b), Koijen, Richmond and Yogo (2020), and Gabaix and Koijen (2021) who find the stock market to be relatively inelastic and the demand elasticity of institutional investors to be around 1. Additionally Koijen, Richmond and Yogo (2020) find that if all large active investors changed their demand to holding the market, the market would experience a

[18] The assets managed globally is estimated by BCG as USD 100 trillion by 2020 (`https://web-assets.bcg.com/79/bf/d1d361854084a9624a0cbce3bf07/bcg-global-asset-management-2021-jul-2021.pdf`). Consistent with the 25% demand following ESG principles measured by the UNPRI, Berk and van Binsbergen (2021) write that the percent of wealth owned by ESG investors is between 2 and 33%, so even the most conservative estimates are several trillion USD.

repricing of 18%. A similar size is found for small or large passive investors. These elasticity estimates suggest that the demand needed is within what could reasonably be expected making the magnitude of the return to sustainable investing for flexible investors sensible.

1.7 Cost and Benefit to Sustainable Investing

Taking a step back, this section gives an estimate of the welfare effects of sustainable investing. Specifically, we estimate the cumulated cost of sustainable investing incurred by the strict investor due to his ESG mandate.[19] We go on to compare the cost estimate to an estimate of the benefit gained by sustainable investing over the same period. The section finishes by giving policy recommendations based on these welfare considerations.

1.7.1 The cost to strict mandate investing: Costly mandates

Our results allow us to estimate the cumulated cost C to strict ESG investing. We estimate the yearly cost c_t due to strict mandates simply by combining the difference in alphas to sustainable investing times the strict investors capital invested in sustainable assets at time t, $K^g_{t,s}$:[20]

$$C = \sum_t c_t = \sum_t \Delta\alpha K^g_{t,s} \tag{1.32}$$

We plot the cumulated cost in Figure 1.5. We see that the cumulated costs to sustainable investing has been increasing over time. This is because sustainable assets held by strict investors grew before the crisis and then again gradually after 2010. Over our sample period, the cumulated cost to sustainable investing exceeds USD 400 billion. This is equivalent to 1.54 times Apple's 2020 revenue.

[Figure 1.5 about here]

1.7.2 The benefit to strict mandate investment: Reduced carbon emissions

After considering the cost, we can also consider the benefit (b) for the strict investor. As the strict investor values ESG stocks, it incentivizes companies to improve their ESG

[19] Our analysis complements He and Xiong (2013) who show there may be gains from limiting an investment managers mandate due to decreasing agency costs. We show that even taking these gains into account, investing with a strict ESG mandate leaves you worse off.

[20] In our case $K^g = 1/4K$ from how we construct our sorts.

score. As we see that flexible investors are able to purchase these the cumulated benefit from strict ESG investing is hence the improved ESG score (Δg) incentivized times the capital that is improved, which in our case is the capital owned by the flexible investors in high ESG stocks at time t[21]

$$B = \sum_t b_t = \sum_t \Delta g K^g_{t,f}. \tag{1.33}$$

As ESG scores and CO_2 emissions are related we can show the benefit in terms of reduced CO_2 emissions from strict mandates. We show this in Figure 1.6. We observe that CO_2 savings have been growing over time. In addition, the rate of CO_2 savings really picked up after the financial crisis and in the latter part of the previous decade as the sustainable investments of flexible investors grew. Over our sample period, more than a billion tons of CO_2 have been saved. This is equivalent to 59 times of what Apple has emitted in 2020 and 20% of what the US emits per year.[22] This also means that CO_2 emissions would be 11% higher had it not been for sustainable investing.[23]

[Figure 1.6 about here]

Table 1.12 documents the relationship between ESG scores and CO_2 emissions used for the above calculation.[24] We find that an increase in the ESG score by 1 level decreases the CO_2 intensity by 0.1 bp. This is equivalent to 10 tons of CO_2 emissions per USD one million of revenue. When including firm fixed effects to only consider variation between firms, the effect is similar at 8 tons CO_2 emissions per USD one million of revenue. This finding is statistically significant and robust to clustering by time and firm.

[Table 1.12 about here]

Also note that reducing CO_2 intensity is impactful because not only does a firm reduce CO_2 emissions this year, but every following year as well. In this regard it is similar to the effect of compounding returns. This effect is the same for the costs, and both are not shown in the figures.

[21] This is equivalent to the welfare effect from Pástor, Stambaugh and Taylor (2021b)'s second channel.

[22] Numbers from Apple's climate progress report for the 2020 fiscal year (`https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2021.pdf`). Numbers for the US are taken from the World Bank (`https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?locations=US`)

[23] The carbon savings in 2018 were 561 million tons and the total US emissions in 2018 were 4,981 million tons.

[24] We retrieve CO_2 emissions data from Refinitiv, which includes CO_2 equivalents from other green house gas emissions.

One can also consider the benefits in USD dollars. An estimate of the negative externality CO_2 emissions produce is the price of CO_2 emissions as seen in the European Union Emissions Trading System, the world's largest cap and trade greenhouse gas emissions market. Allowances for CO_2 emissions are first allocated considering EU directives for the maximum amount of greenhouse gases that can be emitted. Allowances for CO_2 emissions are then auctioned and traded. Based on CO_2 emission prices, reducing emissions by 1 billion CO_2 has reduced the negative externality by USD 9 to 69 billion.[25]

All in all, having reduced the emission equivalent of USD 9 to 69 billion, or 59 times Apple's emissions, for the cost of USD 424 billion, or 1.54 times Apple's revenues, under our modelling framework, it seems like a promising channel for reducing emissions, but also not as efficient in its current form compared to more direct approaches such as carbon capture.[26]

1.7.3 Policy recommendations

What would the policy recommendation be based on these welfare results? Based on our framework, it is not likely that policy can affect the benefit side. However, they may be able to affect the costs through how ESG ratings are defined. Currently, the strict ESG mandates mean that the investors cannot invest in the companies which will have a positive climate impact in the future. Instead, the mandates based on current ESG ratings lead them to purchase higher priced high ESG companies, and hence losing out on positive returns. Today, ESG ratings are calculated based on current factors as, for example, carbon intensity. Were they instead designed to be forward looking, it would mean that from the beginning investors could within their mandate purchase the stocks with impact, and would no longer lose out on the positive returns associated with increasing ESG scores. As a consequence, this would reduce the cost of sustainable investing.

This is in line with the article *The meaning of green* in The Economist published Jan 8, 2022. The article argues that the new EU green investment labelling system, the Taxonomy Complementary Climate Delegated Act, is flawed. This is because the simple labelling may lead to funds excluding dirty assets, instead of buying dirty companies and managing down their emissions. This issue arises because the labels are static. Their solution is to make it easier for investors to track the CO_2 emissions, especially those

[25] Calculated as plus minus 1 standard deviation from the average Carbon emissions allowance log price from `https://tradingeconomics.com/commodity/carbon`. Exchange rate data is from Morningstar and the data is available from April 22, 2005 until March 1, 2022.

[26] Carbon capture costs are estimated at USD 52-60 per ton (USD 70-80 bil for 1.34 bil tons CO_2) by the following paper `https://royalsocietypublishing.org/doi/10.1098/rsfs.2019.0065`.

that have the capacity to reduce their emissions greatly. This will require new disclosure. There has been set up a new global green-disclosure body, The International Sustainability Standards Board, but it has yet to publish their norms for disclosure. However, it is not clear how long this will take or if they will even go away from this static view of ESG scores.

A dynamic view is also in line with Oehmke and Opp (2020) and Green and Roth (2021). The authors propose that for investors to have an impact on firm behaviour they need to have broad mandates and invest compared to a new ESG metric that takes into account the changes in emissions of the firm from the investors' engagements. This further relates to the voice vs. exit discussion, and would favour voice over exit (Broccardo, Hart and Zingales 2020).

1.8 Conclusion

We document a large difference in the returns to sustainable investing across investors. A closer look reveals that this discrepancy arises from investors with a strict mandate being unable to invest into stocks with expected ESG score increases. This implies that strict mandate investors could potentially also see the same investment opportunities, but cannot exploit them due to their strict mandates. In the time series we see that growing climate sentiment boosts the returns to sustainable investing.

Interest in sustainable investing has been accelerating over the last decades, and recent government and institutional changes have only increased the pace of this growth. As more and more assets are invested under sustainable mandates, understanding this shift in preferences becomes increasingly important. A consequence of this is a growing cost to sustainable investing with a strict mandate.

Our findings have real implications for investors and the economy as they show that sustainability is positively priced. From a firm's point of view, our findings affect their cost of capital. It decreases for sustainable firms. However, this does not seem to be the most impactful way towards a greener future. Instead, our results suggest that an additional sustainability demand by investors creates an incentive for firms to become greener. This is ultimately good news, as it both leads to higher returns for the investor, as well as a higher level of sustainability for the economy.

Appendix

1.A Proofs

Proof of Equation (1.3). We start with the maximisation problem of the investor i who maximises their expected utility with respect to their portfolio $\boldsymbol{X}_i$:

$$\frac{d}{d\boldsymbol{X}_i}E[U[W_{1i},\boldsymbol{X}_i]] = \frac{d}{d\boldsymbol{X}_i}E[-e^{-aW_{1i}}] \tag{1.34}$$

$$= \frac{d}{d\boldsymbol{X}_i}E[-e^{-aW_{0i}(1+r_f+\boldsymbol{X}_i'\boldsymbol{r}^e)}] \tag{1.35}$$

$$= -e^{\gamma(1+r_f)}\frac{d}{d\boldsymbol{X}_i}E[e^{-\gamma(\boldsymbol{X}_i'\boldsymbol{r}^e)}], \tag{1.36}$$

where we use that the relative risk aversion γ is equal to aW_{0i}. Taking expectations we further get

$$\frac{d}{d\boldsymbol{X}_i}E[U[W_{1i},\boldsymbol{X}_i]] = -e^{\gamma(1+r_f)}\frac{d}{d\boldsymbol{X}_i}[e^{-\gamma(\boldsymbol{X}_i'\tilde{\boldsymbol{\mu}}+1/2\gamma^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)}] \tag{1.37}$$

$$= e^{\gamma(1+r_f)}(\gamma\tilde{\boldsymbol{\mu}}+\gamma^2\boldsymbol{\Sigma}\boldsymbol{X}_i)[e^{-\gamma(\boldsymbol{X}_i'\tilde{\boldsymbol{\mu}}+1/2\gamma^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)}] \tag{1.38}$$

Setting above equal to zero we get that

$$e^{\gamma(1+r_f)}(\gamma\tilde{\boldsymbol{\mu}}+\gamma^2\boldsymbol{\Sigma}\boldsymbol{X}_i)[e^{-\gamma(\boldsymbol{X}_i'\tilde{\boldsymbol{\mu}}+1/2\gamma^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)}] = 0 \tag{1.39}$$

$$\gamma\tilde{\boldsymbol{\mu}}+\gamma^2\boldsymbol{\Sigma}\boldsymbol{X}_i = 0 \tag{1.40}$$

$$\boldsymbol{X}_i = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\tilde{\boldsymbol{\mu}}. \tag{1.41}$$

Remembering that the strict mandate investor pays a cost C per dollar invested equal to $c(g_i - \boldsymbol{g})$ we can rewrite the expected return such that $\tilde{\mu} = \mu - c(g_i - \boldsymbol{g})$ and

$$\boldsymbol{X}_i = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} - c(g_i - \boldsymbol{g}) \tag{1.42}$$

■

Proof of Equation (1.11). Now the market clearing condition becomes

$$\boldsymbol{w_m} = \int_i \omega_i\boldsymbol{X}_i di \tag{1.43}$$

$$= \int_i \mathbb{1}_{i=f}\omega_i \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} + \mathbb{1}_{i=s}\omega_i \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} + c(g_i - \boldsymbol{g})]di \tag{1.44}$$

$$= (1-\theta)\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} + \theta\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} + c\tilde{\boldsymbol{g}}] \tag{1.45}$$

$$= \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu} + \theta\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}c\tilde{\boldsymbol{g}}. \tag{1.46}$$

Solving for expected excess return yields

$$\boldsymbol{\mu} = \gamma\boldsymbol{\Sigma}\boldsymbol{\omega_m} - \theta c\tilde{\boldsymbol{g}}. \tag{1.47}$$

This in turn means that the market expected excess return is

$$\boldsymbol{\omega_m'}\boldsymbol{\mu} = \gamma\boldsymbol{\omega_m'}\boldsymbol{\Sigma}\boldsymbol{\omega_m} + \theta c\boldsymbol{\omega_m'}\tilde{\boldsymbol{g}}, \tag{1.48}$$

$$\mu_m = \gamma\sigma_m^2, \tag{1.49}$$

as $\tilde{\boldsymbol{g}}$ is demeaned meaning that the market average has to be zero. So we can then rewrite the return to a specific stock using the two above equations by solving the second equation for γ and substituting into the previous equation and get that

$$\boldsymbol{\mu} = \mu_m\boldsymbol{\beta_m} - \theta c\tilde{\boldsymbol{g}}. \tag{1.50}$$

■

Proof of Equation (1.17). The skilled flexible demand is unchanged as they have correct payoff and return predictions. For the unskilled strict demand, we start with the maximisation problem of unskilled investor i who maximises their expected utility with respect to their portfolio $\boldsymbol{X}_i$. In addition, their expectation of their future wealth W_{1i} is biased due to their lack of information when computing their expectation of the return:

$$\frac{d}{d\boldsymbol{X}_i}E^{-\varsigma}[U[W_{1i}, \boldsymbol{X}_i]] = \frac{d}{d\boldsymbol{X}_i}E^{-\varsigma}[-e^{-aW_{1i}}] \tag{1.51}$$

$$= \frac{d}{d\boldsymbol{X}_i}E^{-\varsigma}[-e^{-aW_{0i}(1+r_f+\boldsymbol{X}_i'\boldsymbol{r^e})}]. \tag{1.52}$$

Next we use the unskilled investor's biased expectation which deviates from the true return before costs $\tilde{\boldsymbol{\mu}}$ by $-\theta c\Delta\boldsymbol{g}$ per stock (Equation 1.16):

$$\frac{d}{d\boldsymbol{X}_i}E^{-\varsigma}[U[W_{1i}, \boldsymbol{X}_i]] = \frac{d}{d\boldsymbol{X}_i}[e^{-aW_{0i}(1+r_f+\boldsymbol{X}_i'[\tilde{\boldsymbol{\mu}}-\theta c\Delta\boldsymbol{g}]+1/2a^2W_{0i}^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)}] \tag{1.53}$$

$$= (aW_{0i}[\tilde{\boldsymbol{\mu}} - \theta c\Delta \boldsymbol{g}] + a^2 W_{0i}^2 \boldsymbol{\Sigma}\boldsymbol{X}_i)[e^{-aW_{0i}(1+r_f+\boldsymbol{X}_i'\tilde{\boldsymbol{\mu}}+1/2a^2W_{0i}^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)-a\boldsymbol{X}_i'\theta c\Delta\boldsymbol{g}}] \tag{1.54}$$

$$= (\gamma[\tilde{\boldsymbol{\mu}} - \theta c\Delta \boldsymbol{g}] + \gamma^2 \boldsymbol{\Sigma}\boldsymbol{X}_i)[e^{-aW_{0i}(1+r_f+\boldsymbol{X}_i'\tilde{\boldsymbol{\mu}}+1/2a^2W_{0i}^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)-a\boldsymbol{X}_i'\theta c\Delta\boldsymbol{g}}] \tag{1.55}$$

First order condition requires the first order differential equals zero, so setting above equal to zero we get that

$$(\gamma[\tilde{\boldsymbol{\mu}} - \theta c\Delta \boldsymbol{g}] + \gamma^2 \boldsymbol{\Sigma}\boldsymbol{X}_i)[e^{-aW_{0i}(1+r_f+\boldsymbol{X}_i'\tilde{\boldsymbol{\mu}}+1/2a^2W_{0i}^2\boldsymbol{X}_i'\boldsymbol{\Sigma}\boldsymbol{X}_i)-a\boldsymbol{X}_i'\theta c\Delta\boldsymbol{g}}] = 0 \tag{1.56}$$

Which implies

$$\gamma[\tilde{\boldsymbol{\mu}} - \theta c\Delta \boldsymbol{g}] + \gamma^2 \boldsymbol{\Sigma}\boldsymbol{X}_i = 0 \tag{1.57}$$

Solving for $\boldsymbol{X}_i$:

$$\boldsymbol{X}_i = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\tilde{\boldsymbol{\mu}} - \theta c\Delta \boldsymbol{g}]. \tag{1.58}$$

Remembering that the strict mandate investor pays a cost $\boldsymbol{C}$ per dollar invested equal to $c(g_i - \boldsymbol{g}_1)$ we can rewrite the expected return such that $\tilde{\boldsymbol{\mu}} = \boldsymbol{\mu} - c(g_i - \boldsymbol{g}_1)$ and

$$\boldsymbol{X}_i = \frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - \theta c\Delta \boldsymbol{g} - c(g_i - \boldsymbol{g}_1)] \tag{1.59}$$

So as flexible investors' demand is unchanged we get that for any investor i:

$$\boldsymbol{X}_i = \mathbb{1}_{i=f}\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu}] + \mathbb{1}_{i=s}\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - \theta c\Delta \boldsymbol{g} - c(g_i - \boldsymbol{g}_1)]. \tag{1.60}$$

■

Proof of Equation (1.18). Total demand is given by Equation (1.17) as

$$\int_i \omega_i \boldsymbol{X}_i di = \int_i \mathbb{1}_{i=f}\omega_i\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu}] + \mathbb{1}_{i=s}\omega_i\frac{1}{\gamma}\boldsymbol{\Sigma}^{-1}[\boldsymbol{\mu} - \theta c\Delta \boldsymbol{g} - c(g_i - \boldsymbol{g}_1)]di \tag{1.61}$$

Equilibrium condition require $\boldsymbol{w_m} = \int_i \omega_i \boldsymbol{X}_i di$, so solving for $\boldsymbol{\mu}$ gives

$$\boldsymbol{\mu} = \gamma\boldsymbol{\Sigma}\boldsymbol{w_m} - \theta c\tilde{\boldsymbol{g}}_{\boldsymbol{1}} + \theta^2 c\Delta\boldsymbol{g}. \tag{1.62}$$

Get market return by premultiplying with $\boldsymbol{w_m}$

$$\mu_m = \gamma\sigma_m^2 \tag{1.63}$$

Solve for γ and plug this into return equation to get

$$\boldsymbol{\mu} = \mu_m \boldsymbol{\beta_m} - \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2 c \Delta \boldsymbol{g}. \tag{1.64}$$

■

Proof of Equations (1.19) **and** (1.20). Holdings for each type is:

$$\boldsymbol{X}_i^f = \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} [\boldsymbol{\mu}] \tag{1.65}$$

$$\boldsymbol{X}_i^s = \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} [\boldsymbol{\mu} + c \tilde{\boldsymbol{g}}_{\mathbf{1}} - \theta c \Delta \boldsymbol{g}] \tag{1.66}$$

This means that total holdings, which in equilibrium has to be $\boldsymbol{w_m}$, are

$$\int_i \omega_i \boldsymbol{X}_i di = \int_i \mathbb{1}_{i=f} \omega_i \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} [\boldsymbol{\mu}] + \mathbb{1}_{i=s} \omega_i \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} [\boldsymbol{\mu} - \theta c \Delta \boldsymbol{g} - c(g_i - \boldsymbol{g}_1)] di. \tag{1.67}$$

$$= \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} [\boldsymbol{\mu}] + \theta \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} [c \tilde{\boldsymbol{g}}_{\mathbf{1}} - \theta c \Delta \boldsymbol{g}] = \boldsymbol{w_m} \tag{1.68}$$

Take the individual holdings of each type and plug in for $\boldsymbol{\mu}$ and rewrite in terms of $\boldsymbol{w_m}$:

$$\boldsymbol{X}_i^f = \boldsymbol{w_m} - \theta \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} c \tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2 \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} c \Delta \boldsymbol{g} \tag{1.69}$$

$$\boldsymbol{X}_i^s = \boldsymbol{w_m} + (1-\theta) \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} c \tilde{\boldsymbol{g}}_{\mathbf{1}} - (1-\theta) \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} \theta c \Delta \boldsymbol{g} \tag{1.70}$$

■

Proof of Equations (1.21) **and** (1.22). Start from $E(r)_i = \boldsymbol{X}_i' \boldsymbol{\mu}$

$$\boldsymbol{X}_i^f \boldsymbol{\mu} = [\boldsymbol{w_m} + \theta^2 \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} c \Delta \boldsymbol{g} - \theta \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} c \tilde{\boldsymbol{g}}_{\mathbf{1}}]' [\mu_m \boldsymbol{\beta_m} - \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2 c \Delta \boldsymbol{g}] \tag{1.71}$$

$$\boldsymbol{X}_i^s \boldsymbol{\mu} = [\boldsymbol{w_m} + (1-\theta) \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} c \tilde{\boldsymbol{g}}_{\mathbf{1}} - (1-\theta) \frac{1}{\gamma} \boldsymbol{\Sigma}^{-1} \theta c \Delta \boldsymbol{g}]' [\mu_m \boldsymbol{\beta_m} - \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2 c \Delta \boldsymbol{g}] \tag{1.72}$$

Multiply out

$$E(r_i^{e,f}) = \mu_m - \theta^2 \frac{1}{\gamma} c \Delta \boldsymbol{g}' \boldsymbol{\Sigma}^{-1} \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} + \theta^2 \frac{1}{\gamma} c \Delta \boldsymbol{g}' \boldsymbol{\Sigma}^{-1} \theta^2 c \Delta \boldsymbol{g} + \theta \frac{1}{\gamma} c \tilde{\boldsymbol{g}}_{\mathbf{1}}' \boldsymbol{\Sigma}^{-1} \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} - \theta \frac{1}{\gamma} c \tilde{\boldsymbol{g}}_{\mathbf{1}}' \boldsymbol{\Sigma}^{-1} \theta^2 c \Delta \boldsymbol{g} \tag{1.73}$$

$$\begin{aligned} E(r_i^{e,s}) = \mu_m - (1-\theta) \frac{1}{\gamma} c \tilde{\boldsymbol{g}}_{\mathbf{1}}' \boldsymbol{\Sigma}^{-1} \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} + (1-\theta) \frac{1}{\gamma} c \tilde{\boldsymbol{g}}_{\mathbf{1}}' \boldsymbol{\Sigma}^{-1} \theta^2 c \Delta \boldsymbol{g} + \\ (1-\theta) \frac{1}{\gamma} \theta c \Delta \boldsymbol{g}' \boldsymbol{\Sigma}^{-1} \theta c \tilde{\boldsymbol{g}}_{\mathbf{1}} - (1-\theta) \frac{1}{\gamma} \theta / \omega_i c \Delta \boldsymbol{g}' \boldsymbol{\Sigma}^{-1} \theta^2 c \Delta \boldsymbol{g} \end{aligned} \tag{1.74}$$

Gather terms and coefficients

$$E(r_i^{e,f}) = \mu_m + \theta^4 c^2 \frac{1}{\gamma} \Delta \boldsymbol{g}' \boldsymbol{\Sigma}^{-1} \Delta \boldsymbol{g} + \theta^2 c^2 \frac{1}{\gamma} \tilde{\boldsymbol{g}}_{\boldsymbol{1}}' \boldsymbol{\Sigma}^{-1} \tilde{\boldsymbol{g}}_{\boldsymbol{1}} - 2\theta^3 c^2 \frac{1}{\gamma} \tilde{\boldsymbol{g}}_{\boldsymbol{1}}' \boldsymbol{\Sigma}^{-1} \Delta \boldsymbol{g}, \tag{1.75}$$

$$E(r_i^{e,s}) = \mu_m - (1-\theta)\theta c^2 \frac{1}{\gamma} \tilde{\boldsymbol{g}}_{\boldsymbol{1}}' \boldsymbol{\Sigma}^{-1} \tilde{\boldsymbol{g}}_{\boldsymbol{1}} - (1-\theta)\theta^3 c^2 \frac{1}{\gamma} \Delta \boldsymbol{g}' \boldsymbol{\Sigma}^{-1} \Delta \boldsymbol{g} + 2(1-\theta)\theta^2 c^2 \frac{1}{\gamma} \tilde{\boldsymbol{g}}_{\boldsymbol{1}}' \boldsymbol{\Sigma}^{-1} \Delta \boldsymbol{g}. \tag{1.76}$$

■

1.B Figures

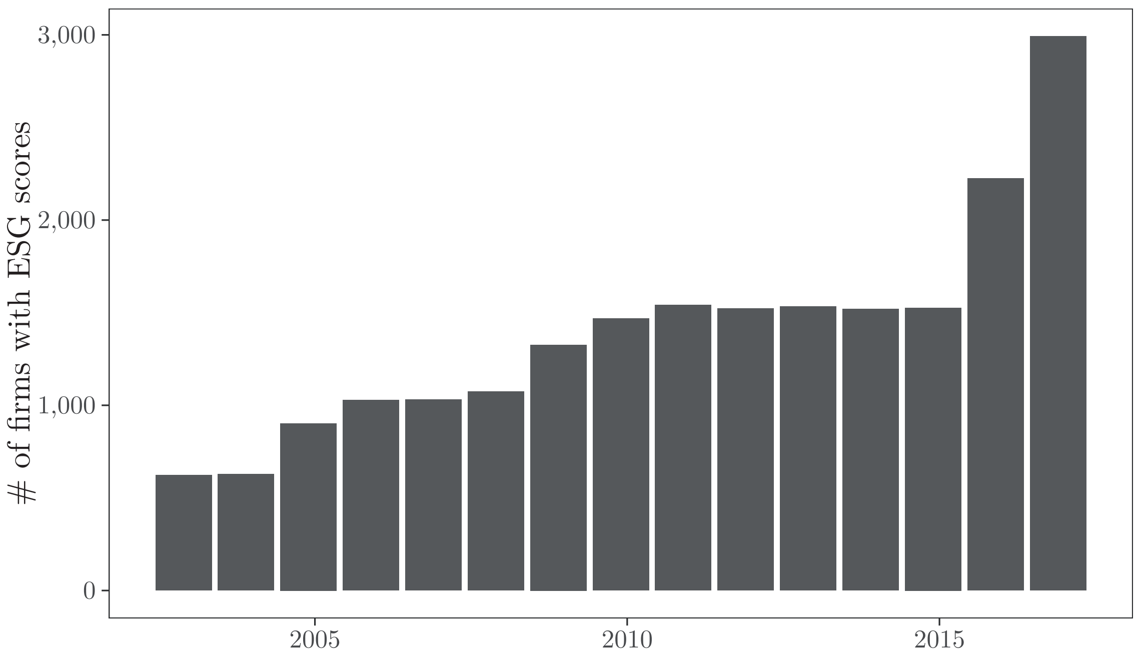


Figure 1.1: ESG data availability

This figure shows the data availability of the ASSET4 ESG score dataset for each year from 2002 to 2016.

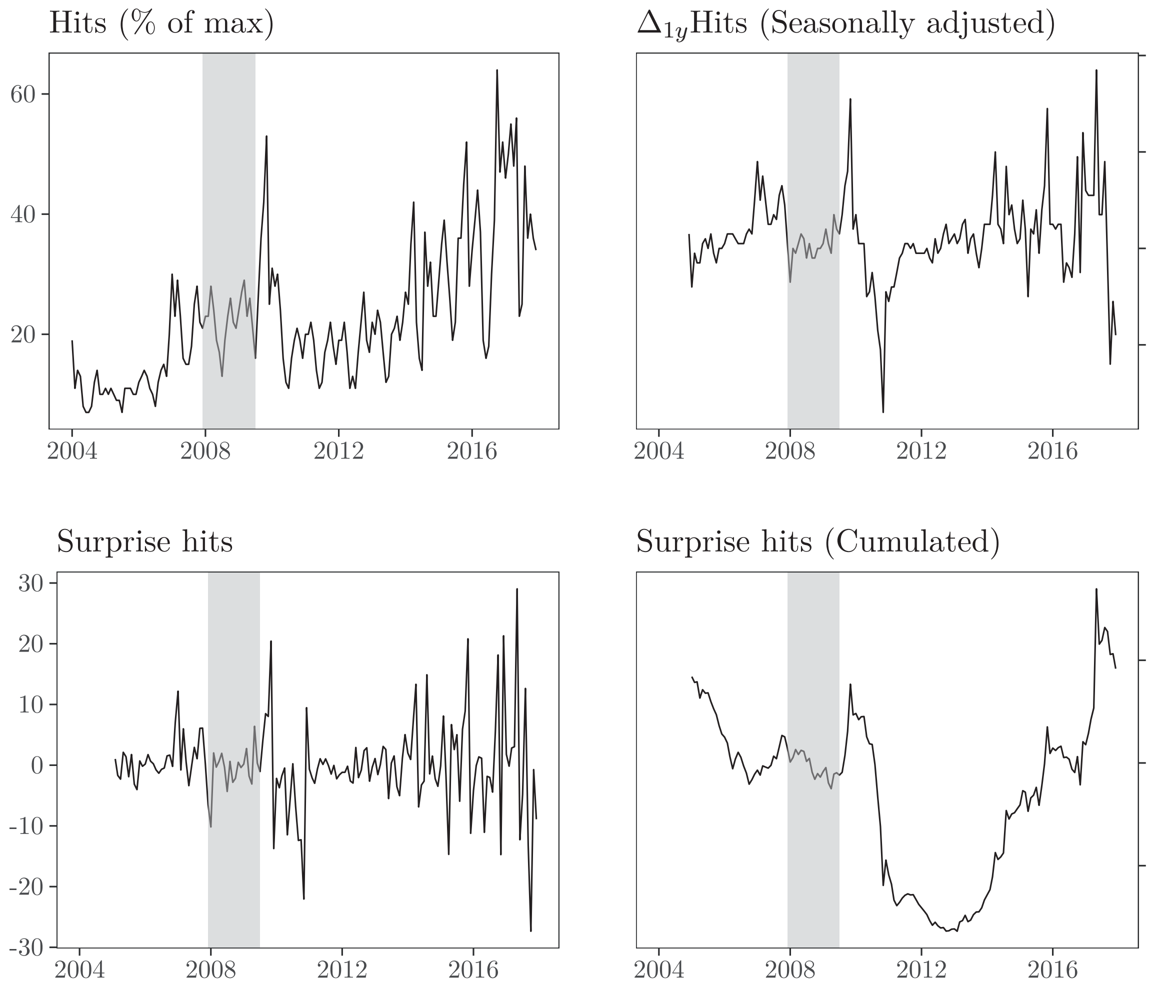
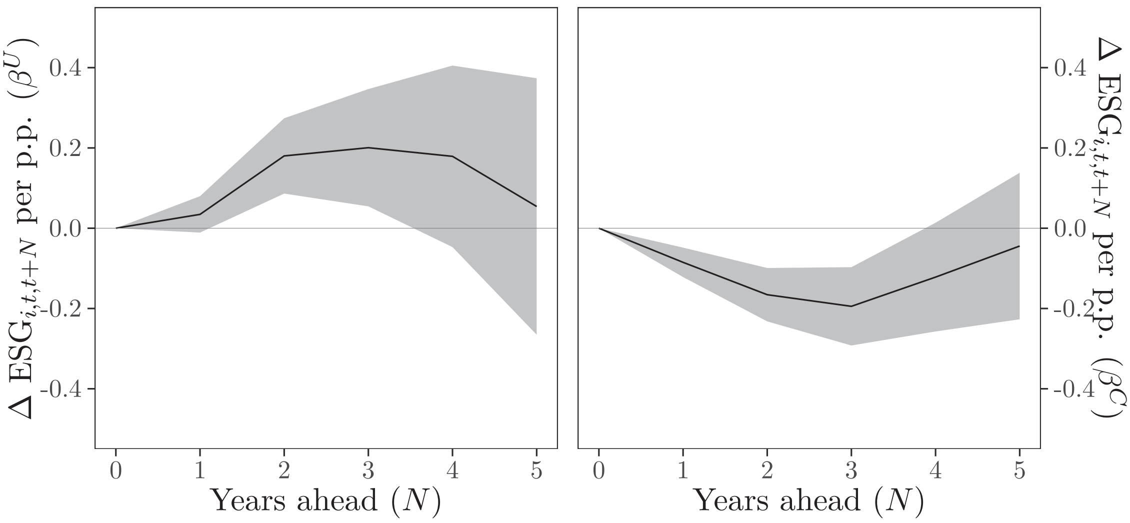


Figure 1.2: Climate sentiment

Here we show how our sentiment measure is constructed. The top left panel shows the monthly Google searches for *Climate change*. As it is clearly seasonally affected, we show the difference to the same month a year ago in the top right panel. The bottom left panel shows the innovations from fitting an AR(1) model on the seasonally adjusted hits. Bottom right shows the cumulated hit innovations. The shaded area denotes recession.



(a) Flexible Investors

(b) Strict Investors

Figure 1.3: Predicting ESG score changes

Figure 1.3a shows flexible (F) ownership in firms and their correlation to future changes in ESG scores, whereas Figure 1.3b shows this effect for strict (S) investors. Specifically, the β-estimate gives an indication for how much the ESG score changes in N years ahead of time, when investor $I = \{F, S\}$ increases ownership by one percent today. Allowing for heteroskedasticity, the gray shade shows White standard errors. Additionally, we control for industry-year effects, and cluster by time to allow for correlation in the cross-sectional error terms.

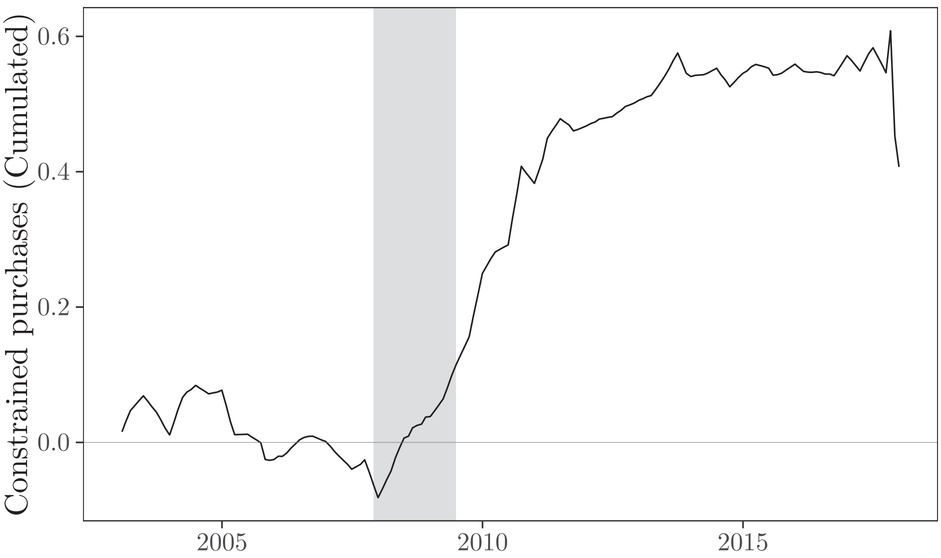


Figure 1.4: Flexible investors sell to strict investors

This figure shows the the difference in ownership shares in the high ESG ($HESG$) and high (HF) versus low (LF) flexible ownership portfolio with respect to the ownership share of strict investors (C). This means we first calculate the delta of strict ownership levels in the high ESG and high flexible ownership portfolio over time. In a second step, we subtract the delta of the strict ownership change in the high ESG and low flexible ownership portfolio over time. Thereby, a positive difference indicator at time t suggests that strict investors indeed buy high ESG and high return (see Table 1.2) stocks from flexible investors. This indicator is calculated on a quarterly basis.

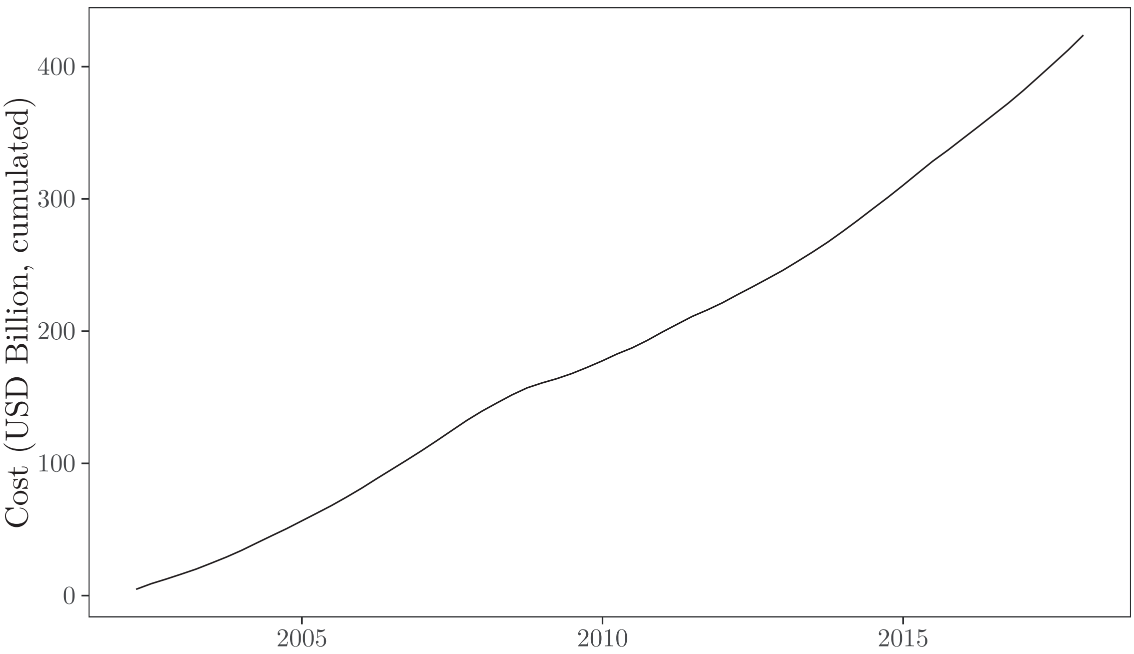


Figure 1.5: Cost to sustainable investing

This figure plots the cumulated cost to sustainable investing estimated using Equation $C = \sum_t c_t = \sum_t \Delta\alpha K^g_{t,s}$. Hence, it exploits our estimates for the difference in returns across investor types to sustainable investing together with the AUM of sustainable investing for the strict investor.

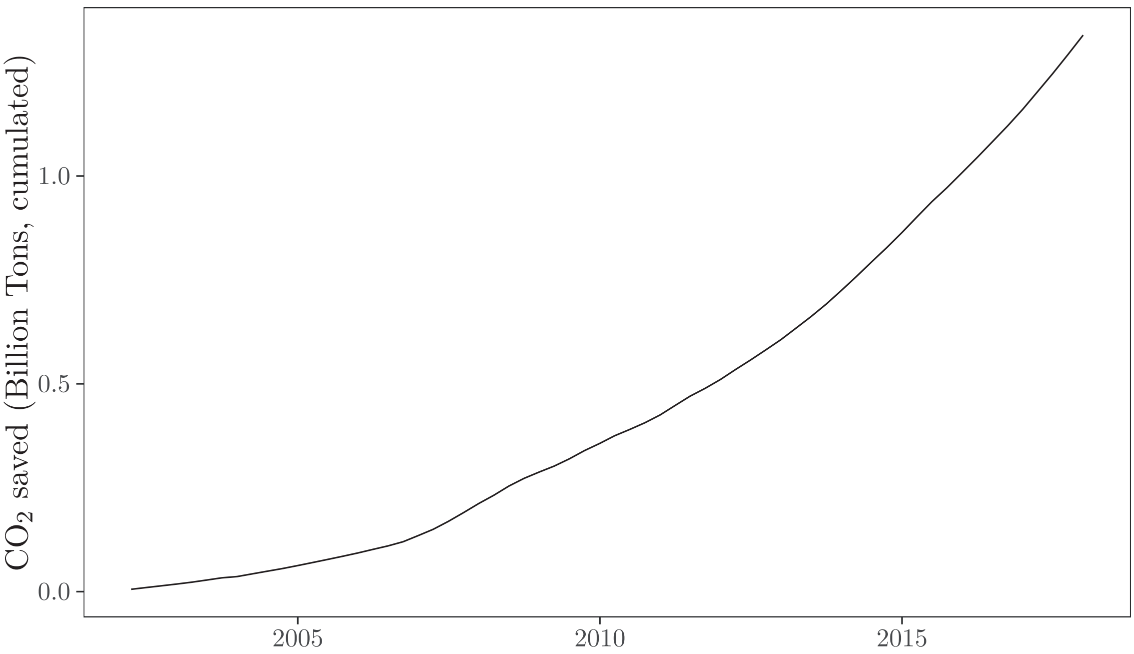


Figure 1.6: Benefit to sustainable investing

This figure plots the cumulated benefit to sustainable investing by estimating $B = \sum_t b_t = \sum_t \Delta g K^g_{t,f}$. Hence, it exploits our estimates for the increased greenness induced by the strict investors' sustainable investing demand, which the flexible investors exploit in their portfolio selection within sustainable investments.

1.C Tables

Table 1.1: Returns to sustainable investing in general

We construct value-weighted decile portfolios based on previous year ESG scores and adjust them in the beginning of each calender year. P1 (P10) depicts the low (high) ESG score portfolio. LS is a time series of returns that goes long in high ESG firms (P10) and shorts low ESG firms (P1). The returns of all ESG portfolios are risk-adjusted through the application of the CAPM, Fama-French 3-factor, and Carhart 4-factor models and we report the alphas. We further disclose monthly excess returns, volatility and Sharpe ratio estimates. $t - values$ test if the estimated returns are significantly different from zero and bold numbers signal significance at the 10% level or less. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	LS
Excess Return	**1.047**	**0.712**	**0.886**	**0.973**	**0.792**	**0.908**	**0.921**	**0.870**	**0.747**	**0.705**	**-0.343**
t-stat	2.997	2.084	2.516	2.855	2.463	2.674	2.676	2.738	2.536	2.736	2.868
CAPM	0.170	-0.171	-0.034	0.092	-0.043	0.020	0.012	0.028	-0.031	0.022	-0.148
t-stat	0.972	-1.407	-0.274	0.987	-0.313	0.196	0.132	0.355	-0.412	0.341	-0.750
3-Factor	0.161	-0.188	-0.041	0.085	-0.043	0.009	0.017	0.038	-0.018	0.029	-0.133
t-stat	0.916	-1.451	-0.277	0.887	-0.327	0.097	0.185	0.493	-0.245	0.419	-0.654
4-Factor	0.193	**-0.205**	-0.039	0.098	-0.041	0.025	0.039	0.035	-0.027	0.028	-0.166
t-stat	1.129	-1.718	-0.264	1.015	-0.324	0.271	0.426	0.454	-0.367	0.414	-0.807
Volatility	4.675	4.584	4.716	4.560	4.298	4.543	4.607	4.257	3.945	3.450	2.712
Sharpe Ratio	0.224	0.155	0.188	0.213	0.184	0.200	0.200	0.204	0.189	0.204	-0.126

Table 1.2: Returns to sustainable investing across investors

This table shows returns of portfolios with high flexible investor ownership (Panel A), strict investor ownership (Panel B), and the difference across the two (Panel C), across firms with low to high ESG scores. High flexible (strict) ownership depicts the stocks in the top quantile of flexible (strict) investor ownership. Specifically, we sort monthly returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their previous quarter's flexible and strict institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios. We rearrange portfolios every quarter, where new holding data is available. ESG data is updated every year. LS is the abnormal return from a long-short strategy which goes long in high ESG and short in low ESG firms, giving us another four portfolios each. We value-weight each portfolio, risk-adjust returns according to the CAPM, 3-Factor and Carhart 4-factor model and document the alpha and t-statistic. Finally, we show risk-adjusted returns to portfolios that go long in high flexible ownership portfolios and short in strict ownership portfolios (Panel C). Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months. Bold numbers depict statistical significance of 10% or below.

	ESG low	Q2	Q3	ESG high	LS
Panel A: Flexible					
CAPM	0.08	0.02	0.19	**0.40**	**0.32**
t-stat	0.64	0.14	1.19	3.89	2.21
3-Factor	0.06	0.01	0.17	**0.39**	**0.33**
t-stat	0.56	0.05	1.15	3.71	2.20
4-Factor	0.09	0.01	0.17	**0.39**	**0.30**
t-stat	0.77	0.04	1.20	3.78	2.03
Panel B: Strict					
CAPM	-0.02	-0.31	-0.21	0.12	0.14
t-stat	-0.11	-1.53	-1.38	1.03	0.84
3-Factor	-0.04	**-0.34**	-0.22	0.12	0.16
t-stat	-0.28	-1.77	-1.26	1.06	0.97
4-Factor	-0.05	**-0.32**	-0.19	0.13	0.18
t-stat	-0.37	-1.76	-1.14	1.11	1.09
Panel C: Difference					
CAPM Monthly	0.10	**0.33**	**0.40**	**0.28**	
CAPM Yearly	1.15	**4.01**	**4.75**	**3.36**	
t-stat	0.69	2.38	1.97	2.81	
3-Factor Monthly	0.10	**0.34**	**0.39**	**0.27**	
3-Factor Yearly	1.20	**4.11**	**4.71**	**3.27**	
t-stat	0.72	2.41	1.86	2.52	
4-Factor Monthly	0.14	**0.33**	**0.36**	**0.26**	
4-Factor Yearly	1.65	**3.94**	**4.36**	**3.15**	
t-stat	0.96	2.37	1.84	2.35	

Table 1.3: Robustness test for returns to sustainable investing for unconstrained investors using different sustainability metrics.

We sort returns according to lagged scores in a total of four portfolios based on ASSET4 (A4), Sustainalytics (S), Sustainalytics Environment (S:E) and Carbon per Revenue (CO2) scores. Data goes from 2002 until 2016 under ASSET4 and 2011 until 2016 otherwise. In the next step, we conditionally sort returns according to their previous quarter's socially unconstrained institutional ownership share and assign them into another four portfolios, ending up with a total of 16 value-weighted portfolios. In another step we construct value-weighted and risk-adjusted returns according to the Carhart four-factor model for a portfolio that goes long in high score (low score for CO2 metric) firms with high socially unconstrained ownership. We adjust standard errors according to Newey and West (1987) with a lag of 12 months and report relevant coefficients and t-values.

	Dependent variable:			
	A4	S	S:E	CO2
	(1)	(2)	(3)	(4)
α	0.392***	0.384***	0.372***	0.585***
	t = 3.784	t = 4.579	t = 3.051	t = 4.080
mkt-rf	0.987***	0.963***	0.988***	1.046***
	t = 39.925	t = 13.709	t = 13.789	t = 16.699
smb	−0.042	0.134**	0.150**	0.088
	t = −0.594	t = 2.113	t = 2.296	t = 0.763
hml	−0.091*	−0.177***	−0.271***	−0.427***
	t = −1.690	t = −2.775	t = −4.350	t = −3.057
mom	−0.001	0.023	0.029	−0.042
	t = −0.039	t = 0.357	t = 0.456	t = −0.647
Observations	180	72	72	72
R^2	0.877	0.816	0.797	0.732
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 1.4: Robustness test for sustainability premia under unconstrained ownership using different sustainability metrics

We sort returns according to lagged scores in a total of four portfolios based on ASSET4 (A4), Sustainalytics (S), Sustainalytics Environment (S:E), Sustainalytics Social (S:S), Sustainalytics Government (S:G) and Carbon per Revenue (CO2) scores. Data goes from 2002 until 2016 under ASSET4 and 2011 until 2016 otherwise. In the next step, we conditionally sort returns according to their previous quarter's socially unconstrained institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios. In a final, step we construct value-weighted and risk-adjusted returns under the Carhart four-factor model for a portfolio that goes long in high score firms and short in low score firms with high socially unconstrained ownership; in the case of CO2, we go long in low emission firms and short in high emission firms both with high socially unconstrained ownership. We adjust standard errors according to Newey and West (1987) with a lag of 12 months and report relevant coefficients and t-values.

	Dependent variable:					
	A4	S	S:E	S:S	S:G	CO2
	(1)	(2)	(3)	(4)	(5)	(6)
α	0.304**	0.226	0.393***	0.160	0.034	0.681**
	t = 2.027	t = 1.414	t = 2.811	t = 0.531	t = 0.155	t = 1.970
mkt-rf	−0.019	−0.055	−0.039	−0.016	−0.071	0.159
	t = −0.355	t = −0.871	t = −0.964	t = −0.133	t = −0.963	t = 0.867
smb	−0.502***	−0.021	−0.034	0.103	−0.139*	−0.048
	t = −4.002	t = −0.256	t = −0.452	t = 0.692	t = −1.701	t = −0.326
hml	0.119	0.255***	−0.011	0.238	0.273***	−0.552***
	t = 1.446	t = 4.023	t = −0.157	t = 1.540	t = 3.215	t = −2.916
mom	0.113**	0.144**	0.022	−0.094	0.018	0.137
	t = 2.492	t = 2.277	t = 0.265	t = −0.855	t = 0.263	t = 1.324
Observations	180	72	72	72	72	72
R^2	0.226	0.092	0.012	0.088	0.106	0.193
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 1.5: Returns to sustainable investing across investors' future holdings

This table shows returns of portfolios with high flexible (Panel A) or strict (Panel B) *future* investor ownership across firms with low to high ESG scores. Specifically, we sort monthly returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their next quarter's flexible and strict institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios. This gives us an indication for what the return on these portfolios would have been if investors would have held firms at the same level a period earlier. We rearrange portfolios every quarter, where new holdings data is available. ESG data is updated every year. LS is the abnormal return from a long-short strategy which goes long in high ESG and short in low ESG firms, giving us another four portfolios each. We value-weight each portfolio, risk-adjust returns according to the CAPM, 3-Factor and Carhart 4-factor model and document the alpha and t-statistic. Finally, we show risk-adjusted returns to portfolios that go long in high *future* flexible ownership portfolios and short in *future* strict ownership portfolios (Panel C). Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months. Bold numbers depict statistical significance of 5% or below.

	ESG low	Q2	Q3	ESG high	LS
Panel A: Flexible					
CAPM	0.14	0.003	0.13	**0.44**	**0.30**
t-stat	1.11	0.02	0.87	5.97	2.14
3-Factor	0.12	-0.01	0.12	**0.43**	**0.31**
t-stat	0.91	-0.05	0.79	5.56	1.99
4-Factor	0.13	-0.01	0.12	**0.42**	0.29
t-stat	0.98	-0.07	0.82	5.55	1.74
Panel B: Strict					
CAPM	0.01	-0.19	-0.06	**0.30**	0.29
t-stat	0.11	-0.67	-0.31	1.99	1.52
3-Factor	-0.01	-0.21	-0.06	**0.31**	0.31
t-stat	-0.06	-0.83	-0.35	2.17	1.50
4-Factor	-0.02	-0.17	-0.04	**0.33**	0.34
t-stat	-0.15	-0.76	-0.21	2.23	1.66

Table 1.6: Returns to ESG score increases in the cross-section

This table shows the results of a standard panel (column 1-2) as well as a Fama and MacBeth (1973) (column 3-4) cross-sectional regression approach including the changes in ESG scores on a yearly basis. The panel regression clusters standard errors on a firm level. The Fama and MacBeth (1973) approach first estimates $\hat{\beta}_j$ exposures for every firm and every risk factor j. In a second step, we regress excess returns against risk exposures for every time instance t, while including the exposure to changes in ESG scores. Specifically, the factor of ΔESG_t depicts the change in the ESG score of the firm that occurs in the current year relative to the last year. In a second approach we use ΔESG_{t-1} instead, documenting the change in the ESG score of the firm from two years ago to last year. We document t-test statistics below the coefficients.

	Dependent variable:			
	r^e			
	(1)	(2)	(3)	(4)
ΔESG_t	0.008***		0.008***	
	t = 3.635		t = 3.200	
ΔESG_{t-1}		0.002		0.001
		t = 0.822		t = 0.620
mkt-rf	1.046***	1.045***		
	t = 136.945	t = 136.881		
hml	0.029**	0.029**		
	t = 2.439	t = 2.439		
smb	0.328***	0.329***		
	t = 26.590	t = 26.685		
mom	−0.144***	−0.144***		
	t = −20.856	t = −20.840		
$\hat{\beta}_{mkt}$			0.425	0.425
			t = 1.074	t = 1.077
$\hat{\beta}_{smb}$			−0.241	−0.241
			t = −1.138	t = −1.138
$\hat{\beta}_{hml}$			−0.135	−0.140
			t = −0.503	t = −0.523
$\hat{\beta}_{mom}$			−0.066	−0.069
			t = −0.134	t = −0.140
γ_0			0.736***	0.758***
			t = 4.638	t = 4.924
Observations	107,310	107,310	107,308	107,308
R^2	0.235	0.235	0.390	0.390
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 1.7: Robustness test of returns to ESG score increases controlling for cash flow changes

This table shows the results of a Fama and MacBeth (1973) (column 3-4) cross-sectional regression approach including the changes in ESG scores on a yearly basis and the dividend return. The Fama and MacBeth (1973) approach first estimates $\hat{\beta}_{i,j}$ exposures for every firm i and every risk factor j. In a second step, we regress excess returns against risk exposures for every time instance t, while including the exposure to changes in ESG scores and dividends. Specifically, the factor of ΔESG depicts the change in the ESG score of the stock that occurs in the current year relative to the last year. d depicts the dividend return, and Δd is its yearly change. Column (1) documents results for the excess return r^e, and Columns (2-5) for $r^{e,exd}$ the excess return purely coming from price changes and not dividends. We document t-test statistics below the coefficients.

	Dependent variable:				
	r^e	$r^{e,exd}$			
	(1)	(2)	(3)	(4)	(5)
ΔESG	0.008***	0.009***		0.008***	0.009***
	t = 3.200	t = 3.491		t = 3.217	t = 3.544
Δd			−0.551***		−0.561***
			t = −4.148		t = −4.205
d				−0.887***	
				t = −11.722	
$\hat{\beta}_{mkt}$	0.425	0.460	0.440	0.428	0.439
	t = 1.074	t = 1.164	t = 1.110	t = 1.083	t = 1.104
$\hat{\beta}_{smb}$	−0.241	−0.195	−0.167	−0.230	−0.166
	t = −1.138	t = −0.923	t = −0.777	t = −1.090	t = −0.775
$\hat{\beta}_{hml}$	−0.135	−0.187	−0.218	−0.144	−0.212
	t = −0.503	t = −0.697	t = −0.817	t = −0.535	t = −0.791
$\hat{\beta}_{mom}$	−0.066	−0.062	−0.095	−0.058	−0.087
	t = −0.134	t = −0.126	t = −0.192	t = −0.118	t = −0.176
γ_0	0.736***	0.538***	0.565***	0.712***	0.545***
	t = 4.638	t = 3.381	t = 3.624	t = 4.578	t = 3.400
Observations	107,308	107,308	107,308	107,308	106,983
R^2	0.390	0.389	0.391	0.392	0.391
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 1.8: Sustainability sentiment from *Climate change* Google hits

In this table we test how climate sentiment explains abnormal returns on the sustainability strategy. The dependent variable for the first three columns is constructed a value-weighted long-short portfolio that goes long in top quartile of ESG firms with the top quartile of high socially unconstrained ownership and short in the low ESG but also high level of unconstrained ownership. The fourth to sixth column's dependent variable is constructed by the simple value-weighted long-short strategy that goes long in high and short in low ESG firms. We test for sentiment in these portfolios using a proxy for climate salience and economic sentiment. The measures we use is the surprise innovations in the Google Hits on the term 'Climate change', as described in Section 1.2, and the $NBER$ recession indicator, which equals 1 in a crisis and 0 otherwise. We control for risk-factors of the Carhart four-factor model, though results are similar for the CAPM and Fama-French three-factor models. Lastly, we control for autocorrelation and heteroscedasticity in the residuals using Newey and West (1987) standard errors with 12 months lag.

	Dependent variable:					
	ESG Long-short return for:					
	Unconstrained (LS_t^U)			Factor (LS_t)		
	(1)	(2)	(3)	(4)	(5)	(6)
Climate salience	0.060***	0.060***		0.039**	0.038*	
	t = 3.120	t = 2.942		t = 1.992	t = 1.948	
α	0.396***			0.156		
	t = 2.692			t = 1.127		
NBER		1.108**	1.214***		0.440	0.303
		t = 2.468	t = 3.280		t = 1.092	t = 0.680
NBER_{False}		0.282	0.305*		0.111	0.096
		t = 1.523	t = 1.668		t = 0.729	t = 0.645
Climate:NBER			0.331***			−0.190*
			t = 2.907			t = −1.836
$\text{Climate:NBER}_{False}$			0.055**			0.041**
			t = 2.416			t = 2.103
mkt - rf	−0.036	−0.009	−0.029	−0.153***	−0.142**	−0.128**
	t = −0.625	t = −0.110	t = −0.379	t = −2.792	t = −2.572	t = −2.548
smb	−0.353***	−0.380***	−0.373***	−0.472***	−0.483***	−0.491***
	t = −3.288	t = −3.077	t = −3.209	t = −6.441	t = −6.542	t = −6.712
hml	0.115	0.131	0.165*	−0.048	0.042	0.069
	t = 1.438	t = 1.458	t = 1.916	t = −0.562	t = −0.463	t = −0.794
mom	0.139***	0.157***	0.147***	0.046**	0.053	0.058*
	t = 3.636	t = 3.116	t = 2.949	t = 1.738	t = 1.573	t = 1.970
Observations	155	155	155	156	156	156
R^2	0.236	0.268	0.281	0.453	0.458	0.467
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 1.9: ESG Index Exclusions and Flexible Ownership: First stage of Instrumented Portfolios

This table shows tests the validity of our instrument of ESG index exclusions on investor holdership shares. Column (1) regresses the change to investor j's ownership of excluded stocks i keeping the value constant. Column (2) considers purely changes in share number and Column (3) looks at the change in investor value without keeping the value constant. In **Panel A**, for each column, the dependent variable is regressed on a constant and a dummy that is one when stock i is excluded from one of the ESG indices at time t interacted with Strict_j, which is a dummy that is one if investor j is a strict investor. In **Panel B**, for each column, the dependent variable is regressed on a constant and a dummy that is one when stock i is excluded from one of the ESG indices at time t interacted with both Strict_j and Flexible_j, which are dummies that are one if investor j is a strict or flexible investor respectively. The time step is in quarters. We use the exclusions from the ESG ETF's of iShares MSCI USA ESG Screened and Vanguard FTSE Social Index Fund, which are the primary funds following the ESG indices to identify the index exclusions. We show the F-statistic of our test at the bottom of the panels in bold.

Dependent Variable:	$\Delta\text{Shares}_{ijt} \times P_{i,t-1}$ (USD 1m)	$\Delta\text{Shares}_{ijt}$	ΔOwnership (USD 1m)$_{ijt}$
Panel A: Strict Ownership	(1)	(2)	(3)
Excluded_{it}:Strict_j	-11.0^{***}	$-197{,}658^{***}$	-2.78^{*}
	t = −4.8	t = −5.4	t = −2.0
Constant	8.2^{***}	$70{,}526^{***}$	−0.71
	t = 5.7	t = 3.0	t = −0.8
Observations	8,786	8,786	8,786
R^2	0.003	0.003	0.0004
F Statistic	**22.7*****	**28.8*****	**3.8***
Panel B: Strict and Flexible	(1)	(2)	(3)
Excluded_{it}:Strict_j	-12.5^{***}	$-220{,}832^{***}$	-2.84^{*}
	t = −5.2	t = −5.8	t = −1.9
Excluded_{it}:Flexible_j	-9.7^{**}	$-154{,}402^{**}$	−0.40
	t = −2.4	t = −2.4	t = −0.2
Constant	9.7^{***}	$93{,}699^{***}$	−0.65
	t = 6.2	t = 3.7	t = −0.7
Observations	8,786	8,786	8,786
R^2	0.003	0.004	0.0004
F Statistic	**14.2*****	**17.3*****	**1.9**
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 1.10: Returns to Instrumented Portfolios across Investor Types

This table shows the results on returns from our instrumented portfolios. For each test we use the change in holdings for the flexible or strict investor arising exogenously from the exclusion of stocks from the leading ESG indices. We them sort and split the stocks cross-sectionally into quartiles dependent on their instrumented ownership for each investor type. Columns (1) and (2) shows results for portfolios with the highest degree of flexible and strict ownership respectively, and Columns (3) and (4) shows results for portfolios with the lowest degree of flexible and strict ownership respectively. The first row of results show the excess returns of each of the four portfolios. The following rows show results for the CAPM alpha, Carhart alpha, and Carhart alpha controlling for changes in the ESG scores respectively. The portfolios are sorted in quartiles and always lagged three months (one quarter) with respect to the returns. The returns are monthly and in percentages. We use the exclusions from the ESG ETF's of iShares MSCI USA ESG Screened and Vanguard FTSE Social Index Fund, which are the primary funds following the ESG indices to identify the index exclusions. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

Portfolio:	Flexible High	Strict High	Flexible Low	Strict Low
	(1)	(2)	(3)	(4)
Excess Returns	-0.145^{***}	0.842^{***}	0.868^{***}	-0.007
	t = -4.0	t = 17.8	t = 19.4	t = -0.2
α (CAPM)	-0.493^{***}	0.389^{***}	0.256^{***}	-0.255^{***}
	t = -15.3	t = 11.8	t = 9.0	t = -9.1
α (Carhart)	-0.572^{***}	0.716^{***}	0.236^{***}	-0.228^{***}
	t = -16.7	t = 19.1	t = 7.3	t = -7.2
α (Carhart + ΔESG)	-1.095^{***}	1.298^{***}	0.478^{***}	-0.434^{***}
	t = -15.0	t = 17.7	t = 6.2	t = -5.6
Note:				$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 1.11: ESG Changes from Instrumented Portfolios across Investor Types

This table shows the results on changes to ESG scores from our instrumented portfolios. For each test we use the change in holdings for the flexible or strict investor arising exogenously from the exclusion of stocks from the leading ESG indices. We them sort and split the stocks cross-sectionally into quartiles dependent on their instrumented ownership for each investor type. Columns (1) and (2) shows results for portfolios with the highest degree of flexible and strict ownership respectively, and Columns (3) and (4) shows results for portfolios with the lowest degree of flexible and strict ownership respectively. The first row of results show the changes in ESG scores in the year following the portfolio holdings. The following row shows results for the year after that. The portfolios are sorted in quartiles and always lagged three months (one quarter) with respect to the returns. The ESG changes are in changes in fractions, for example 0.05 represents an improvement of 5 percentage-points. We use the exclusions from the ESG ETF's of iShares MSCI USA ESG Screened and Vanguard FTSE Social Index Fund, which are the primary funds following the ESG indices to identify the index exclusions. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

Portfolio:	Flexible High	Strict High	Flexible Low	Strict Low
	(1)	(2)	(3)	(4)
Δ ESG$_t$	0.050***	0.044***	0.025***	0.029***
	t = 12.7	t = 12.3	t = 16.2	t = 13.2
Δ ESG$_{t+1}$	0.067***	0.069***	0.034***	0.038***
	t = 46.1	t = 48.9	t = 56.2	t = 49.8
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 1.12: CO_2 change per ESG

This table shows how CO_2 intensities relate to ESG scores. To show this, we regress a firms' CO_2 intensity on its ESG score. The observations are updated on a yearly basis as ESG scores change once a year. CO_2 intensity means million tons of CO_2 per million revenues and is shown in basis points (bp). Standard errors are clustered by firm and their associated t statistics are shown below. The mean of the regressand and the standard deviation of the regressor are also displayed.

	Dependent variable:			
	CO_2 intensity (bp) (Mean is 6.5)			
	(1)	(2)	(3)	(4)
ESG	-0.10^{***}	-0.10^{***}	-0.10^{*}	-0.08^{**}
(SD is 29.71)	t = −5.02	t = −4.59	t = −1.72	t = −2.06
Constant	14.62^{***}	14.62^{***}	14.62^{***}	12.06^{***}
	t = 8.77	t = 7.77	t = 2.92	t = 3.88
Model	Pooled	Pooled	Pooled	Between
Clustering	None	Time	Firm	None
Observations	3,125	3,125	3,125	499
R^2	0.01	0.01	0.01	0.01

Note: *p<0.1; **p<0.05; ***p<0.01

1.D ESG mandates across investor types

In this appendix we consider how strict and flexible investor types conduct their investments related to ESG.

ESG commitments

We follow Hong and Kacperczyk (2009) in the way we split investors. They argue that there is a clear societal norm against ethically low stocks, and hence that many may not want to support companies by investing in their stocks. Anecdotal evidence of this is the adoption of socially responsible investing (SRI) for managers of institutions such as pension funds and endowments. Since their paper, the signatories of the UN's principles of responsible investing (PRI) has had an enormous growth, growing from USD 20 trillion in 2009 to 120 trillion in 2021, and the principles has evolved to focus on incorporating ESG principles in the signatories investments.[27]

In Table 1.13 we display the largest strict and flexible investors and their ESG commitments as according to whether they have signed the UN's PRI. We can see that seven out of the nine strict investors have signed the principles of rosponsible investing. The two that have not are State Farm automotive insurers and Teachers advisors, two highly social companies that are likely to experience social pressures. For the flexible investors, the signing rate drops to four out of six, and one of the signatories, Vanguard, mainly provides index funds with no sustainable investment mandates. In addition to having fewer signatories, flexible investors also tend to sign later than the strict, a difference of two years, showing that flexible investors experience less pressure to follow sustainable investment conventions.

Strictness

To get an understanding of how strict investors implement their preferences, we first plot different portfolios of high and low degrees of strict and flexible ownerships with high and low ESG firms in Figure 1.7. This gives us an idea about the heterogeneity of ESG preferences within the two investor types. The idea is that if stock exclusion is prevalent for an investor type, you will see a large ownership difference between the stocks mostly held by the investor type and the stocks held the least by that investor type. As an

[27] See the UN PRI's Signatory relationship presentation of 2021 Q4 `https://www.unpri.org/download?ac=14962`

Table 1.13: Investor types' ESG commitments

This table displays strict and flexible investors. Within each type, the three largest investors of each subtype are shown. For these investors it is shown whether they have signed UN's principles of responsible investing (PRI), and, if they have, since when.

Type	Subtype	Name	AUM (USD B)	PRI signatory	Since
strict	1	STATE STR	1202	✓	3 May 2012
strict	1	NORTHERN TRUST	386	✓	17 Nov 2009
strict	1	BANK OF AMERICA	367	✓	21 Nov 2014
strict	2	PRINCIPAL FINANCIAL	103	✓	8 Dec 2010
strict	2	STATE FARM AUTO INS	78	✗	-
strict	2	TEACHERS ADVR	75	✗	-
strict	5	BLACKROCK	2061	✓	7 Oct 2008
strict	5	JPMORGAN CHASE	426	✓	15 Feb 2007
strict	5	WELLINGTON	420	✓	26 Apr 2012
flexible	3	COLLEGE RETIRE EQTY	146	✗	-
flexible	3	ALLIANZ	49	✓	23 Apr 2007
flexible	3	GARTMORE MUT FUND	26	✗	-
flexible	4	VANGUARD GROUP	2207	✓	6 Nov 2014
flexible	4	FIDELITY	752	✓	23 Feb 2017
flexible	4	T. ROWE PRICE	586	✓	28 Jul 2010

example if the investor type on average held the market, but 50% exclude stock A due to ESG concerns, you would see the ownership difference being 50% of the market ownership share. On the other hand if they do not exclude any stocks, the ownership difference would be 0%. This allows us to measure the 'strictness' of our investor types.

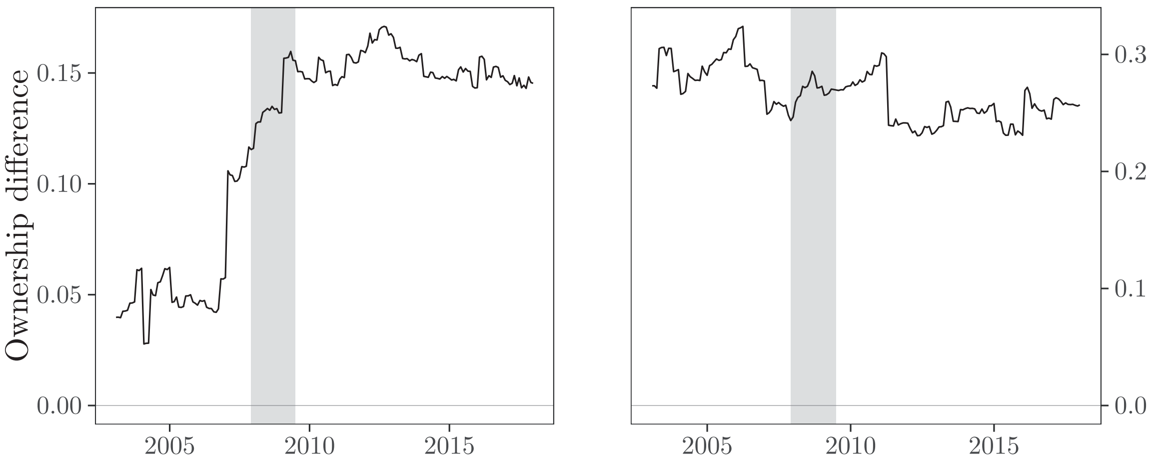
Figure 1.7 shows our strictness measure for the strict and flexible investors over time. The results show that our strict investor type is 6 times as strict in the beginning of the same dropping to twice as strict later in the sample. We the big change for the flexible investor occurring during the financial crisis. Please note that the recession is plotted in grey, but the financial crisis started earlier.

Revealed ESG preferences

We further consider correlations between ESG scores and ownership, now looking how different investor types allocate their capital across firms with different ESG scores. We calculate the absolute value of holdings ($V^I_{i,t}$) in firm i at time t according to

$$V^I_{i,t} = S_{i,t} \times O^I_{i,t} \times P_{i,t} \ , \tag{1.77}$$

where I is the ownership type flexible or strict ($I = F, S$). $S_{i,t}$, $O^I_{i,t}$ and $P_{i,t}$ are the total number of shares, relative degree of ownership of owner I and the price of firm i at



(a) Flexible **(b)** Strict

Figure 1.7: Investor types' strictness

We plot the difference in institutional ownership among high ESG firms with either low or high ownership concentration. We use the quartile with most ownership and subtract the quartile with the least. The results are value weighted. We plot in Panel (a) results for flexible investors. Flexible investors are either investment companies (Type 3) or independent investment advisors (Type 5). Panel (b) shows ownership concentration of strict investors in ESG firms is shown. Strict investors are either banks (Type 1), insurance companies (Type 2) or other institutions (Type 5). The shaded area denotes recession.

time t.

We use the data to test correlations between holding decisions and ESG scores according to the linear panel regressions of

$$V_{i,t}^{I} = ESG_{i,t-1} + F_i + \epsilon_{i,t} \tag{1.78}$$

where $ESG_{i,t}$ is the ESG score of firm i at time t, F_i is the firm fixed effects, and $\epsilon_{i,t}$ is the error term. Table 1.14 shows the results.

Table 1.14 shows that both strict and flexible investors increase their asset allocation with an increase in ESG scores. An increase in the ESG score by one point by one firm leads to an increase in capital allocated of roughly between 41 to 60 Thousand USD per investor type. We notice that strict have a stronger preference for ESG, as they are about 50% more sensitive to the ESG score of firms. So through a revealed preference argument, we see that both investors care about ESG. However, strict investors seem to assert a higher preference to ESG than flexible.

Table 1.14: Revealed preferences: ESG score portfolio tilts

We run regression (1.78) for strict (S) and flexible (F) owners. We control for firm fixed effects. The variable V^I, $I = \{S, F\}$, depicts the absolute invested capital. The ESG score is from the previous firm year of a given firm, i.e. the published score. The observations are updated on a yearly basis as ESG scores change once a year. Standard errors are clustered by firm and shown in parentheses below.

	Dependent Variable:		
	V^S	V^F	$V^S - V^F$
ESG Score	59,839***	41,160***	18,679***
	(7,541)	(3,959)	(5,750)
Firm Fixed Effects	Y	Y	Y
Clustered Errors	Y	Y	Y
Note:			*p<0.1; **p<0.05; ***p<0.01

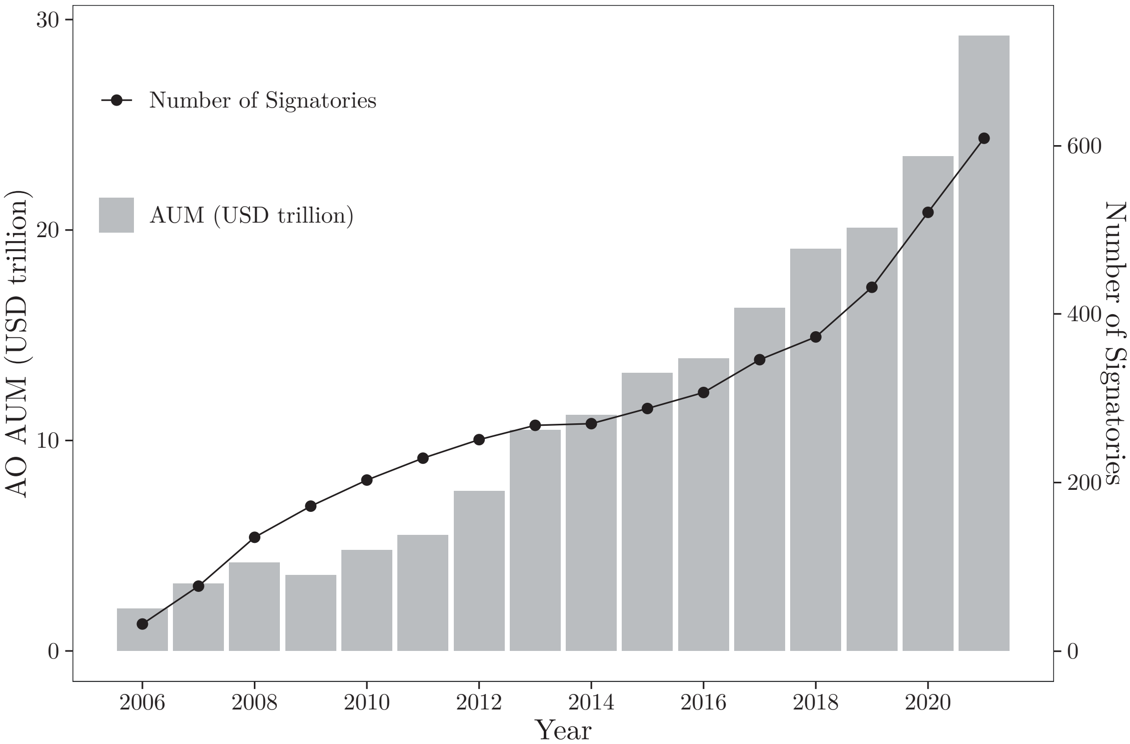


Figure 1.8: ESG assets and UN PRI signatories

This figure shows the number of UN PRI signatories and the sum of their assets under management (AUM). AO AUM only includes the AUM of asset owners and AUM also includes assets for other signatories. Total AUM includes reported AUM and AUM of new signatories provided in sign-up sheet that signed up by end of March of that year. Source: UN PRI `https://www.unpri.org`

Internet Appendix for:
Skills and Sentiment in Sustainable Investing*

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Abstract

This Internet Appendix shows robustness checks and additional results outside of the main analysis of the paper. Specifically, we show more results on ESG ownership and preferences, robustness tests for our ESG premium under both flexible and strict investor ownership as well as additional findings with respect to sentiment considerations in the dynamics of returns. Finally, we show additional portfolio sorts for other variables of interest.

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1.IA Robustness Results

In this section we show robustness results.

Table 1.I1: Returns to sustainable investing across investors and decile portfolios

This table shows returns of portfolios with high flexible investor ownership (Panel A), strict investor ownership (Panel B), and the difference across the two (Panel C), across firms with low to high ESG scores. High flexible (strict) ownership is the stocks in top quartile of flexible (strict) investor ownership. Specifically, we sort monthly returns according to lagged ESG scores in a total of ten portfolios. In the next step, we conditionally sort returns according to their previous quarter's flexible and strict institutional ownership share and assign them into another four portfolios, ending up with a total of 40 portfolios for each investor. We rearrange portfolios every quarter, where new holdings data is available. ESG data is updated every year. LS is the abnormal return from a long-short strategy which goes long in high ESG and short in low ESG firms, giving us another four portfolios each. We value-weight each portfolio, risk-adjust returns according to the CAPM, 3-Factor and Carhart 4-factor model and document the alpha and t-statistic. Finally, we show risk-adjusted returns to portfolios that go long in high flexible ownership portfolios and short in strict ownership portfolios (Panel C). Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months. Bold numbers depict statistical significance significance of 5% or below.

	ESG low	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	ESG high	LS
Panel A: Flexible											
CAPM	-0.13	**0.50**	-0.06	-0.17	0.26	0.17	0.18	**0.40**	**0.42**	**0.44**	**0.57**
t-stat	-0.61	2.10	-0.27	-0.56	1.15	0.70	0.91	2.17	2.57	2.66	2.23
3-Factor	-0.15	**0.49**	-0.09	-0.16	0.24	0.16	0.17	**0.40**	**0.41**	**0.43**	**0.58**
t-stat	-0.79	2.18	-0.50	-0.54	1.05	0.67	1.00	2.06	2.52	2.58	2.18
4-Factor	-0.12	**0.53**	-0.09	-0.15	0.22	0.16	0.16	**0.41**	**0.41**	**0.43**	**0.55**
t.stat.2	-0.61	2.28	-0.50	-0.49	0.94	0.68	1.02	2.09	2.53	2.67	2.11
Panel B: Strict											
CAPM	-0.12	0.16	-0.23	**-0.71**	-0.19	-0.21	**-0.35**	0.23	0.27	0.18	0.30
t-stat	-0.43	0.89	-1.48	-2.14	-1.10	-1.15	-2.30	1.31	1.86	1.09	0.88
3-Factor	-0.15	0.15	-0.25	**-0.73**	-0.21	-0.22	**-0.36**	0.24	0.26	0.18	0.33
t-stat	-0.58	0.88	-1.81	-2.16	-1.49	-1.12	-2.06	1.39	1.91	1.11	1.00
4-Factor	-0.14	0.12	-0.25	**-0.68**	-0.22	-0.19	-0.35	0.29	0.25	0.19	0.33
t-stat	-0.57	0.78	-1.76	-2.11	-1.56	-1.03	-1.93	1.63	1.80	1.13	1.02
Panel B: Difference											
CAPM Monthly	-0.01	0.34	0.17	**0.54**	0.45	0.38	**0.53**	0.18	0.15	**0.26**	
CAPM Yearly	-0.09	4.08	2.07	**6.46**	5.40	4.51	**6.33**	2.12	1.84	**3.14**	
t-stat	-0.03	1.46	0.83	2.39	1.66	1.34	2.37	0.63	1.08	2.16	
3-Factor Monthly	-0.002	0.34	0.16	**0.56**	0.45	0.38	**0.53**	0.16	0.15	**0.25**	
3-Factor Yearly	-0.02	4.07	1.96	**6.76**	5.44	4.54	**6.35**	1.95	1.75	**3.02**	
t-stat	-0.01	1.38	0.84	2.51	1.69	1.26	2.26	0.58	0.99	2.02	
4-Factor Monthly	0.02	0.40	0.16	**0.53**	0.44	0.35	**0.51**	0.13	0.16	0.25	
4-Factor Yearly	0.28	4.83	1.93	**6.42**	5.31	4.25	**6.15**	1.51	1.93	2.95	
t-stat	0.10	1.63	0.82	2.51	1.66	1.23	2.21	0.45	1.07	1.87	

Table 1.I2: Double sort of ESG and ownership of socially unconstrained investors

We first sort returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their previous quarter's socially unconstrained institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios. LS is the abnormal return from a long-short strategy which goes long in high ESG firms and short in low ESG firms. We value-weight these 16 portfolios with the previous month's market values. Finally, we run regressions according to the CAPM and Carhart models and display alphas as well as relevant t-test statistics. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months. Bold numbers represent statistical significance at a level of 5% or below.

	ESG low	Q2	Q3	ESG high	LS
Panel A: CAPM					
Unconstrained ownership low	0	-0.086	-0.052	0.161	0.161
t-stat	-0.002	-0.75	-0.318	1.335	0.704
Q2	0.059	0.049	-0.159	0.012	-0.047
t-stat	0.48	0.39	-1.089	0.138	-0.258
Q3	0.02	0	0.011	0.004	-0.016
t-stat	0.126	0.001	0.086	0.032	-0.09
Unconstrained ownership high	0.079	0.02	0.186	**0.4**	**0.321**
t-stat	0.645	0.141	1.187	3.889	2.211
Panel B: Carhart					
Unconstrained ownership low	0.021	-0.064	-0.03	0.169	0.148
t-stat	0.123	-0.54	-0.177	1.278	0.565
Q2	0.046	0.065	-0.151	0.019	-0.027
t-stat	0.347	0.506	-1.067	0.21	-0.13
Q3	-0.033	-0.017	0.024	0.007	0.041
t-stat	-0.228	-0.121	0.191	0.057	0.217
Unconstrained ownership high	0.088	0.005	0.173	**0.392**	**0.304**
t-stat	0.773	0.041	1.202	3.784	2.027

Table 1.I3: Robustness test of ESG premia for different degrees of socially unconstrained ownership across different models and ownership

We first sort returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their previous quarter's socially unconstrained institutional ownership share and assign them into another four portfolios, ending up with a total of 16 value-weighted portfolios. We construct long-short portfolios that go long in high ESG firms ($HESG$) and short in low ESG firms ($LESG$) on either a high (H) or a low (L) level of socially unconstrained ownership level in $D = \{H, L\}$. We risk-adjust our long-short portfolio returns with the CAPM, 3-Factor as well as the Carhart four-factor model. We adjust standard errors according to Newey and West (1987) with a lag of 12 months and report relevant coefficients and t-values.

	Dependent variable:					
	ESG Long-short return for high or low degree of ownership, LS_t^D, $D = \{H, L\}$:					
	LS_t^H			LS_t^L		
	(1)	(2)	(3)	(4)	(5)	(6)
α	0.321**	0.331**	0.304**	0.161	0.169	0.148
	t = 2.211	t = 2.199	t = 2.027	t = 0.704	t = 0.672	t = 0.565
mkt-rf	−0.169***	−0.055	−0.019	−0.212***	−0.148	−0.120
	t = −3.985	t = −1.295	t = −0.355	t = −2.673	t = −1.456	t = −1.126
smb		−0.491***	−0.502***		−0.295***	−0.304***
		t = −3.763	t = −4.002		t = −3.271	t = −3.207
hml		0.054	0.119		0.060	0.112
		t = 0.667	t = 1.446		t = 0.590	t = 1.161
mom			0.113**			0.091
			t = 2.492			t = 1.274
Observations	180	180	180	180	180	180
R^2	0.058	0.200	0.226	0.087	0.135	0.151
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 1.I4: Robustness test for risk-adjusted returns under unconstrained ownership and sustainability using different models

We sort returns according to lagged scores in a total of four portfolios based on ASSET4 (A4), Sustainalytics (S), Sustainalytics Environment (S:E) and Carbon per Revenue (CO2) scores. Data goes from 2002 until 2016 under ASSET4 and 2011 until 2016 otherwise. In the next step, we conditionally sort returns according to their previous quarter's socially unconstrained institutional ownership share and assign them into another four portfolios, ending up with a total of 16 value-weighted portfolios. In another step, we construct value-weighted and risk-adjusted returns according to the CAPM, Fama-French three-factor, and Carhart four-factor model for a portfolio that goes long in high score (low score for CO2 metric) firms with high socially unconstrained ownership. We adjust standard errors according to Newey and West (1987) with a lag of 12 months and report relevant coefficients and t-values.

	Dependent variable:											
	A4			S			S:E			CO2		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
α	0.400***	0.392***	0.392***	0.352***	0.399***	0.384***	0.337**	0.392***	0.372***	0.513**	0.556***	0.585***
	t = 3.889	t = 3.705	t = 3.784	t = 3.124	t = 4.154	t = 4.579	t = 2.266	t = 3.116	t = 3.051	t = 2.556	t = 3.335	t = 4.080
mkt_rf	0.961***	0.987***	0.987***	0.977***	0.955***	0.963***	1.000***	0.978***	0.988***	1.068***	1.061***	1.046***
	t = 48.180	t = 35.163	t = 39.925	t = 17.886	t = 14.574	t = 13.709	t = 20.391	t = 15.559	t = 13.789	t = 18.443	t = 17.203	t = 16.699
smb		−0.042	−0.042		0.134**	0.134**		0.149**	0.150**		0.090	0.088
		t = −0.594	t = −0.594		t = 2.077	t = 2.113		t = 2.233	t = 2.296		t = 0.796	t = 0.763
hml		−0.090*	−0.091*		−0.191***	−0.177***		−0.289***	−0.271***		−0.401***	−0.427***
		t = −1.704	t = −1.690		t = −3.147	t = −2.775		t = −4.363	t = −4.350		t = −2.602	t = −3.057
mom			−0.001			0.023			0.029			−0.042
			t = −0.039			t = 0.357			t = 0.456			t = −0.647
Observations	180	180	180	72	72	72	72	72	72	72	72	72
R^2	0.874	0.877	0.877	0.795	0.815	0.816	0.759	0.796	0.797	0.679	0.731	0.732

Note: *p<0.1; **p<0.05; ***p<0.01

Table 1.I5: Robustness with Bushee Investor Classifications

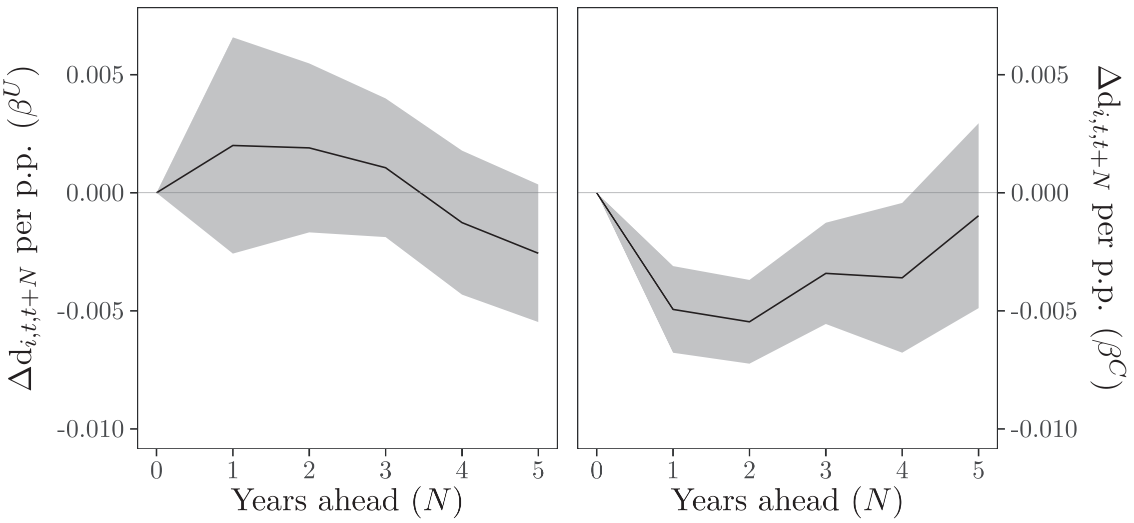
This table shows abnormal returns of portfolios with high flexible investor ownership (Panel A), high independent investment advisor ownership (Panel B), strict investor ownership (Panel C), across firms with low to high ESG scores. In each panel there are used two investor classification methods: First, the original used by Thomson Financial Network (TFN), which is available through the WRDS website. Second, the classification done by Brian Bushee, which is available on his website and used in, for example, Bushee (2001). High flexible (strict) ownership depicts the stocks in the top quantile of flexible (strict) investor ownership. We use the Carhart four-factor model to control for risk. Specifically, we sort monthly returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their previous quarter's flexible and strict institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios. We rearrange portfolios every quarter, where new holding data is available. ESG data is updated every year. LS is the abnormal return from a long-short strategy which goes long in high ESG and short in low ESG firms, giving us another four portfolios each. We value-weight each portfolio and document the alpha and t-statistic. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months. Bold numbers depict statistical significance of 5% or below.

	ESG low	Q2	Q3	ESG high
Panel A: Flexible				
Thomson Financial Network	0.09	0.01	0.17	**0.39**
t-stat	0.77	0.04	1.20	3.78
Bushee	0.09	-0.09	-0.30	**0.28**
t-stat	0.65	-0.49	-1.81	2.67
Panel B: Independent Investment Advisors				
Thomson Financial Network	0.13	-0.01	0.14	**0.34**
t-stat	1.15	-0.10	0.89	3.77
Bushee	0.21	-0.01	-0.09	**0.39**
t-stat	1.63	-0.07	-0.51	3.18
Panel C: Strict				
Thomson Financial Network	-0.05	-0.32	-0.19	0.13
t-stat	-0.37	-1.76	-1.14	1.11
Bushee	0.029	-0.12	0.06	0.11
t-stat	0.25	-0.82	0.63	0.95

Table 1.I6: Robustness of returns from ESG score increases controlling for cash flow changes using total returns

This table shows the robustness results of a Fama and MacBeth (1973) (column 3-4) cross-sectional regression approach including the changes in ESG scores on a yearly basis and the dividend return for total excess returns r^e. The Fama and MacBeth (1973) approach first estimates $\hat{\beta}_{i,j}$ exposures for every firm i and every risk factor j. In a second step, we regress excess returns against risk exposures for every time instance t, while including the exposure to changes in ESG scores and dividends. Specifically, the factor of ΔESG depicts the change in the ESG score of the stock that occurs in the current year relative to the last year. d depicts the dividend return, and Δd is its yearly change. We document t-test statistics below the coefficients.

	Dependent variable:			
	r^e			
	(1)	(2)	(3)	(4)
ΔESG	0.008***		0.008***	0.008***
	t = 3.200		t = 3.217	t = 3.300
Δd		−0.046		−0.057
		t = −0.352		t = −0.430
d			0.113	
			t = 1.499	
$\hat{\beta}_{mkt}$	0.425	0.408	0.428	0.407
	t = 1.074	t = 1.028	t = 1.083	t = 1.023
$\hat{\beta}_{smb}$	−0.241	−0.220	−0.230	−0.219
	t = −1.138	t = −1.026	t = −1.090	t = −1.023
$\hat{\beta}_{hml}$	−0.135	−0.160	−0.144	−0.153
	t = −0.503	t = −0.596	t = −0.535	t = −0.572
$\hat{\beta}_{mom}$	−0.066	−0.090	−0.058	−0.082
	t = −0.134	t = −0.183	t = −0.118	t = −0.166
γ_0	0.736***	0.750***	0.712***	0.732***
	t = 4.638	t = 4.826	t = 4.578	t = 4.581
Observations	107,308	106,983	107,308	106,983
R^2	0.390	0.390	0.391	0.391
Note:			*p<0.1; **p<0.05; ***p<0.01	



(a) Flexible Investors

(b) Strict Investors

Figure 1.I1: Robustness test of predicting dividend changes

Figure 1.I1a shows flexible (F) ownership in firms and their correlation to future changes in dividends, whereas Figure 1.I1b shows this effect for strict (S) investors. Specifically, the β-estimate gives an indication for how much the dividend yield (in %) changes in N years ahead of time, when investor $I = \{F, S\}$ increases ownership by one percent today. Allowing for heteroskedasticity, the gray shade shows White standard errors. We control for firm fixed effects, and cluster by time to allow for correlation in the cross-sectional error terms.

Table 1.I7: Sentiment and strict mandate investors sustainable investments

In this table we test how climate sentiment explains abnormal returns on the sustainability strategy by strict investors. The dependent variable is constructed by a value-weighted long-short portfolio that goes long in the top quartile of ESG firms with the top quartile of high strict ownership and short in the low ESG but also high level of strict ownership. We test for sentiment in this portfolio using a proxy for climate salience. The measures we use is the surprise innovations in the Google Hits on the term 'Climate change', as described in Section 1.2. We control for risk-factors through the CAPM, Fama-French three-factor and Carhart four-factor model. Lastly, we control for autocorrelation and heteroscedasticity in the residuals using Newey and West (1987) standard errors with 12 months lag.

	Dependent variable:		
	LS_t^S		
	(1)	(2)	(3)
Climate saliance	0.029	0.012	0.014
	t = 1.071	t = 0.451	t = 0.540
mkt-rf	-0.160^{***}	-0.127^{**}	-0.162^{***}
	t = −3.440	t = −2.506	t = −3.151
smb		-0.270^{***}	-0.264^{***}
		t = −3.042	t = −3.036
hml		0.190^{**}	0.116
		t = 2.503	t = 1.458
mom			-0.121^{***}
			t = −2.695
Constant	0.147	0.153	0.183
	t = 0.769	t = 0.829	t = 1.007
Observations	155	155	155
R^2	0.076	0.149	0.189
Note:			*p<0.1; **p<0.05; ***p<0.01

1.IB Alternative Research Design

In this appendix we show additional results of our main thesis, that there is a difference in returns to sustainable investing across investor types, derived using a fund-level based analysis. Specifically, we consider fund-level panel regressions utilizing the investor types' portfolio weights of different stocks. This allows us to control for fund, stock, and time fixed effects in a more exhaustive manner.

There are three groups of results. The first group documents whether the stock picks by strict mandate investors within sustainable stocks have performed worse than flexible investors' picks. The second pillar of results shows whether the flexible investors' stock picks have experienced ESG score improvements relative to strict mandate investors' picks. The third set of results revolves around whether strict mandate investors purchase more high ESG stocks than flexible investors and hence exerts a demand effect.

In all three groups of results the independent variable ”portfolio_share_lag” documents the portfolio share of either a strict or flexible investor at the end of the earlier period. The variable ”esg_lag” is the ESG score of the stock at the end of the earlier period. ”strict” is a dummy variable that is 1 if the investor is a strict mandate investor and 0 if not. Hence the effect will be relative to the average result of flexible and strict investors. Sometimes a variable is split into its quantiles or deciles.

The difference in returns to sustainable investing is estimated in Table 1.I8. Model 1 shows that the return for strict investors' high esg stocks are 3.89% lower compared to flexible investors and low esg stocks for a portfolio weight of 100%. This is controlling for the fact that strict investors in general achieve 1.29% higher returns from their general investments under a 100% portfolio weight. The estimate in this specification also controls for the stocks' correlation to the equity risk premium mkt_rf as well as an an unexplained average return of 30bp. Model 2 extends the risk model to include Fama-French's 3-factor model, which makes the cost of strict mandate investing rise slightly to 4.14%. Using the Carhart 4-factor model in Model 3 lowers it then slightly to 4.02%. Model 4 controls for year fixed effects and replaces the risk premia, which results in a more flexible and hence conservative specification than Models 1 to 3. Here, the estimate slightly drops to 3.72%. Under the even more flexible year-month fixed effects, it goes to 3.28%. As the average portfolio weight of strict investors in the top quantile of ESG is 4.4% (the unconditional average is 3.1%) this equates to a cost to strict mandate investing of between 14-18 bp. This is reassuring as this depicts the same size compared to our original approach in

Section 1.6, where we estimate the magnitude of the effect to be 14 bp.

Table 1.I9 shows robustness of the main results using different fixed effects. Model 1 shows the result from including a fund type fixed effect where we see the effect slightly increasing in magnitude suggesting that the difference in returns to sustainable investing is not due to strict investor in general doing worse. Model 2 additionally includes stock fixed effects after which the result remains about the same suggesting that the effect is neither due strict investors generally owning specific stocks that always have lower returns. Model 3 adds manager fixed effects for which we see that it reduces the effect by about a forth suggesting that some of the difference comes from managers general investing mandates, however the majority is still from how specifically their sustainable investing turns out. Model 4 adds year-quarter time fixed effects effects for which the effect does not change so it is not due to differences in general timing either. Model 5 includes all four fixed effects at the same time giving about the same result as Model 3.

Table 1.I10 replaces the general risk factor controls with betas estimated at the stock level. Model 1 shows the effects for the market model, Model 2 for the Fama-French 3-factor model, and Model 3 for the Carhat 4-factor model. All three models show that the effect remains highly significant dropping less than 10% compared to the main specification (Model 1 in Table 1.I8).

Table 1.I11 shows robustness results of the costs to strict mandate investing. Model 1 is the same as in Table 1.I8 and shown as reference. Model 2 replaces the control for strict investors general performance with a form that has an equally sized effect no matter how large their portfolio weight is in the stock instead of the performance being relative to the portfolio weight. Here, the relevant estimate drops to about half. However, this seems to root in misspecification as the more flexible Model 3 includes both effects and the coefficient then drops to 3.75%. Model 4 allows for different skill dependent on the investors' sub-type, again increasing the flexibility of the model. Similarly to Model 5, Model 2 has a fixed effect per type and sees the same drop. As before, when including both effects in a more flexible manner in Model 6, the effect is back at 3.78%. Though not shown, the results are the same with betas instead of risk premia. To sum up, this table suggests the effect to be robust and consistent at a bit below 4% for a correctly specified model.

Table 1.I12 shows the same results but split by ESG quantiles or deciles, respectively, where a higher quantile or decile represents a higher score. Model 2 shows that the effect is concentrated in the top ESG quantile suggesting the investors may be following a best-in-

class investment rule. Additionally, Model 3 has more granularity and shows that indeed the effect arises from the 9th decile meaning the stocks that are close to the top but not quite there yet. Hence, strict investors lose out on return by investing in firms that are close to the top in their class, but only later continue to increase to the top decile.

Table 1.I13 shows the results split by investor sub type. The effect concentrates in types 1, 4, and 5, which are banks, independent advisors and other (which includes endowments and pension funds). Types 2 and 3, that is insurances, mutual funds and hedge funds, seem to be performing best.

Table 1.I14 shows how ESG scores of flexible investors' high ESG investments change over the following year relative to low ESG investments and strict mandate investors for a 100% portfolio weight investment. Model 1 shows that these investments tend to increase in their ESG score by 21 (out of 100). In the model, we control for how non-esg investments performs for the flexible investor and find this to be negative in general. Model 1 also controls for stocks' ESG scores as stocks in general tend to mean revert in their score. Additionally, we employ time-quarter fixed effects. For the mean portfolio size of 4.4%, this equates to an effect of an ESG score improvement of 9 points per year on average. Taking the effects into account that ESG scores tend to decrease in general as does flexible investor ownership, this equates to an improvement of around 2 points for stocks near the top of possible ESG scores. Models 2 and 3 show this is consistent for different or no time fixed effects. Model 4 shows that the effect concentrates in the top quantile of ESG stocks. Hence, we confirm our finding that flexible investors are able to find stocks which increase in their ESG score following the flexible investment. The size of the effect is also close to the 17 points found in section 1.5.1.

Table 1.I15 shows the purchases of stocks dependent on their ESG scores across investor types. Model 1 shows that when looking exclusively at strict mandate investors, their portfolio weights increase more for higher ESG stocks than for lower ESG stocks, hence they on average have been a net buyer of high ESG stocks. Contrary to this, Model 2 shows that the flexible investors have been selling, although not on statistically significant level. Models 3 to 6 show this to be consistent when using different types of time fixed effects. In terms of magnitude, the increase in portfolio weights for high ESG stocks have been 12 bp per year per stock. This means that for a 80 stock portfolio, the portfolio weights of high ESG stocks have increased by 10 percentage points per year for the strict investor.

Figure 1.I2 shows the coefficient of the underperformance in ESG investing for strict

Table 1.I8: Table shows the heterogenous returns to sustainable investing across investor types

The dependent variable is excess returns in percentages per month of stock i. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, and *esg_lag* is the ESG score of stock i at the end of the previous period. Risk factors are included as controls. Standard errors are robust standard errors. T-statistics are shown in square brackets.

	Model 1	Model 2	Model 3	Model 4	Model 5
portfolio_share_lag · esg_lag · strict	**-3.89*****	**-4.14*****	**-4.02*****	**-3.72*****	**-3.28*****
	[−4.94]	[−5.25]	[−5.10]	[−4.44]	[−4.16]
portfolio_share_lag · strict	1.29**	1.39**	1.32**	1.27*	1.07*
	[2.11]	[2.26]	[2.15]	[1.95]	[1.75]
esg_lag	−0.34***	−0.32***	−0.33***	−0.36***	−0.39***
	[−12.11]	[−11.38]	[−11.47]	[−11.63]	[−13.66]
mkt_rf	0.97***	0.99***	0.97***		
	[585.83]	[506.85]	[468.77]		
smb		−0.12***	−0.09***		
		[−48.65]	[−35.49]		
hml		0.11***	0.08***		
		[37.72]	[29.69]		
mom			−0.04***		
			[−23.72]		
(Intercept)	0.30***	0.38***	0.39***	2.01***	0.50***
	[12.54]	[15.70]	[16.47]	[61.80]	[39.57]
Year Fixed Effects	NA	NA	NA	Year	Year-Quarter
Num.Obs.	1 573 168	1 573 168	1 573 168	1 573 168	1 573 168
R2	0.277	0.279	0.280	0.120	0.283

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

mandate investors interacted with a year dummy to get the effect in each year. We also control for the general effect of strict mandate investing and ESG scores as well as the Carhart model. We see that the effect has been negative most years, the strongest time being before the financial crisis and from 2011 to 2014. Strict investors lost less money during the financial crisis.

Table 1.I9: Table shows robustness tests of the heterogenous returns to sustainable investing across investor types when including further fixed effects.

The dependent variable is excess returns in percentages per month of stock i. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, and *esg_lag* is the ESG score of stock i at the end of the previous period. The fixed effects are calculated for a specific group by subtracting the unconditional average of each unit in that group conditioning only on the unit. Standard errors are robust standard errors. T-statistics are shown in square brackets.

	Model 1	Model 2	Model 3	Model 4	Model 5
portfolio_share_lag · esg_lag · strict	**-4.57*****	**-4.49*****	**-3.31*****	**-4.57*****	**-3.22*****
	[−5.28]	[−5.34]	[−3.83]	[−5.29]	[−3.81]
portfolio_share_lag · strict	2.21***	2.10***	2.02***	2.21***	1.90***
	[3.32]	[3.24]	[3.03]	[3.32]	[2.91]
strict	0.02*	0.12***	0.02	0.02	0.11***
	[1.70]	[8.89]	[1.11]	[1.57]	[8.18]
esg_lag	−0.37***	0.07**	−0.09***	−0.37***	0.35***
	[−11.60]	[2.11]	[−2.79]	[−11.62]	[11.10]
(Intercept)	0.87***	−0.07***	−0.05*	0.86***	−1.01***
	[30.90]	[−2.62]	[−1.77]	[30.58]	[−36.37]
Fixed Effects	None	Stock	Manager	Year-Q	Stock, Manager, Year-Q
Number of Observations	1 573 168	1 573 168	1 573 168	1 573 168	1 573 168
R2 (of variation after fixed effects)	0.00	0.00	0.00	0.00	0.00

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.I10: Table shows robustness results of the heterogeneous returns to sustainable investing across investor types when controlling for stock betas.

The dependent variable is excess returns in percentages per month of stock i. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, and *esg_lag* is the ESG score of stock i at the end of the previous period. The betas are calculated for each stock i with respect to the respective factor. Standard errors are robust standard errors. T-statistics are shown in square brackets.

	Model 1	Model 2	Model 3
portfolio_share_lag · esg_lag · strict	**-3.56*****	**-3.63*****	**-3.54*****
	[−4.28]	[−4.37]	[−4.28]
portfolio_share_lag · strict	2.16***	2.18***	2.11***
	[3.35]	[3.39]	[3.30]
esg_lag	0.11***	0.00	0.00
	[3.51]	[−0.08]	[0.09]
beta_mkt	0.13***	0.22***	0.16***
	[7.47]	[9.88]	[4.54]
beta_smb		−0.14***	−0.13***
		[−8.68]	[−6.93]
beta_hml		0.02	−0.01
		[1.61]	[−0.81]
beta_mom			−0.14***
			[−2.66]
(Intercept)	−0.16***	−0.08***	−0.10***
	[−4.77]	[−2.63]	[−3.02]
Stock fixed effect (Alpha)	✓	✓	✓
Number of Observations	1 573 168	1 573 168	1 573 168
R2 (of variation after fixed effects)	0.00	0.00	0.00

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.I11: Table shows robustness of the heterogenous returns to sustainable investing across investor types.
The dependent variable is excess returns in percentages per month of stock i. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, *esg_lag* is the ESG score of stock i at the end of the previous period, and *as.factor(typecode)1-5* are dummy variables which are 1 when the investors typecode is 1,2,3,4 or 5 respectively. Risk factors are included as controls. Standard errors are robust standard errors. T-statistics are shown in square brackets.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
portfolio_share_lag · esg_lag · strict	**-4.02*****	**-2.00*****	**-3.75*****	**-4.07*****	**-2.06*****	**-3.78*****
	[−5.10]	[−7.69]	[−4.74]	[−5.13]	[−7.91]	[−4.75]
portfolio_share_lag · strict	1.32**		1.36**			
	[2.15]		[2.22]			
strict		−0.04***	−0.04***			
		[−3.11]	[−3.26]			
portfolio_share_lag · as.factor(typecode)1				−1.36*		0.54
				[−1.80]		[0.65]
portfolio_share_lag · as.factor(typecode)2				0.94		1.67
				[0.67]		[1.04]
portfolio_share_lag · as.factor(typecode)3				−1.81		2.52
				[−0.64]		[0.66]
portfolio_share_lag · as.factor(typecode)4				0.05		−0.62
				[0.16]		[−1.53]
portfolio_share_lag · as.factor(typecode)5				1.52**		1.38**
				[2.45]		[2.21]
as.factor(typecode)2					0.05	0.02
					[0.82]	[0.31]
as.factor(typecode)3					−0.04	−0.12
					[−0.41]	[−0.90]
as.factor(typecode)4					0.18***	0.18***
					[8.53]	[6.42]
as.factor(typecode)5					0.16***	0.14***
					[7.90]	[5.21]
esg_lag	−0.33***	−0.38***	−0.33***	−0.32***	−0.36***	−0.32***
	[−11.47]	[−16.04]	[−11.67]	[−11.20]	[−15.56]	[−11.30]
mkt_rf	0.97***	0.97***	0.97***	0.97***	0.97***	0.97***
	[468.77]	[468.76]	[468.76]	[468.77]	[468.77]	[468.77]
smb	−0.09***	−0.09***	−0.09***	−0.09***	−0.09***	−0.09***
	[−35.49]	[−35.45]	[−35.45]	[−35.49]	[−35.45]	[−35.45]
hml	0.08***	0.08***	0.08***	0.08***	0.08***	0.08***
	[29.69]	[29.78]	[29.82]	[29.72]	[29.88]	[29.92]
mom	−0.04***	−0.04***	−0.04***	−0.04***	−0.04***	−0.04***
	[−23.72]	[−23.67]	[−23.64]	[−23.69]	[−23.63]	[−23.60]
(Intercept)	0.39***	0.45***	0.42***	0.39***	0.27***	0.25***
	[16.47]	[21.27]	[16.81]	[16.10]	[9.80]	[7.69]
Num.Obs.	1 573 168	1 573 168	1 573 168	1 573 168	1 573 168	1 573 168
R2	0.280	0.280	0.280	0.280	0.280	0.280

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.I12: Table shows the heterogenous returns to sustainable investing across investor types and ESG quantiles.
The dependent variable is excess returns in percentages per month. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, *esg_lag* is the ESG score of stock i at the end of the previous period, and *esg_lag_quartile2-4* are dummy variables which are 1 when stock i's ESG score falls in the 2, 3, or 4th quantile respectively in that period. Hence esg_lag_quartile 1 is absorbed by the intercept. The variables *esg_lag_decile2-10* is the same but for deciles and instead of quantiles. Risk factors are included as controls. Standard errors are robust standard errors. T-statistics are shown in square brackets.

	Model 1	Model 2	Model 3
portfolio_share_lag·esg_lag·strict	**-4.02*****		
	[−5.10]		
portfolio_share_lag·strict	1.32**	−0.03	0.09
	[2.15]	[−0.04]	[0.07]
portfolio_share_lag·esg_lag_quartile4·strict		**-2.57*****	
		[−3.59]	
portfolio_share_lag·esg_lag_quartile3·strict		−0.47	
		[−0.60]	
portfolio_share_lag·esg_lag_quartile2·strict		−0.22	
		[−0.27]	
portfolio_share_lag·esg_lag_decile10·strict			−1.25
			[−0.95]
portfolio_share_lag·esg_lag_decile9·strict			**-5.08*****
			[−3.74]
portfolio_share_lag·esg_lag_decile8·strict			−1.67
			[−1.22]
portfolio_share_lag·esg_lag_decile7·strict			−1.45
			[−1.01]
portfolio_share_lag·esg_lag_decile6·strict			0.37
			[0.26]
portfolio_share_lag·esg_lag_decile5·strict			−0.14
			[−0.10]
portfolio_share_lag·esg_lag_decile4·strict			−1.58
			[−1.06]
portfolio_share_lag·esg_lag_decile3·strict			0.41
			[0.27]
portfolio_share_lag·esg_lag_decile2·strict			0.10
			[0.06]
esg_lag	−0.33***		
	[−11.47]		
esg_lag_quartile4		−0.28***	
		[−9.68]	
esg_lag_quartile3		−0.36***	
		[−11.90]	
esg_lag_quartile2		−0.21***	
		[−6.12]	
esg_lag_decile10			−0.28***
			[−5.17]
esg_lag_decile9			−0.35***
			[−6.54]
esg_lag_decile8			−0.39***
			[−7.06]
esg_lag_decile7			−0.27***
			[−4.88]
esg_lag_decile6			−0.56***
			[−9.99]
esg_lag_decile5			−0.40***
			[−6.65]
esg_lag_decile4			−0.10
			[−1.60]
esg_lag_decile3			−0.13**
			[−2.02]
esg_lag_decile2			−0.01
			[−0.20]
mkt_rf	0.97***	0.97***	0.97***
	[468.77]	[469.18]	[468.83]
smb	−0.09***	−0.09***	−0.09***
	[−35.49]	[−35.44]	[−35.56]
hml	0.08***	0.08***	0.08***
	[29.69]	[29.44]	[29.42]
mom	−0.04***	−0.05***	−0.05***
	[−23.72]	[−23.83]	[−23.86]
(Intercept)	0.39***	0.41***	0.45***
	[16.47]	[14.74]	[8.54]
Num.Obs.	1 573 168	1 573 168	1 573 168
R2	0.280	0.280	0.280

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 1.I13: Table shows the heterogenous returns to sustainable investing across investor subtypes.
The dependent variable is excess returns in percentages per month. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, *esg_lag* is the ESG score of stock i at the end of the previous period, and *as.factor(typecode)1-5* are dummy variables which are 1 when the investors typecode is 1,2,3,4 or 5 respectively. Risk factors are included as controls. Standard errors are robust standard errors. T-statistics are shown in square brackets.

	Model 1	Model 2	Model 3
portfolio_share_lag · esg_lag · as.factor(typecode)1	−3.52*	−1.30	2.10
	[−1.81]	[−1.28]	[0.98]
portfolio_share_lag · esg_lag · as.factor(typecode)2	6.09	−1.09	5.97
	[0.72]	[−0.73]	[0.71]
portfolio_share_lag · esg_lag · as.factor(typecode)3	−1.18	3.48	1.28
	[−0.11]	[0.89]	[0.12]
portfolio_share_lag · esg_lag · as.factor(typecode)4	**-4.40*****	**-1.91*****	**-5.17*****
	[−3.51]	[−4.16]	[−4.10]
portfolio_share_lag · esg_lag · as.factor(typecode)5	**-4.74*****	**-2.16*****	**-4.72*****
	[−5.62]	[−7.92]	[−5.59]
portfolio_share_lag · as.factor(typecode)1	−1.82		−2.65*
	[−1.25]		[−1.83]
portfolio_share_lag · as.factor(typecode)2	−7.34		−6.22
	[−0.99]		[−0.82]
portfolio_share_lag · as.factor(typecode)3	−1.07		1.73
	[−0.12]		[0.19]
portfolio_share_lag · as.factor(typecode)4	2.96***		2.63***
	[2.96]		[2.60]
portfolio_share_lag · as.factor(typecode)5	1.90***		1.96***
	[2.91]		[3.00]
as.factor(typecode)2		0.04	0.06
		[0.55]	[0.80]
as.factor(typecode)3		−0.09	−0.09
		[−0.70]	[−0.64]
as.factor(typecode)4		0.23***	0.24***
		[7.77]	[7.78]
as.factor(typecode)5		0.17***	0.18***
		[6.06]	[6.20]
esg_lag	−0.28***	−0.35***	−0.27***
	[−8.79]	[−14.90]	[−8.68]
mkt_rf	0.97***	0.97***	0.97***
	[468.79]	[468.77]	[468.79]
smb	−0.09***	−0.09***	−0.09***
	[−35.49]	[−35.44]	[−35.44]
hml	0.08***	0.08***	0.08***
	[29.69]	[29.88]	[29.93]
mom	−0.04***	−0.04***	−0.04***
	[−23.72]	[−23.64]	[−23.62]
(Intercept)	0.36***	0.24***	0.17***
	[13.84]	[7.27]	[4.69]
Num.Obs.	1 573 168	1 573 168	1 573 168
R2	0.280	0.280	0.280

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.I14: Table shows the one year evolution of ESG scores of sustainable stocks across investor subtypes.

The dependent variable is changes in ESG scores in fraction per year. The variable *strict* is a dummy variable that is 1 for strict mandate investors and 0 otherwise, *portfolio_share_lag* is how much stock i makes up of investor j's total investments in stocks at the end of the previous period, *esg_lag* is the ESG score of stock i at the end of the previous period, and *as.factor(typecode)1-5* are dummy variables which are 1 when the investors typecode is 1,2,3,4 or 5 respectively. Risk factors are included as controls. Standard errors are robust standard errors. T-statistics are shown in square brackets. Year-Q is year-quarter.

	Model 1	Model 3	Model 4	Model 5
portfolio_share_lag · esg_lag · flexible	**0.21*****	**0.21*****	**0.24*****	
	[19.90]	[19.94]	[21.42]	
portfolio_share_lag · esg_lag_quartile4 · flexible				**0.12*****
				[13.30]
portfolio_share_lag · esg_lag_quartile3 · flexible				**0.09*****
				[7.70]
portfolio_share_lag · esg_lag_quartile2 · flexible				0.03*
				[1.82]
portfolio_share_lag · flexible	−0.16***	−0.16***	−0.19***	−0.10***
	[−17.45]	[−17.46]	[−18.70]	[−10.87]
esg_lag	−0.15***	−0.15***	−0.15***	
	[−392.40]	[−392.57]	[−386.13]	
esg_lag_quartile4				−0.10***
				[−276.15]
esg_lag_quartile3				−0.06***
				[−149.97]
esg_lag_quartile2				−0.01***
				[−10.51]
(Intercept)	0.14***	0.10***	0.14***	0.12***
	[1284.22]	[155.84]	[392.45]	[1718.30]
Time Fixed Effects	Year-Q	Year	None	Year-Q
Num.Obs.	1 715 463	1 715 463	1 715 463	1 715 463
R2	0.191	0.191	0.135	0.188

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.I15: Table shows the purchases of stocks dependent on their ESG scores across investor types.

The dependent variable is changes in portfolio weight in the following quarter. Models 1, 3, and 5 show results just for Strict investor types and Models 2, 4, and 6 just for Flexible types. Standard errors are robust standard errors. T-statistics are shown in square brackets. Year-Q is year-quarter.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Investor Type	Strict	Flexible	Strict	Flexible	Strict	Flexible
esg_lag	**0.0012*****	−0.0001	**0.0012*****	−0.0001	**0.0010*****	−0.0002
	[11.7331]	[−0.8914]	[11.5951]	[−0.8979]	[9.8652]	[−1.1785]
(Intercept)	−0.0028	−0.0021	−0.0039***	−0.0032***	−0.0037***	−0.0024***
	[−0.9994]	[−0.4021]	[−39.9747]	[−9.8343]	[−43.5434]	[−20.7108]
Time Fixed Effects	Year-Q	Year-Q	Year	Year	None	None
Num.Obs.	1 279 019	496 650	1 279 019	496 650	1 279 019	496 650
R2	0.002	0.003	0.002	0.002	0.000	0.000

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

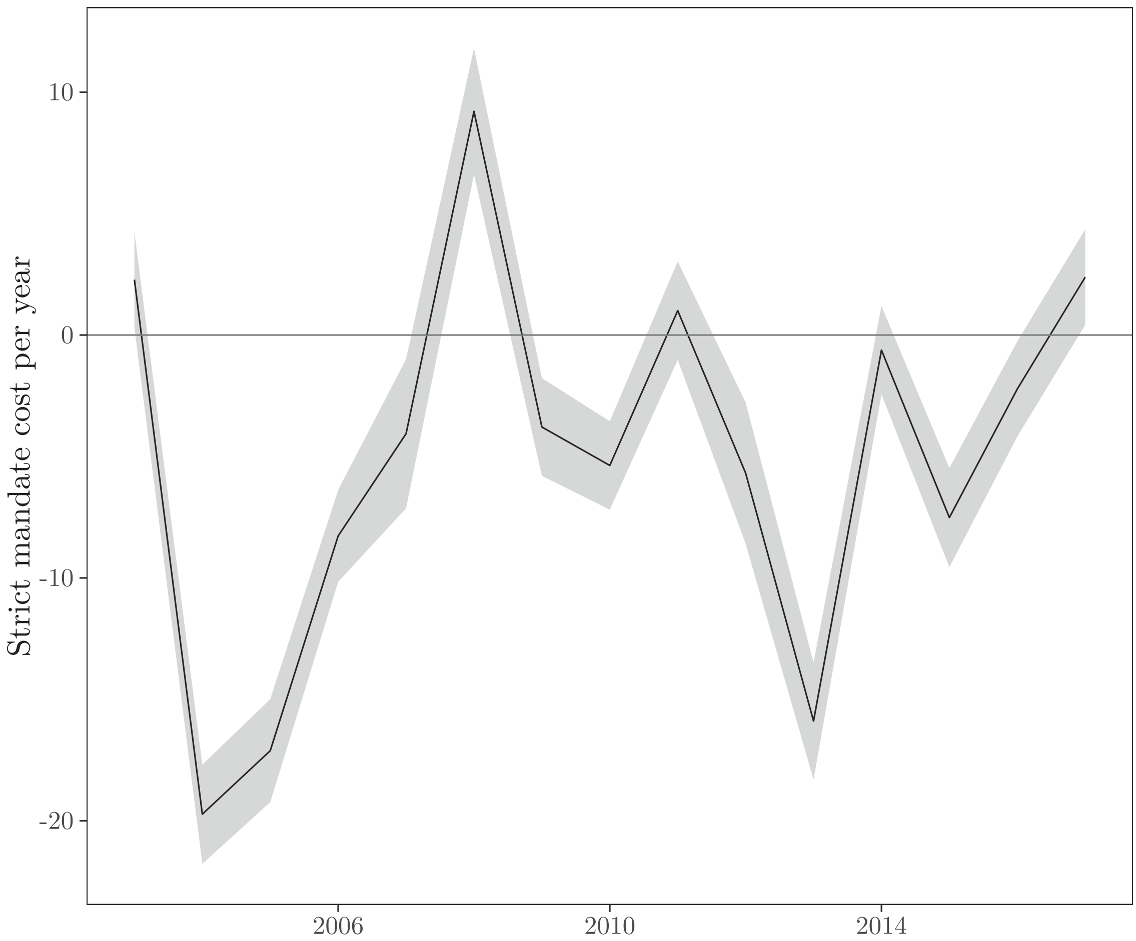


Figure 1.I2: Strict mandate cost per year

This figure shows the coefficient on the underperformance in ESG investing for strict mandate investors interacted with a year dummy to get the effect in each year. There is also controlled for the general effect of strict mandate investing and esg scores as well as the Carhart model. The grey area depicts the 95% confidence interval using robust standard errors.

Table 1.I16: ESG data availability

The table covers the descriptive statistics of the ESG data set used in the analysis. The minimum, quartiles, maximum and standard deviation (equally-weighted) are computed over all companies exhibiting an ESG score for a given year.

Year	# of firms	Min	1. Quartile	Median	Mean	3. Quartile	Max	Std
2002	624	3.260	20.688	41.265	48.168	78.302	98.720	30.722
2003	629	3.800	20.570	42.950	48.663	78.390	98.680	30.364
2004	903	3.740	29.555	54.180	55.151	82.865	98.380	28.482
2005	1,029	4.660	31.590	55.590	57.137	85.860	98.490	28.661
2006	1,030	4.250	31.675	55.045	56.947	85.222	98.250	28.373
2007	1,075	3.880	31.140	57.640	57.548	86.170	97.300	28.326
2008	1,327	3.570	26.680	53.320	54.599	85.345	97.500	29.536
2009	1,469	2.960	27.290	51.920	54.572	85.110	97.460	29.660
2010	1,541	3.580	29.810	55.250	56.883	86.900	97.100	28.884
2011	1,522	3.920	28.395	58.545	57.055	86.980	96.600	29.353
2012	1,534	2.970	27.055	56.760	55.713	86.490	96.800	29.745
2013	1,521	2.970	29.210	57.800	57.057	87.150	96.950	29.386
2014	1,527	3.000	31.575	59.910	57.757	86.515	97.110	28.938
2015	2,225	4.320	14.940	45.590	48.525	82.740	96.590	32.527
2016	2,992	4.830	15.360	28.050	43.897	79.983	96.430	32.300

1.IC ESG Scores

In this appendix we show describe our data on ESG scores in more detail. Figure 1.I3 shows the distribution of ESG scores across the firms and years in our sample. Additionally Table 1.I17 gives the distribution across industries, as well as the mean ESG, volatility of the ESG score and mean returns of those industries. Finally, Table 1.I18 displays the names of the companies that have the most observations, as they are part of every year.

Figure 1.I3 plots ESG scores over all scores available and across companies' yearly averages. Interestingly, many scores locate in the upper and lower score distribution, which might suggest that a company would rather exhibit a low score than not having one at all despite the fact that a low score implies low sustainability.

We also distinguish between different types of industries according to SIC Codes. Table 1.I17 exhibits the results. The manufacturing industry represents the largest share of the sample with a total of 972 firms and a total of 65,476 observations. It also has the largest average score of above 59. Other well-represented industries are transportation, communications, electric gas and sanitary services, finance, insurance, and real estate as well as services. All subsequent findings are hence primarily driven by these industries rather than others. ESG scores vary heavily within most industries with volatilities of up to 30 points.

Table 1.I17: ESG industry composition

We exhibit the total number of observations, number of firms, average ESG scores, ESG score volatility and equally-weighted average returns according to different types of industries.

	#observations	#firms	% of all firms	$\overline{ESG}$	σ_{ESG}	$\overline{r}$
Agriculture, Forestry and Fishing	202	8	0.269	26.123	13.771	1.292
Mining	8,162	136	4.571	47.260	26.544	1.090
Construction	2,445	38	1.277	37.639	23.993	1.309
Manufacturing	65,476	972	32.672	58.595	30.005	1.395
Transportation, Communications, Electric Gas and Sanitary service	20,296	288	9.681	53.195	29.804	1.069
Wholesale Trade	5,035	115	3.866	46.647	27.095	1.204
Retail Trade	12,210	180	6.050	53.691	28.545	1.308
Finance, Insurance and Real Estate	28,161	482	16.202	40.477	26.485	1.176
Services	23,724	453	15.227	40.670	26.473	1.423
PublicAdministration	24	1	0.034	14.745	0.312	0.941
Nonclassifiable	7,646	302	10.151	18.252	12.385	1.752

Out of 63 firms that were part of the highest decile ESG scores in 2002, a significant number of 33 were also part of this portfolio in the end of the sample, suggesting that ESG scores are sticky in the top decile, see Table 1.I18. Interestingly, also firms that one would think are not part of that group, as for example British American Tobacco PLC or Occidental Petroleum Corporation, are members of the high profile ESG group. This suggests that not the objective of the firm matters but instead how well the criteria to obtain a high score are fulfilled. Though this procedure seems rather arbitrary, it proves to allow every firm to obtain a high score regardless of their business model.

1.ID The ESG Factor

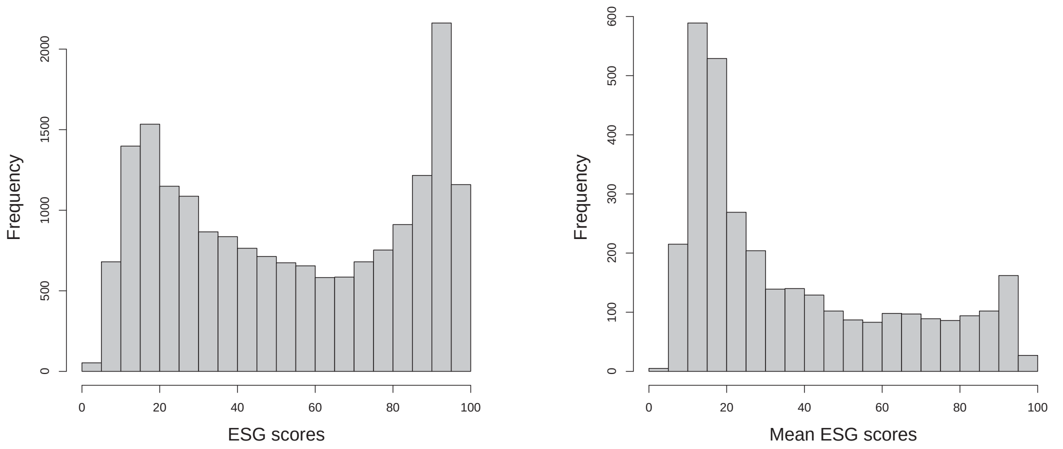
This appendix displays summary statistics for our ESG sorted returns. First, Figure 1.I4 shows the average return for each portfolio. Both for a equally-weighted and value-weighted approach, and we see that the results are relatively similar. Both display no clear relationship between ESG scores and return.

Figure 1.I5 displays the returns of the ESG factor over time. We can see that has had negative returns on average, but that it is fully explained through its negative exposure to risk factors as seen in the previous table. Additionally, we note the interesting fact that as the sentiment measure has a persistent effect, that is a significant AR(1) coefficient, as observed in Figure 1.2 in Section 1.2, this helps explain why cumulative returns on the

Table 1.I18: High profile ESG companies

The table exhibits companies of the highest decile ESG portfolio that were part of this prtfolio in both 2002 and 2016 (beginning and end of the sample). In total, we see 33 companies to be part of this group. The according CUSIP codes can be used to access the companies' information through CRSP.

#	Name	CUSIP
1	A B B LTD	00037520
2	ABBOTT LABORATORIES	00282410
3	BANCO BILBAO VIZCAYA ARGENTARIA	05946K10
4	BANCO SANTANDER CENTRAL HISP SA	05964H10
5	BAXTER INTERNATIONAL INC	07181310
6	B H P LTD	08860610
7	BOEING CO	09702310
8	BRISTOL MYERS SQUIBB CO	11012210
9	BRITISH AMERICAN TOBACCO PLC	11044810
10	CHEVRON CORP	16676410
11	CISCO SYSTEMS INC	17275R10
12	DOW CHEMICAL CO	26054310
13	DU PONT E I DE NEMOURS & CO	26353410
14	DUKE ENERGY CORP	26441C20
15	EASTMAN CHEMICAL CO	27743210
16	ENBRIDGE INC	29250N10
17	GLAXOSMITHKLINE PLC	37733W10
18	HEWLETT PACKARD CO	40434L10
19	IMPERIAL OIL LTD	45303840
20	I N G GROEP N V	45683710
21	INTEL CORP	45814010
22	INTERNATIONAL BUSINESS MACHS COR	45920010
23	JOHNSON & JOHNSON	47816010
24	KONINKLIJKE PHILIPS ELEC N V	50047230
25	MERCK & CO INC	58933Y10
26	MOTOROLA INC	62007630
27	NOKIA CORP	65490220
28	OCCIDENTAL PETROLEUM CORP	67459910
29	PROCTER & GAMBLE CO	74271810
30	STMICROELECTRONICS NV	86101210
31	TEXAS INSTRUMENTS INC	88250810
32	MINNESOTA MINING & MFG CO	88579Y10
33	UNITED PARCEL SERVICE INC	91131210



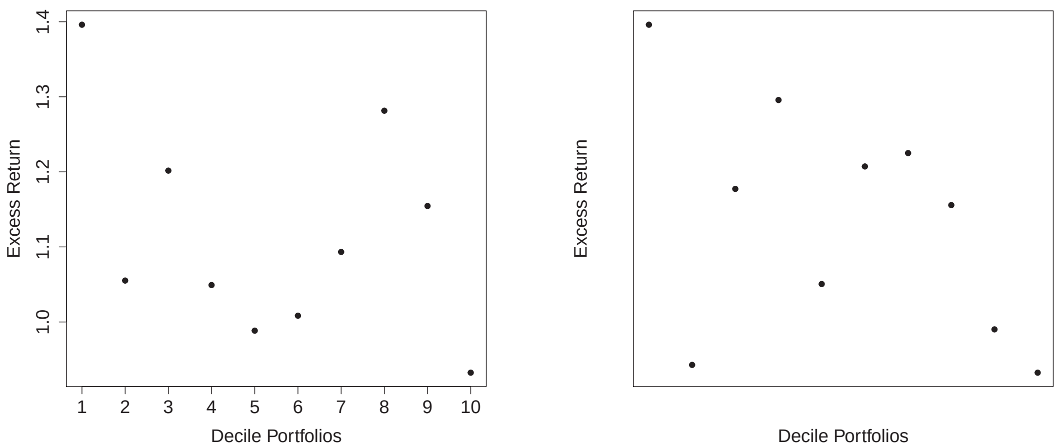
(a) ESG Scores

(b) Mean ESG Scores

Figure 1.I3: ESG distribution

Figure 1.I3a represents the distribution of ESG scores across all single yearly scores. Figure 1.I3b averages the firms' yearly ESG scores, so that every firm exhibits only one average score.

ESG factor follow a boom-bust pattern.



(a) Equally-weighted

(b) Value-weighted

Figure 1.I4: Raw returns

The plots 1.I4a and 1.I4b exhibit the decile portfolio raw return. The high (low) ESG decile portfolio *10* (*1*) depicts the firms with the highest (lowest) ESG scores. Portfolios are rearranged every year according to the previous year's ESG score.

Table 1.I19: Value-weighted ESG factor

This table is an extension from *Panel B* in Table 1.1, in which we construct value-weighted decile portfolios based on previous year ESG scores and adjust them in the beginning of each calender year. We then construct a long-short strategy (LS_t), which goes long in high ESG firms and shorts low ESG firms. The returns of all portfolios ESG portfolios are risk-adjusted through the application of the CAPM, Fama-French 3-factor, Carhart 4-factor, and Fama-French 5-factor models. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

	Dependent variable:			
	LS_t			
	(1)	(2)	(3)	(4)
α	−0.148	−0.133	−0.166	−0.331
	t = −0.750	t = −0.654	t = −0.807	t = −1.556
mkt-rf	−0.239**	−0.148	−0.103	−0.048
	t = −2.581	t = −1.353	t = −0.995	t = −0.464
smb		−0.442***	−0.455***	−0.372***
		t = −6.732	t = −7.479	t = −4.560
hml		0.118	0.200**	0.0001
		t = 1.192	t = 2.001	t = 0.002
mom			0.142**	
			t = 2.255	
rmw				0.474***
				t = 3.597
cma				0.422***
				t = 3.408
Observations	180	180	180	180
R^2	0.121	0.241	0.284	0.331
Note:	*p<0.1; **p<0.05; ***p<0.01			

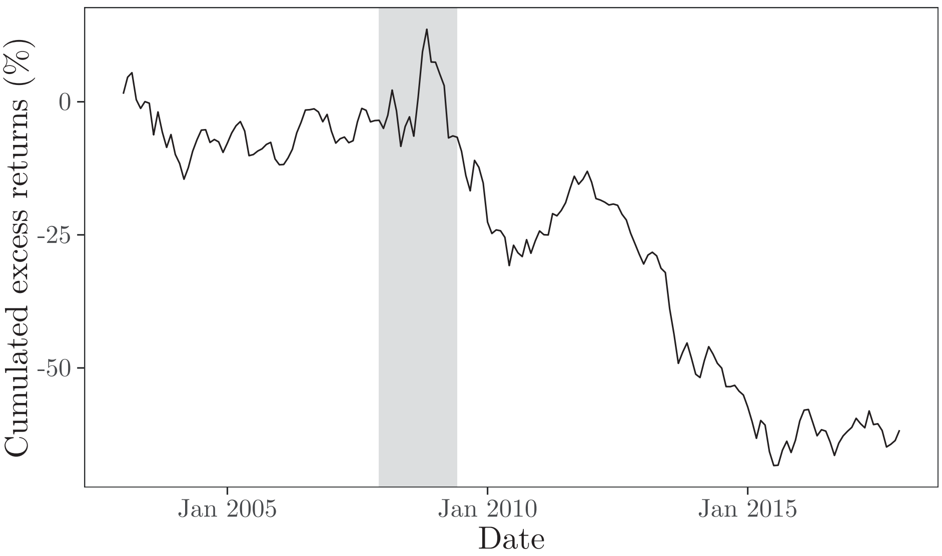


Figure 1.I5: Cumulative excess returns of ESG factor

We plot the value-weighted cumulated excess returns of a long-short portfolio that buys high ESG firms (top 10%) and shorts low ESG firms (bottom 10%). The portfolios are rearranged according to the previous year's ESG scores. The shaded area denotes the recession dates according to NBER.

1.IE Other Sentiment Measures

In this appendix section, we show additional findings on other sentiment measures. These include the Engle et al. (2020) climate change news indicator, the Baker and Wurgler (2006) investor measure as well as an analysis on dividend-price ratios.

Engle et al. (2020) climate change news

In our analysis, we make the argument that ESG returns are driven by salience and specifically the perceived risk of climate change. We provide empirical evidence that our measure of climate sentiment picks up this salience. To see if our sentiment measure shows results similar to other climate risk measures, we test whether salience in the form of high negative news coverage of climate can explain returns of our ESG factor. Specifically, we regress our ESG factor on *chneg*, a dummy variable developed by Engle et al. (2020), that is 1 when there are more than average bad news on climate, and 0 otherwise.

Table 1.I20 Column 1 document our findings. Incorporating other risk factors, this type of salience indeed matters for the returns of our general ESG factor. In periods with more than average amounts of negative news, the factor documents 80 bp of abnormal returns, where as in quiet periods it does not show any abnormal returns. Table 1.I21 confirms the results with different risk models.

Baker and Wurgler (2006) investor measure

We also consider whether the classical measure of sentiment as developed by Baker and Wurgler (2006) can explain our ESG returns. Our hypothesis is that sustainability concerns matter more or less depending on the time of general business sentiment. We use their variable *perp*, depicting their sentiment measure (a principal component of five proxies). We find that in periods with a higher than average amount of sentiment, there are no higher abnormal returns. Instead, abnormal returns tend to be outside of of high sentiment periods (29 bp on average). In fact, we see sustainability sentiment being especially strong in the recession.

Business cycles

To further test whether investors' sustainability sentiment varies with general optimism in the economy, we test whether the ESG factor can be explained by developments in the dividend-price ratio in excess of traditional risk factors.

Table 1.I20: Other sustainability sentiment measures

We first sort returns according to lagged ESG scores in a total of 10 portfolios and value-weight them. We construct a long-short portfolio strategy that goes long in high ESG firms and short in low ESG firms (LS_t). We test sentiment of this portfolio towards three measures. In the first column and denoted by 'chneg' we test against the climate news series from Engle et al. (2020), which is either one in case of lots of news on climate change and 0 otherwise. The second column tests against the sentiment index by Baker and Wurgler (2006), which is one when sentiment is high and 0 otherwise. Finally, column 3 tests against log-changes in the price dividend ratio taken from Robert Schiller's data website. Additionally, we adjust for factor returns under the Carhart four-factor model. We control for autocorrelation and heteroscedasticity in the residuals using Newey and West (1987) standard errors with lag of 12 months.

	Dependent variable:		
	LS_t		
	(1)	(2)	(3)
chneg = 1	0.803***		
	t = 3.102		
chneg = 0	0.013		
	t = 0.084		
perp = 0		0.288*	
		t = 1.703	
perp = 1		−0.041	
		t = −0.202	
Δpd			−0.214**
			t = −2.180
mkt - rf	−0.124**	−0.155***	−0.095
	t = −2.184	t = −2.883	t = −1.532
smb	−0.573***	−0.504***	−0.496***
	t = −6.765	t = −7.015	t = −6.860
hml	−0.003	−0.063	−0.081
	t = −0.030	t = −0.790	t = −1.045
mom	0.073***	0.047	0.032
	t = 2.674	t = 1.616	t = 1.217
α			0.068
			t = 0.577
Observations	109	180	179
R^2	0.517	0.465	0.470
Note:			*p<0.1; **p<0.05; ***p<0.01

We find that a falling price dividend ratio is associated with increased returns on the ESG factor, see Table 1.I20 Column 3. A 1% drop is associated with a decrease in the abnormal return of 21 bp. We again confirm that sustainability sentiment is negatively correlated with general business sentiment.

To illustrate the business cycle effects we plot cumulated excess returns of the four ESG portfolios within this ownership type in Figure 1.I6. In this plot, Q4 refers to high ESG firms, and Q1 for low. It shows that high ESG firms with high flexible ownership

Table 1.I21: Sustainability sentiment

We first sort returns according to lagged ESG scores in a total of 10 portfolios and value-weight them. We construct a long-short portfolio strategy that goes long in high ESG firms and short in low ESG firms. We test sentiment of this portfolio towards three measures. In Column (1) to (3) and denoted by 'chneg' we test against the climate news series from Engle et al. (2020), which is either one in case of lots of news on climate cheng and 0 otherwise. Column (4) to (6) tests against the sentiment index by Baker and Wurgler (2006), which is 1 when sentiment is high and 0 otherwise. Finally, column 3 tests against log-changes in the price dividend ratio as denoted by Robert Schiller. Additionally, we risk-adjust returns under the CAPM, Fama-French three-factor, and Carhart four-factor models. Standard errors are in parenthesis and are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

	Dependent variable:								
	LS_t								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
chneg = 1	0.53**	0.72***	0.80***						
	(0.24)	(0.27)	(0.26)						
chneg = 0	0.17	0.06	0.01						
	(0.14)	(0.14)	(0.16)						
perp = 0				0.25	0.26	0.29*			
				(0.21)	(0.16)	(0.17)			
perp = 1				0.02	0.001	−0.04			
				(0.22)	(0.19)	(0.20)			
Δ pd							−0.23**	−0.23**	−0.21**
							(0.10)	(0.09)	(0.10)
mkt - rf	−0.29***	−0.15**	−0.12**	−0.31***	−0.17***	−0.15***	−0.24***	−0.10	−0.10
	(0.05)	(0.06)	(0.06)	(0.04)	(0.05)	(0.05)	(0.06)	(0.06)	(0.06)
smb		−0.57***	−0.57***		−0.50***	−0.50***		−0.49***	−0.50***
		(0.09)	(0.08)		(0.07)	(0.07)		(0.07)	(0.07)
hml		−0.04	−0.003		−0.09	−0.06		−0.10	−0.08
		(0.09)	(0.09)		(0.08)	(0.08)		(0.08)	(0.08)
mom			0.07***			0.05			0.03
			(0.03)			(0.03)			(0.03)
α							0.08	0.07	0.07
							(0.13)	(0.11)	(0.12)
Observations	109	109	109	180	180	180	179	179	179
R^2	0.26	0.50	0.52	0.25	0.46	0.46	0.26	0.47	0.47
Note:							*p<0.1; **p<0.05; ***p<0.01		

especially seem to do better during the crisis.[2]

We again see that, although the top quartile has performed better throughout the sample, it also fell less in the crisis compared to the bottom two quartiles.

One argument for high ESG returns in the recession could be that as governments

[2] We additionally plot the same plot for strict investors in Figure 1.I7. In the appendix, we furthermore show the long-short ESG portfolio for high degrees of flexible and strict investors in Figure 1.I8 and 1.I9.

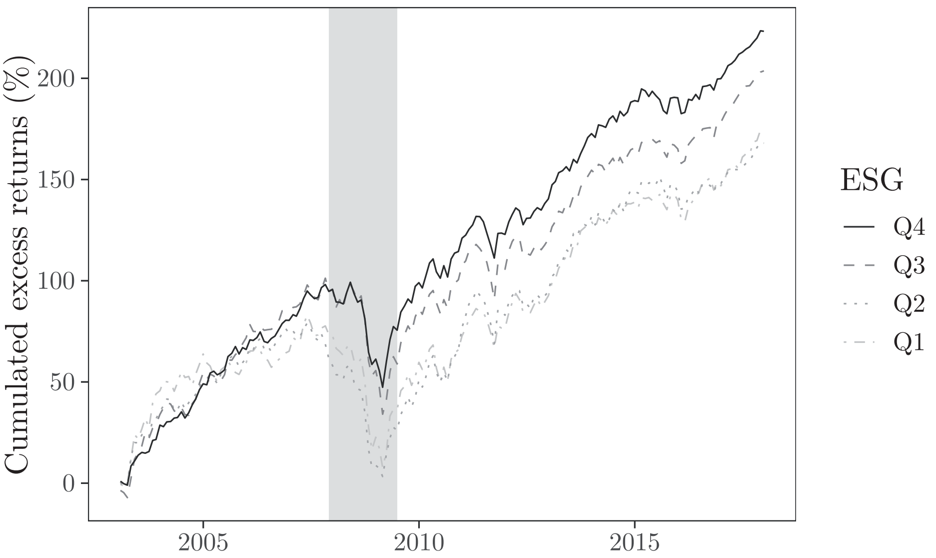


Figure 1.I6: Cumulative excess returns for stocks with different ESG levels within high flexible ownership

This figure shows cumulative returns for different ESG portfolios for stocks with high amounts of flexible ownership (top quartile). The portfolio Q1 (Q4) depicts the lowest ESG firms. The shaded area denotes the recession.

support the economy, there is public pressure that monetary support is given to those firms which emphasize more sustainable business models, as seen during the COVID-19 crisis. For example, the International Monetary Fund (IMF) emphasized and supported a ”Green Recovery” to fight the aftermath of the pandemic.[3] Another argument is that investors care more about ethics in times of crises. Indeed Sapienza and Zingales (2012) show that during the financial crisis we saw a rapid decline in the trust of the financial system, an observation validated by Jha, Liu and Manela (2021), who confirm the findings for a measure of popular sentiment towards finance.

These findings support that climate sentiment seems to correlate negatively with business cycles. In fact, sustainability sentiment may even rise during recessions.

[3]See under: `https://www.imf.org/en/Topics/climate-change/green-recovery`

1.IF Sustainable investment facts and additional robustness checks

This section provides additional figures and tables to give additional insight into our empirical setting. This includes ESG portfolio performance amongst strict investors, see Figure 1.I7, as well as an overview of cumulated excess returns for the ESG strategy amongst flexible owners in Figure 1.I8 and strict owners in Figure 1.I9. Furthermore, we exhibit results of the double-sort methodology of ESG scores and strict investors, see Table 1.I23.

1.6.1 Additional figures

Sustainable returns across investor types

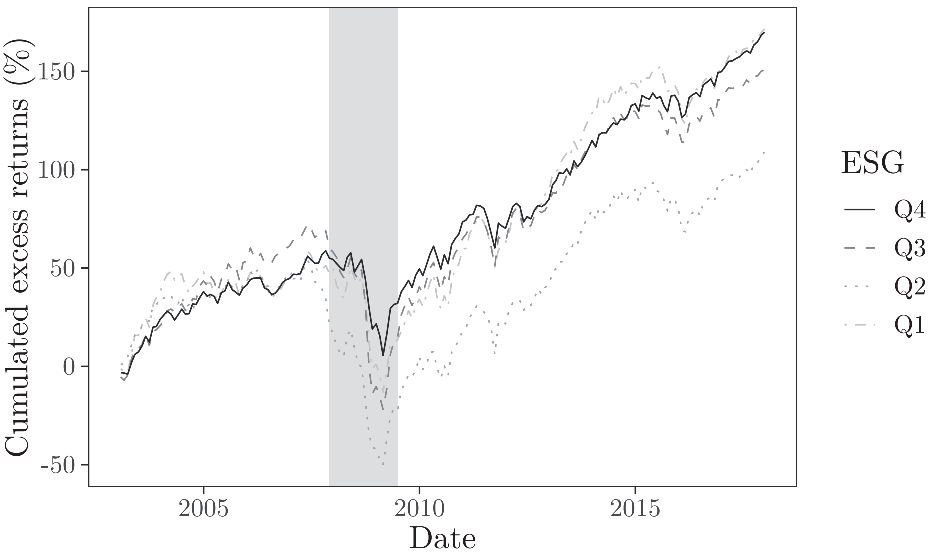


Figure 1.I7: Cumulative excess returns for stocks with different ESG levels and high strict ownership

This figure shows cumulative returns for different ESG portfolios for stocks with high amounts of strict ownership (top quartile). The portfolio Q1 (Q4) depicts the lowest ESG firms. The shaded area denotes the recession.

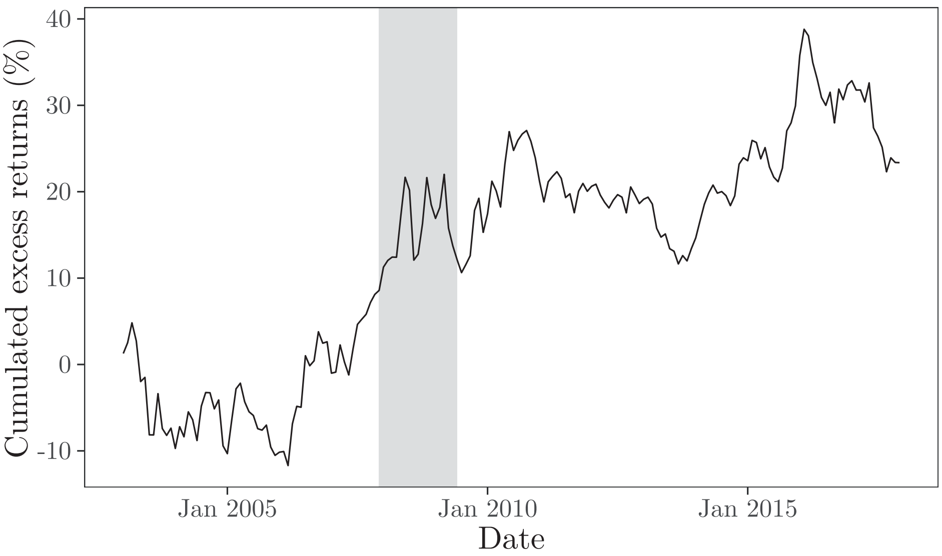


Figure 1.I8: Cumulative excess returns of long-short portfolio for stocks with the largest fraction of flexible owners

This figure shows cumulative returns for a value-weighted long short portfolio, which goes long in the highest ESG and high flexible ownership quartile and short in low ESG and high flexible ownership quartile portfolios. The shaded area denotes the recession.

Figure 1.I9: Cumulative excess returns of long-short portfolio for stocks with the largest fraction of strict owners

This figure shows cumulative returns for a value-weighted long short portfolio, which goes long in the highest ESG and high strict ownership quartile and short in low ESG and high strict ownership quartile portfolios. The shaded area denotes the recession.

1.6.2 Additional tables

Sustainable returns across investor types

Table 1.I22: Returns to sustainable investing across investor types and timings

We first sort returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their previous quarter's flexible and strict institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios. We conduct this procedure on actual holdings at time t (*sorted on actual holdings*), and also at time $t+1$ (*sorted on future holdings*), which gives us an indication for what the return on these portfolios would have been if investors would have held firms at the same level a period earlier. Here, one period equates to three quarters as holding data is available on a quarterly basis. LS is the abnormal return from a long-short strategy which goes long in high ESG and short in low ESG firms, giving us another four portfolios each. We value-weight these 20 portfolios and risk-adjust returns according to the Carhart four-factor model. We display alphas as well as relevant t-test statistics. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months. Bold numbers represent statistical significance at a level of 5% or below.

	Sorted on actual holdings					*Sorted on future holdings*				
	ESG low	Q2	Q3	ESG high	LS	ESG low	Q2	Q3	ESG high	LS
	Sorted on flexible ownership holdings									
	Panel A					*Panel B*				
Low	0.021	-0.064	-0.03	0.169	0.148	-0.118	-0.263	-0.194	-0.032	0.086
t-stat	0.123	-0.54	-0.177	1.278	0.565	-0.597	-1.612	-1.153	-0.253	0.313
2	0.046	0.065	-0.151	0.019	-0.027	-0.218	0.054	-0.039	0.071	0.289
t-stat	0.347	0.506	-1.067	0.21	-0.13	-1.59	0.381	-0.291	0.861	1.453
3	-0.033	-0.017	0.024	0.007	0.041	0.259	0.24	0.107	0.125	-0.134
t-stat	-0.228	-0.121	0.191	0.057	0.217	2.067	1.867	1.038	1.427	-0.841
High	0.088	0.005	0.173	**0.392**	**0.304**	0.132	-0.008	0.121	**0.419**	0.288
t-stat	0.773	0.041	1.202	3.784	2.027	0.975	-0.065	0.824	5.551	1.743
	Sorted on strict ownership holdings									
	Panel C					*Panel D*				
Low	-0.124	0.071	-0.024	0.149	0.273	-0.165	-0.038	-0.183	0.072	0.237
t-stat	-0.672	0.439	-0.174	1.258	1.027	-0.854	-0.236	-1.047	0.599	0.869
2	0.207	0.188	0.094	0.077	-0.129	0.193	0.073	0.193	0.108	-0.084
t-stat	2.72	2.051	0.841	0.933	-1.218	1.788	0.599	1.271	1.337	-0.689
3	0.054	0.038	-0.053	0.074	0.020	0.045	0.179	0.032	0.102	0.057
t-stat	0.296	0.33	-0.436	0.644	0.106	0.279	1.528	0.248	1.207	0.302
High	-0.049	-0.324	-0.190	0.130	0.179	-0.018	-0.171	-0.036	**0.325**	0.344
t-stat	-0.374	-1.765	-1.141	1.108	1.089	-0.145	-0.762	-0.205	2.232	1.661

Table 1.I23: Long-short regressions and socially constrained ownership

We first sort returns according to lagged ESG scores in a total of four portfolios. In a next step, we conditionally sort returns according to their current quarter's socially constrained institutional ownership share and assign them into another four portfolios, ending up with a total of 16 portfolios, which we value-weight. We construct a long-short portfolio (LS_t^D) that goes long in high ESG firms ($HESG$) and short in low ESG ($LESG$) firms on either a high (H) or a low (L) level of socially constrained ownership as denoted by $D = \{H, L\}$. We test our long-short portfolio against the CAPM, Fama-French three-factor as well as the Carhart four-factor model. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

	Dependent variable:					
	ESG Long-short return for High or Low degree of constrained ownership, LS_t^D, $D = \{H, L\}$:					
	LS_t^H			LS_t^L		
	(1)	(2)	(3)	(4)	(5)	(6)
α	0.136	0.158	0.179	0.292	0.299	0.273
	t = 0.838	t = 0.966	t = 1.089	t = 1.241	t = 1.184	t = 1.027
mkt - rf	−0.179***	−0.137***	−0.166***	−0.214**	−0.125	−0.090
	t = −3.579	t = −2.655	t = −3.162	t = −2.351	t = −1.256	t = −0.872
smb		−0.307***	−0.299***		−0.378***	−0.389***
		t = −3.679	t = −3.518		t = −3.832	t = −3.910
hml		0.207***	0.156**		0.037	0.100
		t = 2.762	t = 2.271		t = 0.345	t = 0.945
mom			−0.090**			0.110*
			t = −2.081			t = 1.693
Observations	180	180	180	180	180	180
R^2	0.084	0.176	0.198	0.081	0.155	0.176
Note:						*p<0.1; **p<0.05; ***p<0.01

ESG and market value

In this subsection of the appendix we show results of double sorting on ESG and size.

Table 1.I24: Double-sort regression on size and ESG

We first sort firms according to lagged ESG scores in a total of four portfolios. In a next step, we conditionally sort firms according to their one-month lagged market values and assign them into another four portfolios, ending up with a total of 16 portfolios, which we value-weight with the previous month's market values. We run regressions according to the CAPM and Carhart 4-Factor (excluding the SMB factor) models and displays alphas as well as relevant t-test statistics. Bold numbers represent statistical significance at a level of 10% or below. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

	ESG_{t-1} low	2	3	ESG_{t-1} high	LS
Panel A: CAPM					
Market Value low	0.531	0.303	0.287	**0.553**	0.022
t-stat	1.332	1.005	1.428	2.85	0.066
Q2	-0.033	0.099	-0.03	**0.301**	**0.334**
t-stat	-0.219	0.663	-0.301	2.723	2.398
Q3	0.023	**-0.206**	0.03	0.132	0.109
t-stat	0.2	-1.791	0.24	1.562	0.822
Market Value high	-0.083	0.009	-0.079	-0.039	0.045
t-stat	-0.593	0.073	-1.006	-0.545	0.267
LS	-0.614	-0.294	-0.366	**-0.592**	0.022
t-stat	-1.211	-0.75	-1.571	-2.491	0.05
Panel B: Carhart (excl. SMB)					
Market Value low	**0.718**	**0.434**	**0.397**	**0.63**	-0.087
t-stat	2.133	1.768	2.585	3.597	-0.281
Q2	0.013	0.158	-0.007	**0.337**	**0.324**
t-stat	0.089	1.255	-0.075	3.303	2.269
Q3	0.027	**-0.211**	0.044	0.136	0.109
t-stat	0.235	-1.851	0.351	1.572	0.801
Market Value high	-0.11	-0.004	-0.077	-0.041	0.069
t-stat	-0.807	-0.032	-1.038	-0.576	0.413
LS	**-0.827**	-0.438	-0.474	-0.671	0.156
t-stat	-1.93	-1.291	-2.502	-3.028	0.387

Ownership concentration, ESG and returns

In this appendix we show results of double sorting on ESG and ownership concentration as defined by the Herfindahl–Hirschman Index (HHI). We do not find an ESG premium when controling for HHI as exhibited in Table 1.I25.

Table 1.I25: Double sort of ESG and ownership concentration

We first sort returns according to lagged ESG scores in a total of four portfolios. In the next step, we conditionally sort returns according to their previous quarter's ownership concentration (HHI) and assign them into another four portfolios, ending up with a total of 16 portfolios, which we value-weight. LS is the abnormal return from a long-short strategy which goes long in high ESG and short in low ESG firms or long in the highly concentrated firms and short in the less concentrated firms, respectively. We value-weight these 16 portfolios with the previous month's market values. Finally, we run regressions on portfolio returns according to the CAPM and Carhart four-factor models and display alphas as well as relevant t-test statistics. Bold numbers represent statistical significance at a level of 10% or below. Standard errors are adjusted for heteroskedasticity and autocorrelation using Newey and West (1987) with a lag length of 12 months.

	ESG low	Q2	Q3	ESG high	LS
Panel A: CAPM					
HHI low	-0.204	0.079	**-0.247**	-0.26	-0.056
t-stat	-0.871	0.562	-1.917	-1.386	-0.273
2	0.166	-0.104	0.028	**0.255**	0.089
t-stat	0.726	-0.76	0.201	1.751	0.516
3	0.019	0.056	0.046	-0.01	-0.029
t-stat	0.147	0.317	0.34	-0.099	-0.158
HHI high	0.033	-0.052	-0.089	0.023	-0.009
t-stat	0.21	-0.542	-0.93	0.244	-0.06
LS	0.237	-0.131	0.157	0.283	0.046
t-stat	0.974	-0.755	1.1	1.344	0.189
Panel B: Carhart					
HHI low	-0.181	0.088	**-0.216**	-0.209	-0.028
t-stat	-0.686	0.573	-1.682	-1.214	-0.137
2	0.157	-0.099	0.01	**0.283**	0.126
t-stat	0.824	-0.658	0.072	1.703	0.762
3	0.022	0.057	0.058	0.007	-0.014
t-stat	0.176	0.332	0.482	0.081	-0.087
HHI high	-0.018	-0.057	-0.079	0.008	0.026
t-stat	-0.118	-0.608	-0.794	0.092	0.149
LS	0.163	-0.145	0.138	0.217	0.054
t-stat	0.68	-0.796	0.908	1.005	0.227

1.IG Sorting

Single-sorted portfolios. We start out by selecting only those firm-month observation for which we have ESG information available for the previous year. Within these firms, we distinguish between different degrees of ESG scores. In total, we subdivide our sample into ten portfolios, ranging from the highest to the lowest decile ESG firms. Specifically, we sort returns according to the previous year's ESG scores. For example, ESG scores in 2002 determine our portfolios in 2003 and so forth.

We construct value-weighted decile portfolios for the entire data period, where P10 (P1) depicts the highest (lowest) ESG portfolio, where we use the market-value of a firm from the previous month as a proxy for value. We choose to value-weight, because else portfolio returns would largely be driven by small firms.[4] However, one should note that the value composition between decile portfolios is not evenly distributed. Our data shows that high scores are primarily obtained by rather large firms, and vice versa. Finally, we use the self-developed portfolios to construct a long-short portfolio (LS), which goes long in the highest ESG decile portfolio and shorts the lowest ESG decile portfolio.

Double-sorted portfolios. We utilize ownership information to double-sort returns on two variables; that is, information on how high ownership by strict and flexible owners is in a given firm. Specifically, we first sort firms for a given month based on on the previous year's ESG scores into four portfolios. Thereafter, we conditionally sort on the level of ownership in the previous quarter, so that we end up with a total of 16 portfolios. These portfolios are rebalanced every month and rearranged every quarter as new holding data becomes available. Additionally we incorporate the new ESG data in the rebalancing at year-end. As previously, we value-weight returns within the sorted portfolios. Additionally, we construct long-short portfolios according to ESG and ownership information. Equally-weighted returns are calculated as robustness checks.

Risk-adjusting the sorts. To risk-adjust returns, we use the CAPM, Fama-French three-factor or Carhart model (Carhart 1997, Fama and French 1992, Sharpe 1964). This means we explicitly estimate

$$r_{it} - r_t^f = \alpha_i + \sum_{j=1}^{J} \beta_{ij} f_{jt} + \epsilon_{it}, \tag{1.79}$$

[4]Nevertheless, we conduct all analyses on an equally-weighted portfolio level as well for robustness checks.

where r_{it} depicts portfolio i's return at time t. Moreover, r_t^f, α_i, and J denote the risk-free rate, the abnormal return, and the number of factors. Finally, the β_{ij}, f_{jt} and ϵ_{it} are the factor loadings, factor returns, and the error term, where f corresponds to $\mu_M = r_M^e$ in our theory section for the CAPM model, and in general the factors of the specified risk-model.

Chapter 2

The Future of Emissions

with Jules Hans van Binsbergen

Abstract

We argue for the introduction of firm-level emission futures contracts as a novel way of assessing the real impact of ESG initiatives. Our measure is based on the forward-looking market-based valuation of firm-level CO_2 emissions. We establish both theoretically and empirically that backward-looking subjective ratings are limited to the extent that they fail to capture future reductions in emissions. We show evidence that although lower emissions have predicted higher E ratings, higher E ratings have predicted higher, not lower, emissions. As such, by following these subjective ratings, investors may have inadvertently allocated their money to firms that pollute more, not less. We discuss several applications of our new measure, including executive pay and investment management.

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2.1 Introduction

Socially conscious investment strategies have gained much popularity in the past two decades. While various different approaches have been proposed, one popular way of attempting to achieve social change is by divesting from companies that do not meet certain social criteria. The main mechanism through which such a divestment could have impact is through the stock price. By divesting, socially conscious investors hope to decrease the firm's stock price, implying that for a given number of shares issued, the firm raises less capital. That is, the intended consequence of divestment is to increase targeted firms' cost of capital (Berk and van Binsbergen 2021). This higher cost of capital makes fewer real investment projects a positive net present value (NPV) undertaking, implying a lower growth rate of such firms going forward. Eventually, this lower growth rate reduces the fraction of targeted firms in the economy in the long run. In addition, the threat of this stock price mechanism could induce targeted firms (sometimes called 'brown' firms) to shed their undesirable habits and become "green" firms.

In this paper, we propose a new market-based forward-looking measure for the real impact of social investing based on emission futures contracts. If backward-looking emission measures perfectly predicted forward-looking emissions at the firm level there would be no need for such an additional forward-looking measure. However, we establish both theoretically and empirically that the current backward-looking subjective ratings-based system implies that past emissions do not predict future emissions, quite the opposite. As such, by following these subjective ratings, investors may inadvertently allocate their money to firms that will pollute more not less.[1] In particular, we find that even though (a) the fraction of capital allocated to ESG investing has tremendously increased in the past few decades, and (b) firms have on average reduced their CO_2 emissions over time, the CO_2 emission reductions have preceded increases in ESG investing. Second, when firms are admitted to a leading ESG index (FTSE USA 4Good) they tend to increase rather than decrease their CO_2 emissions. Third, although lower emissions predict higher E scores (i.e., the first category in "ESG"), higher E scores do not predict lower emissions.

[1] Indeed, investors are increasingly sceptical of the current ESG data. Only 20% say that they trust the ESG statements that companies make, lowered from half two years ago, according to a survey of 20,000 consumers and 2,500 executives across 22 industries and 34 countries (IBM 2023). Additionally, executives cite inadequate data as the top barrier holding back ESG progress, even more so than regulatory barriers. 60% of executives say that they lack the ability to access and understand ESG data as they have to make tradeoffs between financial and ESG objectives. This means they cannot accurately predict which plans will improve outcomes and return on investment. This also means that while 95% of organizations have made ESG propositions, only 10% say that they have made significant progress progress towards their goals.

From a theoretical perspective, we contribute to the literature by introducing a general framework of value creation that nests sustainable investing as well as standard firm optimization. We then introduce a model, which features backward-looking ESG ratings combined with standard firm optimization, that can explain the empirical regularities featured above. In the model firms are incentivized to increase their ratings, but not necessarily to improve their social impact. This indeed implies that after improving their ranking, it is optimal to increase emissions.

These theoretical and empirical results raise the question of what mechanism would optimally induce firms to reduce emissions and have a real impact. We argue that a mechanism based on a market-based forward-looking emissions measure improves incentives. Additionally, we show that even without a measurable stock price effect from sustainable investing, linking managerial pay to this new continuous measure aligns incentives and optimizes real impact. That is, even if divestment would lead to measurable price effects in financial markets, currently the incentive structure may not be sufficiently conducive to affecting real change.

Specifically, we propose to base the E measure of a particular firm on the pricing of a new asset class, what we term emission futures. An emission future pays out the dollar value of a firm's emissions at a given future date, and is based on (1) the future path of the traded price of carbon per metric ton and (2) the quantity in metric ton of a firm's future carbon emissions for a given calendar year.[2] The futures price thus reflects the discounted expected value of a firm's emissions.[3] By translating this value into a new E measure we

[2]We propose to have the Emission Future be based on Scope 1 emissions to ease the contracts measurability and enforcability, however as the quality of more comprehensive scopes increase these could also be considered. Scope 3 emissions are hard to assess, due to the difficulty of collecting high-quality data on type or volume of emissions. Scope 2 emissions, as well as scope 3 emissions, fall outside a company's direct control, making them hard to manage. Additionally, scope 2 and 3 emissions will be accounted for by several companies, which raises the question of who should be responsible for them.

[3]We acknowledge that our proposed measure has its limitations, however we see these to be greatly reduced relative to other measures available and not necessarily greater than for any other derivatives contract. Specifically, a firm may be incentivized to sell their own Emission Futures and misreport on their emissions, however this is the same as with dividend futures, and there exists insider trading laws to protect against this. Uncertainty of the underlying data may be an issue, but we do not see this to be any different than other contracts that are traded today. For example take the CPI futures, which rely on government reporting of the consumer price index, which in turn is based on surveys, price samples, and index weights. Misreporting is further disincentivized through legal means. The legal framework of emission monitoring, reporting, and verification has already been developed after the introduction of greenhouse gas emission allowance trading within the European Union (See `https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R2066` and `https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R2067`), and the Greenhouse Gas Reporting Program in the United States, which equally requires the independent verification of emissions data reports by a third party (See, for example, `https://ww2.arb.ca.gov/verification`). Misreporting has already had legal consequences as was the case for Chevron in 2011 (`https://ww2.arb.ca.gov/verification`). See also the greenwashing investigation raid on Deutche bank following ESG misreporting allegations, which already resulted in the resignation of CEO Asoka Wöhrmann, even though the

get a meaningful system that incorporates the expected path of a specific outcome variable that is relevant and measurable. Furthermore, emission futures allow us to measure the impact of corporate actions and investor activism through what we term green impact. The green impact is based on a firm's reduction in the term structure of its future price, which measures reductions in emissions value by calendar year relative to their previous (risk-neutral) expected path. By comparing this improvement in its term structure to the changes in the term structure of the traded price of carbon a firm's expected quantity reduction can be measured. This improvement can then be attributed to the impact by the firm, rather than the economy gradually adapting low-carbon technologies. That is, the unexpected return on a firm's emission futures allows for the measurement of corporate actions that genuinely affect the path of emissions that the firm was on.

Our paper fits into a larger literature that investigates the extent to which socially conscious investors manage to reduce the targeted companies' carbon footprint. Indeed, there is growing evidence that although socially concerned investors hold firms with higher ESG scores and lower carbon intensity, it is not necessarily socially concerned investors, such as pension plans, that are responsible for this reduction (Akey and Appel 2019, Brøgger and Kronies 2022, Heath et al. 2021, 2022, Hong and Kacperczyk 2009, Noh and Oh 2020). Our finding that greener firms have less impact is also in line with psychological findings on 'Moral licensing' (Sachdeva, Iliev and Medin 2009), the tendency of entitlement to do something bad because we've done something good. Moral licensing explains why ethics professors are more likely to say that eating meat is wrong, but no less likely to eat meat (Schwitzgebel and Rust 2014), and ethics professors steal more books than colleagues outside of their field (Schwitzgebel 2009). This evidence is consistent with the idea that while an improved ESG score causes socially concerned investors to become owners of such firms, the reverse causality is more elusive. Given that the stated objective of socially conscious investors is to affect social change, this state of affairs may be less than desirable.

There is also an emerging literature that evaluates the reliability of ESG ratings. In particular, Berg, Kölbel and Rigobon (2022) investigate the divergence of such rating ratings based on data from six prominent rating agencies including KLD, Sustainalytics, Moody's ESG, S&P Global, Refinitiv, and MSCI. They find large divergences between rating agencies and raise important issues related to the scope, measurement, and weight of the various inputs used to construct such ratings. Berg, Fabisik and Sautner (2023) find

legal consequences have not yet concluded.

that Refinitiv ESG scores have been subject to ongoing changes to past scores, further undermining their reliability. We circumvent these issues by simply focusing on commonly-used ESG indices that are presumably replicated and followed by an important group of investors. Therefore, regardless of whether these indices perfectly capture the underlying desired dimensions of the ESG variables, investors following and replicating such indices, and thereby basing their buy and sell decisions on them, are implicitly condoning their measurement. For the purpose of our empirical strategy, the only relevant factor is that investors are following these commonly-used indices.

Indeed new research shows that investing according to the current ESG scores may not be conducive for fostering impact. Cohen, Gurun and Nguyen (2020) find that it is often the brownest firms that are innovating to reduce future carbon emissions. Bams and van der Kroft (2022) find that due to information asymmetry investors invest according to ESG scores instead of sustainable performance. This leads to firms inflating ESG scores and reducing cost of capital, to the extend that ESG is negatively related to sustainable performance. This problem is exacerbated as investors investing into ESG funds, from calculating the average ESG score of the portfolio holdings, pressures the funds to pick stocks based on ESG scores instead of doing their own research (Edmans, Levit and Schneemeier 2022).

Another issue with current ESG scores is that they are prone to “cheap talk”. Indeed, previous work has shown evidence of cheap talk, including social index funds not voting in favour of ESG policies. Bingler et al. (2022a) find using a neural algorithm trained to detect cheap talk that voluntary disclosure is mainly cheap talk and cherry picking. Bingler et al. (2022b) find using the same algorithm that ”institutional ownership, targeted institutional investor engagement, materiality and downside risk disclosures are associated with less cheap talk. Signaling by publicly supporting the TCFD is associated with more cheap talk”. While Curtis, Fisch and Robertson (2021) find that green funds on average vote for green proposals, Michaely, Ordonez-Calafi and Rubio (2021) and Li, Naaraayanan and Sachdeva (2021) find that green funds actually vote strategically in the sense that they vote for sustainable proposals that would pass anyway, but not those they could influence to be enacted.

The findings in our paper are in line with experimental evidence that investors are willing to pay a premium for sustainable investments, regardless of whether their investment has an impact on the projects coming to fruition (Bonnefon et al. 2022), and regardless of additional impact (Heeb et al. 2023). The findings are also in line with current regulatory proposals by the securities exchange comission (SEC) in the US and the EU council in Europe. These proposals include the EU taxonomy for sustainable activities, which proposes filters based on levels as well as an Excel tool to help direct investments. Additionally, the sustainable finance disclosure regulation (SFDR) requires ESG fund managers (referred to as Article 8 and 9 funds) to display sustainability indicators, such as emission levels, to show that they are in accordance with the EU Taxonomy and an explanation of the 'do no harm' principle. This has to be done regularly as well as in their prospectus. Otherwise the fund managers have to show how their fund is not proposing to be an ESG fund. These regulations are supported by the new corporate sustainability reporting directive (CSRD), which requires firms to report levels on these social outcomes, such as emissions. The ECB now also aims to tilt their purchase programs towards greener firms as well as reducing the collateralability of browner firms. In other words the placebo effects of sustainable investment is more important than the actual effectiveness of them.

2.2 Theory

We first split total value into an internal value to investors and an external value. Using the fact that impact is generally defined as the reduction of the negative externality, we evaluate the effectiveness of backward-looking ESG ratings versus forward-looking measures in achieving impact.

2.2.1 A Firm's Internal and External Value

We start by defining the total value of a firm i to society at time t as the present value of its total future dividends $D_{i,t,n}$ at horizons n discounted at the rate $\mu_{i,t,n}$ back to time t as

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

The value generated by a firm either goes to the firm's investors or to the rest of the economy through the firm's externalities, which in principle can be both positive or negative. The value that goes to the firm's investors are the internal dividends, which we name cash dividends, and externalities are the external dividends, termed "externality dividends" hereafter.[4] This means that the total value of a firm is its internal and external value,

[4] As negative externalities are most commonly analysed, they are the default externality in this setting. At the same time it is flexible to incorporate positive externalities, in which case the externality dividends would have a negative sign.

which is given by the sum of its cash and externality dividends as

$$V_{i,t} = \underbrace{\sum_{n=0}^{\infty} \frac{D^c_{i,t,n}}{\exp(n\mu^c_{i,t,n})}}_{V^I_{i,t}} - \underbrace{\sum_{n=0}^{\infty} \frac{D^e_{i,t,n}}{\exp(n\mu^e_{i,t,n})}}_{-V^E_{i,t}}. \tag{2.1}$$

In particular as the investors value the dividends they receive, the price they pay only reflects the cash dividends:

$$P_{i,t} = V^I_{i,t}, \tag{2.2}$$

where we normalize the number of outstanding shares to 1, and we assume wlog and for ease of exposition that the firms are all equity financed.

An example of the importance of this distinction is the seminal work of Modigliani and Miller (1958). Modigliani and Miller show that the internal value of the firm is the same irrespective of financing decisions with regard to debt and equity. This is true in absence of other frictions, and they go on to show that if debt receives a tax benefit, then issuing debt actually increases the internal value by that tax benefit. However, this comes at the cost of an external value loss in tax income, that would otherwise have been redistributed to the economy. Hence, our framework allows us to specifically see how economic incentives lead to agents optimising and value being transferred from one group to another.

Sustainable Investing. We now define sustainable investing within this framework. Sustainable investing is investing that properly accounts for externalities and thus maximises the total value of the firm to society. An important understudied consideration is the time horizon over which sustainable goals are achieved. In our value definition, the whole present value of future externalities are incorporated in the framework. This implies that improvements that take a substantial amount of time to realise are still counted towards the sustainability objectives of the firm. Further, past realised externality dividends play no role in this valuation exercise. This already illustrates an important difference between backward-looking ESG ratings and forward-looking optimal decision making that maximises a firms value to society.

One way to measure impact is to compute the decrease in the discounted horizon specific expected external dividends. Recall that t denotes the current period, n denotes the horizon (number of years in the future), and i denotes the firm, then the impact is simply given by

$$\tilde{I}_{i,t,n} \equiv \frac{\mathbb{E}_{i,t-1}\, D^e_{i,t-1,n+1}}{\exp((n+1)\mu^e_{i,t-1,n+1})} - \frac{\mathbb{E}_{i,t}\, D^e_{i,t,n}}{\exp(n\mu^e_{i,t,n})}.$$

As an example consider the one-year horizon. Impact is then simply given by the difference between the discounted expected external dividend one year ago and its realisation:

$$\tilde{I}_{i,t,1} = \mathbb{E}_{i,t-1}\, D^e_{i,t-1,1} \exp(-\mu^e_{i,t-1,1}) - D^e_{i,t,0}.$$

One downside of using these measures of impact is that a negative impact is measured simply due to the normal expected return the asset earns. By using futures values as opposed to spot values we can remove the risk-free part of this expected return. Further, we will show that the risk-premium on this asset is likely small at least as measured by conventional exposures to market risk. Concretely, let $F_{i,t,n}$ denote the futures price of the externality dividend paid out in n periods by firm i at time t. If we then indeed assume that the risk-premium is sufficiently small, we can simply define impact as the negative dollar return on the future:

$$I_{i,t,n} \equiv F_{i,t-1,n+1} - F_{i,t,n}, \tag{2.3}$$

which under the above stated assumptions is also equal to

$$I_{i,t,n} = \mathbb{E}_{i,t-1}\, D^e_{i,t-1,n+1} - \mathbb{E}_{i,t}\, D^e_{i,t,n}. \tag{2.4}$$

That is, under the above stated assumptions the futures price is simply equal to the expected value of the externality dividend.

Finally, the value of impact is then simply equal to the sum of each year's impact measure across all horizons:

$$V^{\text{Impact}}_{i,t} \equiv \sum_{n=1}^{\infty} I_{i,t,n}. \tag{2.5}$$

2.2.2 ESG Measures, Impact, and Misallocation of Capital

We can use this framework to theoretically analyse the realised impact of two regimes as well as the extent to which the measures (R and M) capture them. In particular we wish to compare a regime where firms respond to subjective backward-looking ESG ratings that are based on a firms history of externalities, what we label regime R (for rating), to a regime that uses market-based forward-looking ESG measures, what we label regime M. The impact at horizon n between the two regimes is then

$$I^{M,R}_{i,t,n} \equiv \mathbb{E}_{i,t}\, D^{e,R}_{i,t,n} - \mathbb{E}_{i,t}\, D^{e,M}_{i,t,n}, \tag{2.6}$$

where the dividend $D^{\mathcal{M}}_{i,t,0}$ will be the prevailing dividend for firm i at time t and horizon n under regime $\mathcal{M}$. Specifically, we have that the realised impact for the 0-horizon is

$$I^{M,R}_{i,t,0} = D^{e,R}_{i,t,0} - D^{e,M}_{i,t,0}, \tag{2.7}$$

which simply means that impact can be achieved by moving to a new measure which delivers a lower equilibrium externality dividend.

We can also analyse whether moving to forward-looking measures improves the investors' allocation to their desired firms, that is, increasing the allocation of capital to the firms that deliver impact. Consequently, if one invests with a noisy or biased rating, it may lead to capital being allocated to firms which may pollute more, not less.[5] Specifically, consider an impact investor who tilts their portfolio according to their expected impact of the firm, then a valid misallocation measure is the absolute difference between the allocation under measure $\mathcal{M}$ and the optimal allocation:

$$|D^{e}_{i,t,n} - \mathbb{E}^{\mathcal{M}}_{i,t}\, D^{e,\mathcal{M}}_{i,t,n}| = |\epsilon^{\mathcal{M}}_{i,t,n}|,$$

where $\epsilon^{\mathcal{M}}$ is the estimation error under measure $\mathcal{M}$. Specifically, the improvement in misallocation from rating R to measure M can be written as

$$\tilde{I}^{M,R}_{i,t,n} \equiv |\epsilon^{R}_{i,t,n}| - |\epsilon^{M}_{i,t,n}|. \tag{2.8}$$

Which taking the average across all firms i can be rewritten as

$$\tilde{I}^{M,R}_{t,n} = \sqrt{MSE^{R}_{t,n}} - \sqrt{MSE^{M}_{t,n}}, \tag{2.9}$$

where $MSE^{\mathcal{M}}_{t,n}$ is the mean squared error under measure $\mathcal{M}$ for horizon n evaluated at time t. The equation shows that the improvement in the allocation can be measured by comparing the predictive ability of the forward-looking measure (MSE) for future externality dividends, with the predictive ability of the the backward-looking rating. Suppose that there exists a forward-looking market-based measure which is unbiased, then the MSE of this market measure is smaller than the MSE of the backward-looking measure, as market prices will reflect more information than that captured by the backward-looking variables used in generating the rating.

[5] Misallocation can also be interpreted as a welfare loss to the investor, where the exact loss will depend on the extend that an investor cares about the impact of his investments.

Next, we set up a model to explain the sources of changes to the equilibrium externality level.

2.2.3 Model of ESG Investing under Different ESG Measures

In this section, we present a model of the costs and benefits that for firms trade off when trying to affect their ESG Scores. After, we will consider how these incentives affect impact through firms' optimisation behaviour.

The Firm's Problem. Firm i maximises its internalised value as given by Equation 2.2 at time t by aiming for an ESG score $E_{i,t}$. That is, their objective is

$$\max_{E_{i,t}} \mathbb{E}_t \sum_{n=0}^{\infty} \frac{D^c_{i,t,n}(E_{i,t+n})}{\exp\left(n\mu^c_{i,t,n}(E_{i,t+n-1})\right)}. \tag{2.10}$$

Firms can increase the valuation of their firm by either increasing cash dividends or reducing their discount rate. Additionally, the cash dividend is given as the difference between revenue $\text{Rev}_{i,t}$ and cost $c_{i,t}$.

A key decision for the firm is which ESG rating $E_{i,t}$ to aim for. This is relevant for the firm because both $\text{Rev}_{i,t}$, $C_{i,t}$, and $r^c_{i,t}$ may be dependent on the firm's ESG score. The revenues $\text{Rev}_{i,t}$ may be affected because governments and ESG activists may impose boycotts of low ESG products.[6] The costs $C_{i,t}$ can be affected because companies can incur costs from having a low ESG score resulting from protests or regulatory costs such as a carbon tax or the purchase of Carbon credits. Finally, the discount rate $r^c_{i,t}$ can change when investors or banks are restricted from investing in firms with low ESG scores (Berk and van Binsbergen 2021, Homanen 2022, Zerbib 2022). There exists investors under strict mandates, such as pension funds. The discount rate $r^c_{i,t}$ may also be affected if investors value high ESG investments as in Pástor, Stambaugh and Taylor (2021a) and Pedersen, Fitzgibbons and Pomorski (2021a).

ESG Adjustment Costs. There is a cost associated with companies changing their ESG scores, for example when they have to transition to a more expensive but cleaner energy source. We model this with capital adjustment costs:

$$E_{i,t} = G_i(B_{i,t}),$$

[6] Examples are government-imposed policies that mandate that all energy investments are carbon neutral.

where G_i is a general function potentially specific to each firm. Further, to get a closed form solution we need to specify the functional form for G_i. A specification that is tractable yet still quite general is

$$E_{i,t} = \frac{1}{k_i} B_{i,t}^{\eta_i},$$

where $B_{i,t+n}$ is the periodic budget needed to sustain an ESG score $E_{i,t+n}$ continuously as a fraction of their cash dividend, and k_i and η_i are constants. The decreasing returns to scale are captured by $0 < \eta_i < 1$. Solving for the budget needed to sustain a certain ESG rating, we see that the periodic dividend after ESG costs is

$$D_{i,t,0}^{c}(E_{i,t}) = D_{i,t,0}^{c,0} \exp\left(-k_i E_{i,t}^{1/\eta_i}\right), \tag{2.11}$$

where $D_{i,t}^{c,0}$ is firm i's cash dividends before ESG related costs at time t.

ESG and the Firm's Discount Rate. There are multiple potential benefits to achieving a higher ESG score though their quantitative relevance is subject to debate (Berk and van Binsbergen 2021). For ease of exposition we will assume here that a higher ESG score has a negative effect on the firm's discount rate. Concretely, let a continuum of investors j maximise their expected utility. Meaning they solve

$$U'_{j,t} \equiv max_{X_j,t}\, \mathbb{E}_t[-\exp(-a_j W_{j,t+1} - bX_{j,t})],$$

where a_j is investor j's risk avertion, $W_{j,t+1}$ is that investor's next period's wealth, and b is the non-pecuniary benefit received from their portfolio $X_{j,t}$. Importantly, b_j is the product of the investors' sustainability sentiment S_j and $g_{i,t}^{e}(E_{i,t})$, the greenness of the firm, which depends on the firm's ESG score. As some investors follow a full exclusion strategy based on some lower threshold and some investors tilt their portfolio gradually, we model the combined effect as

$$b = S_j g_{i,t}^{e} = S_j \ln(E_{i,t}).$$

The investors' optimal portfolio weights are then

$$X_{j,t} = w_{m,t} + (S_j - \bar{S})/\gamma^2 \Sigma^{-1} \ln(E_{i,t}),$$

where w_m are the market portfolio weights, and γ_j is the relative risk aversion ($\gamma_j = A_j/W_j$) for investor j, and Σ is the covariance matrix of their portfolio. In short, investors put higher weights on stocks with higher ESG scores.

The discount rate on firm i will then be

$$r_{i,t}^{c} = \beta_i^M r_t^M - s\ln(E_{i,t}), \tag{2.12}$$

where β_i^M is the beta of firm i's returns with respect to the market return r_t^M, γ_j is the relative risk aversion for investor j ($\gamma_j = A_j/W_j$), and s is equal to $\bar{S}/\bar{\gamma}$, where the bar variables indicate value-weighted averages. For example $\bar{S}$ denotes the value-weighted average sentiment in the economy.

Solution to the Firm's Problem. The first order conditions from the firm's maximisation problem (Equation 2.10) imply for each i, t that

$$D_{i,t,0}^{c'}(E_{i,t}) = \mathbb{E}_t\left[-r_{i,t+1}^{c'}(E_{i,t})\frac{D_{i,t,1}^{c}(E_{i,t+1})}{\exp\left(r_{i,t+1}^{c}(E_{i,t})\right)}\right].$$

At the optimal $E_{i,t}$ score, the marginal cost of increasing the score further, in terms of lower dividends, must equal the marginal benefit in firm value through an expected lower discount rate. Further, we can get from Equation 2.11 that the marginal cost of raising the $E_{i,t}$ score is

$$k_i E^{\frac{1-\eta_i}{\eta_i}} D_{i,t,0}^{c,0}\exp\left(-k_i E_{i,t}^{1/\eta_i}\right),$$

and from Equation 2.12 that increasing $E_{i,t}$ lowers the discount rate incrementally by $s/E_{i,t}$. Additionally, as the problem is symmetric across time $E_{i,t} = E_{i,t+1} = E_i$, we obtain

$$\underbrace{\frac{k_i E^{\frac{1-\eta_i}{\eta_i}} D_{i,t,0}^{c,0}}{\exp\left(k_i E_i^{1/\eta_i}\right)}}_{\text{Marginal cost}} = \underbrace{sE_i^{-1}\,\mathbb{E}_t\left[\frac{D_{i,t,1}^{c,0}\exp\left(-k_i E_i^{1/\eta_i}\right)}{\exp\left(\beta_i^M r_{t+1}^M - s\ln(E_i)\right)}\right]}_{\text{Marginal benefit}}. \tag{2.13}$$

Given these costs and incentives each firm will choose its optimal ESG rating as

$$E_i^* = \psi\left(k_i, s, \beta_i^M, \mu_t^M, \sigma_t^M\right)^{\phi(s,\eta_i)}, \tag{2.14}$$

where ψ is positive definite and ϕ is negative definite given respectively by

$$
\begin{aligned}
\psi &\equiv \frac{k_i}{s} \exp\left(\beta_i^M \mu_t^M - \frac{1}{2}\beta_i^{M2}\sigma_t^{M2}\right), \\
\phi &\equiv \frac{-1}{\frac{1}{\eta_i} - s}.
\end{aligned}
$$

The equilibrium ESG rating E_i^* will be decreasing in ψ with a sensitivity determined by ϕ. Hence E_i^* is decreasing in k_i and the expected market return μ_t^M, and increasing in green sentiment s and the expected market risk σ_t^M. The sensitivity of these effects, in both positive and negative directions, is increasing in both s and the negative returns to scale η.

To close the model, let the E measure under regime R be given by the negative externality arising from the pollution over the same period and in regime M be the expected future negative externalities at horizon n:

$$
\begin{aligned}
E_{i,t}^R &= -D_{i,t,0}^e, \\
E_{i,t}^M &= \mathbb{E}_t[-D_{i,t,n}^e].
\end{aligned}
\tag{2.15}
$$

Now that we have characterised the equilibrium for any regime, let us in the next subsection analyse the impact from moving from the backward-looking R regime to the forward-looking M regime.

2.2.4 Benefits of a Forward-looking Measure: Theory

Based on the model presented above, the benefits of a forward-looking market-based measure relative to a backward-looking subjective rating can be summarised as follows:

i. The lower noise in the market-based measure M relative to the ratings-based measure R increases the marginal benefit in Equation 2.13 and hence decreases the negative externality in equilibrium. Additionally, it leads investors to better allocate their capital to higher impact firms.

ii. Under the ratings-based measure R, cheap talk increases the negative externality level in equilibrium and worsens investors' ability to allocate their capital to higher impact firms.

iii. A continuous measure relative to a threshold-based rating leads investors to better allocate their capital to higher impact firms.

iv. Sustainability-linked pay increases the marginal benefit in Equation 2.13 and hence decreases the negative externality in equilibrium, and more so using measure M.

Now we will explain each of these in more detail:

i. Noisy Ratings Decrease Impact and Increase Misallocation. Let the realised E_i^R score be the target score E_i, plus a realisation of a log-normally distributed noise term σ^R. The marginal cost is the same as it is based on the targeted score, however the marginal benefit will change to

$$MB_i^M \exp\left(-\frac{1}{2}\sigma^{R^2}\right),$$

where MB_i^M is the marginal benefit without noisy ESG ratings.[7]

The new equilibrium score will then be

$$E_i^R = E_i^M \exp\left(-\frac{1}{2}\sigma^{R^2}\right)^{\frac{-1}{\frac{1}{\eta_i}-s}}.$$

Hence, the noisy scores reduce aggregate impact (across all horizons) by

$$\frac{I_{i,t}^{M,R}}{-D_{i,t}^M} = \exp\left(-\frac{1}{2}\sigma^{R^2}\right)^{\frac{-1}{\frac{1}{\eta_i}-s}}.$$

Additionally, the noise and bias leads to an attenuation effect, which increases the misallocation of capital by

$$\tilde{I}_{t,n}^{M,R} = |\epsilon^R| + |\epsilon_{bias}^R| - |\epsilon^M|,$$

where ϵ_{bias}^R is given by

$$\epsilon_{bias} = \left(1 - \frac{var[M]}{var[M+\epsilon_M]}\right)\beta D_{i,t,0}^{\mathcal{M}},$$

where $var[M]$ in turn is the variance in the population of measure M, ϵ_M is the measurement noise of measure M, and β is the true beta between the R measure and realised emissions.

ii. Cheap Talk Decreases Impact and Increases Misallocation With cheap talk a firm i can increase their score by using cheap talk $T_{i,t}$ in addition to spending money $B_{i,t}$ on decreasing the externality as before. Specifically, let θ represent the importance of

[7] Derivation in Appendix 2.B.

the impact budget relative to cheap talk in terms of the achieved ESG rating and k_i and η_i remain as previously defined, then the production function $F_i(.)$ becomes

$$E_{i,t} = \frac{1}{k_i}(B_{i,t}^{\theta} T_{i,t}^{1-\theta})^{\eta_i}.$$

Given an optimal budget mix of cheap talk and real impact by the firm, the cash dividends become

$$D_{i,t,0}^{c}(E_{i,t}) = D_{i,t,0}^{c,0} \exp\left(-k_i' E_{i,t}^{1/\eta_i}\right),$$

where $B_{i,t}'$ is the total spent on impact $B_{i,t}$ and cheap talk $T_{i,t}$. With a k_i' which is

$$k_i \left(\frac{1}{\theta}\right)^{\theta} \left(\frac{p_T}{1-\theta}\right)^{1-\theta},$$

where p_T is the cost of cheap talk relative to impact. Hence, the new equilibrium rating will be

$$E_i^R = E_i^M \frac{k_i'}{k_i}^{\frac{-1}{\frac{1}{\eta_i}-s}}.$$

Additionally, the share spent on impact is reduced by a factor of θ^{-1} as the rest of the expenditure is spend on cheap talk. The effectiveness of the rating is therefore decreased by

$$\theta^{-\eta_i}.$$

Hence, going to a forward-based measure could improve impact by the impact lost from cheap talk, which is

$$\frac{I_{i,t,0}^{M,R}}{-D_{i,t}^{M}} = 1 - \theta^{-\eta_i} \frac{k_i'}{k_i}^{\frac{-1}{\frac{1}{\eta_i}-s}}.$$

Misallocation is in turn increased from cheap talk by

$$\frac{\tilde{I}_{t,n}^{M,R}}{D_{i,t}^{M}} = 1 - \theta^{-\eta_i}.$$

Derivations are in Appendix 2.B.

iii. Threshold-based Investment Increases Misallocation. With $\underline{E}$ as the threshold score for investors to invest into firm i, the discount rate on firm i becomes:

$$r^c = \beta_M r_M - \mathbb{1}_{E > \underline{E}}.$$

The marginal benefit becomes a Dirac delta function around $E = \underline{E}$ with magnitude

$$sE_i^{-1}\,\mathbb{E}_t\left[\frac{D_{i,t,1}^{c,0}\exp\left(-k_iE_i^{1/\eta_i}\right)}{\exp\left(\beta_i^M r_{t+1}^M - s\right)}\right].$$

As the marginal benefit is zero everywhere else, the equilibrium ESG level has to be either $\underline{E}$, or 0, otherwise the cost can be reduced by lowering E towards zero without giving up any benefit.

Next, let the realised ESG rating E^R be equal to E plus some noise ϵ^R. Those firms with a large positive realised error term will now have a rating markedly above the threshold, however when taking the expectation of the next period that expectation will be the threshold. For these firms, the expectation of the next period's ESG score will be lower than their current score. At the same time those firms with a negative realised error will now have a low rating, but in expectation have a higher rating next period. All in all, this implies that those firms which have "overshot" in terms of impact and rating will actually in expectation reduce their impact next period, instead of increasing it. As a result, thresholds-based ratings will lead to investors misallocating capital to firms which go on to pollute more, not less. This misallocation is given by

$$\tilde{I}_{t,n}^{M,R} = |\epsilon^R|.$$

iv. Sustainability-based Pay Increases Impact. To see this consider a manager m of firm i who receives a fixed salary S plus compensation compared to the final dividends of the firm by a fraction k^I and may also be compensated with a bonus based on how sustainable the firm is by a fraction k^E. The bonus is given as a κ ratio increase in his salary from cash dividends. The value of this salary corresponds to relating the first compensation onto the stock price $P_{i,t}$ of the firm i at time t and the second onto the external value of the firm. Hence, his marginal benefit of decreasing the external dividend increases by κ, which will lead to a higher equilibrium impact. Specifically, for the extreme case of no green sentiment the impact increases by

$$I_{i,t,0}^{M,R} = \left(\frac{\kappa}{k_i}\right)^{\frac{\eta_i - 1}{\eta_i}}.$$

Derivation in Appendix 2.B.

2.3 Introducing Emission Futures

To improve the measurement of the external value of the firm ($V_{i,t}^E$ in Equation 2.1) we argue for the introduction of a new financial asset, what we term an "emission futures" contract. We envision an emission future as a standardized firm-specific or index-level contract. Much like a dividend futures contract, at maturity, the buyer pays the futures price, which is determined today, and the seller pays the dollar value of emissions of the underlying firm(s), indexed by i. This emission dollar value to be paid for firm i at time t, denoted $D_{i,t}^e$, is computed as the product of the quantity of CO2 emissions $e_{i,t}$ during a certain calendar year and the daily average carbon price during that calendar year, which is the same across all firms:

$$D_{i,t}^e = e_{i,t} P_t^e. \tag{2.16}$$

Take for example the 2026 Shell emission futures contract. On the third Friday of December 2026, the buyer of the futures contract will pay the futures price, and the seller will pay the emission value $D_{i,t}^e$ which is computed as the product of (1) Shell's scope 1 (and potentially scope 2) CO2 emissions between the third Friday in December of 2025 and the third Friday of December of 2026 and (2) the average daily ETS carbon price in 2026. The contract is settled based on the sum of all emissions throughout the year, and there is no compounding or discounting within the year provided for in the contract.[8]

Let $g_{i,t,n}$ denote the average per-period expected growth rate of firm i's emissions value over the next n periods:

$$g_{i,t,n} = \frac{1}{n} \mathbb{E}_t \left[\ln \left(\frac{D_{i,t+n}^e}{D_{i,t}^e} \right) \right]. \tag{2.17}$$

Then the present value $\mathcal{P}_{i,t,n}$ of $D_{i,t+n}^e$ is given by:

$$\mathcal{P}_{i,t,n} = D_{i,t}^e \exp\Big(n(g_{i,t,n} - \mu_{i,t,n}) \Big), \tag{2.18}$$

which defines the (geometric) discount rate $\mu_{i,t,n}$ for firm i's emissions. By splitting the discount rate into the nominal bond yield for period n, denoted by $y_{t,n}^b$, and a firm-specific, horizon-specific emissions risk premium $\theta_{i,t,n}$ that compensates investors for the emission

[8] In practice, futures contracts require a sufficient volume to get listed by an exchange, which is why we propose to start with a contract on the SP500 as well as the largest polluters for a few horizons, such as 1, 2, and 5 years. In comparison one exchange currently offers contracts on 352 individual firms for maturities of 3, 6, and 12 months. As emissions are concentrated around a few firms, offering contracts on just 58 (10) firms would cover 90% (55%) of total emissions. Once sufficient volume has been established, more firms could then be added.

risk for maturity n of firm i, we can rewrite equation (2.18) as:

$$\mathcal{P}_{i,t,n} = D^e_{i,t}\exp\left(n(g_{i,t,n} - y^b_{t,n} - \theta_{i,t,n})\right). \tag{2.19}$$

The emissions yield for firm i at time t with maturity n is then defined as:

$$y_{i,t,n} \equiv \frac{1}{n}\ln\left(\frac{D^e_{i,t}}{\mathcal{P}_{i,t,n}}\right) = y^b_{t,n} + \theta_{i,t,n} - g_{i,t,n}.$$

The expression above shows that the emissions yield consists of three components. It consists of the nominal bond yield $y^b_{t,n}$, a maturity-specific and firm specific risk premium $\theta_{i,t,n}$ that investors require for being exposed to emissions risk, and the expected growth rate of the emissions value $g_{i,t,n}$, which represents the average expected log growth over the next n periods. Ceteris paribus, a higher expected growth rate makes the price $\mathcal{P}_{i,t,n}$ higher compared to the current emissions value $D^e_{i,t}$. This results in a lower emissions yield.

While in principle, emission value contracts could be traded in the spot market, we propose to have them traded in futures markets, much like other traded commodities. Under no arbitrage, the spot price and the forward price ($\mathcal{F}_{i,t,n}$) are linked through the nominal bond yield:

$$\mathcal{F}_{i,t,n} = \mathcal{P}_{i,t,n}\exp(ny^b_{t,n}). \tag{2.20}$$

We then define the forward emission yield $y^f_{i,t,n}$ as:

$$y^f_{i,t,n} \equiv \frac{1}{n}\ln\left(\frac{D^e_{i,t}}{\mathcal{F}_{i,t,n}}\right) = \theta_{i,t,n} - g_{i,t,n}. \tag{2.21}$$

The forward emission yield is equal to the difference between the risk premium and the expected emission value growth rate. If the forward emission yield is high, this either implies that risk premia are high or that expected emission value growth rates are low. Lastly, we define the one-period dollar change on the forward as:

$$R^{\$}_{i,t,n+1} \equiv \mathcal{F}_{i,t,n} - \mathcal{F}_{i,t-1,n+1}. \tag{2.22}$$

As we will discuss further below, so far, the variation in the emissions values has had a relatively low correlation with other financial market returns, implying that the risk premium on these assets is likely going to be low with little variation. As such, the forward emission yield will be a forward-looking, market-based measure of expected environmental impact (See Figure 2.5). The higher the yield, the more the market expects the firm to cut its emission values. As such higher yields (or improvements thereof) can be directly translated into higher environmental impact ratings.

It is important to emphasize that emission futures are firm, time and horizon specific, which are all important ingredients for effectively measuring environmental progress. In particular, the horizon dimension allows investors to take a stance on the particular horizon over which they think firms will be able to cut their emission values. These market-based horizon-specific expectations can then be compared with the promises made by the firm's management.

The price of emision futures is not only determined by the expected growth path of the emissions value ($g_{i,t,n}$) but also by the risk premium. It is worth discussing what the likely properties of this risk premium will be. First, the CAPM beta of emissions is insignifiant for most firms, and seems to be negative on average. This suggests that on average, we should expect the risk premium to be small and, if anything, negative. What about the cross-sectional variation? Standard asset pricing theory suggests that firms that cut their emissions in bad (good) times, which means that the futures contract has a negative (positive) return, will have a high (low) risk premium ($\theta_{i,t,n}$) and thus a higher (lower) emissions yield, as this yield is the difference between the risk premium and the expected path growth of emissions ($g_{i,t,n}$).

We should wonder whether the risk premium properties described above are desirable in the context of an emissions rating, which is equal to the emissions yield. First, if the only reason firms cut emissions in bad times is because they produce less in bad times, then assigning firms with a higher score for that reason does not seem all that desirable. On the other hand, if it is easier for firms to invest and apply technology that lowers emissions in good times than in bad times, then the firms that are able to cut emissions in bad times indeed deserve a higher rating. Note further that alternatively we could base the scoring on the changes in the emissions yield. In that case the level of the risk premium is differenced out and it is the properties of the *changes* in the risk premium that we should then better understand.

2.4 New Measures

The assets that we have just introduced can be used to measure a firm's future sustainability plans and outcomes relative to the markets expectation. Specifically, we propose the following novel environmental and impact measures. These measures are firm and horizon specific. The first one is the E measure given from the futures price of the emission dividend strip $\mathcal{F}_{i,t,n}$ as

$$\mathcal{E}_{i,t,n} \equiv -\mathcal{F}_{i,t,n}. \tag{2.23}$$

As it is based on the negative of the futures contract price it accurately reflects the market's (risk-neutral) belief of the future value of the emissions of firm i at a time n periods in the future. Under the assumption that the risk-premium is small, this will be equal to the objective belief.

Where the Environmental Rating accurately displays the firms with the lowest future carbon externality.[9] Another way to invest is to actively work to decrease firms expected carbon emissions, so called Impact Investing. Where as investing in low-carbon firms relies on the price-channel to incentivize green firms to grow and brown to shrink, our empirical work, as well as other studies, suggests this effect either does not work, or is an inefficient method. Hence, investing in a way that efficiently creates impact is preferable, so called "impact investing".

We propose a natural measure for impact investing, which reflects how much the firm has decreased its emissions at a given horizon, compared to what was the market previously expected for that firm. Specifically, for the one year horizon, this will be if the firm reduced its emissions relative to the market expectations. For longer horizons, the impact measure will reflect the extend to which firms can plausibly commit to lowering emissions in the future. That is if the market price at that horizon drops this is an indication that the investors do not view the firm's commitments as cheap talk. Green impact is simply defined using the dollar return on a n period emission future at date t on firm i, $R^{\$}_{i,t,n}$, as

$$\mathcal{I}_{i,t,n} \equiv -R^{\$}_{i,t,n}. \tag{2.24}$$

The equation above shows that green impact reflects how the (risk-neutral) expectation of firm i's emissions at horizon n has changed relative to the price was last year.

Our new firm measures can also be used to create new fund measures for a fund j who owns stocks i with ownership shares $w_{j,i,t}$. The fund's E and green impact measures are

[9] Alternative scores are given in Appendix 2.A.

given as

$$\begin{aligned}\mathcal{E}_{j,t,n} &= \sum_i w_{j,i,t}\mathcal{E}_{i,t},\\ \mathcal{I}_{j,t,n} &= \sum_i w_{j,i,t-1}\mathcal{I}_{i,t,n}.\end{aligned} \tag{2.25}$$

Hence, an improvement in the fund's E measure can be achieved in one of two ways. First, by changes in the underlying firms' E measure (the futures prices), and secondly, by decreasing the ownerships shares in the polluting firms. However, a fund's I measure will be given by the dollar return on the underlying firms futures prices weighted by the funds ownership share in the previous period, so this return is entirely driven by the futures prices as the weights remain fixed.

Like with the firm level ratings, the fund level E measure will be fine for passive funds and by following the E measure you would be accurately investing into the firms that would have the lowest emissions going forward in expectation, however mutual funds can outperform on this measure if they are better at predicing which firms will reduce their emissions by more than the markets expectations implied. This outperformance is captured by the fund level green impact measure. If investors choose to base the flow-performance relationship on this outperformance measure more investable capital will be allocated to greener stocks, also going forward.

2.5 Empirical Analysis

In this section we test whether current ratings have been successful in reducing carbon emissions. First we test whether backward-looking ratings are effective in predicting future emission reductions. A hypothesis that we reject. In fact, higher scores are more likely to predict increases rather than decreases in emissions. Second, if the current backward-looking ratings are useful we should see that social capital has decreased emissions. Specifically, we test whether the recent increase in social capital has decreased emissions relative to previous periods with less social capital and we test whether increases in social capital in the cross-section are associated with higher emission decreases. What we see is that social capital has not been a driving force in reducing emissions neither in the time series nor the cross-section.

2.5.1 Data

To construct our dataset of firms' impact we use the Compustat database merged with carbon emission data from Refinitiv. For the cheap talk analysis we use ESG scores from Sustainalytics and we count word usage from firms' SEC filings using WRDS.

The amount of assets invested using ESG principles has been growing rapidly over the last decades as evidenced by Figure 2.1. Figure 2.1 shows that socially invested capital has increased ten-fold from 2007 to 2020. Assets invested under ESG principles now exceeds USD 120 trillion. At the same time, we have seen a decrease in the average emissions per firm (See Figure 2.1).[10] These observations show that firms have reduced their emissions. However, this may be arising from a secular trend, indeed Figure 2.7 in Appendix 2.C shows that emissions relative to GDP has been decreasing since the 1920's. Hence, to understand social capital's role in impacting the emissions of firms we dive deeper in the next sections.

[Figure 2.1 about here.]

2.5.2 Results

Effect of Higher ESG Scores. This subsubsection goes on to evaluate whether higher scoring companies are driving environmental impact. As social capital attempts to achieve impact by investing into high ESG firms this is a requirement for real impact.

To evaluate the scores' impact we conduct a Granger causality test of whether higher E scores lead to lower emissions in the future, in excess of what the emissions today would predict. As seen in Table 2.1 Columns (1) and (2) E scores do not predict impact as measured by emissions. Columns (3) and (4) in fact shows the reverse to be the case. Namely, that if you reduce your emissions you increase your future E score. This also suggests the ESG scores to be backward looking, rather than forward looking. Panel B confirms the results using E scores from Refinitiv instead of Sustainalytics.

Additionally, we can get an estimate of the impact potential from going to a forward-looking score by considering how much predictive power the current scores give. To get such an estimate we can subtract the R^2 of Table 2.1 Column (2) from Column (1), which is indistinguishable from zero, hence giving the highest impact potential possibly for a forward-looking score.

[10]This is also the case if we instead consider the asset weighted total emissions, as depicted in the right side of Figure 2.8 in Appendix 2.C. We also see the same development if we consider emission intensities, meaning emissions over revenue, as shown in Figure 2.9 in Appendix 2.C.

[Table 2.1 about here.]

Social Capital and Impact in the Time Series. To test whether social capital has lead to real impact, we estimate a Granger causality regression of CO_2 emissions on past emissions and the amount of socially invested capital. As emission reductions may take a while to materialize, we do this at horizons of one to five years by sequentially adding an additional lagged variable. We evaluate the likelihood of social capital having lead to real impact using the tests' t-statistic. For this to be likely we need the statistic to be negative and the magnitude large. Generally a value higher than 1.96 is seen as the lowest bar to conclude that there may be an effect.The maximum of these t-values is depicted in Figure 2.2 for each horizon. We see that the effect is never significant for any horizon, even becoming positive at higher horizons. The regressions underlying this figure are shown in Table 2.2.[11]

[Figure 2.2 about here.]

[Table 2.2 about here.]

Social Capital and Impact in the Cross-Section: Effect of Being in a Social Index. In this subsubsection we evaluate social capital's impact using a second approach, namely using inclusions to a social index. We do so by considering what happens to firms' emissions after they are included in the social index, driving an inflow of social capital to the firm. Figure 2.3 shows the evolution in the emissions of firms either in the social index or outside it. While for firms in the index the average emissions have remained stable at around 2.5 million tons CO_2 equivalents, for firms outside of the index this has dropped by 10 million tons from around 12 to 2 million tons CO_2 equivalents. This shows that the reduction in emissions have generally come from firms not in the social index.

To understand how firm emissions adjust around index inclusions we in Figure 2.4 show emissions for firms from five years before and after inclusion relative to the firms lifetime emissions controlling for average emission changes year-to-year. What we can see is that firms who enter the social index lower their emissions at around three years before inclusion to below their lifetime average. After inclusion, the firms' emissions increase rapidly and two years after inclusion they are back at to their baseline. At 3 years and

[11] An intuitive confirmation of this finding can be seen by simply plotting emission growth by ESG asset growth, either lagged or concurrent. Figure 2.10 in the Appendix shows there exists an insiginificant relationship between these two variables, if anything there is a concurrent weakly significant *positive* relationship.

above they emit more than they usually do, an increase that continues to rise at time goes on.[12]

An alternative explanation is that the decreases in emissions have been driven by the benefits from inclusion. To test this we compare the time series emission reductions of firms who have the possibility to enter a social index versus firms who can never join the index due to being in an industry that is excluded from the index, so called “sin” firms. Correspondingly, we label ordinary firms “saint” firms. These results are shown in Figure 2.12 in the Appendix. Here we see in Panel A that the CO2 emissions have been lowered for both saint and sin firms. Panel B shows the year-on-year change in percent rather than total emissions and the evolution is similar across the two types of firms. Panel C cumulates the CO2 changes and we see that the cumulated changes for saint and sin firms are not significantly different at any point in our sample.

As depicted in Table 2.3 we see in Column (1) that firms in the index generally have lower emissions as expected. Column (2) shows this is also the case in relative terms. However we see in Column (3) that after firms are included, they increase their emissions. Column (4) shows that this is also the case in relative terms. Column (5) and (6) repeat the same result but with the baseline being not in the index compared to being in the index.

Table 2.5 in Appendix 2.C shows that the effects are the same across specifications. Specifically, Column (1) and (2) repeat results from the previous table. Column (3) shows results including firm and time fixed effects- Column (4) includes a variable for the year of inclusion showing a similar sized effect for the inclusion year, but higher when having year fixed effects as in Column (5). For both firm and time fixed effects (Column 6) we lose power for the inclusions and it is no longer significant. Table 2.6 in Appendix 2.C shows the effect to be the same for the first, second, and third year ahead. Simply accumulating the increase in emissions. Even columns include an inclusion dummy and Columns (1-6) are relative changes where as Columns (7-12) are absolute changes. The change is stable at 2% increase per year.

These results suggest that social capital has not been driving impact. In fact the arrival of social capital seems to have lowered impact.

[Figure 2.3 about here.]

[Figure 2.4 about here.]

[12] Figure 2.11 in the Appendix shows this finding in terms of changes in the emissions instead of absolute emissions.

[Table 2.3 about here.]

Emission Future Betas. We plot the emission beta estimates for each firm in our sample in Figure 2.5. In the first columns (Panels A and C) we have results for the beta with respect to purely emissions and in the second columns (Panels B and D) we have results for the beta with respect to emission futures, which are the emissions times the price of carbon emissions. In the top row the betas are plotted and in the bottom row the t-stats of the betas are plotted. The beta means how much the emission changes or changes in the value of a firm's emission future co-varies with the market return. Panel A shows that the betas are closely clustered around zero and while some t-stats are significant this is what we would expect from the type-1 error rate corresponding to the level of significance. Panel B shows that the betas related to the emission futures are more widely distributed, however their t-stats are equally insignificant. Overall, there is no evidence that the betas of emission futures should be significantly positive or negative.

[Figure 2.5 about here.]

Cheap Talk. As we have seen that social capital does not seem to be impactful we explore whether so-called 'Cheap Talk' may be driving ESG scores. This would lead to social capital being less effective in driving impact. Panel A in Figure 2.6 shows how cheap talk has increased over time. We see that that the use of the word 'Sustainability' has increased exponentially over the last two decades starting close to zero and ending at over two thousand mentions per firm per year in their official investor communications. Panel B shows the cross-sectional distribution and we see that there is quite a wide range of yearly mentions per firm. As this has been increasing over time we also display the cross-sectional distribution subtracting the time-series effects in Panel C and see that there tends to be two groups of firms: some that mention Sustainability about a thousand times more than the average and another group that mention it a thousand times less.[13]

We conduct a Granger causality test of cheap talk on ESG scores in Table 2.4. Here we see that the word frequency of Sustainability increases the future ESG scores in excess of what the current ESG score as well as impact would predict.[14] Table 2.4 also shows the equivalent Granger causality tests on cheap talk and impact in Panel B and C respectively. We see in Panel B that cheap talk does not lead to impact and in Panel C that getting a higher ESG score makes you do more cheap talk.

[13]Figure 2.13 in Appendix 2.C shows the same for the word 'ESG' for which we see the same results.

[14]Table 2.7 in Appendix 2.C shows the same for several words and show that several have affect but 'Sustainability' is the most effective.

From Table 2.8 in Appendix 2.C we can see that the elasticities of cheap talk to impact is 0.73 meaning you have to mention 'Sustainability' 0.73% more to pollute 1% more and achieve the same E score. This decreases to just 0.13% for ESG scores. In absolute values this is 17 words per 10 million tons CO_2 emitted.

[Figure 2.6 about here.]

[Table 2.4 about here.]

2.6 Conclusion

This paper proposes a new measure for the real impact of ESG investing. This increasingly popular way of investing has been hindered by rating systems that are inherently subjective, backward-looking, and hence inconsistent across rating issuers. In this paper, we have proposed a novel measure based on a novel financial instrument: firm and horizon-specific Emission Futures. These futures contracts are market-based and forward-looking. We argue that basing decisions on this measure increases the effectiveness of ESG investing relative to the status quo.

Our measure can also be used for social index construction as an index's impact is simply a weighted average of the forward-looking measure we propose. Another use case is that the new measure can be used to accurately evaluate previous classifications into green and impact funds. On top of being useful for sustainability-linked corporate managerial pay, it is useful for linking impact fund managers' pay to their real impact. A last benefit is the resources that can be saved from both the firms' side in attempting to prove sustainability results and in regulators' efforts to attempt to verify these firms' claims, which may be diluted by cheap-talk.

Our framework can be extended in various directions. First, it can be applied to any observable variable related to an externality (positive or negative), not just emissions (the S and G in ESG). Secondly, the framework may prove valuable for other asset classes other than stocks such as sustainability-linked bonds.

2.7 Figures and Tables

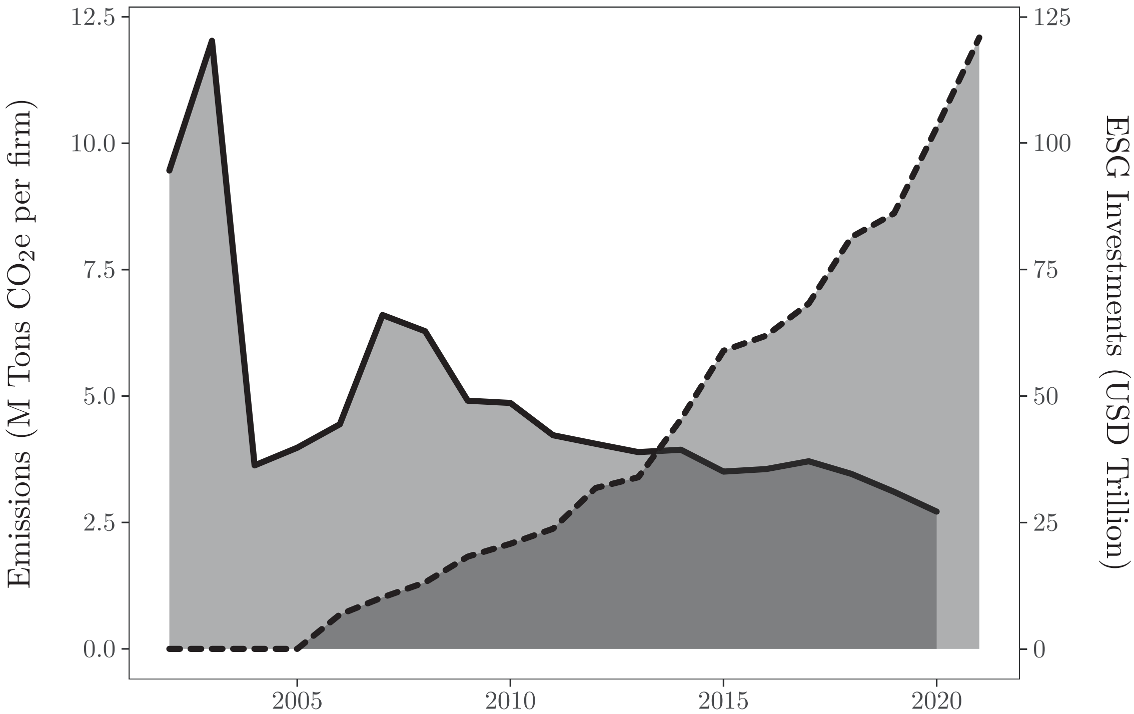

Figure 2.1: Emissions versus Socially Invested Capital

This figure plots the average emissions of firms over time as well as the amount of socially invested capital as reported by United Nations Principles of Responsible Investment. The CO2 emissions include direct CO_2 emissions.

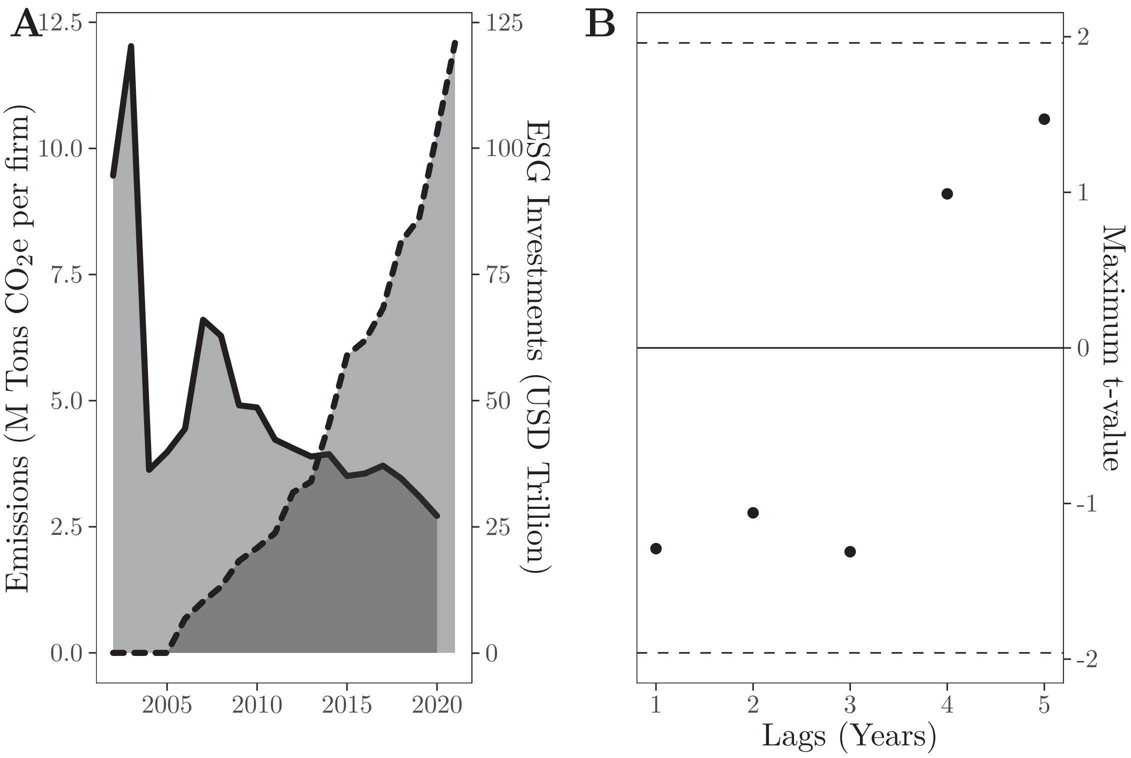

Figure 2.2: Social Capital's influence on Emissions from Granger Causality Tests

Figure's Panel A repeats Figure 2.1. Panel B plots the maximum t-value from a Granger Causality regression of the form $CO2_t = \sum_{t-n,t-1} AUM_{t-n} + CO2_{t-n} + \epsilon$ for n ranging from one to five years. AUM is the amount of socially capital invested as reported by United Nations Principles of Responsible Investment. The CO2 emissions include direct CO_2 emissions and is average per firm. The dotted lines indicate the threshold of significance at the 5% level.

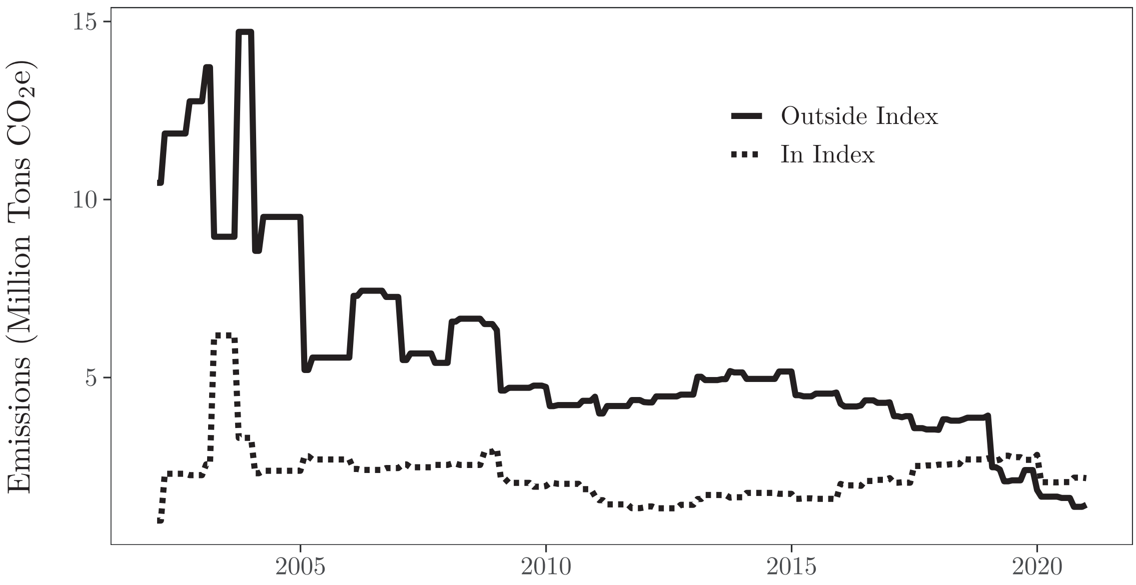

Figure 2.3: Index Effect in the Time Series

Figure shows how being in the Social Index are correlated with a firm's emissions. We see that the average emissions of the firms in the index has not changed since 2001. On the other hand we see that it is the firms outside the index that have decreased their emissions in this time period. Emissions are averages per firm. The emissions measure includes both direct and indirect emissions. However the figure is similar if we only consider direct emissions.

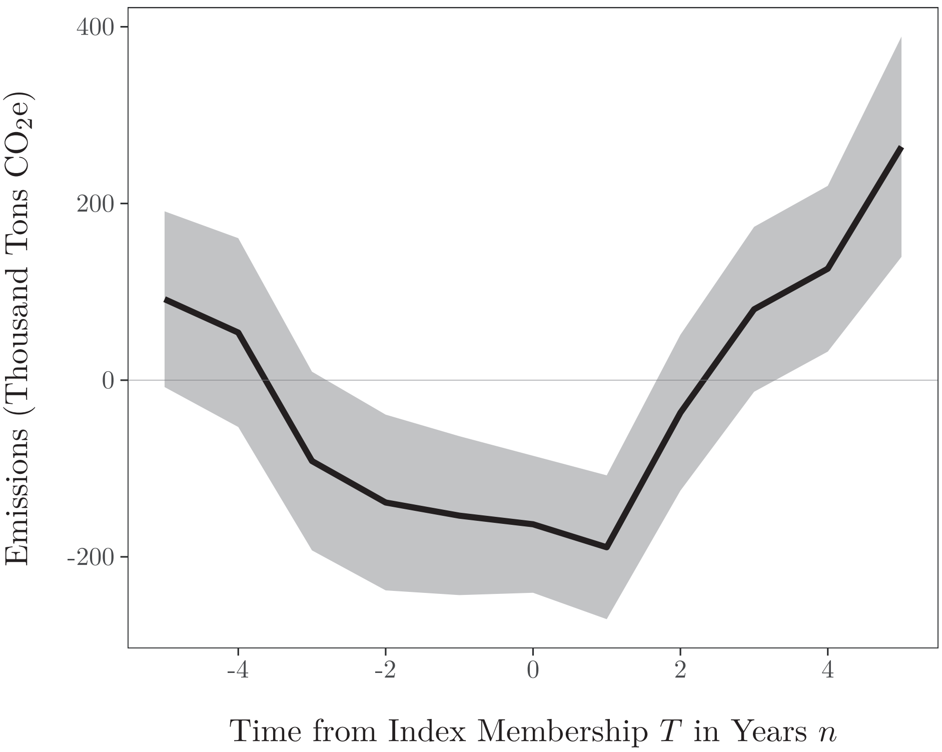

Figure 2.4: Index Effect in the Cross-section

Figure shows how emissions adjust before and after firms are admitted to the social index. Emissions is compared to firms' time and cross-sectional average by including firm and time fixed effects. Band signifies significance at 95% level. Standard errors clustered at firm-month.

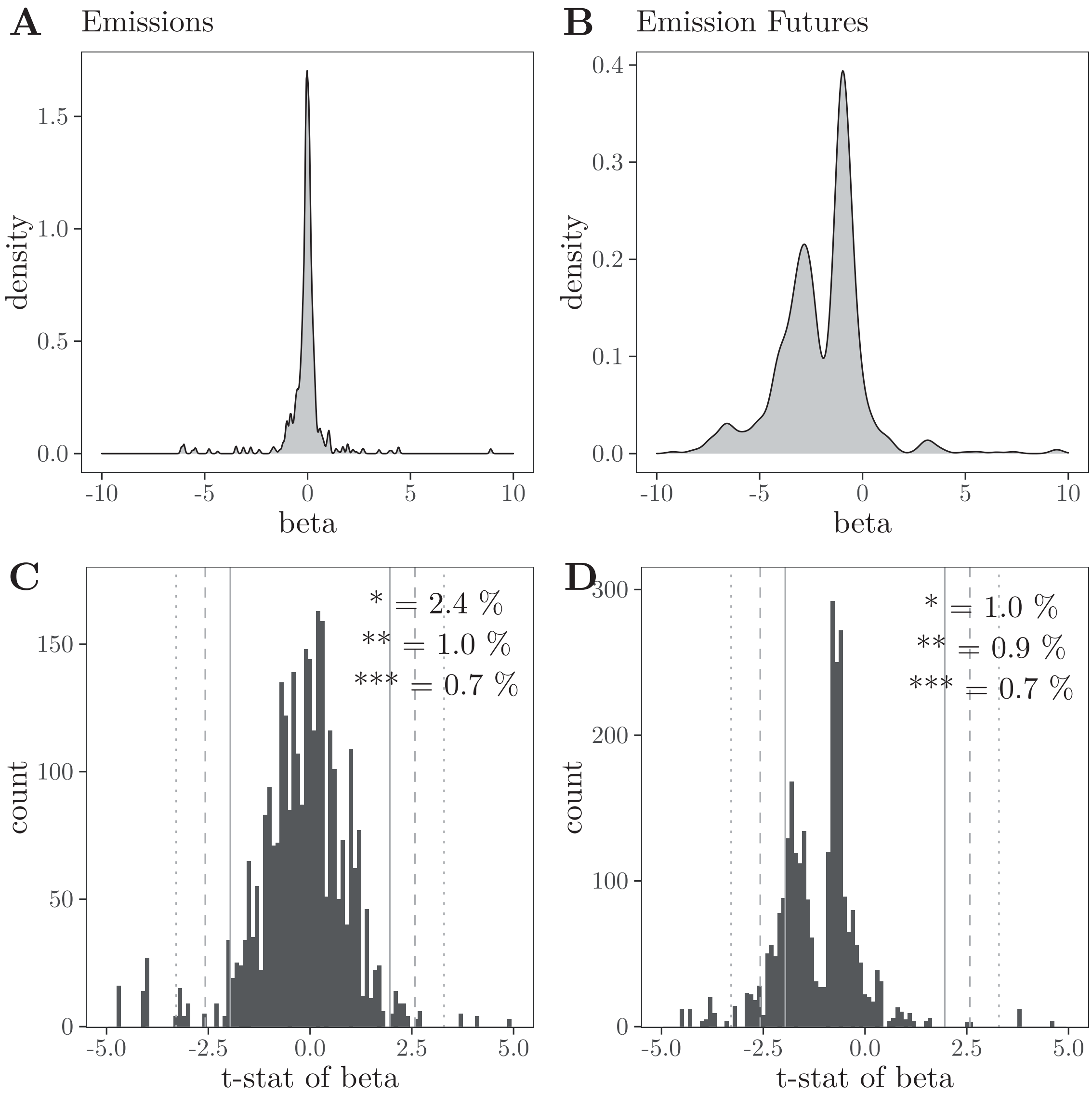

Figure 2.5: Carbon Emission Betas

This figure plots the carbon dioxide (CO_2) emissions and Emission Future betas with respect to the SP500. CO_2 is the percentage difference and the as the carbon price the carbon future price is used (expiry in December). Carbon price data from investing.com.

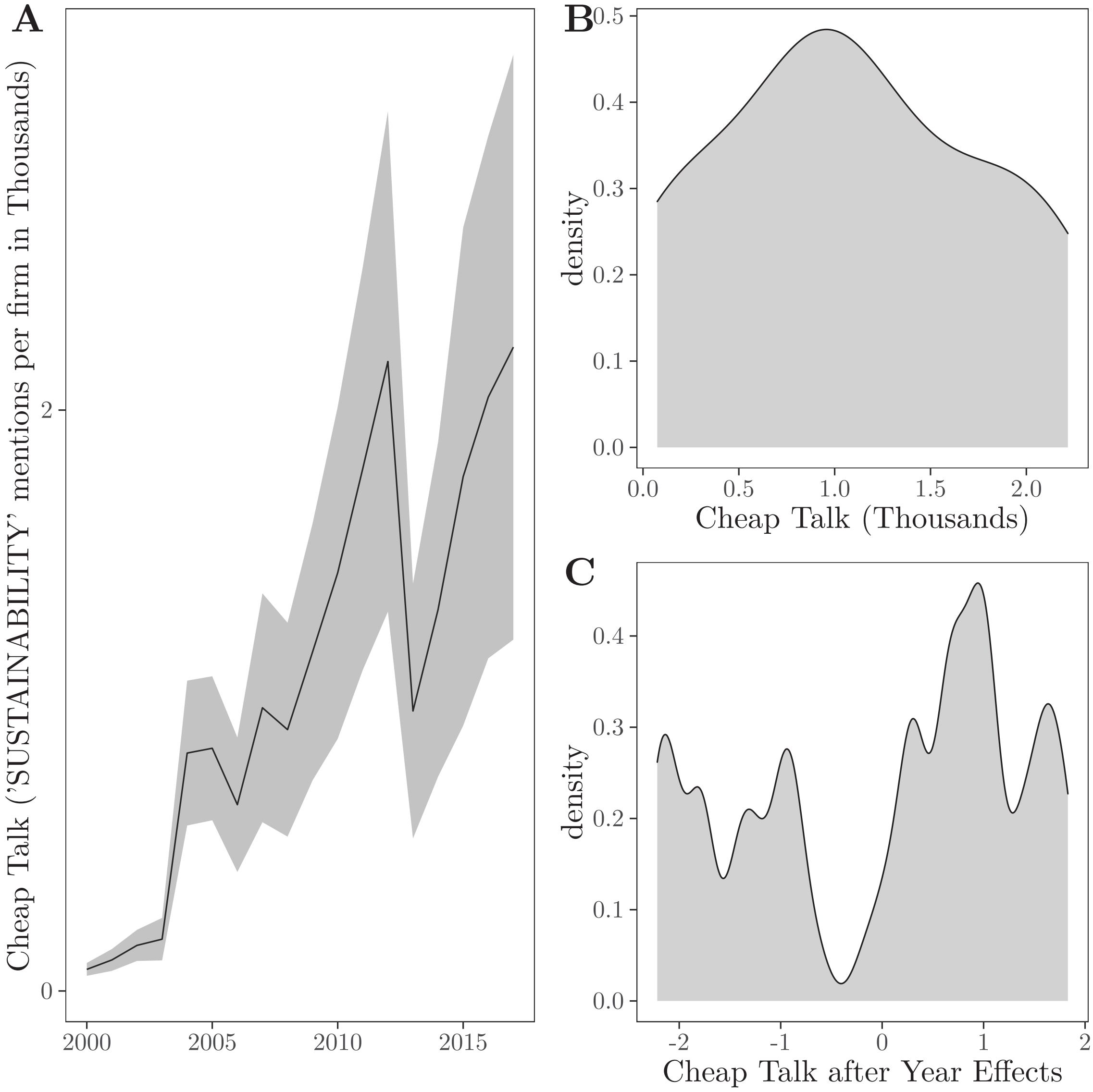

Figure 2.6: Cheap Talk in Time Series and Cross-section

Cheap talk is measured as 'ESG' mentions per firm in Thousands. Data from their public reports to the securities exchange commission. In Panel A grey area represents one standard deviation variation.

Table 2.1: Effect of ESG Scores on Impact: A Granger Causality test

Table shows the effects of ESG scores on impact. Specifically, it shows the output from a Granger causality test of emissions and environment scores on past emissions and environment scores. Panel A uses Refinitiv 'E' scores and Panel B uses Sustainalytics 'E' scores.

Panel A: With Refinitiv Scores

	Emissions next year (T Tons CO_2e)		E Score Next year (0-100)	
	(1)	(2)	(3)	(4)
E Score Current (0-100)		-1.48	0.92^{***}	0.85^{***}
		[-0.4]	[158.1]	[91.4]
Emissions Current (T Tons CO_2e)	0.97^{***}	0.97^{***}		-0.00^{***}
	[362.4]	[358.4]		[-3.9]
Constant	60.64	149.81	5.20^{***}	10.86^{***}
	[1.22]	[0.64]	[16.40]	[19.06]
Observations	2,334	2,334	4,881	2,470
R^2	0.983	0.983	0.837	0.778

Panel B: With Sustainalytics Scores

	Emissions next year (T Tons CO_2e)		E Score Next year (0-100)	
	(1)	(2)	(3)	(4)
E Score Current (0-100)		1.64^{*}	0.91^{***}	0.81^{***}
		[1.8]	[728.8]	[390.6]
Emissions Current (T Tons CO_2e)	0.96^{***}	0.96^{***}		0.00
	[719.8]	[717.2]		[0.02]
Constant	150.5^{***}	28.70	7.79^{***}	15.91^{***}
	[7.2]	[0.4]	[102.5]	[98.8]
Observations	45,271	45,240	100,044	47,708
R^2	0.92	0.92	0.84	0.76
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 2.2: Social Capitals Impact on CO2 Emissions in Time Series

Table shows how social capital has affected CO2 emissions of the firms in the economy. The regressions are Granger Causality regressions of the form $CO2_t = \sum_{t-n,t-1} AUM_{t-n} + CO2_{t-n} + \epsilon$ for n ranging from one to five years. AUM is the amount of socially capital invested as reported by United Nations Principles of Responsible Investment. The CO2 emissions include direct CO_2 emissions and is average across firm in a given year. Standard errors are robust standard errors with automatic type and lag length choice. T-statistics are shown in square brackets.

	Emissions in Million Tons CO_2e per firm at time t ($CO_{2,t}$)				
	Model 1	Model 2	Model 3	Model 4	Model 5
AUM_{t-1} (T USD)	−0.02	0.03	0.00	0.00	−0.01
	[−1.29]	[0.67]	[0.27]	[−0.06]	[−0.30]
AUM_{t-2} (T USD)		−0.07	0.01	0.03	0.05
		[−1.06]	[0.59]	[0.99]	[1.47]
AUM_{t-3} (T USD)			−0.03	−0.03	−0.03
			[−1.31]	[−0.75]	[−0.76]
AUM_{t-4} (T USD)				0.00	0.00
				[−0.12]	[0.09]
AUM_{t-5} (T USD)					−0.03
					[−1.18]
$CO_{2,t-1}$ (M Tons)	0.44	0.05	0.67***	0.38	0.18
	[0.74]	[0.15]	[5.87]	[0.59]	[0.32]
$CO_{2,t-2}$ (M Tons)		−0.06	0.00	0.05	0.41
		[−0.28]	[−0.17]	[0.10]	[0.81]
$CO_{2,t-3}$ (M Tons)			0.05’	−0.07	−0.57
			[2.06]	[−0.56]	[−1.48]
$CO_{2,t-4}$ (M Tons)				0.22	0.44
				[1.19]	[2.05]
$CO_{2,t-5}$ (M Tons)					0.04
					[0.26]
(Intercept)	2.83	4.94*	1.01	1.43	1.45
	[0.93]	[2.72]	[1.68]	[1.67]	[1.42]
Num.Obs.	18	17	16	15	14
R2	0.436	0.500	0.947	0.967	0.988

’ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.3: Index Effect in Cross-section

This table's Panel A shows how firms in the social index compares to firms outside of the index in terms of their emissions. Panel B shows how firms' emissions adjust while in the social index compared to outside of it Δ's are year differences. Column (1) is the absolute change and Column (2) is the relative fractional change.

	Panel A:		**Panel B:**	
	CO_2 (T Tons)	$\log(CO_2)$	$\Delta CO_{2,t,t+1}$ (T Tons)	$\Delta(\log CO_2)_{t,t+1}$
	(1)	(2)	(1)	(2)
Firm in Index	−2,480***	−23%***	69***	2.3%***
	[−28.9]	[−11.2]	[3.6]	[6.5]
Constant	4,645***	13.1***	−86***	−2.93%***
	[73.68]	[874.57]	[−6.25]	[−11.69]
Observations	41,508	41,508	37,056	37,056
R^2	0.02	0.003	0.0003	0.001
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 2.4: Effects of Cheap Talk on ESG Scores and Impact

Table considers how cheap talk by firms affects future ESG scores and impact. ESG Scores are considered in Panel A, and impact on carbon emissions in Panel B. Panel C considers whether firms with higher ESG scores do more cheap talk. Analyses take a Granger causality approach meaning they see if the dependent variable is predicted by lagged realisations of an independent variable in excess of its own lagged realisations.

Panel A:

	ESG Score Next Year			
	(1)	(2)	(3)	(4)
ESG Score This Year	0.818***	0.817***	0.813***	0.812***
	(0.012)	(0.012)	(0.012)	(0.012)
CO_2/Assets This Year		−0.0004***		−0.0004***
		(0.0001)		(0.0001)
SUSTAINABILITY Mentions This Year			0.014**	0.014**
			(0.006)	(0.006)
Constant	12.249***	12.428***	12.414***	12.584***
	(0.770)	(0.770)	(0.772)	(0.773)
Observations	1,505	1,505	1,505	1,505
R^2	0.747	0.749	0.748	0.750
Note:				*p<0.1; **p<0.05; ***p<0.01

Panel B:

	CO_2 over Assets Next Year		
	(1)	(2)	(3)
Word Mentions	−0.084		−0.108
	(0.175)		(0.177)
ESG Score		0.283	0.315
		(0.346)	(0.350)
CO_2/Assets	0.917***	0.917***	0.917***
	(0.005)	(0.005)	(0.005)
Constant	3.139	−15.463	−16.355
	(3.511)	(21.918)	(21.973)
Observations	1,158	1,158	1,158
R^2	0.965	0.965	0.965
Note:			*p<0.1; **p<0.05; ***p<0.01

Panel C:

	SUSTAINABILITY Mentions Next Year			
	(1)	(2)	(3)	(4)
CO_2/Assets	−0.0001			−0.0001
	(0.001)			(0.001)
ESG Score		0.149***	0.087*	0.086*
		(0.037)	(0.052)	(0.052)
Word Mentions	0.665***	0.573***	0.658***	0.658***
	(0.026)	(0.022)	(0.027)	(0.027)
Constant	4.378***	−4.439**	−0.982	−0.948
	(0.523)	(2.204)	(3.221)	(3.239)
Observations	1,219	1,766	1,219	1,219
R^2	0.342	0.306	0.344	0.344
Note:				*p<0.1; **p<0.05; ***p<0.01

Appendix

2.A Alternative Measures

2.1.1 Market Adjusted E Measure

An environmental score adjusted for the correlation with the market outcomes is given as

$$\tilde{\mathcal{E}}_{i,t,n} \equiv -\mathcal{P}_{i,t,n} exp(n\theta_{i,t,n}).$$

2.1.2 Market Adjusted Green Impact

The market corrected impact score is given as

$$\tilde{I}_{i,t,n} \equiv \mathcal{F}_{i,t-1,n} \exp(-\theta^{e}_{i,t-1,n}) - \mathcal{F}_{i,t,n-1}.$$

2.1.3 Green Impact per Dollar Measure

A green impact investor may be interested how to achieve the highest impact per dollar, in which case it would be

$$\mathcal{G}_{i,t,n} \equiv \frac{R^{\$}_{i,t,n}}{P_{i,t-1}}.$$

2.1.4 Emission Reduction Measures

A set of measures that capture expected CO_2 reductions are given by:

$$\mathcal{R}_{i,t,n} \equiv y^{f}_{i,t,n},$$
$$\tilde{\mathcal{R}}_{i,t,n} \equiv -g_{i,t,n}.$$

where the tilde ($\sim$) denotes a measure adjusted for correlation with the market.

2.B Derivations

2.2.1 Derivation of Optimal ESG Score

We have the following cash flow equation

$$D^c_{i,t}(E_{i,t}) = D^{c,0}_{i,t} \exp\Big(-B_{i,t}\Big(E_{i,t}\Big)\Big) = D^{c,0}_{i,t} \exp\Big(-k_i E^{1/\eta_i}_{i,t}\Big),$$

And cost of equity equation

$$r^c_{i,t} = \beta^M_i r^M_t - s\ln(E_{i,t}),$$

and optimality condition

$$D^{c'}_{i,t}(E_{i,t}) = \mathbb{E}_t\left[-r^{C'}_{i,t+1}(E_{i,t})\frac{D^c_{i,t+1}(E_{i,t+1})}{\exp\Big(r^c_{i,t+1}(E_{i,t})\Big)}\right].$$

Then start from Equation 2.13 repeated below for which it follows that

$$\underbrace{\frac{k_i E^{\frac{1-\eta_i}{\eta_i}} D^{c,0}_{i,t}}{\exp\Big(k_i E^{1/\eta_i}_{i,t}\Big)}}_{\text{Marginal cost}} = \underbrace{sE^{-1}_i\,\mathbb{E}_t\left[\frac{D^{c,0}_{i,t+1}\exp\Big(-k_i E^{1/\eta_i}_i\Big)}{\exp\Big(\beta^M_i r^M_{t+1} - s\ln(E_i)\Big)}\right]}_{\text{Marginal benefit}},$$

$$\begin{aligned}
k_i E^{\frac{1-\eta_i}{\eta_i}} &= sE^{-1}_i\,\mathbb{E}_t\Big[\exp\Big(s\ln(E_i) - \beta^M_i r^M_{t+1}\Big)\Big],\\
k_i E^{\frac{1}{\eta_i}} &= s\,\mathbb{E}_t\Big[\exp\Big(s\ln(E_i) - \beta^M_i r^M_{t+1}\Big)\Big]\\
&= sE^s_i\,\mathbb{E}_t\Big[\exp\Big(-\beta^M_i r^M_{t+1}\Big)\Big],\\
E_i^{s-\frac{1}{\eta_i}} &= \mathbb{E}_t\Big[\exp\Big(\beta^M_i r^M_{t+1}\Big)\Big]\frac{k_i}{s},\\
E^*_i &= \left(\mathbb{E}_t\Big[\exp\Big(\beta^M_i r^M_{t+1}\Big)\Big]\frac{k_i}{s}\right)^{1/(s-\frac{1}{\eta_i})},\\
E^*_i &= \left(\frac{k_i}{s}\exp\left(\beta^M_i \mu^M_t - \frac{1}{2}\beta^{M\,2}_i \sigma^{M\,2}_t\right)\right)^{\frac{1}{s-\frac{1}{\eta_i}}}.
\end{aligned}$$

As $\eta \in (0,1)$, and reasonable values for sentiment lie within $s \in (0,1)$ it means that

$$E_i^* = \psi\left(k_i, s, \beta_i^M, \mu_t^M, \sigma_t^M\right)^{\phi(s,\eta_i)},$$

where ψ is positive definite, and ϕ is negative definite.

This means that E will be decreasing in ψ with a strength determined by ϕ. Hence E_i^* is decreasing in k_i and μ_t^M, and increasing in s and σ_t^M. The market exposure β_i could be either. The strength of this effect is increasing in both s and η.

2.2.2 Derivation of Noisy Ratings Impact Decrease

Tet the realised E_i^R score be the target score E_i, plus a realisation of a log-normally distributed noise term σ^R. The marginal cost is the same as it is based on the targeted score, however the marginal benefit will change to:

$$sE_i^{-1}\,\mathbb{E}_t\left[\frac{D_{i,t,1}^{c,0}\exp\left(-k_i E_i^{1/\eta_i}\right)}{\exp\left(\beta_i^M r_{t+1}^M - s\ln(E_i^R)\right)}\right] \tag{2.26}$$

$$= sE_i^{-1}\frac{D_{i,t,1}^{c,0}\exp\left(-k_i E_i^{1/\eta_i}\right)}{\mathbb{E}_t\left[\exp\left(\beta_i^M r_{t+1}^M - s\ln(E) + \frac{1}{2}\sigma^{R^2}\right)\right]} \tag{2.27}$$

$$= sE_i^{s-1}\frac{D_{i,t,1}^{c,0}\exp\left(-k_i E_i^{1/\eta_i}\right)}{\mathbb{E}_t\left[\exp\left(\beta_i^M r_{t+1}^M + \frac{1}{2}\sigma^{R^2}\right)\right]} \tag{2.28}$$

$$= MB_i^M\exp\left(-\frac{1}{2}\sigma^{R^2}\right), \tag{2.29}$$

where MB_i^M is the marginal benefit without noisy ESG ratings.

2.2.3 Derivation of Cheap Talk Effects

Let E be governed by the Cobb-Douglas CES function:

$$E_{i,t} = (B_{i,t}^{\theta} T_{i,t}^{1-\theta})_i^{\eta}, \tag{2.30}$$

where θ signifies the importance of that factor in the production function.

We start by finding the optimal mix of impact and cheap talk to achieve ESG score E. For B and T to be in optimal proportions the marginal rate of substitution between B and T must equal the relative cost of B and T:

$$MRS = \frac{p_I}{p_T}. \tag{2.31}$$

We can find the MRS defined as $\partial T/\partial B$ by taking the ratio of $\partial E/\partial B$ and $\partial E/\partial T$ as

$$\begin{aligned} \frac{\partial E}{\partial B} &= \frac{\theta\eta}{B}(B^{\theta}T^{1-\theta})^{\eta} = \frac{\theta\eta}{B}E, \\ \frac{\partial E}{\partial T} &= \frac{(1-\theta)\eta}{T}(B^{\theta}T^{1-\theta})^{\eta} = \frac{(1-\theta)\eta}{T}BE, \end{aligned} \tag{2.32}$$

so

$$\frac{\partial T}{\partial B} = \frac{\theta}{1-\theta}\frac{T}{B} = MRS. \tag{2.33}$$

Hence

$$MRS = \frac{\theta}{1-\theta}\frac{T}{B} = \frac{p_I}{p_T} = \text{relative price}. \tag{2.34}$$

Solving for T gives

$$T = \frac{p_I}{p_T}\frac{1-\theta}{\theta}B. \tag{2.35}$$

The budget B' is defined as the sum of expenditures on impact and cheap talk:

$$B' = p_I B + p_T T \tag{2.36}$$

Substituting T into the budget equation, and solving for B, we get the optimal impact as

$$B^* = \frac{B'}{p_I}\theta. \tag{2.37}$$

Which we can rewrite to get the share of the budget spend on impact $(B^* p_I/B')$ as:

$$\frac{B^* p_I}{B'} = \theta. \tag{2.38}$$

Similarly we get

$$T^* = \frac{B'}{p_T}(1-\theta). \tag{2.39}$$

Hence the ratio is given by

$$\frac{B^*}{T^*} = \frac{\theta}{1-\theta}\frac{p_T}{p_I}. \tag{2.40}$$

We get the budget needed to achieve a score E by taking the ESG production function (Equation 2.30) and substituting in the equations for optimal impact and cheap talk (Equations 2.37 and 2.39), and solving for B':

$$B' = E^{1/\eta}\left(\frac{p_I}{\theta}\right)^{\theta}\left(\frac{p_t}{1-\theta}\right)^{1-\theta}. \tag{2.41}$$

Wlog we can normalise $p_{I,i,t+n} = 1$. Hence they do more impact, the higher θ is and the higher $p_{T,i,t+n}$ is (where the price of cheap talk now is relative to the price of impact), which may be firm specific. As a simplifying example consider if $p_{T,i,t+n} = 1$, here firms do most impact and less cheap talk if θ is above 0.5.

This means the cash dividends become

$$D^c_{i,t,0}(E_{i,t}) = D^{c,0}_{i,t,0}\exp\left(-B'_{i,t}\left(E_{i,t}\right)\right) = D^{c,0}_{i,t,0}\exp\left(-k'_i E^{1/\eta_i}_{i,t}\right),$$

where k'_i is the constant $k_i\left(\frac{1}{\theta}\right)^{\theta}\left(\frac{p_T}{1-\theta}\right)^{1-\theta}$.

It is useful to note that we can recover the version without cheap talk versus impact by setting $k'_i = k_i$.

Credability of Cheap Talk. Next we turn to the consequence of firms needing to be credible to ensure their ESG discount. As the investor is not interested in funding cheap talk the investors strategy is that they only give discount if the firm does not do cheap talk. They infer the firm does cheap talk if they are more than 95% sure their ESG score is from cheap talk. Both the firms cheap talk and impact is a signal.

Corollary 1 (Cheap Talk to Impact Ratio). *The largest cheap talk to impact ratio that they can have before losing benefit is*

$$\frac{T}{B} = 1.96\sqrt{\sigma_T^2 + \sigma_B^2}. \tag{2.42}$$

Proof. The signal the investor checks is larger than zero is

$$\frac{T}{B} = \frac{T}{E-T}. \tag{2.43}$$

And the noise, when uncorrelated, is

$$\sqrt{\sigma_T^2 + \sigma_B^2}. \tag{2.44}$$

So test is on

$$\frac{T/B}{\sqrt{\sigma_T^2 + \sigma_B^2}}. \tag{2.45}$$

Hence, the investor does not think the firm does cheap talk when [15]

$$\frac{T/B}{\sqrt{\sigma_T^2 + \sigma_B^2}} \leq 1.96. \tag{2.46}$$

So the largest fraction of cheap talk to impact that the firm can have before losing their benefit is

$$\frac{T}{B} = 1.96\sqrt{\sigma_T^2 + \sigma_B^2}. \tag{2.47}$$

■

2.2.4 Derivation of Sustainability-based Pay Impact Increase

Let the negative of the external value of the firm be the price of an emission future $\mathcal{P}_{i,t}$. Then his income Y is:

$$Y_{m,t} = S + k^I P_{i,t} - \mathcal{P}_{i,t} k^E P_{i,t}.$$

Divide through by k^I and introduce $\kappa = k^E/k^I$

$$Y_{m,t}/k^I = S/k^I + P_{i,t} - \mathcal{P}_{i,t}\kappa P_{i,t}.$$

The manager's objective is to maximise his income by choosing which ESG score $E_{i,t}$ the firm should aim for:

$$\max_{E_{i,t}} Y_{m,t} = \max_{E_{i,t}} Y_{m,t}/k^I.$$

Then by comparison to Equation 2.13 his costs versus benefits optimality condition becomes:

$$\frac{k_i E^{\frac{1-\eta_i}{\eta_i}} D_{i,t}^{c,0}}{\exp(k_i E_i^{1/\eta_i})} - \frac{\kappa D_{i,t}^{c,0}}{\exp(k_i E^{1/\eta_i})} = s E_i^{-1}\, \mathbb{E}_t \left[\frac{D_{i,t+1}^{c,0}(1+\kappa E_i)\exp\left(-k_i E_i^{1/\eta_i}\right)}{\exp\left(\beta_i^M r_{t+1}^M - s\ln(E_i)\right)} \right].$$

[15] Assuming a large number of observations. Which implies that the threshold is larger for younger firms.

$$k_i E^{\frac{1-\eta_i}{\eta_i}} - \kappa = s E_i^{-1} \, \mathbb{E}_t \left[\frac{1+\kappa E_i}{\exp\left(\beta_i^M r_{t+1}^M\right)} \right] E_i^s.$$

$$k_i E^{\frac{1-\eta_i}{\eta_i}} - \kappa = s E_i^{s-1} \frac{1+\kappa E_i}{\mathbb{E}_t \left[\exp\left(\beta_i^M r_{t+1}^M\right) \right]}.$$

An extreme case would be for the situation with no extra help from sustainability sentiment, $s = 0$, in that case it will be that

$$k_i E^{\frac{1-\eta_i}{\eta_i}} = \kappa,$$

and optimal E rating is

$$E_i^* = \left(\frac{\kappa}{k_i} \right)^{\frac{\eta_i - 1}{\eta_i}}.$$

Which means that the increase in impact from sustainability linked pay is

$$I_{i,t,0}^{R,M} = \left(\frac{\kappa}{k_i} \right)^{\frac{\eta_i - 1}{\eta_i}}.$$

2.C Additional Results and Robustness Tests

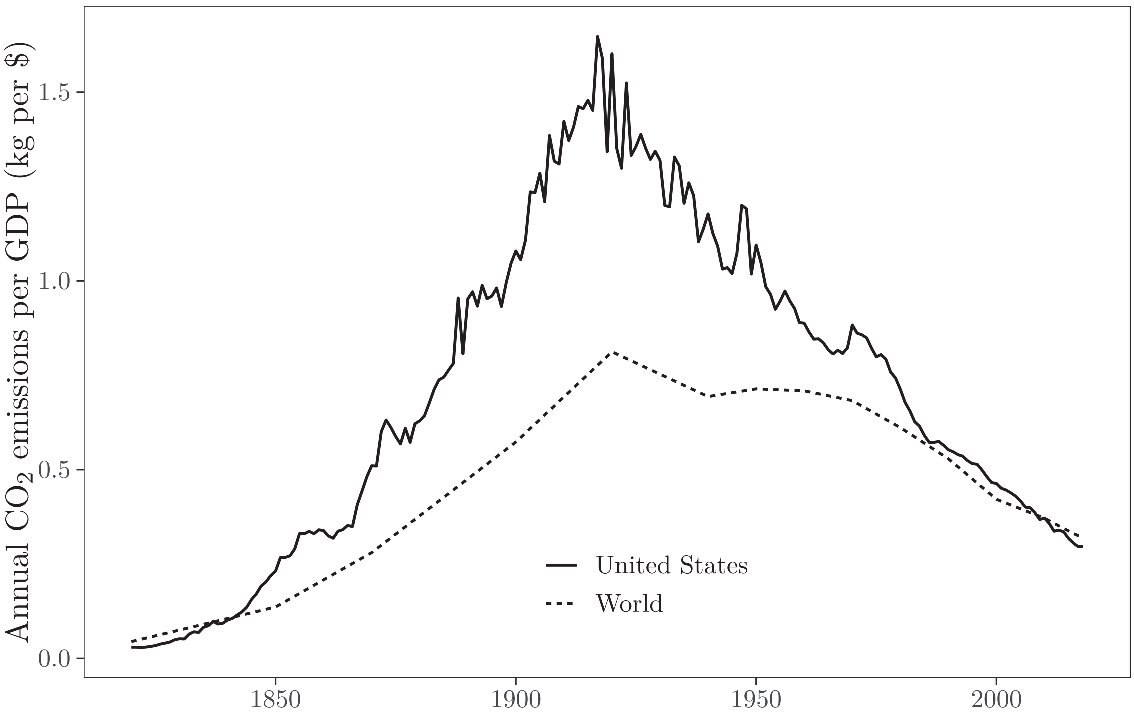

Figure 2.7: Carbon Emission Intensity Across the World

This figure plots the carbon dioxide (CO_2) emissions intensity of the United States and the World over time. CO_2 intensity measured in kilograms of CO_2 per $ of GDP (measured in international-$ in 2011 prices). Data from Global Carbon Project (Andrew and Peters, 2021) and Maddison Project Database 2020 (Bolt and van Zanden, 2020).

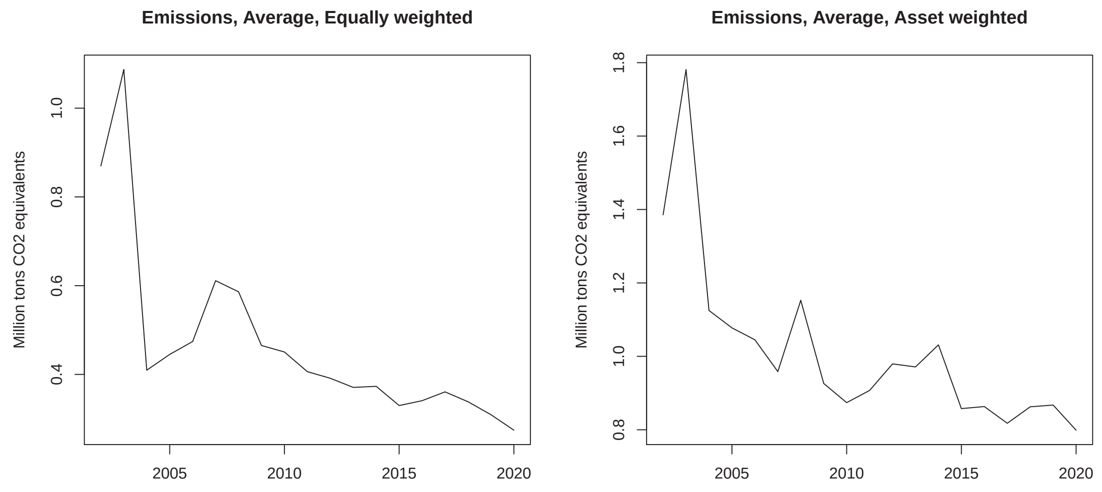

Figure 2.8: Emissions over time

These figures plot the average carbon dioxide (CO_2) emissions across US firms over time. The left hand figure's average is computed using equal weights across firms, where as the right hand figure is computed using weights proportional to the assets of the firm.

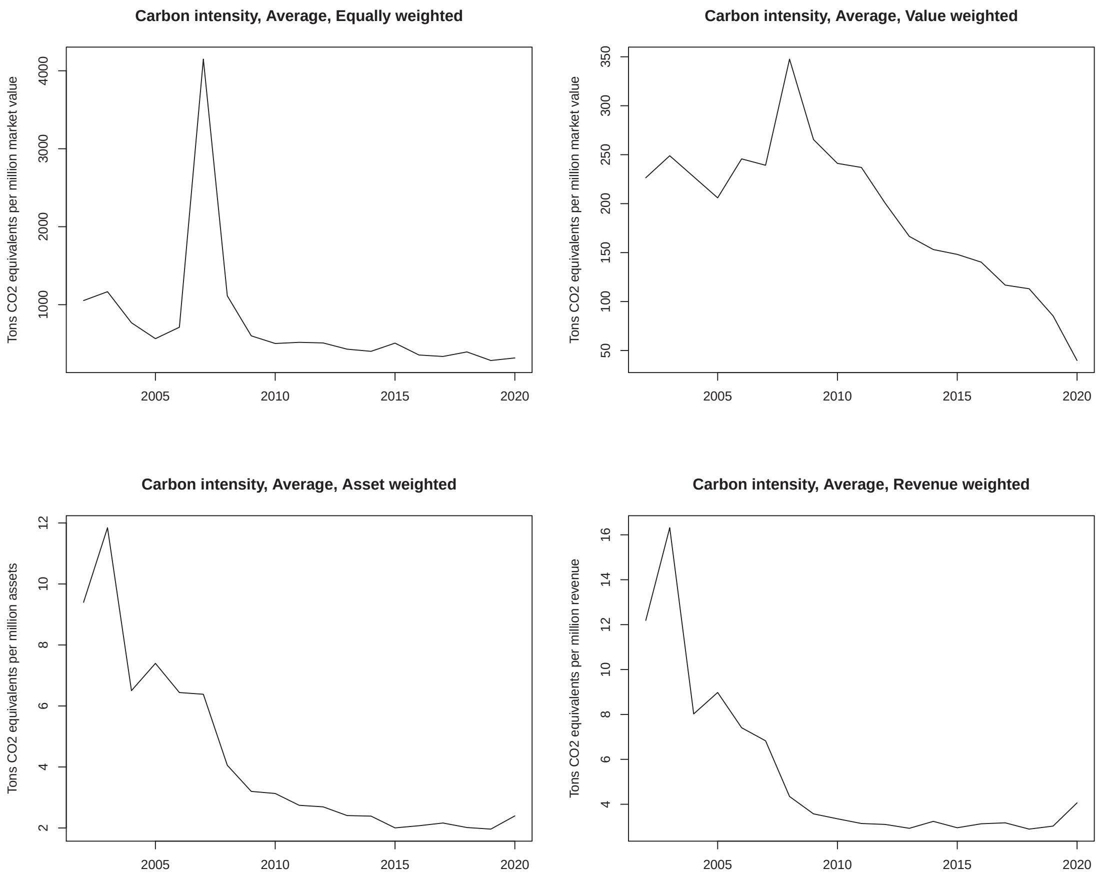

Figure 2.9: Emission intensity over time

These figures plot the average carbon dioxide (CO_2) emissions intensity across american firms over time. The top left hand figure's average is computed using equal weights across firms, where as the top right hand figure is computed using weights proportional to the market value of the firm. The bottom left hand figure's average is computed using weights proportional to the market value of the firm, and the bottom right hand figure uses weights proportional to the the firm's revenue.

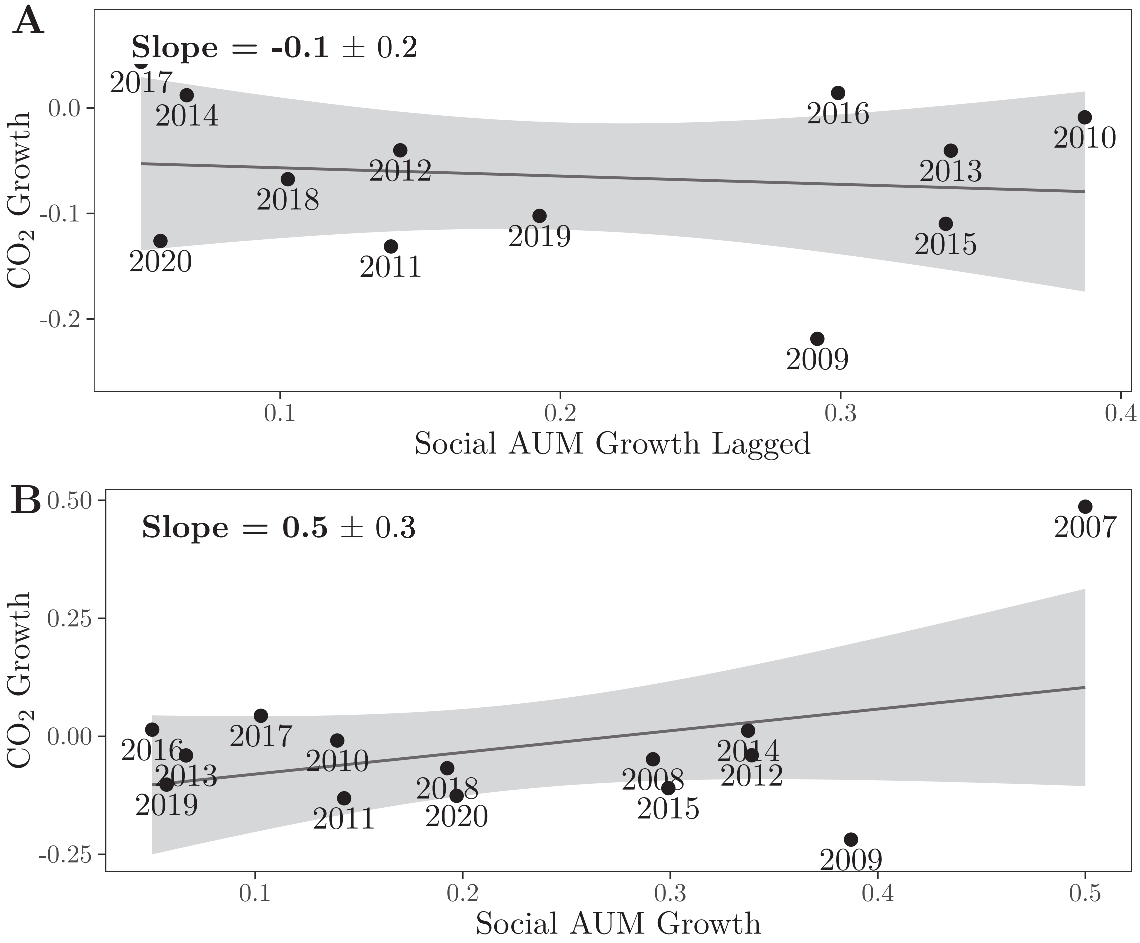

Figure 2.10: CO_2 Emissions versus Socially Invested Capital

This figure plots the average emissions of firms over time as well as the amount of socially invested capital as reported by United Nations Principles of Responsible Investment. Panel A is for lagged social investment growth, and Panel B is for simultaneous growth. The CO2 emissions include direct CO_2 emissions. R^2 of Panel A is 0.02 and R^2 of Panel B is 0.15.

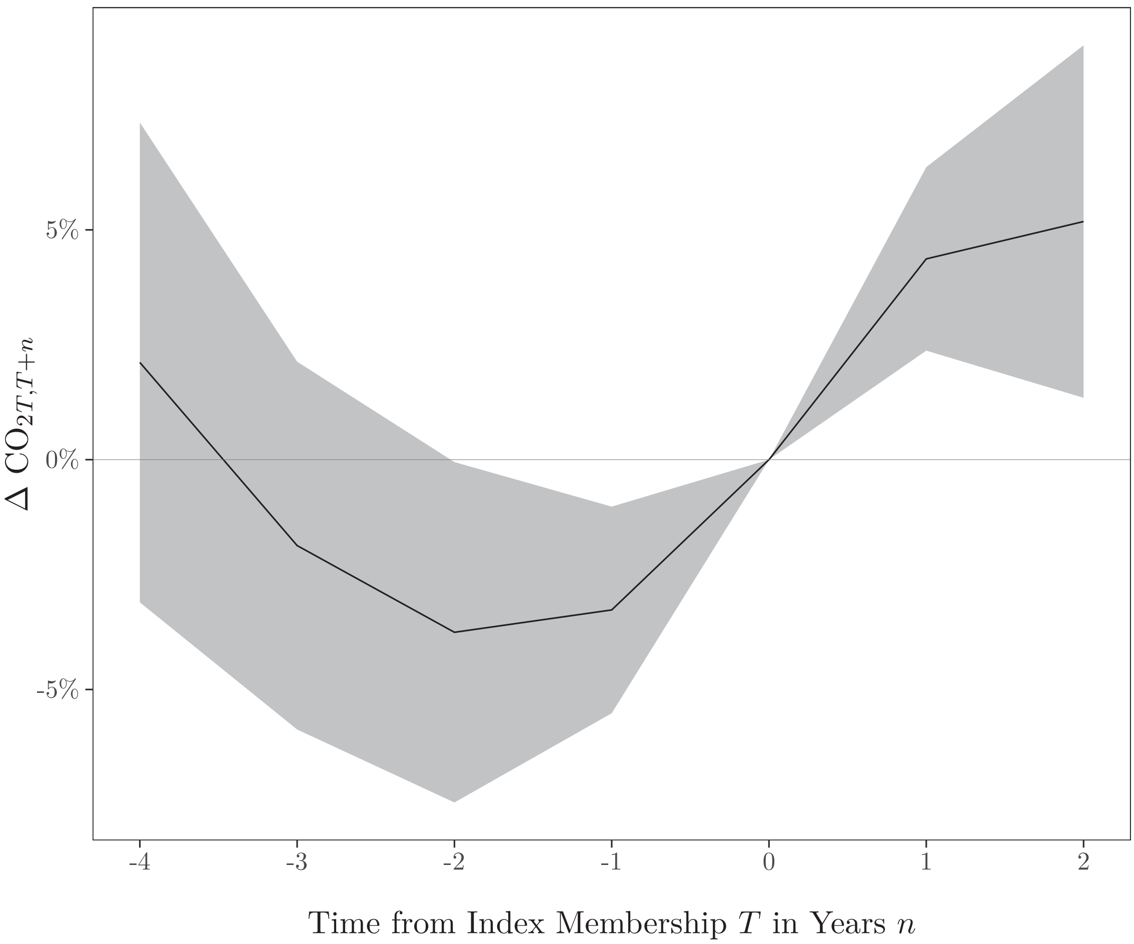

Figure 2.11: Inclusion to Index Effect

This figure shows the inclusion to index effect in terms of changes in their emissions. Emissions change is compared to cross-sectional average by including time fixed effects. Band is a standard deviations away from the estimate. Standard errors clustered at firm-month.

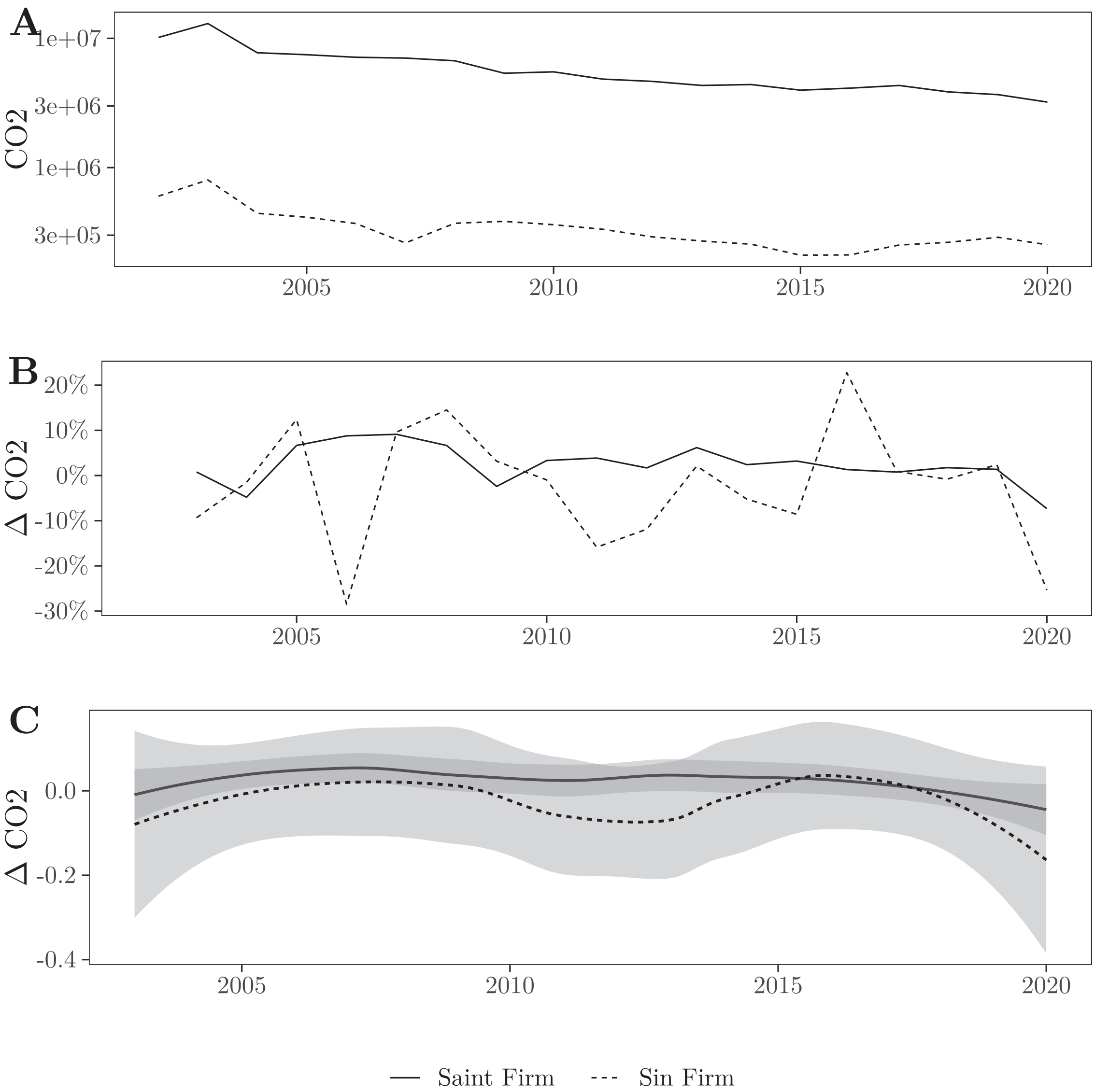

Figure 2.12: Inclusion to Index Effect: Saints versus Sinners

This figure shows the emissions of saint and sinner firms over time. Specifically, Panel A shows the average emissions per group per period. Panel B shows the period-by-period change in percentages for each group. Panel C shows the cumulative effect of emission changes in ratios. Band is 3 standard deviations away from the period estimate.

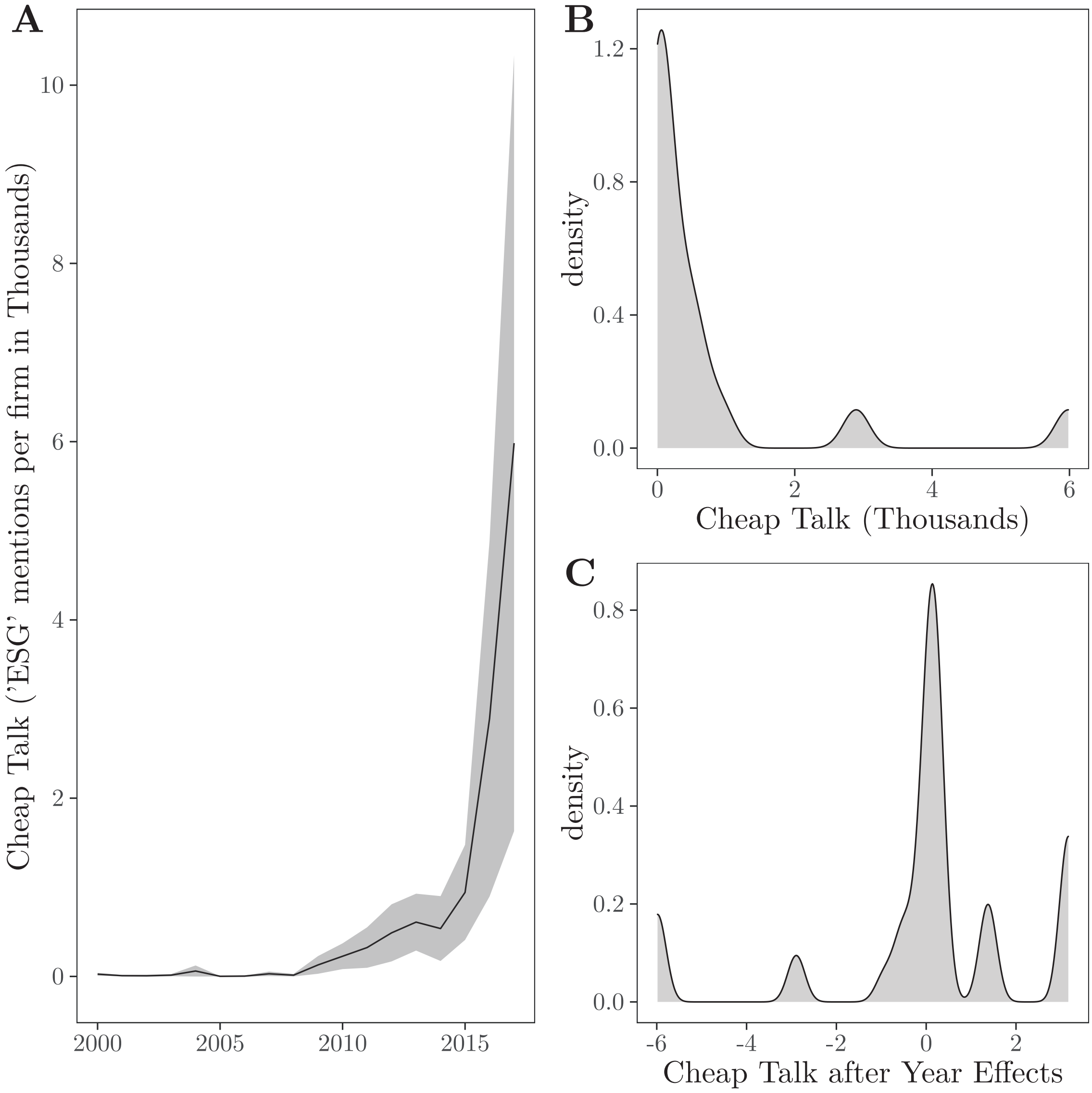

Figure 2.13: Cheap Talk in Time Series and Cross-section

Cheap talk is measured as 'ESG' mentions per firm in Thousands. Data from their public reports to the securities exchange commission. In Panel A grey area represents two standard deviations variation.

Table 2.5: Effect of being in index, Robustness with different specifications and models

Table shows how firms in the social index compares to firms outside of the index in terms of their emissions for different models. Column (1) and (2) repeats Column (3) and (4) in Table 2.3. The columns following add controls to Column (2). Specifically, Column (3) adds firm and time fixed effects, Columns (4), (5), and (6) add a dummy for the date of firm inclusion to the social index. Additionally, Column (5) adds time fixed effects and Column (6) has firm and time fixed effects. Emission changes are 1-year changes in CO_2 equivalents.

	Δ $CO_{2,t,t+1}$ (T Tons)			$\Delta \log CO_{2,t,t+1}$		
	(1)	(2)	(3)	(4)	(5)	(6)
Firm in Index	69^{**}	$2.3\%^{**}$	$1\%^{**}$	$2\%^{**}$	$3\%'$	$1\%^{**}$
	(3.60)	(6.50)	(2.72)	(6.39)	(0.02)	(0.01)
Firm just included				$3\%'$	$138\%^{*}$	3%
				(1.33)	(0.77)	(0.02)
Constant	-86^{**}	$-2.93\%^{**}$		$-3\%^{**}$	$-4\%^{**}$	
	(−6.25)	(−11.69)		(−11.69)	(0.01)	
FE	None	None	Firm+Time	None	Time	Firm+Time
Observations	37,056	37,056	37,056	37,056	352	37,056
R^2	0.0003	0.001	0.0002	0.001	0.01	0.0002
Note:						*p<0.2; **p<0.1; ***p<0.05

Table 2.6: Effect of being in Index, Robustness to 1 to 3 years ahead

Table shows how firms in the social index compares to firms outside of the index in terms of their emissions across different horizons. Columns (1) to (6) are log changes and Columns (7) to (12) are absolute changes. For each group of two the first column is for a horizon of one year, second two years, and third three years. Within each group there is the first the ordinary result and then controlling for inclusions. Emission changes are 1-year changes in CO_2 equivalents.

	$\Delta \log CO_{2,t,t+1}$		$\Delta \log CO_{2,t,t+2}$		$\Delta \log CO_{2,t,t+3}$		$CO_{2,t,t+1}$ (T Tons)		$CO_{2,t,t+2}$ (T Tons)		$CO_{2,t,t+3}$ (T Tons)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Firm in Index	0.02^{**}	0.02^{**}	0.04^{**}	0.04^{**}	0.06^{**}	0.06^{**}	69^{**}	70^{**}	193^{**}	195^{**}	336^{**}	335^{**}
	(6.50)	(6.39)	(8.43)	(8.36)	(10.23)	(10.25)	(3.60)	(3.62)	(6.60)	(6.65)	(8.68)	(8.64)
Just Included		$0.03'$		0.02		−0.03		−61		−204		94
		(1.33)		(0.58)		(−0.68)		(−0.45)		(−0.97)		(0.30)
Constant	-0.03^{**}	-0.03^{**}	-0.06^{**}	-0.06^{**}	-0.09^{**}	-0.09^{**}	-86^{**}	-86^{**}	-218^{**}	-218^{**}	-352^{**}	-352^{**}
	(−11.69)	(−11.69)	(−17.11)	(−17.11)	(−21.63)	(−21.63)	(−6.25)	(−6.25)	(−10.63)	(−10.63)	(−13.23)	(−13.23)
Observations	37,056	37,056	32,832	32,832	28,812	28,812	37,056	37,056	32,832	32,832	28,812	28,812
R^2	0.001	0.001	0.002	0.002	0.004	0.004	0.0003	0.0004	0.001	0.001	0.003	0.003
Note:												*p<0.2; **p<0.1; ***p<0.05

Table 2.7: Effects of Cheap Talk on ESG Scores, Granger Causality, Group of Words

Table considers how cheap talk by firms affects future ESG scores and impact across cheap talk as measured on different words. The cheap talk measure is frequency of the given word. Analyses take a Granger causality approach meaning they see if the dependent variable is predicted by lagged realisations of an independent variable in excess of its own lagged realisations.

	ESG Score Next Year			
	(1)	(2)	(3)	(4)
SUSTAINABILITY	0.016***	0.014**	0.093***	0.014**
	(0.005)	(0.005)	(0.011)	(0.005)
SUSTAINABLE	0.021***	0.010	0.063***	0.010
	(0.006)	(0.007)	(0.013)	(0.007)
ESG	0.004	−0.004	−0.023	−0.004
	(0.009)	(0.013)	(0.026)	(0.013)
ENVIRONMENT	0.004***	0.001	−0.004	0.001
	(0.001)	(0.001)	(0.003)	(0.001)
SOCIAL	0.005***	0.002	0.014***	0.001
	(0.001)	(0.002)	(0.003)	(0.002)
GOVERNANCE	0.001***	0.0005	0.002*	0.0004
	(0.0004)	(0.0005)	(0.001)	(0.0005)
CLIMATE	0.009***	0.002	0.011	0.004
	(0.003)	(0.003)	(0.007)	(0.004)
ESG Score This Year	0.889***	0.821***		0.821***
	(0.003)	(0.004)		(0.004)
CO_2/Assets			−0.001***	−0.0003***
			(0.0001)	(0.00005)
Constant	✓	✓	✓	✓
Observations	23,297	12,598	12,598	12,598
R^2	0.827	0.764	0.012	0.764
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 2.8: Elasticities of Cheap Talk and Impact

Table considers how firms' cheap talk and real impact affects their one year ahead ESG or E scores. Cheap talk is the word frequency of 'Sustainability'.

	Dependent variable:				
	log ESG_{t+1}	log E_{t+1}	E_{t+1}		ESG_{t+1}
	(1)	(2)	(3)	(4)	(5)
$\log(CO_2/Assets)_t$	0.003**	−0.017***			
	(0.001)	(0.002)			
$\log(\text{Cheap Talk})_t$	0.024***	0.029***			
	(0.003)	(0.004)			
$CO_{2,t}$			−0.00000***		
			(0.00000)		
$CO_2/Assets_t$				−0.003***	−0.001***
				(0.0004)	(0.0002)
Cheap $Talk_t$			0.073***	0.072***	0.084***
			(0.019)	(0.019)	(0.012)
Constant	4.090***	4.136***	62.567***	62.473***	62.516***
	(0.007)	(0.011)	(0.361)	(0.358)	(0.233)
Observations	1,505	1,505	1,509	1,505	1,505
R^2	0.056	0.062	0.045	0.046	0.036
Note:					*p<0.1; **p<0.05; ***p<0.01

Chapter 3

Corporate Asset Pricing

Abstract

I show the new fact that idiosyncratic volatility significantly predicts the convenience yield. This fact poses a puzzle with current safe asset theories. I develop a new theory that reconciles this puzzle - a theory I label Corporate Asset Pricing (CAP). CAP explains 29% of future convenience yield variation and is verified in the cross-section of firm treasury holdings. I show theoretically that when managers are exposed to moral hazard, corporate demand will be determined by their idiosyncratic risk. I isolate my demand-based effect from confounders by using exogenous cross-sectional variation from corporate size and industry exposures. The results provide support for the importance of corporates as an investor group.

Keywords: Safe asset demand, Convenience yield, Idiosyncratic volatility, Investment.

JEL Classification: G11, G12, G31, G32.

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3.1 Introduction

Convenience yields are hard to reconcile with standard asset pricing models.[1] The CAPM would say that a risk free asset should give you the risk free rate. Not more, not less. This has led papers such as Sidrauski (1967), Krishnamurthy and Vissing-Jorgensen (2012), and Nagel (2016) to include money in the utility function to explain why some risk free assets give a return below the risk free rate. The insufficiencies of current models are further demonstrated by Koijen, Richmond and Yogo (2020), Koijen and Yogo (2019a), who show that the majority of asset price variation is left unexplained. I, on the other hand, show that convenience yields can be explained without departing from our standard risk-based frameworks.

If we are to make progress as a field, we need frameworks that work out of sample, meaning across a wide range of asset-classes, markets and settings. If we for each anomaly add a new factor, motivated from a different model we end up with a factor zoo and no fundamental knowledge. Instead, this paper centers around the fundamental principle of finance that the marginal utility of the marginal investor should price assets. Hence, figuring out who the marginal agents are, and understanding how they make financial choices, are critical for understanding asset prices. Recent work by Koijen, Richmond and Yogo (2020), Koijen and Yogo (2019a) show that unexplained latent demand is responsible for 81% of the cross-sectional variance in stock-returns and 43% in bond yields. This paper helps explain where this latent demand arises from. Although often overlooked, I find that companies, and corporations in general, are a key investor group in many assets. As an illustration, I show that corporate demand has created a convenience yield on treasuries of on average 31 bp, which amounts to 83% of the average convenience yield. The effects this investor group has on asset prices in general are summarized in this paper as the theory of Corporate Asset Pricing (CAP) and the effects on convenience yields in particular are referred to as the theory of Corporate Safe Asset Demand.

The growing influence of corporations is evidenced by their assets increasing from 31% of GDP in 1950 to a massive 183% by the end of 2019. At the same time the fraction of their assets held in financial assets increased from 7% in 2000 to 12% by 2019, peaking at 17% in 2017. Combined, these two facts mean that corporates have been a growing

[1] The convenience yield refers to the difference in return between a particularly attractive safe asset, such as U.S. Treasury bonds, and another equally safe benchmark, such as a bank's protected deposit account. In this analysis we will generally look at the difference between U.S. Treasury bonds and an option-implied risk-free rate as the benchmark.

group of investors who today manages trillions of dollars of financials securities. In other words their holdings make up a sizeable fraction of several asset markets. At the same time, firms cash holdings have increased from close to 0% in the 60's to 6.3% by the end of 2019 and their investment ratio has been steadily declining since its peak in the 80's of 11.3% to 4.8% by the end of 2019, a puzzle to a large literature.[2] Together, this means that corporates are now an investor group that we cannot continue to ignore.

As mentioned, this paper centres around the fundamental idea of asset pricing: $P = E[m * R]$, where m is the marginal investors marginal utility, and R is the return on the financial asset. This implies that the marginal investor's marginal utility can be used to price assets and as a consequence what factors into their optimality conditions should price assets.

Even though isolating the impact of corporate demand on asset prices is hard, one key insight allows me to identify demand effects. This new insight is that due to the moral hazard arising from the principal-agent problem inherent in owner-managers of corporates with separate owner and managers, corporate demand will be determined by their idiosyncratic risk.[3] Considering how asset prices are influenced by the idiosyncratic risk of corporates also has the benefit that it is uncorrelated with the supply of safe assets. Another benefit of using idiosyncratic volatility over using asset holdings as our measure of demand is that asset holdings are only observable at the quarterly level, and the data quality is poor.[4] On the other hand idiosyncratic volatility is measured from equity prices, which are highly liquid and available at the same frequency as other asset prices (for example daily). Additionally, there is a timing issue, as the demand of a firm may rise today, which due to general equilibrium effects would manifest in prices right away, however one would not observe the change in asset holdings until the next quarter, or the next if they gradually work towards their optimal portfolio. All of these issues are avoided when using idiosyncratic volatility as a proxy for corporate demand.

I start off by providing the motivating fact that there indeed exists a strong relationship between my measure for corporate demand, idiosyncratic volatility, and the future convenience yield. When plotting the future convenience yield against the past idiosyncratic volatility, a clear linear relationship is visible. Indeed, the correlation is high at

[2]See Bloom, Bond and van Reenen (2007), Bond and Van Reenen (2007), for an overview of how firms underinvest relative to what would be predicted from the neoclassical q-model. Also related is the idea of underinvestment from the seminal work by Myers (1976) and Stulz (1990), and more recent work by Bloom, Bond and Van Reenen (2007) involving uncertainty and underinvestment. Finally, Asker, Farre-Mensa and Ljungqvist (2015) speaks to public firms underinvesting.

[3]I will formalise this insight in the conceptual framework section.

[4]Additionally the reporting standards may vary from firm to firm.

65%.[5] The result is robust as it is not driven by our choice of measure. In other words, the same outcome emerges both for realised and implied idiosyncratic volatility as well as for other measures of safe asset premia, such as the Banks acceptance rate to Treasury Bill spread used by Nagel (2016).

To identify the corporate demand effects, I go on to construct a conceptual framework of corporate asset pricing. My framework leads to corporate demand being determined by their idiosyncratic volatility. In standard asset pricing models such as the Capital Asset Pricing Model (Lintner 1965, Sharpe 1964), and Arbitrage Pricing Theory (Ross 1976), investors idiosyncratic volatility does not affect their decisions, as it can get diversified away. However, I show that the existence of moral hazard in corporate managers behaviour, requires us to do away with this simplified result. Instead, the firm owners optimal contract demands that managers take on uninsured idiosyncratic risk to ensure high (unobservable) effort is exerted. In fact, surprisingly, it turns out that systematic risk alternatively has no effect on this channel.

Moral hazard, compared to a hypothetical situation without its existence, leads to higher savings and less investment, a wedge that is increasing in the idiosyncratic volatility of the firm. I confirm both the saving and investment effects is in the data. Overall, this means that investment has been around 5% lower annually, than it would have been without moral hazard.

Overall, the important testable implications of my theory are that as idiosyncratic volatility increases: (1) Convenience yield increases, (2) Investment decreases, and (3) Savings increase. To test these I create measures of idiosyncratic volatility. I take the volatility of the unexplained variance from a regression of CRSP firm returns on a widely used asset pricing model, such as the Fama-French 3 factor model used in Ang et al. (2006, 2009). As an alternative, I create an option implied idiosyncratic volatility measure using CBOE SP500 options. As asset prices to test, I use the Convenience yield measure by Van Binsbergen, Diamond and Grotteria (2021), other safe asset returns from Nagel (2016), corporate yields from Moodys, and aggregate market returns from French' website. To test idiosyncratic volatilities effects on savings and investment I use Compustat to get firms' savings and investment. This new implied measure provides useful external validation, both for myself and the literature on idiosyncratic volatility at large.

After constructing the data, I first regress the asset price returns on my proxy for corporates' demand (the idiosyncratic volatility measures), and find that corporate demand

[5] The convenience yield is from Van Binsbergen, Diamond and Grotteria (2021).

explains up to 69% of the time series variation and can explain 83% of the average convenience yield. Additionally, understanding corporates helps explain prices in other assets, which they are a large part of the investor base; such as corporate debt, commercial paper, deposits, as well as the expected risk premium.

As idiosyncratic volatility is a valid measure for corporate demand I can get an estimate of corporates' price impact. To do this I instrument corporate treasury holdings on their past idiosyncratic volatility, which is highly significant. Using the instrumented demand in a two-stage least squares regression, I then find the price impact to be around 50 bp, as measured by % price change per % of outstanding assets sold. This is a bit smaller than the macro-estimates found in Gabaix and Koijen (2020) of around 5%, and larger than the micro-estimates found in Koijen and Yogo (2019a) of 25 bp, which is sensible as corporate sector level is in between the asset class level and the single seller level.[6] Also important to keep in mind, is that prior theoretical estimates based purely on rational expectations puts the price impact at around 100 times lower than both mine and Gabaix and Koijen (2020)) estimates, hence I provide supporting evidence that the price impact is higher than previously thought. And hence that understanding investors behaviour is more important than previously thought.

I go on to show that idiosyncratic volatility explains and predicts the risk premia and convenience yield in excess of current asset pricing models including competing theories. My corporate demand proxy has better explanatory power, and especially predictive power, than the intermediary asset pricing proxy of He, Kelly and Manela (2017), also in excess of the dividend-price ratio. The intermediate asset pricing factor also becomes insignificant when including the corporate demand factor in explaining the convenience yield. This speaks to the debate on whether idiosyncratic volatility matters for the equity risk premium. In addition to previous findings, I show that idiosyncratic volatility innovations do matter throughout a long time period for a capitalisation-weighted measure, and while controlling for the dividend-price ratio and the market volatility.[7]

I provide a plethora of robustness tests. I show that my results are robust to controlling for total realised volatility, implied volatility (VIX), different ways of correcting the standard errors, using different maturities, and considering a difference-in-difference specification. I find that my proxy explains the government yield, but not the option

[6] Koijen and Yogo (2019a) measure price impact as % price change from a 10% demand change of an investor. It also makes sense that the price impact on bonds should be smaller than that on stocks on the aggregate level, which they use in those papers.

[7] See Bali et al. (2005), Garcia, Mantilla-Garcia and Martellini (2014), Goyal and Santa-Clara (2003), Wei and Zhang (2005).

implied rate, which makes sense as most managers do not have a mandate to invest in options, but are allowed to have bonds on their balance sheet. This finding confirms the validity of market segmentation ensuring the spread remains. This is because for financial intermediaries, the risk-free return achievable from options completely dominates the one achievable from government debt. However, as corporates cannot access options to the same extend, they are left with other safe assets, such as government debt. Additionally, it is not possible for the intermediaries to equalise the rates through shorting government bonds, as the markets are not developed nor large enough. Lastly, there is also a fee to shorting, which the spread would not be able to go below. Overall, my results are confirmed by all of these additional tests.

To test empirical predictions (2) and (3) I regress firms investment and savings rate in a panel "within" regression and indeed find evidence in accordance with my empirical predictions. This validates my proxy. On average idiosyncratic volatility has lead to a decrease in the investment rate of 5% over the time period, partially explaining the underinvestment puzzle.

A problem in my identification arises if idiosyncratic volatility is not randomly distributed across firms and time, as then it may be correlated with variables that move prices. For example idiosyncratic volatility may be high in periods of market turbulence, which also leads to higher risk aversion and lower prices. Or, idiosyncratic risk may be high at firms with risk-loving CEO's who take on idiosyncratic risk and hold a large fraction of financial assets on their books. To account for this, I instrument idiosyncratic volatility with exogenous variation purely from factors which are plausibly exogenous: variation in firms size using the Granular Instrumental Variable method of Gabaix and Koijen (2019), and firms exposure to external risk factors from Alfaro, Bloom and Lin (2018). When doing so I confirm and give causal evidence that corporate demand is a determinant of the convenience yield.

Overall, my contribution is to narrow the gap of our understanding of what drives asset prices. I do so by introducing a new corporate demand based asset pricing framework, corporate asset pricing, which helps explain previously unexplained demand movements which are the cause of 81% of the variation in cross-sectional stock-returns. My framework, as an example, provides the first demand based convenience yield explanation. The implication is that to understand asset price movements it is important to figure out who the marginal investor is and what factors affect their financial decisions.

In doing so, my work additionally helps quantify an economic cost of moral hazard, as it has decreased investment and growth in the economy, in addition to inflating prices on government debt and money leading to deflationary effects. It also helps explain the breakdown of the lower interest rates and investment growth relationship as witnessed in the last decades.

A policy implication of my results is that if central banks try and lower rates, they may not be effective if these changes also reduce non-financials idiosyncratic risk. A situation which is not unlikely. Additionally, if lowering interest rates actually leads to reaching for yield and increasing idiosyncratic volatility, it would reduce investment and curb the stimulating effect of the lower rates.

This work has implications for how we view asset pricing. Specifically, knowing who the marginal investor is and what matters to them can help us price assets widely across the economy, such as what the government pays to fund its debt, and firms' cost of capital. This in turn affects investment materialization through their financing cost and ultimately affects how our economy develops.

Contribution to the literature. I provide an explanation of latent demand, which explains a large fraction of price changes (Koijen and Yogo (2019a)). Other papers that consider the effects of demand on asset prices include Shleifer (1986), Harris and Gurel (1986). Chang, Hong and Liskovich (2015) study index inclusions, and Ben-David et al. (2021) consider advice driven demand from Morningstar.

What separates my work is that I am the first to provide a demand-based explanation of the convenience yield. The closest paper to mine empirically is Jiang, Krishnamurthy and Lustig (2018), but their empirical analysis instead uses the convenience yield to explain exchange rate phenomena. Additionally, they do not provide an explanation of where the foreign convenience yield arises from, but instead derives from a no-arbitrage relationship given the existence of the foreign convenience yield. Another close paper is Koijen, Richmond and Yogo (2020) as they also get a measure of foreign demands influence on convenience yield, however their analysis is also not an explanation of where the latent demand arises from, which is what I present. Papers that instead empirically consider safe asset returns from a supply perspective include Krishnamurthy and Vissing-Jorgensen (2012), Sunderam (2015), and Nagel (2016).

A theoretical contribution is to link the moral hazard of corporate managers to the convenience yield earned on safe assets. This new insight allows me to be the first to supply a theory of safe asset demand, and get a convenience yield, *without* money in the utility function such as Gorton and Pennacchi (1990), Dang, Gorton and Holmström

(2012), Krishnamurthy and Vissing-Jorgensen (2015), Diamond (2020).

Theoretically, some previous work has considered idiosyncratic volatility and interest rates, and others have considered moral hazard and investment. But not moral hazard on interest rates, and hence giving an explanation as to why the idiosyncratic volatility of corporates should be left uninsured. Previous studies of idiosyncratic volatility and safe assets include Aiyagari (1994), who theoretically shows that uninsured idiosyncratic risk leads to a risk-free rate below the time preference rate and an increase in aggregate savings, and Angeletos (2007) who illustrate that uninsured idiosyncratic risk, from incomplete markets, leads to lower investment, worsened by a higher exogenous risk. Boileau and Moyen (2010) document that cash to assets have roughly doubled between 1971 and 2006. They mention that prior research attributes this increase to a rise in firms' cash flow volatility, and divide this between a precautionary savings motive and liquidity need. They conclude that liquidity is the main driver. Sánchez and Yurdagul (2013) are a bit more careful in their conclusion, they mention that increases in aggregate risk together with idiosyncratic risk may have led to the increase in cash holdings of firms. My work provides a single simple model which unifies these theoretical and empirical findings and extends the results to the convenience yield and risky assets.

Studies considering idiosyncratic volatility in combination with moral hazard include Ramakrishnan and Thakor (1984), who show that idiosyncratic risk will generally be important in investment decisions, but they do not endogenise the investment decision.[8] Ou-Yang (2005) constructs an equilibrium asset pricing model with idiosyncratic risk and moral hazard, and show it affects the expected return through systematic risk. The closest paper to ours is written by Panousi and Papanikolaou (2012), who show that executive incentives induce effort, but expose them to idiosyncratic risk, and if they are risk-averse they may under invest when idiosyncratic volatility increases. Authors additionally empirically document this decrease, and that it is larger when managers own a larger fraction of the firm. This effect can be lowered by using options rather than stock compensation, or if institutional investors form a large part of the shareholder base. I extend this analysis by letting the optimal contract be an endogenous outcome, and considering the effects on the equilibrium risk-free rate and convenience yields.

My explanation exploits identification from corporate driven finance. Baker (2009) provide a summary of capital market-driven corporate finance, and Ma (2019) shows the importance of nonfinancial firms in asset markets as arbitrageurs of their own securities.

[8]Moral Hazard started by canonical paper by Holmstrom (1979), extends work by Mirrlees (1976), Harris and Raviv (1979).

Recently Mota (2020) show that non-financials strategically issue debt. Whereas these papers focus on the supply side of corporates, my paper on the other hand shows that the demand side is important.

As I consider corporates demand effects, a relevant paper is Duchin et al. (2017), which shows that non-financial firms investment into non-cash risky financial assets. The paper finds that risky assets make up 40% of the financial assets and 6% of total book assets, and confirms the growing importance of corporates as an investor group.

To proxy for corporate demand I use realised and implied idiosyncratic volatility. Other papers that consider the realised idiosyncratic volatility effects on asset prices include Ang et al. (2006, 2009), Chen and Petkova (2012), Herskovic et al. (2016), and Chen et al. (2020). Other papers that consider option implied volatility effects include An et al. (2014), who look at stocks, and Cao et al. (2019) who look at bonds, but they do not distinguish between idiosyncratic and systematic implied volatility.

For identification I partially rely on segmented markets. Another paper that considers the implications of separated markets include Vandeweyer (2019).

Recently, an active literature on uncertainty and low investment has started lead by Bloom (2007). Gilchrist, Sim and Zakrajšek (2014) looks at idiosyncratic risk lowering investment versus financial frictions empirically and in a macroeconomic model. Other papers include Bloom, Bond and van Reenen (2007), Gilchrist, Sim and Zakrajšek (2014), and Tella (2020). DeMarzo et al. (2012) consider q-theory and incentive contracting (hence on investment), but do not consider the demand for safe assets and the effect on the convenience yield.

As mentioned, the closest paper to mine is Panousi and Papanikolaou (2012), who also consider the implications of moral hazard on investment. However they do not solve for endogenous contracts and neither do they investigate the effects of increased idiosyncratic risk on the convenience yield.

3.2 The Convenience Yield Puzzle

Until 2009 the Treasury Bond supply and the interest rate has been good explanators for the convenience yield, as shown in Figure 3.1. The figure additionally shows that this is not the case after 2009 as the predicted convenience yield is much higher than the actual convenience yield. This is illustrated in the figure as the shaded green area.[9] These

[9]Figure 3.8 in Appendix 3.A shows that the difference is unlikely to be driven by bond purchases as they make out a reasonably small portion of the total bond supply.

findings of the convenience yield puzzle are further shown in Table 3.1. Robustness are shown in Table 3.2. Here Column 1 shows that the Krishnamurthy and Vissing-Jorgensen (2012) model works well prior to 2009. Column 2 shows this is also the case for the Nagel (2016) model. The figure shows in blue that the puzzle is resolved when instead using the idiosyncratic volatility to explain the convenience yield. The shaded blue area is much smaller than the green. This result is also visible in Column 3 of Table 3.1.

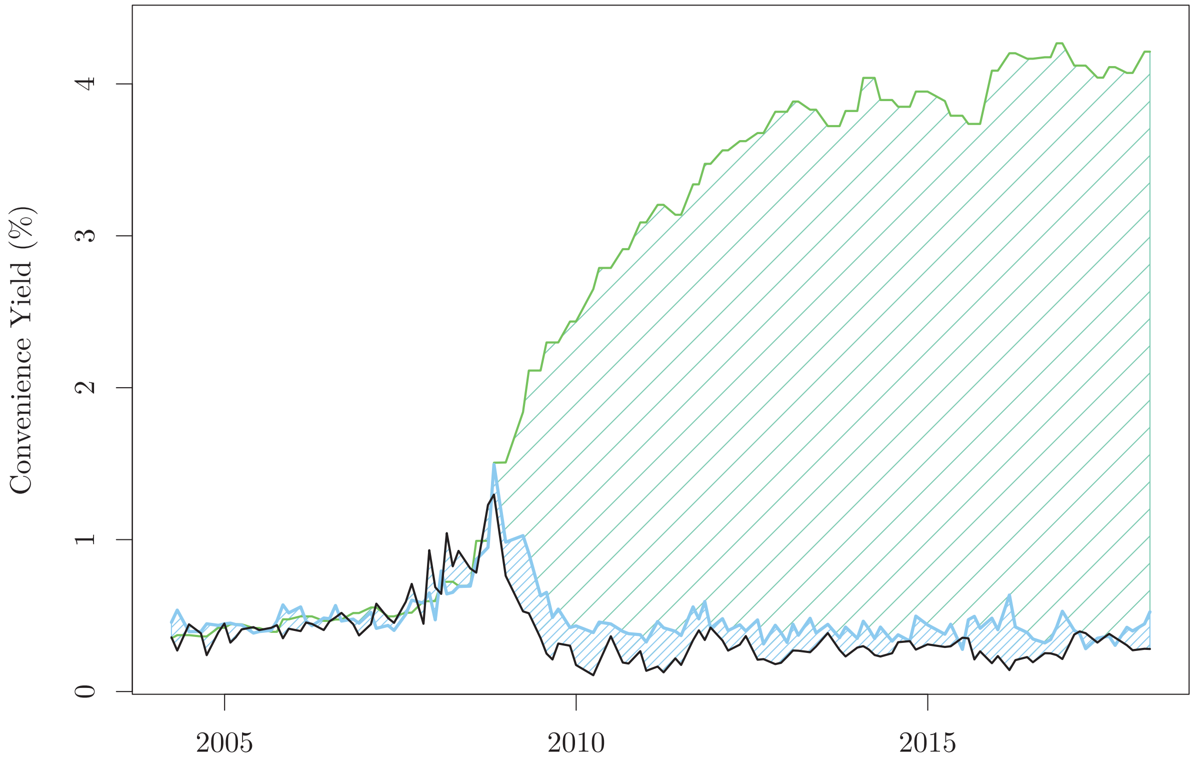

Figure 3.1: Figure shows the Convenience Yield Puzzle (Green area) and the Corporate Asset Pricing solution (Blue area).

Green line shows the predicted convenience yield as estimated from dates prior to 2009 using Krishnamurthy and Vissing-Jorgensen (2012) and Nagel (2016). The black line shows the actual convenience yield. The shaded green area is hence the prediction error and illustrates the Convenience Yield Puzzle. The blue line shows the predicted convenience yield as estimated from dates prior to 2009 using idiosyncratic volatility of corporates. Shown for a maturity of 18 months and idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Idiosyncratic volatility is annualized.

[Table 3.1 and 3.2 about here]

3.3 The Corporate Balance Sheet Expansion

The growing influence of corporations is evidenced by their assets increasing from 31% of GDP in 1950 to a massive 183% by the end of 2019. At the same time the fraction of their assets held in financial assets increased from 7% in 2000 to 12% by 2019, peaking at 17% in 2017 (Figure 3.2). Combined these two facts mean that corporates have been a growing investor group and today manage trillions of dollars of financials securities. Their holdings make up a sizeable fraction of several asset markets, as depicted in Figure 3.3.[10] At the same time, firms cash holdings have increased from close to 0% in the 60's to 6.3% by the end of 2019. Their investment ratio has been steadily declining since its peak in the 80's of 11.3% to 4.8% by the end of 2019, a puzzle to a large literature.[11] Together, this means that corporates are now an investor group that we cannot continue to ignore.

[Figure 3.2 and 3.3 about here]

3.4 A Theory of Corporate Safe Asset Demand

3.4.1 A Simple Conceptual Framework

Here I illustrate why performance based pay of managers leads to a convenience yield. To be able to do so, we make some functional assumptions. First, let the manager's utility U be characterised by the standard negative exponential function:

$$U(w, a) = \mathrm{E}[1 - e^{-Aw+a^2}], \tag{3.1}$$

where w is the manager's wealth, A captures the manager's degree of risk aversion, and a his effort level. Secondly, let the investment technology available be equal to $\sqrt{k}$, such that the manager can invest $\sqrt{k}$ to gain k units of capital.

Assumption (Performance based pay). The manager's performance based pay make up such as large fraction of their income that they cannot feasible hedge it all. Alternatively, they may not be allowed by the board to short the company. Later, it will

[10] Their ownership can also be volatile as seen from the drop in financial ownership from 17% to 13% in just one year in 2018. Equivalent to USD 292 billion.

[11] See Bloom, Bond and van Reenen (2007), Bond and Van Reenen (2007), for an overview of how firms underinvest relative to what would be predicted from the neoclassical q-model. Also related is the idea of underinvestment from the seminal work by Myers (1976) and Stulz (1990), and more recent work by Bloom, Bond and Van Reenen (2007) involving uncertainty and underinvestment. Finally, Asker, Farre-Mensa and Ljungqvist (2015) speaks to public firms underinvesting.

be shown that this assumption in fact is a natural consequence from agency frictions as well as being empirically apt.

Proposition (Idiosyncratic risk and the convenience yield). In equilibrium the convenience yield will be given by

$$\boxed{R^c = \frac{1}{2}A\sigma_i^2 - k^{-1/2},} \tag{3.2}$$

where the total volatility of the company is $\sigma = \sigma_{i+m}$, and σ_i and σ_m is the idiosyncratic and market risk, respectively, of the corporate where the manager works.[12]

Proof. Let μ and σ denote the expected earnings and volatility thereof of the corporates assets. Additionally, the first order condition requires the marginal utility of investment U'_k to equal the marginal utility of saving in safe assets U'_b, where b will later denote the amount of the safe asset purchased by the manager. It then follows that

$$U'_k = U'_b \tag{3.3}$$

$$U'_k = (k^{-\frac{1}{2}}A\mu + \frac{1}{2}A^2\sigma^2)e^{-A\mu\sqrt{k}+1/2A^2k\sigma^2-a^2} \tag{3.4}$$

$$U'_b = (R^c + R^f)Ae^{-A\mu\sqrt{k}+1/2A^2k\sigma^2-a^2}, \tag{3.5}$$

which gives that

$$R^c = \frac{1}{2}A\sigma^2 - k^{-1/2} - R^f.$$

As the risk free rate is given by

$$R^f = \frac{1}{2}A\sigma_m^2, \tag{3.6}$$

we can rewrite the convenience yield as

$$R^c = \frac{1}{2}A\sigma_{i+m}^2 - k^{-1/2} - \frac{1}{2}A\sigma_m^2$$

$$= \frac{1}{2}A(\sigma_{i+m}^2 - \sigma_m^2) - k^{-1/2}$$

$$R^c = \frac{1}{2}A\sigma_i^2 - k^{-1/2}.$$

The convenience yield is hence increasing in the idiosyncratic volatility and amount invested. The reason why there can be a difference to the risk free rate is because of moral hazard leading the principal to requiring manager to be exposed to the additional idiosyncratic risk. A risk that is increasing in k.

[12] Note for later that the market risk is the same as the systematic risk in this setup.

3.4.2 Empirical Specification

Testing. We can test by $R^c \sim \beta\sigma^2 + \gamma k^{-1/2}$ or more simply by $R^c \sim \alpha + \beta\sigma + \gamma k$. This means that we just have measurement error left at the end, like so: $R^c = \alpha + \beta\sigma + \gamma k + \epsilon$, where ϵ is measurement errors and time varying factors that affect the convenience yield who are outside the model.

A few remarks are in order. First, I note that measurement error in σ_i and k will bias downward my effect, and hence what I present is a lower bound of the actual effect. Second, note that if there are more investors the parameters σ_i and k will be the asset-weighted idiosyncratic risk and investment respectively. Third, one reason why the return on the risk-free benchmark, meaning the option-implied risk free rate which is obtained from a combination of put, call, and futures, is not pushed down to the return on the safe asset, is due to market segmentation. More specifically, because of the difficultly of chief executive officers and chief financial offers to invest in a large scale in such specific and sophisticated options. Another reason being the cost and risk for more sophistical investors to short safe assets such as treasuries.[13]

3.5 Creating an Idiosyncratic Volatility Measure

Data. To test this I create measures of idiosyncratic volatility. I create both realised and implied idiosyncratic volatility measuries. Aditionally for the realised I create both a daily and monthly version. My preferred measure is the implied one. Here I create an option implied idiosyncratic volatility measure using CBOE SP500 options. It is the product of the square-root of implied correlation subtracted by 1 multiplied by the implied volatility (VIX), both from CBOE. This idiosyncratic volatility measure is inspired by Kelly, Lustig and Van Nieuwerburgh (2016), and is a simple consequence of the facts that the total variance, $TVAR$, is the sum of systemic variance, $SVAR$, and idiosyncratic variance, $IVAR$, $TVAR = SVAR + IVAR$, and that the systemic variance is proportional to the the total variance and the value-weighted correlation of stocks, ρ, $SVAR = TVAR\rho$, and that the variance is equal to the volatility squared, $VAR = VOL^2$, which substituting for $SVAR$ and $IVAR$, and solving for the idiosyncratic volatility $IVOL$, gives that $IVOL = \sqrt{1-\rho}\sqrt{TVAR}$.

For the realised measure I take the volatility of the unexplained variance from a regres-

[13]See Wall Street Journal, Thinking of 'Shorting' Treasurys? Tread Lightly. 2013, February 15.

sion of CRSP firm returns on my preferred asset pricing model, such as the Fama-French 3 factor model used in Ang et al. (2006, 2009). For the monthly I average within the month. For daily I run rolling regressions covering the last year.

As asset prices to test I use the Convenience yield measure by Van Binsbergen, Diamond and Grotteria (2021), other safe asset returns from Nagel (2016), corporate yields from Moodys, and aggregate market returns from French' website. To test idiosyncratic volatilities effects on savings and investment I use Compustat to get firms' savings and investment.

3.6 Measuring the Impact of Corporate Demand

3.6.1 Motivational result

Corporate idiosyncratic volatility. Figure 3.4 provides motivational evidence that my proxy for corporate demand, idiosyncratic volatility is important for the future convenience yield, as a clear linear relationship can be seen between lagged idiosyncratic risk and the next period convenience yield. The correlation between these two variables is high at 65%. Figure 3.5 shows the similarity in the evolution of the convenience yield and the idiosyncratic volatility in the time series. The convenience yield measure is from Van Binsbergen, Diamond and Grotteria (2021) and the idiosyncratic volatility measure is the option implied idiosyncratic volatility measure defined in Section 3.5.

[Figure 3.4 and 3.5 about here]

3.6.2 Main result

This section exhibits why corporates are important for asset prices.

Corporate demand and asset prices (time series result). Motivated by theory I will start off the result section by using idiosyncratic volatility as a proxy for corporate demand. In this spirit, Table 3.3 shows how increased corporate demand increases the prices of safe assets such as the convenience yield; the banks acceptable rate to t-bill spread, and the commercial deposit T-bill spread. Also safe assets such as debt on AAA-rated firms are affected, and even less safe debt as BBB-rated debt.

[Table 3.3 about here]

We further see that corporate demand has a higher explanatory power in markets where corporates are a bigger player, which seems sensible, and further validates the findings.

We also see that the option implied measure seems to do better, which I suspect is because it is a forward looking measure, rather than a backwards looking measure such as the standard IVOL measure. And that is faster to update as it is computed daily and not as an average over a month. Both of these factors are important as we look at the explanatory power of a lagged variable on future asset prices.

By far the largest explanatory power is for the convenience yield, perhaps because it is so precisely measured. Because of this, and because there is still little known about what determines the convenience yield, the rest of this section will mainly focus around the convenience yield results.

The timeline of the different regressions differs to a great extend. Our main specification with the convenience yield starts in 2007 and ends in 2018, and is limited by the availability of the Convenience yield measure. On the other hand the banks acceptance rate regression data starts in 1926 and goes until 2011, and the others are in between. This suggests that my results are not driven by a specific time period, but is instead applicable to all.

As both idiosyncratic risk and the prices are autocorrelated, a worry is that the error term also will be. Hence I correct this by using Newey and West (1994) errors with automatic lag length choice.

In terms of price impact it tends to follow where corporates are a bigger player, as we see the corporate demand proxy having its largest coefficient in corporate bond markets and less so in government bonds and the bank rates.

The effect is economically meaningful as a 1 standard deviation increase in the daily idiosyncratic volatility moves the convenience yield 9 bp. And equivalently 12 bp when measured from implied idiosyncratic volatility changes. This means that 3 days of 1 standard deviation moves, or a single 3 standard deviation event, would move the convenience yield 36 bp, which is equivalent to it's long term average. This is visible in Figure 3.6, which plots the model implied convenience yield next to the realised convenience yield.

[Figure 3.6 about here]

Importantly, this effect comes purely from corporates, and only from their idiosyncratic risk exposure. And the reason they do not move the option implied risk free rate is because they are largely excluded from this market due to institutional differences, costs of having an option desk, and owners management provisions. This effect has swung the convenience yield 88 bp from peak to through, with an average effect over the sample of 31 bp or 84% of the average size of the convenience yield.

Price impact. Table 3.4 gives us an estimate for the price impact of corporate demand. We see that the convenience yield increases 171 to 105 bp per USD trillion treasuries bought by the corporates for the ordinary least squares estimate, depending on duration. However the instrumental variable estimate is an increase of 523 to 467 bp per USD trillion treasuries bought. This difference suggests that confounding factors are biasing our estimate downwards. For example that corporates may tend to purchase more treasuries when they know the price impact is low. On the other hand our instrumental variable result is more reliable as the treasury purchases are instrumented from the exogenous change in the corporates idiosyncratic volatility.

[Table 3.4 about here]

To get an idea of the economic meaning of the price impacts consider the case where treasuries outstanding had been constant during the period at USD 10 trillion, which is close to the average value. Then we get that if corporates were to buy 1% of the treasuries it would increase the convenience yield by 50 bp, suggesting a price impact of $\frac{1}{2}$ in terms of yields.

This equates to approximately the same for prices as the duration is around 1 year (6 months to 18 months). In general the price impact in terms of returns are declining in maturity, helping to equalise the price impact in terms of unit prices. This is a bit smaller but in line with the findings by Gabaix and Koijen (2020) of around 5%, and is within the two-sigma confidence interval. Additionally, theirs is an estimate for equities, and it makes sense that the price impact on bonds to be lower than for equities. Also important to keep in mind that prior theoretical estimates based purely on rational expectations puts the price impact at around 100 times lower than both mine and Gabaix and Koijen (2020) estimates, hence I provide supporting evidence that the price impact is higher than previously thought. And hence that understanding investors behaviour is more important than previously thought. Additionally, my estimate is higher than the price impact found in Koijen and Yogo (2019a), which is for an individual investor, and as Gabaix and Koijen (2020) is at the completely aggregate level, it makes sense that my result will be somewhere in between.

[Table 3.5 about here]

Prices when including investment (full model specification). My theory suggests that the model specification should be equal to

$$R^c = \frac{1}{2} A \sigma_i^2 - k^{-1/2}.$$

And hence the convenience yield should in equilibrium be affected by the level of investment. I run regressions including the investment level of corporates in Table 3.6. The results show that the coefficient of investments indeed is negative. This means that an increase in investment *increases* the convenience yield, as investment k is raised to a negative power, which combined by the negative coefficient gives a positive relationship. The observation that the coefficient is not one, is explained by the simple assumption of the functional form of the investment function, in a more complicated model this coefficient would be pinned down by the returns to investing, meaning how efficiently investment converts capital today to capital tomorrow. The main point now is that it has the correct directional relationship, as this is a robust feature of both type of models. It also holds for all maturities of the convenience yield. The standard errors are corrected using generalised least squares. The coefficient on idiosyncratic volatility corresponds to a risk aversion of around 13, which fits within an order of magnitude of external estimates of the risk aversion coefficient. The estimated convenience yield from this model specification is shown to capture the realised convenience very well as can be seen earlier in Figure 3.6.

[Table 3.6 about here]

Risk premium explanation and prediction. Table 3.7 shows that implied idiosyncratic risk innovations predict future returns on the market portfolio. It hence works as a risk-factor, the beta of which is approximately 10% and highly significant. Column (2) includes the Fama-French three factors, as controls as they are known to explain equity returns, and does not alter the predictability of the idiosyncratic volatility. The same goes for Column (3) which includes the momentum factor. Column (4) and (5) adds the Intermediary Asset Pricing factor and Intermediary Asset Pricing Leverage ratio from Kelly He Manela (2017). The factor is around as significant as the idiosyncratic volatility factor, but the leverage ratio itself is not. The idiosyncratic volatility innovations remain around 10% and highly significant for all specifications, and illustrates the relevance of corporates in explaining the expected equity premium in the time series.

[Table 3.7 about here]

Table 3.8 shows that the variance of the idiosyncratic volatility factor, or more precicely the square of the idiosyncratic volatility innovations explain the risk premium, as they predict the return of the market portfolio. They do this in excess of the dividend-price ratio (Column 2) and the variance of the market portfolio (Column 3).

[Table 3.8 about here]

Table 3.9 repeats Table 3.7's specification for explanation instead of prediction where the idiosyncratic volatility factor remains highly significant. Important to notice here that current realisations command a negative return, which together with the observation from the previous table that they predict higher returns going forward, are exactly what we would expect from a risk factor which commands a positive risk premium. This again yields support to the validity of this framework derived from our model.

[Table 3.9 about here]

Table 3.10 shows that the idiosyncratic volatility is measure is not just better for risk premiums but is also much better than the intermediary asset pricing factors in explaining the convenience yield as considered previously. This is also the case for prediction shown in Table 3.11.

[Table 3.10 and 3.11 about here]

Impulse response functions of convenience yield on idiosyncratic volatility shocks. Figure 3.7 shows that idiosyncratic volatility shocks take about a month to get into the government bond prices. And that they have a permanent effect. The results are shown for convenience yield maturities of 6, 12, and 18 months, and are similar across. The numerical results are also available in tabular form in Table 3.12. The specification of the VAR also includes changes in the total volatility and the autocorrelation of the convenience yield. The daily change of the convenience yield associated with a 1 standard deviation shock to the idiosyncratic volatility is about 20 bp in the first day to 15 after a month, after which there are no more significant daily changes. This accumulated to a change in the convenience yield after two weeks, assuming no other shocks, of about 2%.

[Figure 3.7 and Table 3.12 about here]

3.6.3 Robustness

Table 3.13 shows that the main results are robust to different error specifications.

Table 3.14 shows that the main results are robust to considering different maturities.

Table 3.15 shows that the main results are robust to using a differences-on-differences specification. This specification gets rid of worries that both convenience yield and idiosyncratic volatility is driven by the same stochastic trend.

Note that the results are robust to both using the realised idiosyncratic volatility and the option implied idiosyncratic volatility. Additional results of the option implied measure are shown in Table 3.16. The results are also robust to estimating the idiosyncratic volatility using other risk models such as the CAPM. The results are also robust to measuring idiosyncratic volatility at the daily level using a rolling regression with a window of 1 year, instead of averaging the daily rates to a monthly value, which is the method of Ang et al. (2006, 2009).

Table 3.17 shows that the main results are robust to controlling for total volatility, however due to correlation between the two variables multicollinearity can cause the standard errors to occasionally blow up.

Table 3.18 shows that corporate demand proxied by idiosyncratic volatility affects government bond yields, but does not affect the option implied box yield. This is consistent with the idea of market segmentation, where corporates do not have access to trading the option implied safe asset, but can purchase government bonds.

[Table 3.13, 3.14, 3.15, 3.16, 3.17, and 3.18 about here]

Also note that Table 3.3 shows that the results are robust to considering other convenience yield measures. Table 3.3 also shows that the results are robust to considering different time periods.

Important to note that the results are robust to excluding financial firms in the calculation of the idiosyncratic volatility, which is done for idiosyncratic volatility measures.

3.6.4 Panel including cross-sectional results

Table 3.19 shows if firms experience higher idiosyncratic risk then they increase their savings and reduce investment. Columns (1) - (4) report the investment results.

Column (1) shows that the investment rate decreases by 1.7 percentage points (pp) if the idiosyncratic risk is doubled. This estimate decreases to 0.7 pp in Column (2), where

I control for the systemic risk. However note that idiosyncratic risk and systemic risk is correlated and is thus prone to multi-colinearity which may bias the coefficients and inflate the standard errors. Columns (3) and (4) show that a doubling in the idiosyncratic volatility is associated with a decrease in the amount spent on property, plant, and equipment by 5.2 pp. Dropping to 4.5 pp when controlling for systemic risk.

Columns (5) and (6) show that a doubling of the idiosyncratic risk leads to an increased cash holding rate of 4.2 pp (2.5 pp when controlling for systemic risk). Columns (7) and (8) show this to almost double to 7.6 (4.9) pp when including cash equivalents to in the savings measure. On the other hand Column (9) shows that this effect is partly offset by a decrease in short term investments, as a savings measure which include cash, cash equivalents and short term assets decreases to 1.2 (1.3) pp.

These panel findings provide cross-sectional validity for my theory. Overall, the average level of idiosyncratic risk has decreased corporate investment by around 5% annually over the sample.

[Table 3.19 about here]

3.7 Instrumental Variables Results

This section shows that the main result is robust to instrumenting idiosyncratic volatility with several sources of exogenous variation. The reason to consider this is that one may be concerned about confounding factors that may affect the convenience yield and be correlated with the aggregate level of idiosyncratic volatility.

Such as systemic volatility, which due to multicolinearity issues may be hard to control for in a normal regression. Another example is that Nagel (2016) shows that the interest level to be a determining factor of the convenience yield, and this may be correlated with the aggregate idiosyncratic risk. Maybe from a reach for yield channel. Again, this may be hard to control for in a normal regression, maybe due to non-linearities near the zero lower bound. A last example is that the supply of government debt may be a confounding factor. An increase in the supply of government debt may decrease the convenience yield, and be correlated with aggregate idiosyncratic volatility, for example around large crises which demand fiscal intervention. Of course, this effect goes in the opposite direction, and would imply that my estimate for the convenience yield effect is a lower bound.

Nevertheless, exploiting these sources of exogenous variation, is a way to control for these confounding factors, and certify the external validity of my results.

Table 3.20 shows that the main result is robust to using exogenous variation in firm sizes arising from exploiting the Granular Instrumental Variables of Gabaix and Koijen (2019). The idea of this method is that since idiosyncratic is determined at the firm level, one can control for the factors affecting idiosyncratic risk by subtracting an equally weighted idiosyncratic risk measure from the original value-weighted idiosyncratic risk measure, leaving just the effect from the fact that larger firms happen to have an increase in their idiosyncratic risk relative to the average change. Hence, it is a way to exploit differences in firm size, which is plausibly exogenous to the confounding factors we are worried about, to construct a measure that is independent of factors affecting idiosyncratic risk, but still is correlated to the aggregate idiosyncratic risk level. I then use this measure to instrument for the aggregate level of idiosyncratic risk and run a two-stage least-squares estimation and compare it to the ordinary least squares estimates. This is done for all three maturities: 6, 12, and 18 months. Column (1) and (2) shows the results for the 6 month maturity, where Column (1) is the OLS estimate from Section 3.6.2. Column (2) on the other hand shows the new granular instrumental variable result. Here we see that effect is still significant, although highly attenuated. Columns (3-6) show the results for the other maturities. I note that the instrument is not weak as the first stage F test statistic is very high at 9634. It makes sense that the GIV estimates to be weaker, as they indicate that if a firm has increased idiosyncratic risk independently of the rest, their price impact also tend to be smaller, as there are less firms competing for the safe assets. Overall, the results help establish a causal relationship from the idiosyncratic volatility to the convenience yield.

[Table 3.20 about here]

Another way to see this is shown in Table 3.21. This table shows that the main result is robust to using the exogenous variation in industry external exposures from Alfaro, Bloom and Lin (2018). I use the exposure to the implied variance of the external factors, while controlling for the exposure to the implied change in the factors. The variation in these exposures are used to instrument for each firms idiosyncratic volatility, after which I value-weigh the instrumented idiosyncratic volatility as previously. I can then regress the convenience yield on this instrumented idiosyncratic volatility measure, without worrying about endogeneity concerns. This is done for all three maturities: 18, 12, and 6 months. Column (1) shows the result for the 18 month maturity. Here we see that the effect is still significant, and very close to the OLS estimate from Table 3.20. Columns (1) and (2) show the results for the other maturities, where the effect is decreased a little compared to the OLS estimates and the errors also increase. It makes sense that the errors increase as we are losing variation. The instrument is not weak as the first stage F test statistic is 18.3. The results suggest that our main estimates are not greatly biased and help establish a causal relationship from the idiosyncratic volatility to the convenience yield.

[Table 3.21 about here]

Table 3.22 shows that the main result of idiosyncratic volatility leading to higher savings and less investment is robust to instrumenting idiosyncratic volatility with the same measure from Alfaro, Bloom and Lin (2018) as used in Table 3.21. Columns (1)-(3) report savings results and Columns (4)-(6) report investment results. First the OLS result is repeated and then the IV result is shown but without and with controlling for the first order moments of the instruments. We see from the IV estimates of Columns (2), (3), (5), and (6) that controlling for the 1st moment does not change the results much. We also see that the IV and OLS results have the same sign, but that they are much greater, suggesting our original results to have been biased downwards.

[Table 3.22 about here]

3.8 Discussion and Concluding Remarks

Overall, my paper shows the importance of corporates as an investor group. And that their previously unexplained demand can partially be explained by an optimal exposure to the firms idiosyncratic risk. A great example is for the convenience yield, where corporate demand can explain 84% of the convenience yield over the time period. Hence, my paper gives hope to understanding outstanding asset pricing and macroeconomics puzzles, as it shows that the largely unexplored avenue of taking corporates moral hazard issue seriously and incorporate their idiosyncratic risk as a factor is promising

One implication of my finding is if you could measure CEO effort better then one could reduce the externality on investment. Additionally, constructing better payoffs using options is also a way to reduce the externality. Indeed, this is a move we see more and more in the industry.

Understanding who the marginal investor is and their asset demand is a promising avenue to pursue. Whilst my work has focused on corporate firms, important work still exists in understanding other large investors such as pension funds, hedge funds, banks, and other institutional investors, and how they interplay.

Additionally on a more macroeconomic level, my work helps quantify an economic cost of moral hazard, as it has decreased investment and growth in the economy, in addition to inflating prices on government debt and money leading to deflationary effects. It also helps explain the break down of lower interest rates and investment growth as witnessed in the last decades. And in terms of future work my paper opens up for the interesting research question of whether the increase in (knowledge-based) intangible assets, which are prone to creative destruction, has lead to an increase in idiosyncratic risk, which could help explain the higher degrees of savings and drop in investment that we have observed over the last decades.

I provide a highly tractable framework that can easily be extended to help explain current macro-finance questions, such as the idea of an interest rate trap or reversal-rate.[14]

[14] Reversal-rate is the idea that there is an interest rate level that if you lower it below this it would lead to less growth, rather than higher growth. To see this in my framework one simply needs to implement the idea that investors have an absolute return requirement. The channel would be that as the interest rate is lowered there will be an increasing incentive for the investor/owner to incentivise the manager to take on more risk, but this would require a higher managerial compensation due taking on more investments with moral hazard. There would then be a level where the lower investment due to moral hazard outweighs the investors preference for higher returns. In such a situation the right policy would not be monetary, but to reduce idiosyncratic volatility for example through fiscal spending.

Figures and Tables

Figures

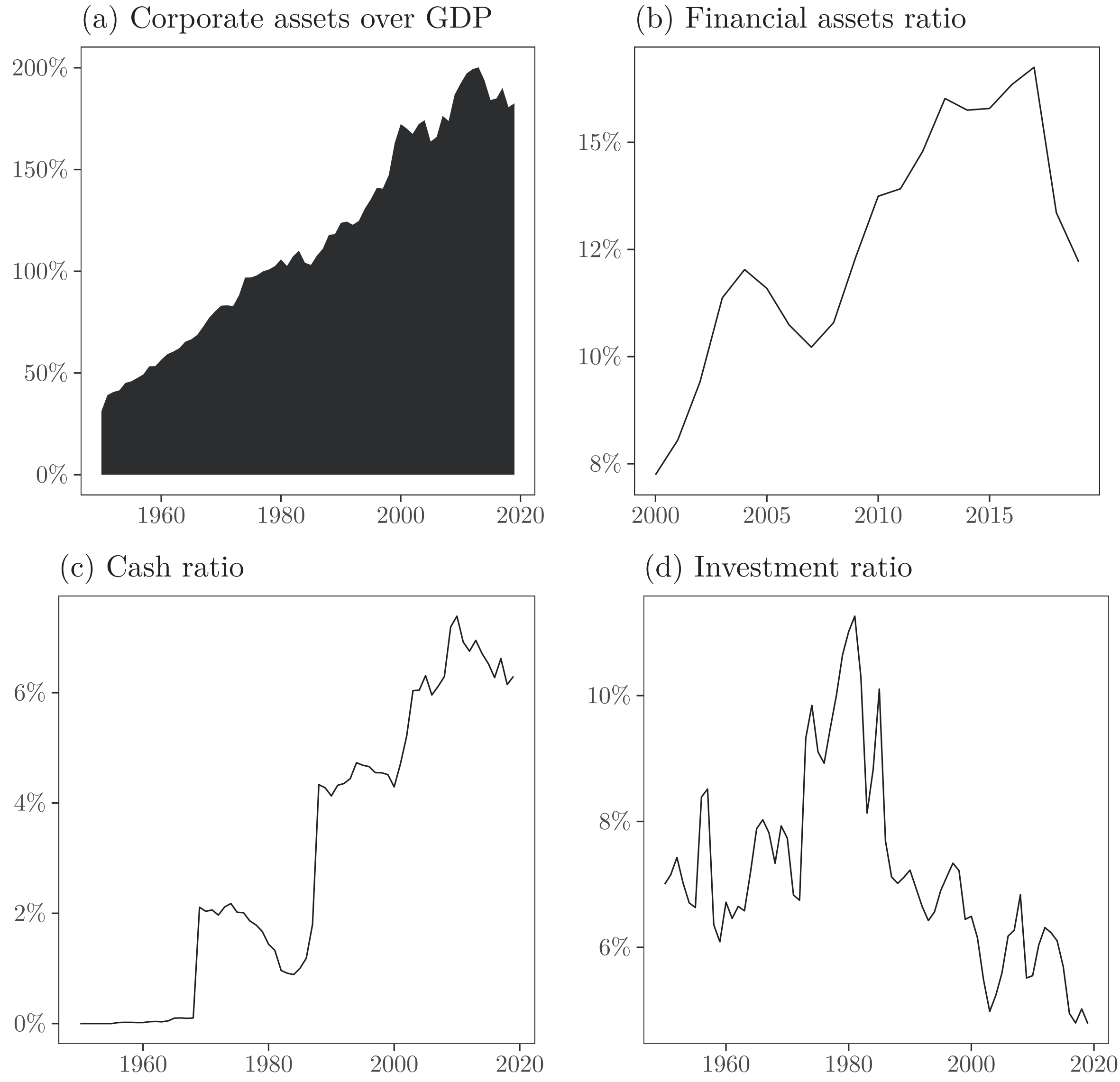

Figure 3.2: The Rise of the Corporate Investor Group

Panel (a) shows firms total assets as a fraction of GDP. Panel (b) shows total financial assets held by firms as a fraction of their assets. Panel (c) shows firms savings as amount of their assets placed in cash or cash-equivalents. Panel (d) shows corporates investment ratio.

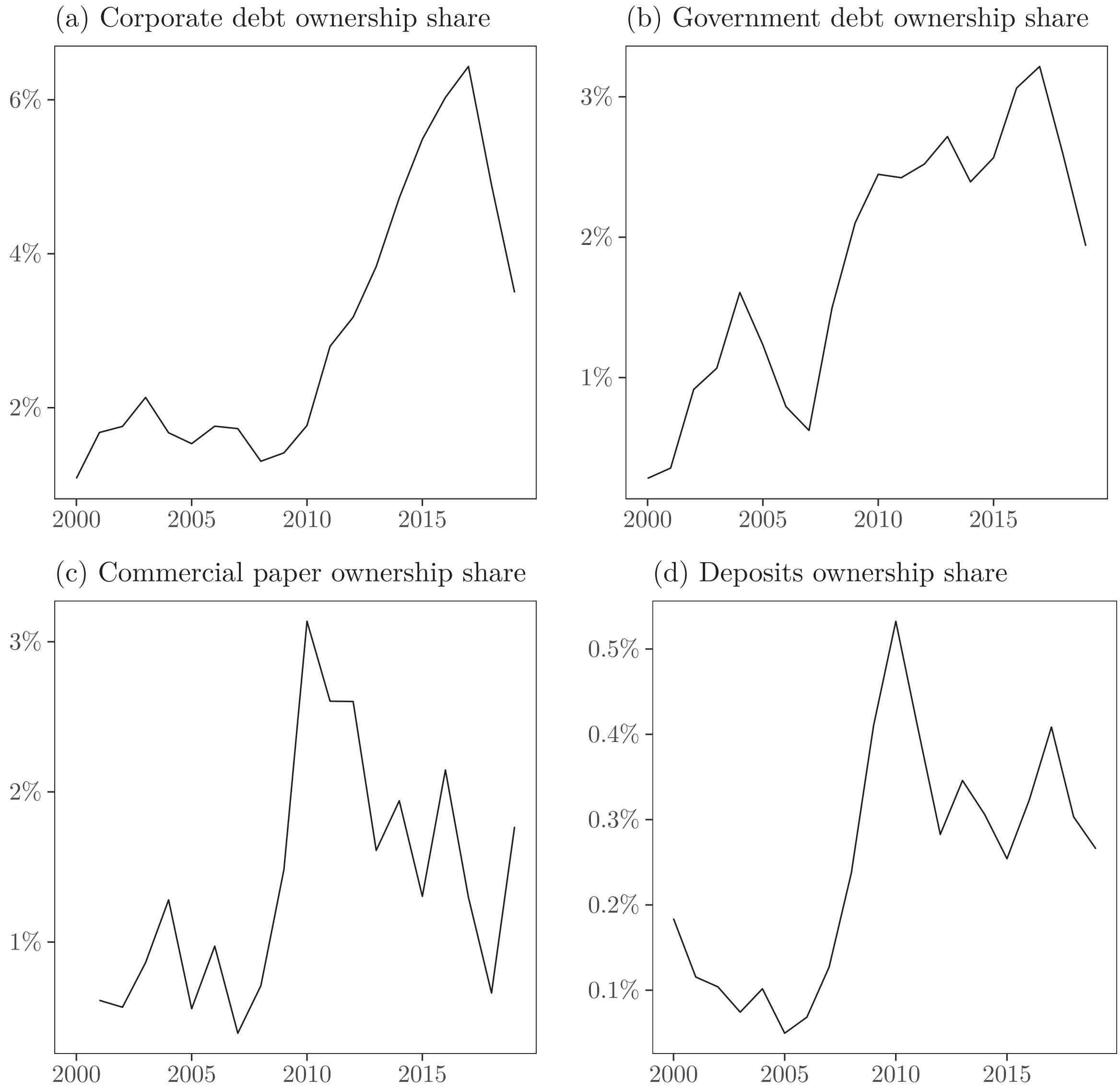

Figure 3.3: Corporates Security Ownership Shares

Panel (a) shows firms total ownership of corporate debt as a fraction of corporate debt outstanding in the US. Panel (b) shows firms total ownership of government debt as a fraction of government debt outstanding in the US. Panel (c) shows firms total commercial paper ownership ratio. Panel (d) shows firms total deposit ownership ratio.

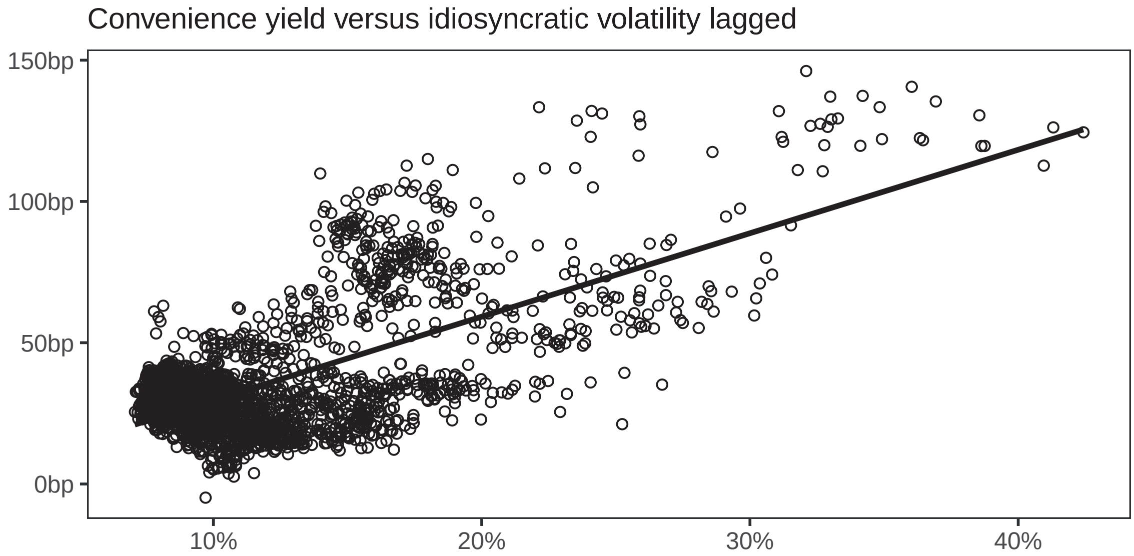

Figure 3.4: Figure shows how the Idiosyncratic Volatility predicts Idiosyncratic Volatility

Black line shows the OLS regression line $R_t^c = \alpha + \beta\sigma_{t-1}^i + \epsilon$. Pearsons correlation coefficient (r) is 65%. Shown for a maturity of 18 months and option implied monthly idiosyncratic volatility. Idiosyncratic volatility is annualized.

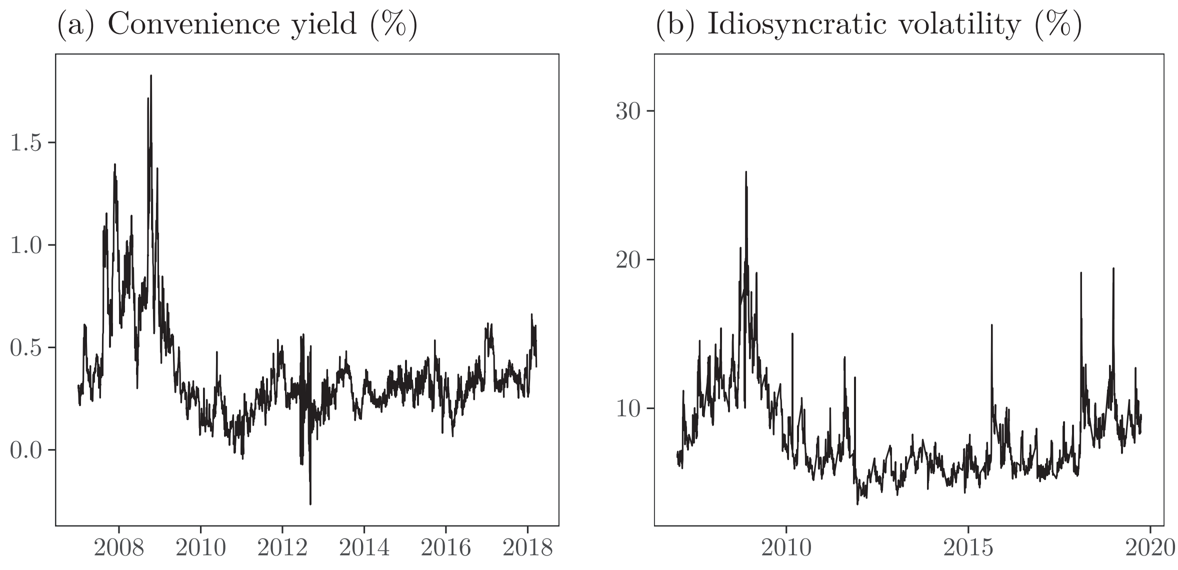

Figure 3.5: Convenience Yield and Idiosyncratic Volatility over time

The correlation of the two graphs is $61\% \pm 2\%$. Convenience yield is for 6 months and is from Van Binsbergen, Diamond and Grotteria (2021). Idiosyncratic volatility is the product of the square-root of implied correlation subtracted by 1 multiplied by the implied volatility (VIX), both from CBOE. This idiosyncratic volatility measure is inspired by Kelly, Lustig and Van Nieuwerburgh (2016).

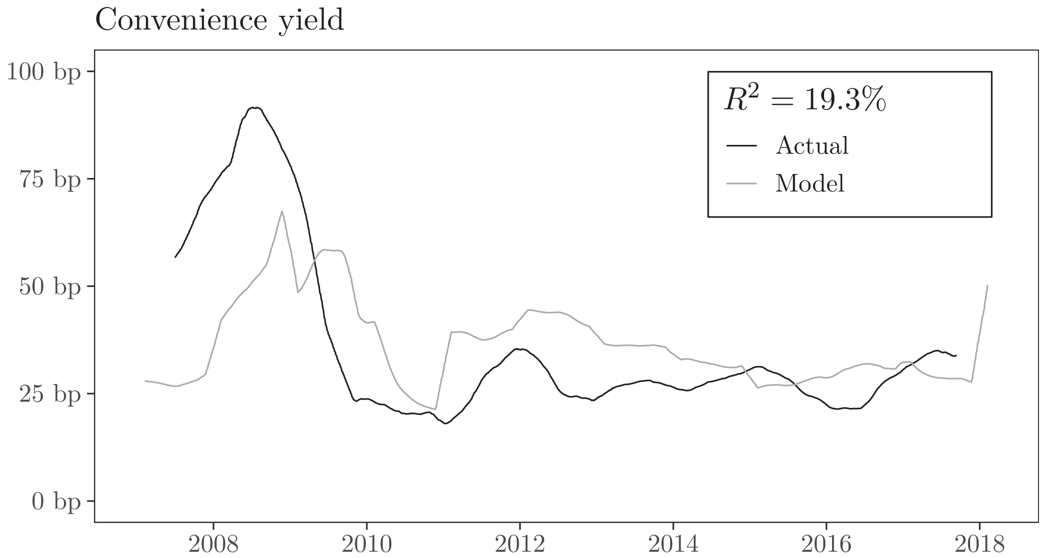

Figure 3.6: Realised versus Model Implied Convenience Yield

Figure shows the convenience yields. Black line shows the yearly smoothed actual yield. Grey line shows the smoothed predicted value from the OLS regression $R^c = \alpha + \beta\sigma^i + \gamma k^{-1/2} + \epsilon$. The explained variance is 19.3%. Shown for a maturity of 18 months and daily realised idiosyncratic volatility.

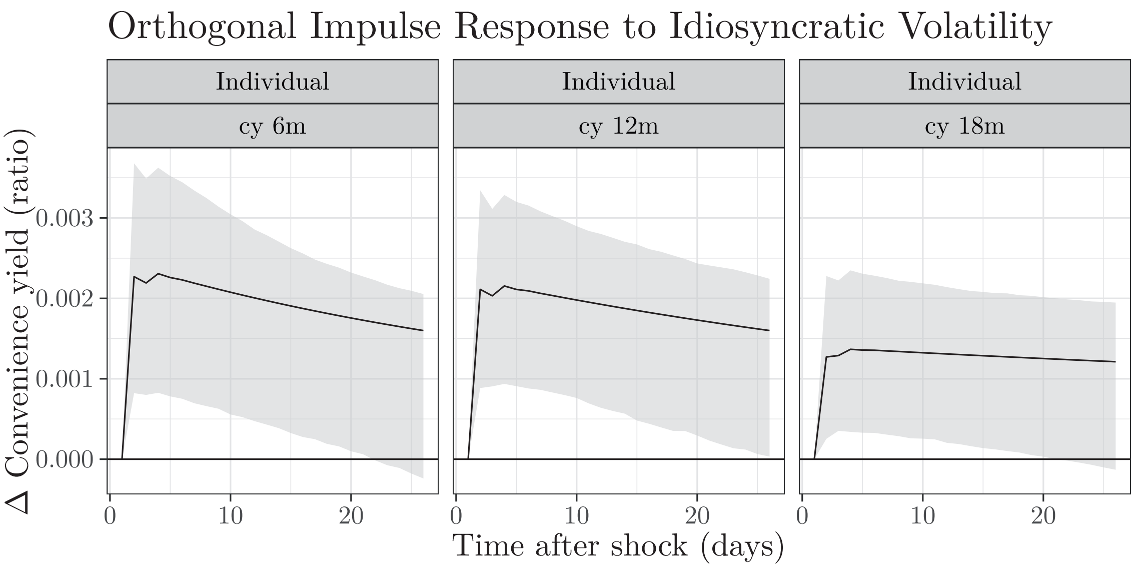

Figure 3.7: Figure shows the Daily Cumulative Response of the Convenience Yield to a Shock to Idiosyncratic Volatility

Measured as the orthogonal impulse response to a one standard deviation shock. Confidence bounds in grey. Lower bound is the 10th decile and upper 90th of a 1000 bootstraps. Resulting from a vector autoregression with two lags on convenience yield, idiosyncratic volatility and total volatility.

Tables

Table 3.1: The Convenience Yield Puzzle

Table shows how well previous theories explain the convenience yield. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. Results are shown for 18 month maturity, but are the same for the other maturities I have data on (6 and 12 months). The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Fundfunds is the Fed funds rate as used in Nagel (2016) and is from FRED. The debt to GDP ratio as used in Krishamurthy and Vissing-Jorgensen (2012) and is from FRED. IVol is the idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Standard errors are Newey-White (1994) with automatic lag length choice. T-statistics are shown in square brackets.

	Convenience Yield (%)		
	Before 2009	After 2009	
	Model 1	Model 2	Model 3
(Intercept)	−4.795***	0.723***	0.057
	[−17.449]	[3.572]	[0.185]
debt_to_gdp_fred	8.605***	−0.475*	−0.026
	[19.013]	[−2.368]	[−0.106]
fedfunds	−0.165	7.280	5.642
	[−0.172]	[1.056]	[0.453]
ivol_mvmean			21.283**
			[3.358]
Num.Obs.	42	77	77
R2	0.737	0.128	0.307
R2 Adj.	0.723	0.104	0.278
AIC	−47.7	−141.6	−157.3
BIC	−40.8	−132.3	−145.6
Log.Lik.	27.865	74.823	83.667

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.2: Robustness of the Convenience Yield Puzzle

Table shows how well previous theories explain the convenience yield. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. Results are shown for 18 month maturity, but are the same for the other maturities I have data on (6 and 12 months). The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Fundfunds is the Fed funds rate as used in Nagel (2016) and is from FRED. The debt to GDP ratio as used in Krishamurthy and Vissing-Jorgensen (2012) and is from FRED. IVol is the idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Standard errors are Newey-White (1994) with automatic lag length choice. T-statistics are shown in square brackets.

	Convenience Yield							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
(Intercept)	−4.812***	0.628**	0.639	0.273***	−4.795***	0.723***	−5.294**	0.057
	[−16.974]	[3.171]	[0.524]	[13.835]	[−17.449]	[3.572]	[−3.262]	[0.185]
debt_to_gdp_fred	8.623***	−0.355+			8.605***	−0.475*	9.562**	−0.026
	[18.436]	[−1.794]			[19.013]	[−2.368]	[3.093]	[−0.106]
fedfunds			−2.675	3.322	−0.165	7.280	−0.376	5.642
			[−0.099]	[0.628]	[−0.172]	[1.056]	[−0.298]	[0.453]
ivol_mvmean							−6.799	21.283**
							[−0.330]	[3.358]
Num.Obs.	42	77	42	77	42	77	42	77
R2	0.737	0.075	0.026	0.013	0.737	0.128	0.738	0.307
R2 Adj.	0.730	0.062	0.002	0.000	0.723	0.104	0.717	0.278
AIC	−49.7	−139.1	5.2	−134.1	−47.7	−141.6	−45.9	−157.3
BIC	−44.5	−132.0	10.4	−127.1	−40.8	−132.3	−37.2	−145.6
Log.Lik.	27.858	72.538	0.408	70.052	27.865	74.823	27.939	83.667

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.3: Corporate Safe Asset Demand

Table shows asset prices as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. Results are shown for 18 month maturity, but are the same for the other maturities I have data on (6 and 12 months). The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). BAcc/T-Bill is the spread of the Bank Acceptance Rate and Treasury Bill Rate from Nagel (2016). Also from this paper is the Commercial Deposit Rate minus Treasury Bill Spread (CD/T-Bill). The AAA and BBB Yield are the yields on corporate debt with the corresponding rating. Data is provided by Moody's. IVOL is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). IIVOL is the option implied idiosyncratic volatility. Results are the same for other models, such as the CAPM-model. Standard errors are Newey-White (1994) with automatic lag length choice. T-statistics are shown in square brackets.

	Convenience Yield		BAcc/T-Bill		CD/T-Bill		AAA Yield		BBB Yield	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IVOL(t-1)	0.2945***		0.2310***		0.2655		2.1824***		2.9517***	
	[5.7570]		[2.6273]		[1.4897]		[2.8458]		[3.9062]	
IIVOL(t-1)		0.1137***		0.0803*		0.6115***		0.5975***		1.0403***
		[16.2499]		[1.7579]		[4.2508]		[5.5895]		[9.3752]
Intercept	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Start Date	2007-01-03	2007-01-03	1926-07-31	2007-01-31	1976-01-31	2007-01-31	1926-07-31	2007-01-31	1926-07-31	2007-01-31
End Date	2018-03-19	2018-03-19	2011-12-31	2011-11-30	2011-12-31	2011-11-30	2019-12-31	2018-11-30	2019-12-31	2018-11-30
Observations	2797	2307	1026	36	432	36	1122	85	1122	85
R^2	**0.19**	**0.29**	**0.04**	**0.10**	**0.02**	**0.38**	**0.10**	**0.43**	**0.17**	**0.69**
Stand. errors	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.4: Corporate Demand and Convenience Yield: Price Impacts of Asset Purchases

Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). Holdings are in USD trillions. IVol is in percent daily. The second stage results are limited back in time due to the availability of the convenience yield measure. T-statistics are shown in square brackets.

	Dependent variable:						
	Holdings(t-1)	$\Delta_{2,-1}$ Convenience Yield (bp). Maturity:					
		18m		12m		6m	
	1 Stage	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Holdings(tri), t -1		171**	523*	149**	467*	105*	391
		[3]	[2]	[2]	[2]	[2]	[2]
Implied IVol, t -2	20540***						
	[4]						
Constant	20408***	-15852**	-48867*	-13792**	-43661*	-9486*	-36249
	[3]	[-3]	[-2]	[-2]	[-2]	[-2]	[-2]
Obs (Quarters)	279	28	28	28	28	28	28
F-stat, p	0.00005						
Weak Instruments, p			0.07		0.07		0.07
Wu Hausman, p			0.05		0.09		0.06
Wald test p-value	0.00	0.02	0.07	0.04	0.10	0.07	0.10

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.5: Corporate Demand and Convenience Yield: Price Impacts of Asset Purchases. Earlier purchasing period

Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVOL is the option implied idiosyncratic volatility. IVOL is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). Holdings are in USD trillions. IVOL is in percent daily. The second stage results are limited back in time due to the availability of the convenience yield measure. T-statistics are shown in square brackets.

	Dependent variable:						
	Holdings(t-1)	$\Delta_{1,-2}$ Convenience Yield (bp). Maturity:					
		18m		12m		6m	
	1 Stage	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Holdings(tri), t -1		116*	478**	96	451**	85	322**
		[2]	[2]	[1]	[2]	[2]	[2]
Implied IVOL, t -2	20540***						
	[4]						
Constant	20408***	-10727	-44817**	-8872	-42261**	-7645	-29879*
	[3]	[-2]	[-2]	[-1]	[-2]	[-1]	[-2]
Obs (Quarters)	279	28	28	28	28	28	28
F-stat, p	0.00005						
Weak Instruments, p			0.07		0.07		0.07
Wu Hausman, p			0.05		0.09		0.06
Wald test p-value	0.00	0.10	0.03	0.18	0.05	0.13	0.05

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.6: The convenience yield curve with idiosyncratic volatility and investment

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for three different maturities: 6, 12, and 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:			
	Convenience Yield			
Maturity:	6 months		12 months	18 months
	(1)	(2)	(3)	(4)
Idiosyncratic Volatility	27.930^{***}	30.946^{***}	25.967^{***}	27.244^{***}
	t = 14.970	t = 16.199	t = 14.602	t = 15.514
Investment	0.0001^{***}			
	t = 8.349			
-Investment$^{-1/2}$		58.617^{***}	55.980^{***}	40.253^{***}
		t = 10.460	t = 11.558	t = 8.680
Constant	✓	✓	✓	✓
Regression method	GLS	GLS	GLS	GLS
Observations	2,798	2,798	2,798	2,798
R^2	0.074	0.086	0.076	0.079
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.7: Idiosyncratic volatility and equity premium prediction

Table shows the Equity premium as affected by corporate demand proximated by idiosyncratic volatility. The equity premium is from Ken French' website. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). Results are the same for other models, such as the CAPM-model. T-statistics are shown in square brackets.

	Dependent variable:				
	Equity premium$_t$				
	(1)	(2)	(3)	(4)	(5)
f^{IIVOL}_{t-1}	0.121***	0.116***	0.117***	0.093***	0.101***
	t = 3.801	t = 3.602	t = 3.638	t = 2.742	t = 2.952
f^{smb}_{t-1}		0.033	0.037	0.040	0.039
		t = 0.754	t = 0.840	t = 0.911	t = 0.880
f^{hml}_{t-1}		−0.057	−0.011	0.035	0.019
		t = −1.599	t = −0.241	t = 0.709	t = 0.377
f^{mom}_{t-1}			0.050*	0.029	0.037
			t = 1.682	t = 0.942	t = 1.168
f^{iapf}_{t-1}				−3.971**	
				t = −2.376	
f^{iapr}_{t-1}					−2.529
					t = −1.343
Alpha	0.037	0.036	0.036	0.036	0.037
	t = 1.523	t = 1.506	t = 1.507	t = 1.498	t = 1.540
Observations	2,460	2,460	2,460	2,460	2,460
Adjusted R^2	0.005	0.006	0.007	0.009	0.007
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 3.8: Monthly idiosyncratic volatility and equity premium prediction

Table shows the Equity premium as affected by corporate demand proximated by idiosyncratic volatility. The equity premium is from Ken French' website. The ivol factor f^{IVOL} is the square of the AR(1) innovations in the idiosyncratic volatility estimated at daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Results are the same for other models, such as the CAPM-model.

	Dependent variable:		
	Equity Premium$_t$		
	(1)	(2)	(3)
f^{IVOL}_{t-1}	−140.499***	−137.016***	−119.155**
	t = −3.840	t = −3.744	t = −2.427
Dividend-Price ratio$_{t-1}$		0.036*	0.046*
		t = 1.755	t = 1.782
(Equity Premium^2)$_{t-1}$			−1.314
			t = −1.020
Constant	0.001***	0.003***	0.003***
	t = 3.836	t = 3.234	t = 2.891
Observations	815	815	539
Adjusted R^2	0.017	0.019	0.017
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 3.9: Idiosyncratic volatility and equity premium explanation

Table shows the Equity premium as affected by corporate demand proximated by idiosyncratic volatility. The equity premium is from Ken French' website. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). f^{iapf} and f^{iapr} is the intermediary asset pricing factor and intermediary leverage ratio of He and Krishnamurthy (2017) respectively. Results are the same for other models, such as the CAPM-model. T-statistics are shown in square brackets.

	Dependent variable:				
	Equity Premium				
	(1)	(2)	(3)	(4)	(5)
f^{IIVOL}	-0.636^{***}	-0.541^{***}	-0.547^{***}	-0.276^{***}	-0.200^{***}
	t = −21.821	t = −20.340	t = −21.002	t = −13.354	t = −10.591
f^{smb}		0.361^{***}	0.342^{***}	0.308^{***}	0.303^{***}
		t = 9.885	t = 9.552	t = 11.332	t = 12.397
f^{hml}		0.672^{***}	0.437^{***}	-0.067^{**}	-0.215^{***}
		t = 22.701	t = 11.961	t = −2.228	t = −7.725
f^{mom}			-0.254^{***}	−0.023	0.039^{**}
			t = −10.523	t = −1.231	t = 2.249
f^{iapf}				43.829^{***}	3.648^{*}
				t = 42.746	t = 1.907
f^{iapr}					51.617^{***}
					t = 23.978
Alpha	0.037^{*}	0.036^{*}	0.036^{*}	0.039^{***}	0.020
	t = 1.669	t = 1.820	t = 1.857	t = 2.650	t = 1.519
Observations	2,461	2,461	2,461	2,461	2,461
Adjusted R^2	0.162	0.319	0.348	0.626	0.697
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 3.10: Corporate vs intermediary based asset pricing: Convenience yield explanation

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. Shown for a convenience yield of 18 months maturity. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). f^{iapf} and f^{iapr} is the intermediary asset pricing factor and intermediary leverage ratio of He and Krishnamurthy (2017) respectively.

	Dependent variable:			
	Convenience Yield			
	(1)	(2)	(3)	(4)
IIVol	0.054***	0.054***		
	t = 50.516	t = 50.593		
f^{IIVOL}			0.031***	0.032***
			t = 4.841	t = 5.086
f^{iapf}	0.022		−0.218	
	t = 0.137		t = −0.900	
f^{iapr}		0.076		0.005
		t = 0.453		t = 0.018
Constant	−0.062***	−0.062***	0.365***	0.365***
	t = −6.816	t = −6.839	t = 78.425	t = 78.402
Observations	2,334	2,334	2,310	2,310
Adjusted R^2	0.524	0.524	0.012	0.012
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.11: Corporate vs intermediary based asset pricing: Convenience yield prediction

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. Shown for a convenience yield of 18 months maturity. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). f^{iapf} and f^{iapr} is the intermediary asset pricing factor and intermediary leverage ratio of He and Krishnamurthy (2017) respectively.

	Dependent variable:			
	Convenience Yield$_t$			
	(1)	(2)	(3)	(4)
IIVol$_{t-1}$	0.047***	0.047***		
	t = 37.629	t = 37.668		
f^{IIVOL}_{t-1}			0.031***	0.033***
			t = 4.783	t = 5.001
f^{iapf}_{t-1}	0.261		0.007	
	t = 1.421		t = 0.029	
f^{iapr}_{t-1}		0.299		0.207
		t = 1.543		t = 0.796
Constant	−0.004	−0.004	0.365***	0.365***
	t = −0.387	t = −0.383	t = 77.121	t = 77.114
Observations	2,307	2,307	2,283	2,283
Adjusted R^2	0.381	0.381	0.010	0.010
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.12: Predictive convenience yield curve regressions: VAR specification

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for three different maturities: 6, 12, and 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:		
	$cy\_6\_m_t$	$cy\_12\_m_t$	$cy\_18\_m_t$
	(1)	(2)	(3)
$IVol_{t-1}$	6.319***	4.686***	3.315***
	[3.758]	[3.360]	[2.953]
$TVol_{t-1}$	−3.645***	−2.752***	−1.919***
	[−3.631]	[−3.300]	[−2.878]
cy_6m_{t-1}	0.953***		
	[166.481]		
cy_12m_{t-1}		0.963***	
		[190.627]	
cy_18m_{t-1}			0.976***
			[238.126]
Constant	−0.004	−0.002	−0.003
	[−0.743]	[−0.312]	[−0.676]
Observations	2,797	2,797	2,797
R^2	0.925	0.940	0.962
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 3.13: Idiosyncratic volatility and the convenience yield: Different regression methods.

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The columns vary how the main regression specification is computed. The Convenience Yield is shown for a maturities of 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:		
	Convenience Yield		
	OLS	White	GLS
	(1)	(2)	(3)
Idiosyncratic Volatility	16.551***	16.551***	25.457***
	[17.796]	[12.536]	[19.125]
Constant	0.129***	0.129***	0.007
	[9.255]	[7.760]	[0.384]
Observations	2,798	2,798	2,798
R^2	0.102	0.102	0.116
Note:	*p<0.1; **p<0.05; ***p<0.01		
	T-stat in square brackets		

Table 3.14: The convenience yield curve

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for three different maturities: 6, 12, and 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:		
	cy_6m	cy_12m	cy_18m
	(1)	(2)	(3)
IVol	18.655***	18.131***	25.457***
	[13.380]	[13.502]	[19.125]
Constant	0.105***	0.117***	0.007
	[5.679]	[6.708]	[0.384]
Standard errors	GLS	GLS	GLS
Observations	2,798	2,798	2,798
R^2	0.060	0.061	0.116
Note:			*p<0.1; **p<0.05; ***p<0.01 T-stat in square brackets

Table 3.15: Idiosyncratic volatility and the convenience yield: difference-on-difference specification

The convenience yield curve. Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for the maturity of 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). For the monthly frequency a rolling version is not necessary and not used. Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:	
	ΔConvenience Yield$_t$	
	(1)	(2)
Δ Idiosyncratic Volatility$_{t-1}$	0.012***	0.014**
	[5.912]	[2.296]
Constant	0.000	0.000
	[-0.333]	[-0.460]
Frequency	Daily	Monthly
Observations	2740	72
R^2 Adjusted	0.049	0.157

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.16: Option implied idiosyncratic volatility

Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The results control for the market return and volatility, both realised and implied. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. T-statistics are shown below.

	Dependent variable:				
		cy_6m		cy_12m	cy_18m
	(1)	(2)	(3)	(4)	(5)
IIVol	0.050***		0.070***	0.060***	0.060***
	t = 40.077		t = 34.895	t = 31.936	t = 33.458
IIVol^2		0.002***			
		t = 38.873			
Equity Premium			0.0003	−0.0004	−0.001
			t = 0.083	t = −0.135	t = −0.205
Equity Premium^2			0.001	0.003***	0.002***
			t = 1.396	t = 3.477	t = 2.626
VIX			−0.009***	−0.005***	−0.003***
			t = −12.417	t = −7.486	t = −4.478
Constant	✓	✓	✓	✓	✓
Observations	2,334	2,334	2,334	2,334	2,334
R^2	0.408	0.393	0.447	0.468	0.528
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 3.17: Idiosyncratic volatility and the convenience yield: Controlling for total volatility

Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The results control for total volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Dependent variable:		
	cy_6m	cy_12m	cy_18m
	(1)	(2)	(3)
Idiosyncratic Volatility	123.311***	117.929***	120.868***
	[24.526]	[26.023]	[27.568]
Total Volatility	−64.491***	−60.638***	−57.634***
	[−21.557]	[−22.673]	[−22.378]
Constant	−0.181***	−0.172***	−0.276***
	[−8.430]	[−8.500]	[−13.835]
Standard errors	GLS	GLS	GLS
Observations	2,798	2,798	2,798
R^2	0.197	0.215	0.262
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 3.18: Idiosyncratic volatility and the convenience yield: Different rates

Table shows different rates as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Dependent variable:			
	box_6m	gov_6m	box_12m	gov_12m
	(1)	(2)	(3)	(4)
IVol	−6.704	−19.683***	1.370	−10.159*
	t = −1.093	t = −3.515	t = 0.232	t = −1.883
Constant	1.365***	1.181***	1.294***	1.086***
	t = 14.886	t = 14.099	t = 14.682	t = 13.453
Observations	2,798	2,798	2,798	2,798
R^2	0.0004	0.004	0.00002	0.001
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 3.19: Idiosyncratic volatility leads to less investment and higher savings

Table shows investment and savings as affected by by corporates idiosyncratic volatility. A is total assets. CAPX is capital expenditure. PPEGT is property plant and equipment. CH is cash. CHE is cash and cash equivalents. CHECH is CHE plus short term assets. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). SVol is systemic volatility. T-statistics are shown below.

	Dependent variable:									
	Investment				Savings					
	$\frac{\texttt{capx}}{\texttt{A}}$		$\frac{\Delta_{0,-12}\texttt{ppegt}}{\texttt{A}_{t-12}}$		$\frac{\texttt{ch}_t}{\texttt{A}_t}$		$\frac{\texttt{che}_t}{\texttt{A}_t}$		$\frac{\texttt{chech}_t}{\texttt{A}_t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IVol_{t-12}	-0.017^{***}	-0.007^{***}	-0.052^{***}	-0.045^{***}	0.042^{***}	0.025^{***}	0.076^{***}	0.049^{***}	0.012^{***}	0.013^{***}
	t = −44.507	t = −16.475	t = −15.954	t = −12.725	t = 47.411	t = 26.348	t = 76.865	t = 45.500	t = 10.619	t = 10.955
SVol_{t-12}		-0.032^{***}		-0.023^{***}		0.052^{***}		0.085^{***}		-0.005^{***}
		t = −60.783		t = −5.211		t = 43.153		t = 63.163		t = −3.056
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	1,965,336	1,965,336	1,784,510	1,784,510	1,977,215	1,977,215	2,012,746	2,012,746	1,976,925	1,976,925
Adjusted R^2	−0.016	−0.015	−0.017	−0.017	−0.016	−0.015	−0.014	−0.012	−0.017	−0.017

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

Table 3.20: Instrumented Idiosyncratic Volatility's and the Convenience Yield

Table shows the convenience yield as affected by corporates idiosyncratic volatility. Results are also shown for idiosyncratic volatility instrumented using exogenous variation in firms size as in Gabaix Koijen (2019). The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Dependent variable: Convenience Yield					
	6m		12m		18m	
	OLS	GIV	OLS	GIV	OLS	GIV
	(1)	(2)	(3)	(4)	(5)	(6)
IVol	18.97***	3.06**	16.79***	-0.60	22.63***	4.09***
	[14.83]	[2.08]	[13.93]	[-0.43]	[19.04]	[2.94]
Constant	0.09***	0.32***	0.12***	0.38***	0.03*	0.30***
	[4.55]	[14.53]	[6.78]	[18.00]	[1.65]	[14.48]
N (years)	2798	2798	2798	2798	2798	2798
R^2	0.07	0.02	0.06	0.00	0.11	0.04
F 1st stage		9634		9634		9634

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.21: Instrumented Idiosyncratic Volatility's and the Convenience Yield

Table shows the convenience yield as affected by corporates idiosyncratic volatility. Here idiosyncratic volatility is instrumented using exogenous variation in firms foreign risk exposures as in Alfaro et al. (2018). The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Convenience Yield		
	18m	12m	6m
	(1)	(2)	(3)
IVol	20.47**	14.21*	13.24
	[2.44]	[1.83]	[1.64]
Constant	-0.82	-0.47	-0.44
	[-1.67]	[-1.02]	[-0.91]
N (years)	10	12	12
R^2	0.43	0.25	0.21
F 1st stage	18.3	18.3	18.3

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.22: Instrumented Idiosyncratic Volatility's effect on Savings and Investment

Table shows savings and investments as affected by by corporates idiosyncratic volatility. Here the idiosyncratic volatility is instrumented using exogenous variation in firms foreign risk exposure from Alfaro et al. (2018). A is total assets. Savings S is cash. Investment K is capital expenditure. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown in square brackets.

	Saving, S(t)/A(t-1)			Investment, K(t)/A(t-1)		
	OLS	IV		OLS	IV	
	(1)	(2)	(3)	(4)	(5)	(6)
IVol(t-1)	0.09***	1.25**	1.18**	-0.01*	-1.33***	-1.21***
	[4.08]	[2.56]	[1.97]	[-1.76]	[-5.65]	[-3.93]
N	19448	19448	19448	19552	19552	19550
1st Moment 10IV(t-1)			✓			✓
Firm FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
F 1st stage	18.3	18.3	18.3	18.3	18.3	18.3

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

3.A Appendix

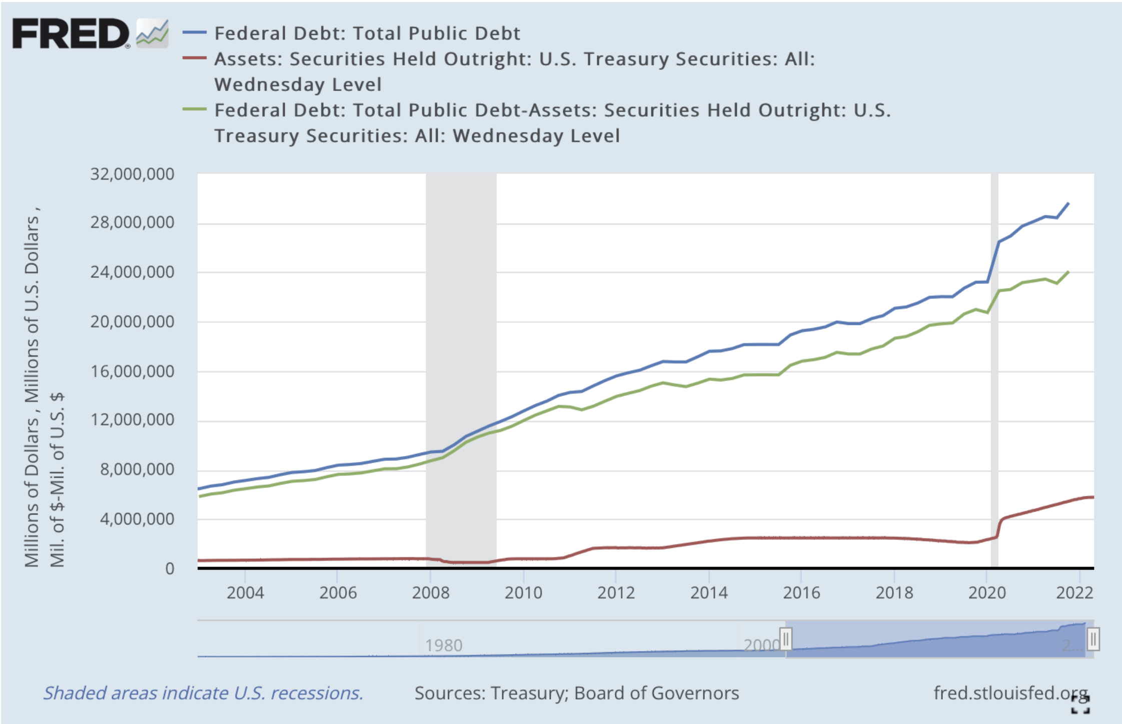

Figure 3.8: Figure shows the Net Bond Supply

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