The Financial Impact of Fossil Fuel Divestment
How Does Divestment Affect the Share Price of Targeted Companies?

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<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AAR</td>
<td>Average Abnormal Returns</td>
</tr>
<tr>
<td>AODP</td>
<td>Asset Owners Disclosure Project</td>
</tr>
<tr>
<td>APT</td>
<td>Arbitrage Pricing Theory</td>
</tr>
<tr>
<td>AR</td>
<td>Abnormal Returns</td>
</tr>
<tr>
<td>BIC</td>
<td>Bayesian Information Criterium</td>
</tr>
<tr>
<td>C</td>
<td>Celsius</td>
</tr>
<tr>
<td>CAAA</td>
<td>Comprehensive Anti-Apartheid Act</td>
</tr>
<tr>
<td>CAAR</td>
<td>Cumulative Average Abnormal Returns</td>
</tr>
<tr>
<td>CAPM</td>
<td>Capital Asset Pricing Model</td>
</tr>
<tr>
<td>CAR</td>
<td>Cumulative Abnormal Returns</td>
</tr>
<tr>
<td>CFP</td>
<td>Corporate Financial Performance</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>CPI</td>
<td>Climate Policy Initiative</td>
</tr>
<tr>
<td>CRSP</td>
<td>Center for Research in Security Prices</td>
</tr>
<tr>
<td>CSR</td>
<td>Corporate Social Responsibility</td>
</tr>
<tr>
<td>EMH</td>
<td>Efficient Market Hypothesis</td>
</tr>
<tr>
<td>FML</td>
<td>Full-Information Maximum Likelihood</td>
</tr>
<tr>
<td>Gt</td>
<td>Giga tons</td>
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</table>
| HML          | ‘High-Minus-Low’  
(Fama-French Factor measuring the performance of firms with a high book-to-market ratio as compared to firms with a low book-to-market ratio) |
| IEA          | International Energy Agency |
| IMF          | International Monetary Fund |
| LGCM         | Latent (Growth) Curve Modeling |
| LOP          | Law of One Price |
| NGO          | Non-Governmental Organization |
| NR           | Normal Returns |
| NYSE         | New York Stock Exchange |
| OECD         | Organisation of Economic Co-operation and Development |
| OLS          | Ordinary Least Squares |
| R&D          | Research and Development |
| SEM          | Structural Equation Modeling |
| SET          | Social Exchange Theory |
| SMB          | ‘Small-Minus-Big’  
(Fama-French Factor measuring the performance of firms with a small market capitalization as compared to firms with a large market capitalization) |
| SRI          | Socially Responsible Investing |
| TDM          | Taylored Design Method |
| U.S.         | United States |
| USD          | United States Dollar |
| WTI          | West Texas Intermediate |
1. Introduction

The fossil fuel divestment movement has reached global heights. As of fall 2017, 798 institutions have committed to divest from fossil fuel companies. Financial assets amounting to 5.53 trillion US dollars have been declared as ‘fossil free’, ‘coal free’ or ‘free of tar sands’ (Fossil Free 2017a). Initiated at U.S.-based universities in 2010, within seven years, the campaign has not only become the fastest growing campaign in history. It has further spread globally and has motivated institutions of all kinds to divest their holdings in the biggest oil, gas, and coal companies. The initially morally motivated divestors, mainly educational institutions, faith-based organizations, non-governmental organizations (NGOs), and philanthropic foundations, have recently been joined by an increasing number of financially motivated actors. These insurance companies, pension funds, and banking institutions have divested fossil fuels to avoid the financial and fiduciary risks associated with investment in a sector that relies on a business model which proves incompatible with the globally declared goal of keeping the world below 2°C (Arabella Advisors 2016: 1–3).

As part of a broader climate movement, divestment activists have claimed that fossil fuel divestment could weaken the destructive fossil fuel industry financially and release funds to finance the transition to a low-carbon economy. However, a much stronger focus has been put on the campaign’s broader potential to delegitimize destructive business practices, mobilize pressure on political and corporate leaders and shift public opinion laying the ground for a societal transformation (Seidman 2015: 1023–1028).

Consistent with activists’ perception of the greater importance of societal, cultural and political rather than financial impacts of divestment, empirical research on the fossil fuel campaign has so far highlighted its role as a lever for social change from a social movement perspective (Apfel 2015; Seidman 2015; Ayling and Gunningham 2015; Linnenluecke et al. 2015; Bratman et al. 2016; Grady-Benson and Sarathy 2015). Fossil fuel divestment’s financial impact, on the other hand, has received less attention. Although some authors investigate the question if divesting institutions benefit financially from abandoning fossil fuel assets (Fischel 2015; Cornell 2015; Trinks et al. 2017; Mercer 2015), divestment’s financial impact on targeted companies has not been systematically assessed.

Notwithstanding this gap, it has been argued that divestment’s potential to hurt firms financially should be negligible as the mere selling of stocks will not change future cash flows (e.g. Cornell 2015; Fischel 2015; Allen et al. 2009; Hunt, Weber, and Dordi 2016). Indeed, research on former divestment campaigns gives little hope for a strong financial impact (Ding, Parwada, and Shen 2014; Teoh, Welch, and Wazzan 1999).

However, even for earlier campaigns, reliable empirical studies are rare, and their results inconclusive. Further, and more importantly, divestment from fossil fuels should not be prematurely set equal to other divestment movements. The industries targeted by former campaigns, e.g. tobacco, alcohol or arms production, have always – notwithstanding their immoral character – been profitable and could hope to continue to be so in the future. In

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1 Divestment means the removal of funds such as shares, bonds or credit from companies engaged in activities which are considered unethical. Fossil Fuel divestment means “eliminating investments in major coal, oil, and gas companies and refusing to acquire new investments in such companies moving forward” Schneider et al. (2016: 109). In the following chapter, a more detailed definition will be given and discussed.
contrast, the days of the fossil fuel industry are commonly believed to be numbered (Baron and Fischer 2015). Against the backdrop of a global commitment to keep global warming below 2°C, fossil fuel companies might be forced to leave four fifths of their fossil reserves unburned\(^2\). The processing of these fuels however has, most probably, already been priced into the companies’ stock (Carbon Tracker Initiative 2014; Baron and Fischer 2015). In the context of this »carbon bubble« (Carbon Tracker Initiative 2014), the campaign could induce other investors, regardless how reckless, to sell assets before they become ‘stranded’. Heavy selling would, in turn, force stock prices down and seriously hurt the sector financially.

To explore the potential of the current divestment campaign adequately, it is hence indispensable to not only investigate its broader societal relevance but also to explore its financial impact. So far, there are no empirical analyses on this issue. This shortcoming is firstly to the detriment of the movement: Understanding the potentials of and the mechanisms behind hurting the fossil fuel sector financially would enable campaigners to adjust their (discursive) strategies and join forces effectively. Secondly, from an academic point of view, the opportunity should be seized to analyze the effects of what might (and most probably will) become the most important divestment movement in history. Insights can add a further piece to the puzzle of sustainable investment’s opportunities and limitations.

The present paper is an attempt to fill this gap. To improve understanding of the movement’s financial impact, divestment’s potential to depress stock prices of fossil fuel companies is scrutinized. The direct, short term, and indirect, mid to long-term, impacts of divestment on stock prices of the 200 largest coal, gas and oil firms are estimated. To this end, new data on divesting institutions was gathered. Including, inter alia, divestment dates, detailed sums divested, targeted companies and divestors’ motivation of 149 divesting institutions, the data set is the most extensive on divestment so far (including all previous campaigns, to the author’s best knowledge).

The theoretical reasoning behind divestment’s financial impact is straightforward: Divestment should depress share and bond prices what, in turn, increases capital costs inducing a company to invest less and produce less, which results in lower emissions. The present paper focusses on the very first part of this mechanism, namely divestment’s potential to depress share prices. Theoretical arguments can be put forward for both a direct, rather short term and an indirect, medium to long term effect: Building on Merton (1987) and Miller (1977), I argue that the reduction of demand for shares in the short term should cause a small depression in stock prices.

Divestment’s indirect, medium to long term effect is set in the context of an overvaluation of fossil fuel based investment assets. I use models of rational herding (Bikhchandani, Hirshleifer, and Welch 1992; Abreu and Brunnermeier 2003) to provide a framework in which a »carbon bubble« remains in place even if investors are rational and well aware of the overvaluation. In this setting, divestment sends a signal to ‘neutral’ investors and informs the market that the bubble is soon to burst. Such a signal should, in turn, induce ‘neutral’ investors to sell, resulting in the bubble’s burst and a strong decline in asset prices.

To test these theoretical propositions empirically, an event study is set up, investigating the short-term stock price impact of divestment announcements. For the medium to long term, I employ latent growth curve modeling to analyze how fossil fuel stock price development is affected by accumulated divestment announcements and increasing funds withdrawn.

\(^2\) This is the amount which would have to remain unburned to have an 80% chance of limiting global warming to 2°C.
Consistent with the theoretical reasoning, the event study reveals a weak, short-term depression of the stock price which is quickly offset in some of the analyses. In the long run, a positive effect is found, which contradicts theoretical claims. Consistent with theory, however, the long-term analysis further indicates that divestment is most influential when driven by financial, rather than purely moral motivations. I conclude that, especially to understand divestment’s long-term effects, further research and a reflection on appropriate methods is necessary.

The paper is structured as follows: First, I give an overview of the current movement for fossil fuel divestment. I then present the existing literature on fossil fuel divestment and former divestment campaigns. Thereupon, I argue theoretically how divestment could affect targeted companies in general and their share price in particular. Subsequently, I present my survey of divesting institutions. I elaborate on data and methods before empirically testing the predicted mechanism. The last section concludes.

2. Divestment and the Fossil Fuel Divestment Campaign

*Divestment* is defined as “a socially motivated activity of private wealth owners, either individuals or groups such as university endowments, public pension funds, or their appointed asset managers [who] decide to withhold their capital—for example, by selling stock market listed shares, private equities, or debt—from firms engaged in a reprehensible activity” (Ansar, Caldecott, and Tilbury 2013: 21). Divestment should be distinguished from the purely economically motivated liquidation of investments for example because of poor financial performance of a firm. Nonetheless, divestment can also be financially motivated: If a wealth holder divests from companies involved in an activity which, in addition to its social controversy, is considered as unprofitable in the future (as often the case with fossil fuel divestment) this will be called divestment as well. Divestment should further not be confused with *disinvestment* defined as the elimination of individuals’ or corporations’ ownership of physical assets in an industry or jurisdiction³ (ibid.: 22).

While the idea of ethical investment goes back to times before our calendar (e.g. directed by Jewish law) (Schueth 2003: 189), the first prominent politically motivated divestment campaign emerged in the 1960s as a response to South African Apartheid: U.S. based churches and universities called for divestment from companies operating in South Africa, a movement that reached its heights in the 1980s. The campaign, by some, has been considered an important factor in pressuring the repressive regime back on the negotiation table with civil society representatives which finally resulted in the fall of Apartheid⁴.

The campaign against South Africa was followed by other divestment movements targeting repressive and/or aggressive regimes: Pro-Palestine activists have pledged investors to withdraw funds from companies in Israel, a campaign was launched against firms collaborating with the Sudan government during the Darfur conflict, and divestment has been, though lacking a visible political campaign, suggested against Northern Ireland, Iran, Myanmar and Saudi Arabia.

Other campaigns have targeted ‘unethical’ industries: Divestment has attacked companies involved in tobacco production, in alcohol, gambling, arms, nuclear power as well as firms involved in the sex industry.

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³ The literature provides contradicting definitions of divestment and disinvestment. Throughout this paper, the abovementioned definitions will be used.

⁴ The academic debate about success and failure of the different campaigns will be presented in the next chapter.
Fossil Free®, the current divestment campaign, joins the ranks of movements targeting a ‘sin industry’. It attacks those companies which are involved in drilling, selling or manufacturing fossil fuels, or which, in the words of campaign activists, “benefit from wrecking the climate” (Fossil Free 2017d). Fossil fuel divestment can be defined as “eliminating investments in major coal, oil, and gas companies and refusing to acquire new investments in such companies moving forward” (Schneider et al. 2016: 109).

Considering the number of divesting institutions, the sum divested and the campaign’s visibility in the public, the fossil fuel divestment campaign has superseded South African divestment as the most important and fastest growing divestment movement in history5 (Fossil Free 2017a).

Like most former divestment campaigns, the movement had its beginnings in the U.S. The first initiators in 2010 were students from Swarthmore College. In an effort to solidarize with local citizens affected by mountaintop-removal coal mining in the Appalachian Mountains, they prompted their college to divest from the largest 200 fossil fuel companies and freeze new investment in the fossil fuel industry (Apfel 2015: 914; Linnenluecke et al. 2015: 479). In 2011 and 2012, several other universities and colleges joined the campaign (Bratman et al. 2016: 680).

The support for the young movement increased immensely when in 2012, a Rolling Stone Magazine article, ‘Global Warming’s Terrifying New Math’, written by the environmentalist Bill McKibben, went viral (McKibben 2012): In the article, McKibben explains what environmental scientists had already claimed in 2009 (in the Nature journal; Allen et al. 2009; Meinshausen et al. 2009): To maintain an 80% chance of keeping global warming below the critical 2°C value, only a fifth of the proven oil, gas and coal reserves may be burned. Following the young campaign’s line of reasoning, McKibben asserts that individual climate action will not prevent the remaining four fifth of reserves from being extracted6. Neither has political lobbying through green NGOs proved sufficient in fighting climate change. Instead, McKibben highlights the need for a movement, attacking those who benefit from climate’s wrecking, namely the fossil fuel industry. Referring to the success of the South Africa divestment campaign in abolishing apartheid, he advocates for a new divestment movement which could have the potential to change public opinion, stigmatize the fossil fuel industry, and pressure community leaders and politicians towards meaningful regulation.

The fast proliferation of the campaign, also beyond the U.S., was facilitated by its online network, the platform ‘gofossilfree.org’. The website is led by 350.org7, an organization founded by a group of university students and supported by McKibben. The campaign’s digital connection has also helped to hold together the diverse and independent local groups of the spreading grassroot movement.

Despite their autonomous organization, fossil fuel divestment activists of all sort claim to share three “building blocks” (Fossil Free 2017c): Firstly they build on what they call a ‘theory of change’. This theory asserts that the

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5 It is hard to compare the number of divesting institutions and divested sums during the fossil fuel divestment movements with long-lasting stock boycotts against tobacco, alcohol, gambling or weapon-production. However, never has the boycott of any of these ‘sin industries’ been accompanied by a strong political campaign which referred to divestment. It is hence legitimate to talk about the most important divestment movement, even though more institutions might withhold investment from tobacco or alcohol.

6 “Since all of us are in some way the beneficiaries of cheap fossil fuel”, McKibben (2012) argues “tackling climate change has been like trying to build a movement against yourself – it’s as if the gay-rights movement had to be constructed entirely from evangelical preachers, or the abolition movement from slaveholders.”

7 The NGO’s name refers to the upper limit of a safe CO₂ concentration in the atmosphere: 350 parts per million.
fossil fuel industry is the biggest obstacle to climate progress with its destructive business model, its proximity to politics, its receipt of public funds and its influence on the public. The rich and powerful companies could, however, be opposed by a grassroots movement which “hits them where it hurts” (Fossil Free 2017d), i.e. in their financial security by divesting or pressuring institutions to divest (ibid.). Secondly, the movement shares an “open-source Fossil Free identity” (Fossil Free 2017c). This identity is characterized by professional, catchy videos and nicely designed advertisement tools provided on the website and by an immense exchange of pictures and videos on successful actions all over the world via Facebook and twitter. Thirdly, the local campaigns commit to four organizing principles: “We are inclusive”, “We are open source”, “We are all leaders” and “We take action” (ibid.).

Divestment advocacy does not stand alone. Instead, it is part of a broader, increasingly unified, global movement towards climate justice and fossil fuel resistance. The movement includes »Climate Marches« (demonstrations for a more ambitious climate policy), »Keep it in the Ground« (civil disobedience activism opposed to extractive projects), as well as trials for climate damages and endeavors to suspend fossil fuel subsidies. Reinforcing each other, the different campaigns frame a larger narrative about the decline of fossil fuels with the hope to assert regulatory, legal, political and cultural pressure on the fossil fuel industry (Arabella Advisors 2016: 2–3).

Irrespective of divestment’s impact on the fossil fuel industry, the divestment campaign has quickly succeeded its first ‘intermediate goal’, i.e. in pressuring institutions to divest: After the first colleges and universities had signed investment pledges in 2011, the movement soon spread to faith-based organizations, NGOs, city, state and national governments, and philanthropic foundations. These morally motivated ‘first wave divestors’ have been joined by an increasing group of ‘second wave divestors’ mainly concerned about the increased financial and fiduciary risks of a business model that proves incompatible with the goal of keeping the world below a 2° Celsius warming (Ansar, Caldecott, and Tilbury 2013: 10–11; Arabella Advisors 2016: 1; Fossil Free 2017a).

As by October 2017, 798 institutions governing funds worth USD 5.53 trillion and more than 58,000 individuals have committed to divestment. As shown in figure 1, within the last two years, the number of divesting institutions has increased by over 70%, the sum governed by these institutions by more than 80% and the number of divesting individuals has multiplied 30-fold (Arabella Advisors 2016: 5; Fossil Free 2017a).

![Figure 1: Divestment Commitments Over Time September 2015 (grey bars) and October 2017 (orange bars)](source: Own representation based on Arabella Advisors 2016: 5; Fossil Free 2017a)
»Fossil Free« is not only the fastest growing divestment movement in history: With more than half of the divesting institutions and individuals based outside the U.S., the movement has also become truly global. Moreover, as depicted in figure 2 divestors are very diverse with no sector making for more than a quarter of commitments (Arabella Advisors 2016: 1).

The divesting community further differentiates regarding the scope of their commitment. The questions which fuels and which business activities to divest have been solved in different ways by different organizations: Some have only excluded coal from their portfolio while others have divested all fossil fuel assets. Many have only withdrawn from companies that own fossil fuels, especially from the companies listed in the »Carbon Underground 200«, i.e. the companies with the largest CO2 potential in their proven oil, gas or coal reserves. Others have, in addition, excluded companies which are involved in extraction, equipment and services, mid-stream and down-stream production or power generation (Eastman: 7–13). Still others have chosen to divest from companies based on subjective criteria, for example depending on a company’s efforts in reducing carbon emissions (Arabella Advisors 2016: 4). Finally, many have followed a divest-invest approach in that they have strategically reinvested divested capital in renewable energy, alternative energy systems, sustainable agriculture, local business or other ‘climate solutions’ (ibid.: 2).

As manifold as the different divestment strategies are the opinions about divestment’s effectiveness. In the next chapter, the literature investigating the impacts of fossil fuel divestment is reviewed.

### Figure 2: Divesting Institutions

(As by September 2017)

<table>
<thead>
<tr>
<th>Institution Type</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Faith-based Organizations</td>
<td>22.7%</td>
</tr>
<tr>
<td>Philanthropic Foundations</td>
<td>22.5%</td>
</tr>
<tr>
<td>Governments/States/Cities</td>
<td>18.0%</td>
</tr>
<tr>
<td>Educational Institutions</td>
<td>15.3%</td>
</tr>
<tr>
<td>Pension Funds</td>
<td>11.8%</td>
</tr>
<tr>
<td>NGOs</td>
<td>5.1%</td>
</tr>
<tr>
<td>For-Profit Corporations</td>
<td>2.5%</td>
</tr>
<tr>
<td>Healthcare Institutions</td>
<td>1.6%</td>
</tr>
<tr>
<td>Cultural Institutions and Other</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Source: Own representation based on Arabella Advisors 2016: 5; Fossil Free 2017a

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8 The decision to exclude companies involved in extraction, equipment and services, mid-stream and down-stream production or power generation has in turn brought up the question how high the revenues from fossil fuel should be to actually lead to exclusion (Eastman: 7–13).

### 3. What is Known of the Impact of the (Fossil Fuel) Divestment? A Review of the Existing Literature

The growing public debate about the Fossil Free movement and the sense and nonsense of divestment initiatives has been accompanied by an academic debate. In the following chapter, I will first give an overview of the literature on the current fossil fuel divestment movement and its impact. As the existing research on the fossil fuel campaign allows only limited conclusions regarding its financial impact, research on earlier divestment and stock boycott initiatives is presented subsequently. It is discussed to what extent conclusions can be drawn for
the current case of fossil fuel divestment. Contrasting Ansar et al. (2013) I will point out that findings from other campaigns are of little help when assessing the current campaign’s financial impact. It will become evident that an empirical analysis tailored towards fossil fuel divestment, such as the present paper, is necessary to draw robust conclusions.

3.1 The »Fossil Free« Campaign in the Literature

Literature on the fossil fuel divestment campaign can be broadly divided into three strands: A first group of researchers, often involved in the movement themselves, assesses the campaign’s dynamics and impacts from a social movement perspective. A second group evaluates the financial outcome for divesting institutions. A third strand is concerned with the campaign’s economic or financial impact on the fossil fuel sector and the overall economy. The three strands have in common that they often take a clear case for or against divestment. Some of the contributions are clearly interest-led. I will therefore point out a paper’s context when necessary.

3.1.1 Fossil Fuel Divestment as a Lever for Social Change: The Social Movement Perspective

The social movement literature highlights the campaign’s potential as a lever for social change. »Fossil Free« is seen as a critical step towards climate justice and towards the emergence of a new energy system compatible with a healthy planet (Grady-Benson and Sarathy 2015). As such, divestment is considered an essential part of a broader “regime complex for climate change” (Ayling and Gunningham 2015; building on Abbott 2012).

Rooted in students’ frustration about insufficient climate policies (Grady-Benson and Sarathy 2015), over the years, the divestment movement has emerged as a Transnational Activist Network (Ayling and Gunningham 2015: 132; building on Keck and Sikkink 1999). The network’s potential, rather than actually creating economic damage to the fossil industry, lies in the clear cut moral message it sends (Apfel 2015). Activists redraw moral lines around acceptable behavior (Seidman 2015) and emphasize the responsibilities of corporate and social actors. Moreover, they highlight the opportunities for change as well as the urgent need for action and foster public debate about the severity of climate change (Apfel 2015; Seidman 2015; Ayling and Gunningham 2015).

Following Apfel (2015), activism for divestment involves an extraordinary potential to encourage and uphold public debate: During the process of the movement, several opportunities for victory emerge. Each local campaign can create one more success story by obliging one additional institution to divest. Even when an activist group is unsuccessful in this endeavor, the failure can be transformed into a media-effective story which brings up the debate around fossil fuels and climate change once again.

The campaign is “target rich” (ibid.: 932) as it addresses universities, insurances, pension and health care funds, churches and government institutions at all levels. Questions about how to deal with the challenges of climate change are thus brought up at various places and stages at the same time preventing political and social inertia. The movement provides ample opportunities for a broad variety of people to get involved with the institutions they are already connected with. It hence creates a fertile ground for a persistent grassroot movement (Alexander, Nicholson, and Wiseman 2014; Apfel 2015; Seidman 2015; Ayling and Gunningham 2015).

Activists are described to follow an “inside-outside strategy of exerting pressure upon and simultaneously collaborating with [...] authorities” (Bratman et al. 2016: 678). This strategy forces affiliates of various institutions,

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9 As the body of research is very young and truly academic papers have not been produced in large numbers yet. In line with former publications in the field, I will present commissioned papers in addition to journal articles.
in particular their board members, to deal with questions of climate change and reconsider their own responsibility (Apfel 2015; Seidman 2015).

Alexander, Nicholson, and Wiseman (2014: 3) describe the movement as the “disruptive innovation” needed to drive and strengthen public support for rapid decarbonization. Similarly, Ayling and Gunningham (2015) acknowledge the campaign’s role in social steering to catalyze the energy revolution. In a new form of “private investor-targeted climate change governance”, the campaign fulfils the function of a “norm entrepreneur” (ibid.: 1). By making a case for climate justice and against complicity with the fossil fuel economy, it pressures members of different communities to rethink their collective moral stance and question their lifestyle. Consistent with former Transnational Activist Networks, the movement is thus an “important sources of new ideas, norms and identities in the international system” (Ayling and Gunningham 2015: 140, 2015; building on Keck and Sikkink 1999). As such, it also provides neglected knowledge about climate-related issues to the public. In particular, knowledge about stranded assets\(^\text{10}\) is made salient to the financial community (Alexander, Nicholson, and Wiseman 2014; Apfel 2015).

Several scholars highlight the radical and political nature of the fossil fuel divestment movement. Grady-Benson and Sarathy (2015) conclude from participant observations and activist interviews that Fossil Free triggers a change, away from individualized sustainability efforts (like consumer boycott or greening initiatives at universities) towards a youth-led collective political action and the recognition of climate change as a social justice issue (ibid.). Hence, sustainability politics are repoliticized and traditional power relations and conceptualizations of what environmentalism entails are challenged (Bratman et al. 2016).

The movement’s gradual radicalization (Grady-Benson and Sarathy 2015) can partly be explained by the strong resistance it has faced: Opponents of divestment have frequently blamed activists as backwards hypocrites who themselves could not do without fossil fuels in their daily lives and who, with their demand for an energy change, would take poorer countries their opportunity to ‘develop’ (Schneider et al. 2016). This, in turn, has motivated activists to fight back even harder and highlight the need for a radical social and political change to create circumstances under which a sustainable life is possible in the first place (Apfel 2015).

Social movement scholars also point on the campaign’s more concrete effects on corporate and political actors. By ‘naming and shaming,’ the campaign helps to stigmatize long-held business practice and expose the fossil industry as a moral pariah to withdraw its social license to operate (Seidman 2015; Ayling and Gunningham 2015). Regarding political decision-makers, activists push for regulation to change the rules within business is ran (Ayling and Gunningham 2015).

Taken together, the social movement literature appreciates the movement for its broad societal impact. This positive view on divestment is challenged by another strand of literature that questions the effectiveness of divestment based on a cost-benefit analysis (Cornell 2015; Fischel 2015). Divestment, so the argument goes, does not cause any harm on targeted companies. At the same time, it ends up as a costly decision which contradicts divesting institutions’ fiduciary duty (ibid.). In the next section, these financial costs of divestment for divesting institutions will be explored in greater detail.

\(^{10}\) The debate about stranded assets will be presented in more detail in the next chapter.
3.1.2 Financial Implications for Divesting Institutions

The debate about financial implications for divesting institutions is mainly build around two arguments: One side argues that fossil fuel related assets are indispensable to diversify portfolios and that their exclusion will inevitably lead to lower performance and high transaction costs. The other side counters that the fossil fuel industry has ceased to be the save and profit-yielding investment it once was due to its increasing exposure to political and economic risks. Either side backs their arguments with empirical findings:

A frequently cited study by Fischel (2015) compares the risk-adjusted\textsuperscript{11} return of an optimal portfolio with a fossil free portfolio for the fifty years from 1965 to 2015. He finds that the costs of divestment for divesting institutions are substantial. Fischel explains the worse performance of the fossil-free portfolio with the occurrence of trading costs, diversification costs and compliance costs. Cornell (2015) provides estimates of these costs for five prestigious American universities with large endowments. He relates the performance of a proxy portfolio for the universities’ investment to an identical fossil free portfolio and finds that per year, the risk adjusted return would have been 0.31\% lower if the institutions had not owned fossil fuel assets over the last 20 years.

The two studies do not get tired of pointing out that “basic financial economic principles” (Cornell 2015: 2; Fischel 2015: 3) would unambiguously predict a loss due to a lack of diversification. This is interesting insofar, as Fischel, contrary to ‘basic’ theoretical and empirical literature in the field, does not distinguish between diversifiable and systematic risk in the risk-adjustment procedure on which his empirical analysis is built\textsuperscript{12}. Further, even if fossil fuel investment was profitable for the second half of the 20th century, this would not allow any prognosis of its future performance. Industry regulation because of climate change considerations are a recurring issue in global politics. This was not the case in the 1960s and 70s on which Fischel relies. Moreover, his naïve statistical analysis (mean comparison without any inferential significance test) does not allow any predictive conclusions\textsuperscript{13}. Hunt, Weber, and Dordi (2016: 75) demonstrate that, since 2014, the stock index Standard and Poor’s Global 1200 (and thus the average share prices of the most important global companies) has outperformed the development of the energy sector. Fischel and Cornell’s ignorance of these critical issues might be explained by the fact that both, despite their strategy to present their argument as an ‘expert view’, wrote for the consultancy compassLexecon which in turn was commissioned by the Independent Petroleum Association, a U.S. based organization of oil and gas producers\textsuperscript{14} (Apfel 2015, 2015: 929).

\textsuperscript{11} To adjust for risk, Fischel “allocated a share of the funds in the optimal portfolio including energy stocks to an essentially risk-free asset (a one-month U.S. Treasury bill), and adjusted this share to make the volatility of the optimal portfolio, measured by the standard deviation, equal to that of the non-energy stock index, which has a standard deviation of 15.7 percent.” (Fischel 2015: 11). This form of “risk adjustment”, contrary to most theoretical and empirical literature in the field, does not distinguish between systematic and diversifiable risk. The higher returns of the portfolio that includes energy stock could therefore be an artifact of its higher systematic risk (as compared to diversifiable risk). This suspicion is supported by the findings of Trinks et al. (2017) which will be presented later in this section.

\textsuperscript{12} See foot note 5.

\textsuperscript{13} To counter Fischel’s (2015) and Cornell’s (2015) results with an equally simple mean comparison for a shorter but more recent period, the “decarbonizer” provided by the “Corporate Knights – Company for Clean Capitalism” is a nice tool. It calculates the extra money one would have earned if having divested from different fossil fuel based assets three years ago and gives out a consistently positive sum (www.decarbonizer.co; Clean Capitalist (2015)).

\textsuperscript{14} One could interpret the fossil fuel industry’s strong efforts to show, with the help of scientists, how costly and ineffective divestment is, as a sign that divestment does actually pose a real threat to the industry.
A third study released by compassLexecon estimates the frictional costs of divestment, i.e. transaction costs, ongoing monitoring and active management costs (Bessembinder 2016). The authors argue that illiquid assets are costly to sell, active management is expensive, and fossil fuel divestment induces exclusion of more assets than those directly related to fossil fuels which increases diversification costs even further. Their empirical analyses find that these costs add up to 2-10% of endowment value, respectively 1.4-7.4 billion U.S. dollars for a typical large university endowment. The author states that these numbers are obtained by building on “academic and industry literature estimates of the total transaction costs” (ibid.: 15). However, the paper remains vague about how the calculation was done exactly.

In contrast to the abovementioned findings, Trinks et al. (2017) find that fossil-free investing does not impair financial performance of a well-diversified portfolio. Instead, a fossil free portfolio does not significantly underperform the unconstrained market portfolio. Their explanation for this contrasting result is that fossil fuel company portfolios do neither generate above-market performance nor do they provide great diversification benefits. Higher mean returns generated by holdings in fossil fuel companies can instead be explained by their higher exposure to systematic risk factors (as shown by comparing Sharpe and Sortino ratios for fossil fuel and fossil free portfolios from 1927 to 2015 and relating returns to risk factors via the Carhart four-factor model).

The consultancy Mercer (2015) probes several future scenarios to assess the expected performance of portfolio investment in times of climate change. The Mercer report commissioned by UK aid, the International Finance Corporation of the World Bank Group (IFC), and British and German ministries assumes different climate change scenarios. It evaluates different portfolios’ exposure to four risk factors, namely technology risk (like competition by green energy), resource availability with changing weather patterns (like the lost possibility to grow certain crops), physical impact of climate change (like destroyed infrastructure) and policy (like carbon regulation). The paper predicts an immense fall in returns for broad parts of the fossil energy sector in all scenarios. For example, depending on the climate scenario applied, returns from coal could fall between 18% and 74% over the next 35 years, which would erode between 26% and 138% of average returns in the coming decade. The return of renewable energy investment, on the other hand, is estimated to increase between 6% and 54%. A further noticeable result of the study is that in the long run, the ‘4°C warming scenario’ with little political action, high fragmentation and damage predicts the greatest economic losses for investments of all kind. The authors therefore suggest that investors should incorporate climate change risks more in their investment considerations and portfolio choices. In particular, they are advised to keep climate sensitive industry sectors, like the fossil fuel industry, in focus.

To sum up, research on the financial implications for divesting institutions remains inconclusive. While it can be argued that divestment induces transaction and diversification costs, another mechanism, the possible depression of fossil fuel assets, induces costs of not divesting. However, a closer consideration of the methodology and possible vested interest of the authors renders the studies which find a negative effect of divestment on portfolio performance little trustworthy.

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15 This is the case as universities and other institutions often invest in mutual or commingled funds containing fossil fuel assets in addition to many other assets. To divest from fossil fuels, they sell these mutual or commingled funds and therefore also repel assets other than fossil fuel based. This leads to further diversification losses.

16 But most severely for agriculture, timberland, real estate and emerging market equity.
3.1.3 The Impact of Fossil Fuel Divestment on the Targeted Industry

The question if divestment accomplishes its goal to weaken the fossil fuel industry economically and financially has not been systematically studied. The scarce empirical work which assesses divestment’s impact on targeted companies, i.e. on corporate policy, stock prices and capital costs, is presented in this section.

Kiar and Wittneben (2015) analyze if fossil fuel divestment can be made responsible for the relative shift towards sustainability of the top four German energy providers. The four companies are ideal targets for the divestment campaign because of their high share of energy generation from lignite, the most environmentally problematic fuel. In their study, Kiar and Wittneben acknowledge that, at some time in the future, a strong civil support of the campaign might increase climate change concerns of large power providers. Divestment could thus become a matter in business decisions, even though it is found to be rather irrelevant at the moment. Investigating past policy changes, the authors find that other factors can be made responsible for the changes in corporate policies.

Linnenluecke et al. (2015) study the controversial divestment strategy of the Australian National University. Re-evaluating the university’s selection of companies for divestment, the authors find that divested firms stock prices react negatively on divestment. Targeted companies experience significant negative cumulative abnormal returns when measured against the market portfolio for a seven-days period around divestment announcements. Unfortunately, as the effect on share prices is only a side remark of the study, the authors do not test for alternative measures of abnormal returns nor do they control for other factors which might bias their results.

The most systematic and most frequently cited assessment of the impact of fossil fuel divestment on targeted firms is the paper of Ansar, Caldecott, and Tilbury (2013). The authors apply an ‘outside view’ as proposed by Kahneman and Tversky (Kahneman 2013). They show how the relationship between divestment, share prices of targeted companies, their access to capital and finally their competitiveness is mediated by market norms and stigmatization processes.

Building on research on former divestment campaigns and stock boycotts, several conclusions are drawn for the current campaign: Divestment makes for a very small amount of all fossil fuel based assets and divested sums will quickly find their way to neutral investors. In consequence, the direct impact of the campaign should be limited. A direct impact on valuation could, however, arise due to a change in market norms as a norm change would restrict access to previously available money. Further, if the campaign succeeded in constraining debt markets (e.g. by limiting bank’s financing of fossil fuel projects) it could directly impede new fossil investment. This is most probable for the coal sector, especially in countries with low financial depth. Here, some Capex projects in difficult technical or political environments could be prevented. Oil and gas companies, on the other hand, will not experience a direct effect because of the liquid capital markets they access.

Ansar, Caldecott, and Tilbury (2013), however, argue that the most severe harm is anyways induced indirectly through stigmatization of targeted firms. Experience from other campaigns show that stigmatized firms or sectors...
will most probably face restrictive legislation and multiple depression which in turn increases uncertainty about their future cash flows. This insecurity will seriously hurt the firms’ position in capital markets and eventually their competitiveness. However, experience also demonstrates that some of the firms, most probably of the coal sector, might be held as scapegoats while others could manage to avoid disapproval and the negative associated effects (see also Vergne 2012).

Summing up the existing evidence regarding divestment’s impact on the fossil sector leaves us with a very fragmented picture\(^ {20}\). Except for Ansar, Caldecott, and Tibury’s contribution, the studies are tailored to a specific case. Ansar, Caldecott, and Tibury’s work suggests that it might be useful for the divestment campaign to target coal firms and focus on debt financing to increase the direct effect on targeted companies. However, these findings are based on data from previous campaigns. Even though there are reasons to believe that insights from other campaigns can be transferred to the current movement, there are also important distinctions regarding the campaign’s context and dynamics. To understand the main takeaways from previous campaigns without drawing premature conclusions, it is hence useful to take a closer look into research regarding former divestment campaigns and other forms of stock boycott. This will be done in the next section.

### 3.2 The Impact of Divestment: Experience from Previous Campaigns

With the first prominent divestment campaign targeting the South African Apartheid regime, divestment has also evolved as an issue of scientific interest. Today, a broad-based literature with diverse research foci is available. For the purpose of this paper, I will distinguish between campaigns targeting foreign governments (divestment from South Africa, Sudan and Israel), campaigns targeting a ‘sin industry’ (divestment from tobacco, alcohol, gambling, arms, nuclear power and the sex industry), and divestment in the context of a sustainable investing strategy (i.e. refraining to invest in companies which are relatively ‘unsustainable’ as evaluated by various criteria)\(^ {21}\). Like before, for each campaign type, I present research with a broader perspective on the campaign, research on the financial impact on divesting institutions and, of most interests to this paper, research covering the impact on the targeted government or industry.

#### 3.2.1 Divestment Targeting Foreign Governments

The most prominent campaign before »Fossil Free« was the divestment movement targeting the South African Apartheid regime. The campaign started in the late 1960s and lasted till the end of Apartheid. In a nutshell, the movement pressured U.S. institutions to withdraw money from firms operating in South Africa to deprive the

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\(^ {20}\) Regarding divestment’s impact on the overall economy, one further interesting paper is the simulation study of Glomsrød and Taoyuan (2016). They estimate divestment’s potential for a broader impact on the global economy and total carbon emissions. Using the multi-sector, multi-regional, recursively dynamic computable general equilibrium model GRACE (“Global Responses to Anthropogenic Change in the Environment”), the study predicts the future impact of divestment and green bonds purchases on the global economy, on financial flows, and on carbon emissions. In a strong divestment scenario, global CO2 emissions are found to be 550Mt lower than in a business-as-usual scenario (BAU) in 2030. Over the whole period, emissions corresponding to the yearly emissions of the EU and Japan are prevented. This reduction takes place despite an increase in global GDP by 1.6% above BAU which counters the positive climate effect to some extent (a phenomenon which is known as “rebound effect” in the related literature, see Jevons (1866), Khazzoom (1980) and A. Greening, Greene, and Difiglio (2000). The main reason behind the large estimated emission reduction is a shift of investments from fossil to alternative energy.

\(^ {21}\) It is impossible to draw a clear line between the three groups as sustainable investment strategies often include divestment from morally questionable regions or industries. In this review, each paper will be presented in the group where its major focus lies.
South African economy of financial capital. This should weaken the real economy to finally collapse or abolish the government that defended Apartheid. The campaign also involved corporate withdrawal of U.S. firms from South Africa. Some firms signed the »Sullivan Principles« and committed themselves to improve the situation of black South Africans through targeted business policies instead of leaving the country.

Initial papers published on South African divestment were rather critical towards its effectiveness. Kaempfer, Lehman, and Lowenberg (1987) for instance show that firms operating in South Africa have not suffered a decline in share prices. Nevertheless, Kaempfer et al. argue that divestment affected the South African situation, albeit a counterproductively: While reduced availability of foreign capital hurt the whole population in the long run, the authors claim that, in the short run, white South African wealth owners benefitted from depressed stock prices and cheaply acquired production sites. The authors reason that the higher rate of return on South African wealth in turn generated higher tax income which in the end, stabilized the Apartheid regime.

Lansing and Kuruvilla (1988) added to this argument and stated that divestment mainly harmed black South Africans as the withdrawal of US firms resulted in a reduction of black employment and a cut in social welfare. The Sullivan principles which relied on managerial engagement rather than on divestment in contrast had improved the economic and social status of blacks.

After the fall of the Apartheid regime, Mangaliso (1992) and Arnold and Hammond (1994) countered these claims. Under the existing circumstances, especially the extreme stratification of the South African society, a ‘trickle down’ effect from positive business practices was practically impossible (Mangaliso 1992). Instead, in the contested ideological terrain of accounting, the Sullivan principles served corporations as an ideological tool to legitimize their actions while sustaining their own interest (Arnold and Hammond 1994; building on Gramsci 1971[1929-1935]).

Divestment advocates, on the other hand, opened the discourse on corporate responsibility, politicizing institutional investment decisions (Arnold and Hammond 1994). Consistently, Westermann-Behaylo (2009) shows how activists in both the South African campaign and the campaign in Sudan during the Darfur genocide have challenged the institutional norm of Freeman’s (1994) »separation thesis«22: The campaigns had initiated a shift in institutional norms, away from the separation thesis’ dogma of ‘business is business’ towards engagement and divestment discouraging unethical business activity.

In retrospect, the South African divestment campaign is often considered an important factor in the support of the domestic struggle forcing the Nationalist Party to the bargaining table with representatives of all South Africans (e.g. Mangaliso 1992).

To assess the financial impact on institutions which have divested during the South Africa campaign, several event studies have been conducted. Rather than analyzing the financial impact for financial divestors like universities and pension funds, most studies evaluate the share price reaction of disinvesting firms. More specifically, the stock price reaction on corporate announcement to withdraw business or business units from South Africa is most often assessed23:

22 The »separation thesis« supported by Freeman (1994) contends that business issues can clearly be separated from ethical issues.
23 Note that this corporate disinvestment, i.e. a company’s management decision to divest parts of its (physical) holdings, differs from the divestment we are interested in for the fossil fuel campaign namely the withdrawal of funds from financial
Meznar, Nigh, and Kwok (1994) find a significant drop in the stock value of withdrawing firms, particularly for firms withdrawing at an early stage of the campaign. Their event study is however sharply criticized by McWilliams and Siegel (1997) because of its very long event windows (up to 41 days) and the authors’ failure to properly account for confounding events. McWilliams and Siegel’s replication of the study renders the abnormal returns insignificant. A second replication by the original authors taking into account parts of the critique, again, reports a negative effect, which, however, remains significant for early movers only (Meznar, Nigh, and Kwok 1998).

In a similar study, Wright and Ferris (1997) consistently find significant negative excess returns after companies’ announcement to disinvest business units from South Africa. In contrast, Posnikoff (1997) reports significantly positive abnormal returns after disinvestment announcements.

The contrasting findings can be explained in two ways: First, the studies use a different methodology to calculate abnormal returns: While Meznar, Nigh, and Kwok (1994) and Wright and Ferris (1997) apply the Capital Asset Pricing Model (Sharpe 1964), Posnikoff (1997) predicts the normal return by the average return of each stock for the preceding 250 days.

An alternative explanation for the divergent findings is given by Meznar, Nigh, and Kwok (1998). They suggest that all results are in line with their hypothesis that disinvestment in early stages, i.e. before the U.S. Congress’ override of Ronald Reagan’s veto against the Comprehensive Anti-Apartheid Act in October 1986, hurt firms while benefitting them in later years. In the beginning, so their argument goes, the costs of selling business parts at low prices dominated and later, when prohibitions and sanctions against firms with investments in South Africa formalized, benefits became more prevalent.

Consistent with the hypothesis that in later years, corporate disinvestment’s benefits did at least outweigh the costs, Teoh, Welch, and Wazzan (1999) find no effect on withdrawing firms’ stock price when controlling for market and industry returns. They further show how disinvestment of U.S. corporations caused a reaction in the investment of U.S. pension funds: several pension funds divested their money from corporations before their withdrawal from South Africa and returned to invest in the firms as soon as they had drawn back from South Africa.

Teoh, Welch and Wazzan’s (1999) comprehensive study is also one out of the very few papers to properly investigate the effect of financial divestment from U.S. institutions on targeted firms’ stock price and on the South African financial market: In an event study design, the authors show that announcements of U.S. pension funds to divest have neither affected the share price of U.S. corporations with South African holdings nor the South African financial markets. Similarly, Davidson, Worrell, and El-Jelly (1995) conclude from an event study of several South Africa divestment activities that stock prices of targeted firms have remained unaffected.

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investors. The present paper is not concerned with the effects of corporate disinvestment. However, many papers on fossil fuel divestment (e.g. Ansar, Caldecott, and Tilbury 2013) present the papers covering South African disinvestment as if they treated divestment and as if their findings could therefore be applied to the current divestment campaign. To draw a clear distinction and clarify that these papers’ findings cannot provide insights for the fossil fuel divestment campaign, they will be presented in their right context here.

24 The Comprehensive Anti-Apartheid Act (CAAA) is considered the most important official U.S. American opposition against apartheid. It entailed 18 different sanctions. On August 16, 1986 the Senate passed the CAAA; on September 12, 1986 the House passed it; on September 27, 1986 it was vetoed by President Reagan but the veto was overridden on October 3, 1986 and, by December 12, 1986, the act was fully implemented (Meznar, Nigh, and Kwok 1998: 720).
However, for the Sudan divestment campaign, Ding, Parwada, and Shen’s (2014) panel regression shows significant negative effects on targeted companies. In their analysis, increased campaign’s intensity (as measured by media coverage) significantly depresses the stock price of four companies collaborating with the Sudan government.

The design of this study is quite relevant for the present paper: The companies analyzed are four emerging market oil or gas firms. Three of them are among the 18 firms with the highest oil and gas reserves proved globally (Fossil Free Indexes 2016a) and as such also subject of the present study.

Unfortunately, even though they only analyze oil and gas firms, the authors do not control for the oil price nor for a general market performance when estimating the campaign’s effect on the stock price. Further, one element of the authors’ measure of ‘campaign intensity’ are newspaper articles including the targeted firm’s name and the term »genocide«. This proxy does however not only measure divestment’s intensiveness. In addition, the gathered newspaper articles could also hint on other situation-specific firm characteristics. They could, for instance, contain information on a firm’s ability to continue drilling business as usual in Sudan. As this information – though unrelated to the campaign – is expected to depress the share price, the study might have mistakenly assigned the negative effect to divestment.

Moreover, Ding, Parwada, and Shen take the quarterly percental stock return as dependent variable and interpret the higher percental stock returns as being equal to a depressed stock price. This interpretation might be true for some situations, but not for all. Especially if divestment reached its aim to depress the share price over a long term, ever falling stock prices would, quite on the contrary, be associated with shrinking returns.

3.2.2 Divestment from ‘Sin Stocks’

A second important target of divestment are ‘sin industries’, namely tobacco, alcohol, gambling, the sex industry, nuclear power and arms production. In the following, literature investigating the effect of this ‘sin stock’ divestment is presented.

In his ‘lessons from basic finance’, Wall (1995) suggests how activist investors should use stock boycott to hurt a company or industry. To make it harder for a firm to continue with its unethical business and to impede a firm’s physical investment, an investor should increase the firm’s weighted average cost of capital by significantly depressing the firm’s stock price for a period of time. To explain why the share price should be affected by a boycott, many divestment scholars rely on Merton’s (1987) model of segmented markets. Financial markets are called segmented if a group of stocks is neglected by many investors. According to the model, the price of

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25 They only control for size, Book-to-Market ratio, turnover and a momentum factor. It is reasonable to assume the absence of Omitted Variable Bias as oil price and market performance should not be associated with the main dependent variable, campaign intensity. However, both factors will affect all four analyzed firms alike which might cause serious bias.

26 The fact that ethical investors consider gambling a ‘sin industry’ has sometimes led to ironic comments as the foundations of share market investment themselves involve a strong gambling element (Cullis, Lewis, and Winnett 1992: 21).

27 As has been pointed out, the question if companies will be harmed by a lower stock price is highly controversial. Anecdotal evidence from divestment campaigns however indicates that firms are concerned about their stock price in the context of divestment. For example, Wander and Malone (2006) analyze how Philipp Morris gave in to activist’s demand to inform consumers in countries of the South about the risk of smoking. Besides the fact that Philipp Morris widely benefitted from its relenting, the authors find that main reasons for the company’s decisions were the attempt to counteract divestment campaigns and the firm’s fear of a depressed share price. Concordantly, competitors in tobacco retail claimed that Philipp Morris’ “real” reason for [the initiative was] ‘the share price’ (ibid.: 2051).
neglected shares will be lowered to account for the limited risk sharing which investors who do invest in these shares experience.\(^{28}\)

Hong and Kacperczyk (2009) carry Merton’s argument forward by stating that, under the condition of segmented markets and inadequate risk sharing, the Capital Asset Pricing Model does no longer hold. Then, idiosyncratic risk rather than systematic risk will matter for pricing. Consequentially, shunned stocks should be cheaper than ‘neutral’ stocks exposed to a comparable level of systematic risk. Hong and Kacperczyk (2009) analyze tobacco, alcohol and gambling and find that the stock price of the avoided firms is between 15% and 20% lower as compared to ‘neutral’ stocks. ‘Sin industries’ thus systematically outperform the market regarding risk-adjusted returns. As these higher returns translate into higher capital costs, the authors conclude that stock boycott increases firms’ cost of equity. As a consequence, ‘unethical’ firms rely relatively more on debt than on equity.

Durand, Koh, and Tan (2013) replicate Hong and Kacperczyk’s study (which is based on Western investors) for 7 Pacific basin markets. A similar pattern of sin stock outperformance is found for the countries whose culture is similar to the U.S., i.e. for Australia and New Zealand, while in other regions the effect disappears. The authors conclude that investors’ response to sin stocks depends on cultural values and claim that, the more individualistic a culture, the more inclined are investors to neglect morally problematic stocks.\(^{29}\)

The existence of a ‘sin premium’ for controversial stock is also confirmed by Kim and Venkatachalam (2011) for gaming, tobacco, alcohol, and adult entertainment, by Fabozzi, Ma, and Oliphat (2008) for alcohol, tobacco, defense, biotech, gaming, and adult services, by El Ghoul et al. (2011) for tobacco and nuclear power and Chong, Her, and Phillips (2006) analyzing the VICE fund. The former add to the argument that sin stocks show a low quality in their financial reports. Fabozzi, Ma, and Oliphat highlight the specific position the ‘sin industry’ inhibits in the real economy: As the sector is often highly regulated, only a few companies survive which are then able to earn positive monopolistic returns.\(^{30}\)

In the ‘sin stock’ setting, higher returns for ‘neutral investors’, higher capital costs for the targeted firm and a lower risk-adjusted return for moral investors avoiding these stocks\(^{31}\) are equivalent. Adler and Kritzman (2008) note that a portfolio that is obtained from a sub-universe will always underperform an unconstrained portfolio on a risk-adjusted basis. This is true for any theoretical model which assumes no arbitrage opportunities. Lee et al. (2010) estimate that screening away irresponsible stock will reduce risk-adjusted returns by around 0.7%.

\(^{28}\) Merton’s model will be explained in greater detail in the next chapter.

\(^{29}\) This interpretation has its flaws however, as the analyzed ‘sin stocks’, namely alcohol, tobacco, gaming and defense, are considered as unethical in Western societies and might not equally be seen as sinful in other cultures (take smoking for example). Investors from less individualistic cultures might just neglect other stocks instead (e.g. pork in Islamic investment).

\(^{30}\) Note that this argument cannot serve as an alternative explanation for the segmented market hypothesis. In non-segmented markets, the higher returns earned by a firm would bid up its stock price, resulting in average risk-adjusted returns for financial investors.

\(^{31}\) Or: a higher risk-adjusted return for those investors who strategically invest in them.
3.2.3 Divestment in the Broader Context of Socially Responsible Investing (SRI)

It should nevertheless not prematurely be concluded that socially responsible investing necessarily results in lower returns.

The “shunned stock hypothesis” (Derwall, Koedijk, and Ter Horst 2011), claiming that controversial stocks have superior returns as value oriented investors shun and push down stock prices below those of responsible stock, is only one part of the story of sustainable investing.

It is countered by the “error in expectation hypothesis” (ibid.) stating that socially responsible stocks actually should have *higher* risk adjusted returns because the market is slow in realizing the positive impact of corporate social responsibility (CSR) on companies’ future cash flows. When analyzing socially responsible investing (SRI) it is thus indispensable to distinguish between what Derwall et al. call a ‘value driven segment’ (applying negative screens which experience below-average returns) and a ‘profit driven segment’ (applying positive screens and a ‘best-in-class’ approach which experience higher returns).

As many responsible investors apply both forms of screening, both mechanisms should be present. However, Derwall, Koedijk and Ter Horst suggest that the positive mechanism of value-driven investing is restricted to the short run. In the long run, the market will price CSR appropriately and the ‘shunned stock hypothesis’ will therefore dominate, resulting in negative financial impact for ethical financial investors.

Keeping this framework in mind enables us to make sense of the numerous studies investigating the complex of CSR and Corporate Financial Performance (CFP). As the literature regarding financial impacts of CSR is very broad, I will mainly present review studies or papers that are considered of specific interest to the topic of the present paper.

Adding to Hong and Kacperczyk’s (2009) empirical study of sin stock shunning, Durand, Koh, and Limkriangkrai (2013) compare ‘sin stocks’ with ‘saint stocks’: Consistent with the literature presented above, ‘saints’ have a higher analyst coverage, lower returns, and rely less on debt financing as compared to ‘sinners’. Benefitting responsible investors, ‘saint stocks’ do however pay more dividends and offer more share repurchases; “Virtuous lines of business appear to be associated with virtuous financial policies” (ibid.: 167).

This claim is consistent with Orlitzky, Schmidt, and Rynes’ (2003) conclusion reviewing 52 empirical studies: The overwhelming majority of empirical studies before 2002 finds that social responsibility of firms and, to a lesser extent, also environmental responsibility, is associated with improved financial performance. The association is mediated by the reputation of a firm.

However, the causal direction of the positive relationship remains unclear: Most studies are consistent both with the hypothesis that better CSR improves CFP and the hypothesis that firms with a better financial performance can ‘afford’ more CSR. The relation is hence bidirectional (ibid.).

Lu et al.’s (2014) review of 84 studies from 2002 to 2011 does not find a clear positive association and instead reports that the field remains inconclusive. The two reviews – positive findings for SRI in early years which disappear in later years – are consistent with the aforementioned prediction that the days of a positive effect from SRI are numbered.

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32 A “best in class” approach means that investors invest in all sectors but pick those companies of each industry that are considered most responsible, for example because they rank best in sustainable rankings.
Michelson et al. (2004) suspect that the good performance of ethical funds is a mere artefact company type: As ‘profit driven’ responsible investors had comparatively more technology companies in their portfolio, the good performance has reflected the short term sectoral growth in ‘fashionable’ industries of the late 1990s and early 2000s. This suspicion is consistent with McWilliams and Siegel’s (2000) claim that the positive correlation between CSR and CFP is due to the misspecification of most studies, in particular their disregard of research and development (R&D), which is positively associated with both corporate social and the financial performance. When controlling for R&D, positive findings render insignificant.

Nevertheless, there are good reasons to believe that standing out by bad CSR could bear negative consequences for firms at financial markets: Krüger (2009), for example, reports a decline in share prices following negative reported CSR events in the media while the market does not react on positive CSR news. Goss and Roberts (2011) find that firms with social responsibility concerns pay between 7 and 18 basis points more for bank loans than firms which are more responsible. CSR leaders do not experience any positive effect however.

Goss and Roberts (2011) divide their sample according to borrowers’ quality and find that high quality borrowers are punished with higher yields for CSR concerns while low quality borrowers are penalized when ‘overinvesting’ in CSR. CSR can hence be considered a second order determinant of yield spread.

For bond markets, Menz (2010) finds that the risk premia of responsible firms are not significantly lower, contradicting the thesis that irresponsible firms pay more for debt. This result could however be due to Menz’ methodology. He controls for credit ratings in all models which could ‘explain away’ the effect of CSR as, the rating also covers most CSR aspects (ibid.: 128).

To avoid the noise present in realized returns, El Ghoul et al. (2011) regress different measures of CSR on firms’ ex ante costs of capital and find that firms which improve responsible employee relations, environmental policies and product strategies face cheaper equity financing.

To estimate how many investors would have to boycott an irresponsible firm before it is successfully incentivized to switch to a more sustainable technology, Heinkel, Kraus, and Zechner (2001) calculate that 20% of investors would have to invest exclusionary ethical in order to make a polluting firm reform.

Summing up, from a responsible investor’s perspective, there are two contradicting mechanisms at place: On the one hand, neglecting unethical industries should result in lower returns. On the other hand, picking firms with a good CSR could, at least in the short run, improve returns. Applying both strategies at the same time, the effects will cancel out to some extent. From a firm’s perspective, being involved in immoral activities and attracting negative CSR related attention will increase capital costs. An outstanding CSR performance will however not lower capital costs substantially.

3.2.4 Is Divestment Counterproductive? The Debate of »Exit« versus »Voice«

Notwithstanding the impacts of divestment, it is often argued that responsible investors should engage with companies in which they invest rather than withdrawing their money. Shareholders, especially institutional investors, could use their »voice« to compel changes in business practice. By coordinating with other stakeholders, bundling and exercising voting rights, management could be pressured towards more sustainable business practices for example investments in cleaner technology, better working conditions or sequestration alternatives (Grundfest 1993; Johnsen 2003; Linnenluecke et al. 2015: 480).
Through the act of divestment, responsible investors during the governance mechanism of shareholders within companies before or in addition to divesting. It is impossible to review the full amount of literature regarding shareholder engagement in this paper. I will therefore only present a few selected studies which directly link exit and voice and are therefore interesting for divestment.

Connecting the two governance mechanisms Edmans and Manso (2008) have coined the term Wall Street Walk. They build on the claim that, in a structure of multiple blockholders, monitoring and exerting voice by shareholders is impeded by free-rider problems. Building on game-theoretic approaches, they argue that the very same co-ordination difficulties strengthen the governance mechanism of exit, namely disciplining the management through competitive trading. Following the authors, the threat of disciplinary exit, the Wall Street Walk induces higher efforts from the management.

Edmans (2009) shows that blockholders who cannot intervene in a firm’s operations can still exert governance through the exit mechanism. Gallagher, Gardner, and Swan (2008) compare the effectiveness of both mechanisms with daily blockholder data and find that “the threat of exit speaks more authoritatively than voice” (ibid.: 1). On the contrary, Admati and Pfleiderer (2009) argue that, even for a large institutional investor, the threat of exit may be ineffective. This is found to be true especially for the attempt to pressure a firm towards ‘good corporate policy’ (as compared to the case in which a firm is put under pressure to refrain from a ‘bad corporate policy’). Instead, a combination of both governance mechanisms might be most useful, i.e. threatening exit to make your voice being heard.

Empirically, the effectiveness of active shareholder strategies is found to be very limited (Haigh and Hazelton 2004) despite a few exceptions (Angel and Rivoli 1997: 57–58; Menz 2010: 120–121; Monks and Minow 1996; Smith 1996). Voice is almost exclusively used by institutions rather than individuals. However, even institutions use exit as their primary governance mechanism nowadays (McCahery, Starks, and Sautner 2010). In the sample of divesting institutions from this paper, 38 percent of divesting institutions have engaged themselves as shareholders within companies before or in addition to divesting.

3.3 Building on the Experience of Previous Campaigns: What can be Learned Regarding the Current Campaign’s Impact on Targeted Firms?

What can be learned from previous campaigns regarding the impact of fossil fuel divestment?

Concerning the campaign’s intensity, the current campaign resembles the South African divestment movement. There are some important parallels: Both campaigns were norm-driven and encouraged exclusionary screening of unethical investment. Both were initiated by smaller institutional and private investors and, over time, bigger,

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33 The idea that it is the shareholders’ task to monitor a company’s management is widely acknowledged. It largely builds on agency theory. For an assessment and critique of agency theory in the context of contemporary financial markets see Bower and Paine (2017).
institutional investors such as pension funds joined in. A declared goal of both campaigns was to raise public awareness and harm targeted firms’ reputation by stigmatization. Finally, divestment in both campaigns was initiated from an ethical-moral argument but, eventually, also made sense from a purely financial perspective (Hunt, Weber, and Dordi 2016).

An important lesson to be learned from the South African campaign is that stigmatization is a useful strategy, both for putting firms under pressure and for changing political attitudes over time (Ansar, Caldecott, and Tilbury 2013). However, conclusions on the impact of the fossil fuel campaign on targeted companies are difficult to draw as the basic objective and envisioned outcome of the two campaigns differs profoundly: Activists in the South African campaign aimed at destabilizing the economy to foster a collapse of the incumbent government. Fossil free divestment activists, on the other hand, want to limit the fossil fuel sector from financial capital to stop its expansion and continuation of business as usual; their ultimate target is the incumbent industry.

In the South African campaign, firms were pressured to leave the country; it tried to induce change in management behavior. The fossil fuel campaign on the other hand attacks fossil fuel firms at its core business to reduce their power and competitiveness (Hunt, Weber, and Dordi 2016). Further, for most companies during Apartheid, South Africa was only one sub-market which could be given up. The fossil industry is, however, challenged on its very base. The main problem in applying insights from South Africa to the questions whether Fossil Free will hurt companies lies in the lack of conclusive insights. The implications from the presented South Africa studies stand in direct contradiction with the results from Sudan, even though the campaigns are much more similar than »Fossil Free« (see also ibid.: 71).

In targeting a controversial industry, the fossil fuel campaign resembles the boycott of a ‘sin stock’. Like the campaigns targeting tobacco or alcohol, the moral problem is inherent in the industry and cannot be solved by a change in management behavior. The higher capital costs which are reported for several ‘sin stocks’ are therefore likely to occur for the fossil fuel sector as well, at least as soon as fossil fuels are consequently shunned by responsible investors.

However, there are two reasons why results from research on sin stocks can only partly be applied to the fossil fuel campaign: First, other ‘sin stocks’ have never experienced a campaign of comparatively intensity including the associated media attention and public debate. Concomitantly, research on ‘sin stocks’ mainly reports existing differences in capital costs for ‘sin industries’ as compared to ‘neutral industries’ instead of scrutinizing the direct impact of divestment.

A second, and very important difference between fossil fuel divestment and other stock boycott is that former ‘sin industries’ have never been questioned on basis of their ability to generate future earnings. Whether for tobacco, alcohol, gambling or arms production; there has never been any reason to call their future profitability into question. Therefore, the neglect of ‘sin stocks’ by norm-constrained investors directly benefitted neutral investors who earned the mentioned ‘sin premium’.

In contrast, as will be shown in the next section, the future profitability of the fossil fuel sector is highly uncertain due to the various risks it is exposed to. Of the several risks, regulation risk is the most striking: Even half-hearted political attempts to stick to the 2°C target could seriously hurt the company’s earnings prospective and render fossil fuel investment assets ‘stranded’\(^{34}\). Divestment can therefore not only be justified by ethical but also by

\(^{34}\) The argument around stranded assets will be presented in more detail in the next chapter.
financial considerations. Contrary to previous boycotts, neutral investors should not be able to unanimously benefit from their moral flexibility. Instead, staying in the industry could eventually generate high losses in a scenario of ever-decreasing share prices.

In this scenario, capital costs of the companies and returns of investors cease to be two sides of the same coin: Even though fossil fuel companies would be exposed to ever increasing capital costs, shareholders would experience steady losses because of declining share prices. Extensive fossil fuel divestment could hence serve as an important signal to financial markets and initiate a financial necessary downgrading of overvalued fossil fuel companies.

The fossil fuel campaign, with its rapid spread and its special context of ‘stranded assets’ has therefore a considerably higher potential to actually influence the share price and hurt targeted companies than former ‘sin stock’ boycotts (Ansar, Caldecott, and Tilbury 2013; Apfel 2015: 929–932; Carbon Tracker Initiative 2014; Baron and Fischer 2015).

To conclude, research on former campaigns is important to understand the current campaign. Lessons can be learned regarding the potential of stigmatization and the likely different outcomes for different sectors (coal versus oil), different regions (shallow versus deep financial markets), and different asset types (debt versus equity) (Ansar, Caldecott, and Tilbury 2013). Nevertheless, literature on previous campaigns is of little help to evaluate the current campaign’s impact on the fossil fuel industry in general and on stock prices in particular. Due to the lack of empirical research building on data from the current campaign, it is still unclear whether fossil fuel divestment can hurt the fossil fuel sector financially (Hunt, Weber, and Dordi 2016: 71).

The present paper is an attempt to close this gap. Using new data on fossil fuel divestment, it seeks to shed light on the campaign’s impact on share prices of targeted companies. Recognizing the campaign’s context of a possible »carbon bubble«, the present study estimates divestment’s impact on share prices using an event study for the short term (as suggested by ibid.: 78) and latent growth curve modeling to account for indirect, medium to long term impacts.


In this chapter, a theoretical framework for the analysis of divestment’s share price impact will be provided. Before focusing on the divestment-share price link, mechanisms through which fossil fuel divestment could harm fossil fuel companies financially and thus help to reduce carbon emissions are presented more broadly. The role of share prices in this mechanism is discussed. I then distinguish between direct, short term effects from a reduction in demand of shares and indirect, mid to long-term effects in the context of a probable overvaluation of the fossil fuel sector.

For the direct effect, I build on Miller (1977) and Merton (1987). I hypothesize that direct effects should be present but negligible and very short-lived because of the small fraction of stock owned by divesting institutions and the quick replacement of money by neutral investors. However, building on theories of rational bubbles of Bikhchandani, Hirshleifer, and Welch (1992) and Abreu and Brunnermeier (2003) I show how divestments’ indirect effect — signaling the market in a credible way that fossil fuel assets are overvalued — could turn out to be substantial in the long run.
4.1 The Broader Mechanism: On the Relationship Between Divestment, Share Prices and Emission Reduction

In theory, divestment should affect fossil fuel companies like depicted in figure 3. A reduction in demand for shares and bonds of the targeted company should ceteris paribus depress the firm’s share and bond prices. Share and bond prices which are kept persistently low translate into higher costs of capital by both augmenting a company’s current costs of capital (Renneboog, Ter Horst, and Zhang 2008) and raising its costs of new capital (Knoll 2002). Higher capital costs are accompanied by a higher discount rate applied to future cash flows rendering formerly profitable investments unprofitable. Investment of the polluting companies should in turn be reduced, resulting in less drilling or fossil fuel processing and eventually in less emissions. At the same time, increased capital costs should weaken the financial security of the industry. They should further worsen the competitive position of fossil energy as compared to alternative energy providers. The latter face unchanged, lower capital costs. In consequence, the share of alternative energy production should be increased which further reduces carbon emissions (Baron and Fischer 2015: 16; Hunt, Weber, and Dordi 2016: 70; Wall 1995: 4)

Figure 3: A stylized theoretical mechanism between divestment, share prices and carbon emissions

Source: Own representation based on Baron and Fischer (2015)

1st Objection: Will Depressed Stock and Bond Prices Increase Capital Costs?
This stylized mechanism is highly debated in the literature, especially for equity capital (Ansar, Caldecott, and Tilbury 2013). To start with, it is unclear if lower stock prices do really translate into higher capital costs: Even if the campaign succeeded in depressing share prices substantially for a relevant time frame, little would have changed from the perspective of a targeted company. The fact that, after divestment, equity is owned by other investors who might have purchased it at a lower price does not necessarily distress the management. In contrast, neutral investors who bought the divested security at a discount might even be satisfied with lower dividends. This should reduce financial pressure. A management planning to buy back shares, e.g. to compensate employees, even benefits directly from depressed stock prices.

The downsides of a lower stock price should become important when a firm wants to raise additional equity capital. However, the majority of companies does not regularly use the stock market as an external source of financing investments in development and utilization of productive capabilities (Baker and Wurgler 2002; Menz

35 Other proposed mechanisms include management behavior and argue that depressed stock prices should induce management to change its policies (e.g. Kaempfer, Lehman, and Lowenberg 1987). However, as mentioned in the section on the fossil fuel divestment campaign, changing the behavior of managers is not the campaign’s aim. It strives to bring down the fossil industry rather than reforming it.
This is also true for the fossil fuel sector, which, compared to other industries, relies on large amounts of financial capital to invest in new projects (nearly USD 900 billion were raised in 2014 alone (Brogan 2014: 1)).

Debt capital on the other hand is more frequently raised. Lower bond prices at secondary markets, again, do not directly translate into higher capital costs. Nonetheless, firms will have to adjust prices in the next issuing of new bonds which results in higher capital costs (Ansar, Caldecott, and Tilbury 2013: 33).

The greater sensitivity of costs of debt to divestment gives hope for an effect via equity as well: A depressed share price will most likely affect bond prices negatively, not least because it can be perceived as a signal of financial insecurity. In addition, depressed share prices and bond prices could make bank loans more expensive if they are considered an indicator for financial insecurity (ibid.).

2nd Objection: Will Increased Capital Costs for Public Fossil Fuel Companies Decrease Emissions?

Critics further argue that, even if the campaign managed to significantly increase capital costs and made targeted companies decrease their production and emissions, the overall effect would be negligible: After all, the 10 largest oil and gas companies36 which control 80% of global oil reserves are owned or at least backed by states (The Economist 2011).

The biggest listed oil and gas company, Exxon Mobile, for instance owns less than a tenth of the oil reserves of Saudi Aramco, the Saudi Arabian state-owned oil giant (Market Watch 2014; Yahoo Finance 2014). The largest quoted company37, Gazprom, ranks 5th in proven reserves (The Economist 2011; also see Ansar, Caldecott, and Tilbury 2013: 67; Ayling and Gunningham 2015: 134; Thamotheram 2014).

Why Share Prices Matter Nonetheless

Based on these arguments, one must admit that the effectiveness of fighting the fossil industry by a depressed share price might be limited. However, there are convincing reasons why share prices should matter nonetheless. First, empirical studies show that fluctuations in stock prices actually change financing constraints of a company. Campello and Graham (2013) for example show how high stock prices relax financing constraints and therefore influence corporate policies.

Second, dominant theories in the field, above all agency theory, claim that keeping up the company’s stock price should be the main concern of any management: Agency theory claims that the management is a mere agent of its principal, the company’s owners, i.e. its shareholders. As shareholders’ common interest is assumed to earn as much as possible, management policies must simply aim at maximizing shareholder value and hence increasing the share price (Friedman 1970; Jensen and Meckling 1976).

In reality, pursuing the single goal of maximizing shareholder value might “be an appropriate strategy for running down a company” (Lazonick and O’Sullivan 2010: 33; see also Bower and Paine 2017; and for a contrasting view Shiller 2012: 21).

However, for the importance of the share price in management decisions it does not matter if agency theory is a good depiction of reality. It is neither relevant if the theory’s implications benefit the long-term value of the firm.

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36 Ranked by proven oil reserves.
37 Though state-backed.
The share price is of importance for firm policies as soon as the management considers it to be so, i.e. because the management is convinced, or simply aware of agency theory. In practice, Chief Executive Officers (CEOs) are often rewarded with stock or options on their company’s shares to incentivize them to follow the path predicted by agency theory. Management officials should consequently align their policies with the aim of holding up share prices, be it for their belief in agency theory, for their own financial benefit\textsuperscript{38} or for psychological mechanisms in which high prices are a “reward signal”\textsuperscript{39} (Shiller 2012: 20–21; see also Bower and Paine 2017 for a critique of agency theory’s detrimental influence in modern financial markets; and Lazonick and O’Sullivan 2010 for a historical analysis of the ideology of maximizing shareholder value).

In line, many theoretical papers in the field of sustainable finance start with the assumption that “firms act to maximize the share price” (e.g. Edmans and Manso 2008: 10; Heinkel, Kraus, and Zechner 2001: 432).

As has been mentioned, »Fossil Free« does not actually aim at changing management policies. Here, a third argument for the need to assess share prices in response to divestment comes into play: Share prices are part of any theoretical argument about the financial impact of divestment. Hence, even though it remains unclear what will happen as a consequence of depressed share prices, in a first step, it is useful to know if they are depressed at all.

4.2 Fossil Fuel Divestment’s Theoretical Impact on Share Prices: Overview and Definitions

Even though restricting debt might be more effective than restricting equity for a firm, the present paper focuses on share prices. This emphasis is put as theories in the field build on stock prices rather than bond prices when suggesting mechanisms. Most arguments can be analogously applied to bond prices\textsuperscript{40}.

In the following, a share price is defined as the price which is paid for a company’s share on the financial market. I will not differentiate between bid and ask price as the difference does not matter for my analysis. The return on share is defined as the percental change in share prices over time. Contrary to other papers (e.g. Ding, Parwada, and Shen 2014; Hong and Kacperczyk 2009), returns will not be interpreted as being the same as capital costs. The expected relationship between share prices and capital costs has been outlined above. When analyzing fossil fuel divestment, it does not make sense to equate investors’ financial returns with firms’ capital costs: An ever-decreasing share price (which the divestment movement calls for) will depress returns of investors and increase capital costs of firms\textsuperscript{41}.

The market value or market capitalization of a firm is the company’s share price times the number of outstanding shares.

\textsuperscript{38} Contrasting this claim, Jensen and Murphy (1990) find that corporate strategies which immensely increase (decrease) a firm’s market value will only marginally affect the top executives financial benefits.

\textsuperscript{39} On the contrary, Wright and Ferris (1997) show how managers give in to activists’ demands to disinvest from South Africa despite its negative effect on the share price. They explain this behavior contradicting agency theory by the management’s desire for good reputation in the public.

\textsuperscript{40} Note that this doesn’t mean that the full argument of divestment is the same for debt and equity. As has been noted, a firm might be more effectively harmed if channels of debt are closed than if its equity is restricted. What is assumed however is that the relationship between bond selling by divestors and bond prices is analogous to the relationship between stock selling by divestors and the share price.

\textsuperscript{41} This holds as investors who own shares with ever-declining prices can only sell with a loss. A firm whose share prices fall permanently will have difficulties in raising new capital, no matter if debt or equity (see above).
The economic, fundamental or intrinsic value of a firm is defined as the present value of its future cash flows. The fundamental or intrinsic value of a share accordingly is the present value of the cash flows generated by one share of the company (Ansar, Caldecott, and Tilbury 2013: 21–22).

The theoretical framework provided in this chapter will address the following question: Assuming the factors which are unaffected by divestment\textsuperscript{42} to be unchanged, does fossil fuel divestment cause a decline in the stock price of fossil fuel companies and hence decrease their market capitalization?

This question will first be discussed regarding the direct effects of divestment on share prices, namely direct demand effects, which are assumed to be most important in the short run. Second, the indirect effects of divestment, first and foremost signaling effects in the context of the overvaluation of fossil fuel assets, will be discussed. They are assumed to be of importance in the medium to long run.

In both sections, different and sometimes contradicting theories will be presented. I decided to cover a variety of theories rather than sticking to one line of reasoning for two reasons: First, different theories capture different aspects of divestment and complement each other for the understanding of divestment’s impact. Looking at various approaches prevents me from overlooking important mechanisms involved. Second, I consider some of the presented theories to be more suitable to depict fossil fuel divestment than others. Regardless, some of the less suitable theories are frequently used in the debate about divestment’s effect on share prices. I decided to present these often-made arguments, not least to contrast them to other perspectives.

In the end of each section, I will make transparent which theoretical claims are core to my argument. I will derive hypotheses from these claims to be tested in the subsequent empirical analysis.

4.3 Fossil Fuel Divestment’s Direct Effect: The Short-Term Impact of Reduced Demand of Fossil Fuel Based Assets

Most simply, divestment means that shares of fossil fuel companies are sold by divesting institutions. In the following, different theoretical perspectives will be presented which help to understand how this selling should directly affect share prices.

4.3.1 The Law of One Price (LOP)

Under the assumption of no-arbitrage, perfect information and homogenous actors, the Law of One Price (LOP) suggests that the share price should equal the present value of the stock’s expected cash flows. The market value of a stock should hence be identical to its intrinsic value\textsuperscript{43}. Divestment does not change the expected cash flows generated the activities of a firm, at least not directly. Accordingly, it should not affect the share price at all. Any asset sold on the secondary market to divest will be bought by another investor (who, depending on the literature, is called “unscrupulous” (Ayling and Gunningham 2015: 135; Hunt, Weber, and Dordi 2016: 70) or “neutral” (Ansar, Caldecott, and Tilbury 2013: 30)). Hence, even though the stock might be sold at a discount by the norm-constrained divestor, the price will quickly return to its intrinsic value as this is the price all neutral investors are willing to pay. As Ansar, Caldecott, and Tilbury (2013: 70) note, “larger fossil fuel funded sovereign wealth funds

\textsuperscript{42} Especially the supply of outstanding shares.

\textsuperscript{43} Following the Law of One Price, if the intrinsic value of a stock exceeds its market value, arbitrageurs will quickly buy the stock with profit and bid up the market value to its intrinsic value (or the other way round if the intrinsic value exceeds the market value).
such as Norway\textsuperscript{44} or Abu Dhabi may even welcome the opportunity to increase their holding of fossil fuel companies—businesses they understand very well—particularly if the stocks entail a short-term discount”.

Obviously, the mere existence of norm-constrained investors and neutral investors stands in direct contrast to the theory’s assumptions of homogenous investors. However, investors who have committed to fossil fuel divestment (still) make for a tiny share of the investor base and will not inhibit a share’s convergence to its intrinsic value. In highly liquid markets (i.e. if enough neutral investors exist), a company’s stock price should therefore not diverge in any persistent, substantial way from its fundamental value.

\textsuperscript{44} Obviously, Ansar, Caldecott, and Tilbury (2013) did not foresee that the Norwegian Pension Fund would divest (at least from coal) two years after their publication.

\textsuperscript{45} Portfolios that maximize return for a given variance, or, equivalently, minimize variance for a given return.

\textsuperscript{46} i.e. (the part of) an asset’s variance which is uncorrelated with market risk.

\textsuperscript{47} i.e. (the part of) an asset’s variance which is correlated with market risk.

\textsuperscript{48} The increased risk of fossil fuel based assets from divestment will most likely be countercyclical to the risk of, for example, green energy assets. Investors should therefore be able to diversify away this increased risk.
4.3.3 Putting the Analysis on the Level of the Stock Market – The Elasticity of Demand for Shares

On the level of the stock market, the proposition that all investors are willing to pay the same price for an asset, no matter if cash flows are certain (as in the LOP) or risky (as in the CAPM or the APT), translates into a perfectly elastic demand.

As shown in figure 4 (neutral) investors will always want to purchase any amount of the stock at its fundamental price. With the assumption of a fixed supply (which is fulfilled except for the rare case when new shares are issued) both the quantity of shares and the share price remain unaffected by divestment (Chen, Noronha, and Singal 2004: 1901; Teoh, Welch, and Wazzan 1999: 83). Divestment’s only impact is then the redistribution of gains from norm-constrained investors who sell the shares at a discount to neutral investors who buy them below their fundamental value.

However, many researchers question the claim that demand for each individual stock is perfectly elastic. In reality, investors would instead diverge in their willingness to pay for a stock (Wall 1995: 7). In the following, two models of this strand will be presented. They argue that divestment should indeed affect the share price when some critical assumptions are loosened: Merton (1987) relaxes the assumption of full information in his »investor recognition hypothesis«. Miller’s (1977) model accounts for heterogeneity in investors’ expectation.

4.3.4 What if There is No Full Information? Merton’s Model of Segmented Markets

Merton’s (1987) »investor recognition hypothesis« or »segmented markets model«④ starts from nearly the same assumptions as the CAPM. Merton does however acknowledge that investors have limited information about investment opportunities. Investors merely know a subset of available securities. For securities they know, investors have homogenous expectation. Obviously, investors will only buy and sell assets of whose existence they are aware. The market for a firm’s equity which is only traded by a limited number of investors becomes ‘segmented’ which restricts risk-sharing among investors. Consequently, idiosyncratic risk rather than systematic risk will matter for the price of a security (Hong and Kacperczyk 2009: 17). Share prices in segmented markets are thus lower as compared to unsegmented markets. This effect will play out the stronger, the smaller the share of investors who has knowledge about an asset.

④ For an extension of Merton’s model into a dynamic general equilibrium model, see Shapiro (2002)
The neglecting of fossil fuel assets by divesting institutions should have a similar effect as ignorance of the assets’ existence. Hence, if an important segment of investors shuns a fossil fuel stock, its market value and share price should decrease. This is consistent with the presented ‘sin stocks’ literature (Ding, Parwada, and Shen 2014: 5; El Ghoul et al. 2011: 2390; Angel and Rivoli 1997: 59; Chen, Noronha, and Singal 2004; Hong and Kacperczyk 2009) and with empirical findings in other settings (Huberman 1999; Falkenstein 1996).

Given a firm’s size and risk exposure, Merton’s model can be used to estimate how much a firm value will decrease when avoided by a given fraction of investors: Angel and Rivoli (1997) conclude that a substantial share of investors would have to boycott a firm to achieve a discernible effect. Heinkel, Kraus, and Zechner (2001) estimate 20% of the investor base would have to neglect a stock to incentivize a firm to reform its polluting technology and become ‘clean’.

In segmented markets, increasing a stock’s idiosyncratic risk helps to depress its share price. As has been argued, the fossil fuel divestment campaign will most probably be unable to increase this risk in the short term. However, it could succeed in doing so in the long run, a possibility that will be discussed later.

Merton’s initial assertion that stocks are neglected because of a lack of knowledge about them also contains some negative implications for the current campaign. The »investor recognition hypothesis« is consistent with the claim that any attention given to a company can expand its investor base. Following this »attention story« (Gervais, Kaniel, and Mingelgrin 2001) an increased public debate about fossil fuel assets could draw neutral investors’ attention to fossil fuel stocks. In the hope of realizing a ‘sin premium’ neutral investors could be incentivized to purchase these assets above average. This interpretation is in line with the strong opposition »Fossil Free« has faced from major institutional investors such as Warren Buffett (Ding, Parwada, and Shen 2014: 5)

4.3.5 What if Investors’ Expectations are Heterogenous? Miller’s Argument under “Divergence of Opinion”

A second model which allows for an influence of divestment on share prices is provided by Miller (1977). Miller rejects the assumption of homogenous expectations among investors regarding uncertain future cash flows: Instead, “the very concept of uncertainty imply[ed] that reasonable men may differ in their forecasts” (ibid.: 1151). He starts from a market with restricted short selling in which expectations about returns from a risky security vary among investors. Without loss of generality, it is assumed that each investor can only buy one single share. Maximizing their investments’ net present value, investors buy a stock if they expect its risk-adjusted return to exceed the safe investing alternative. Due to their different evaluation of the stock’s prospect, different investors are willing to pay different amounts to purchase a stock.

Figure 5 shows the cumulative distribution of investors who are ready to buy the stock at a given price (red curve). The higher the price, the lower the number of investors who consider investment in the stock more rewarding than the safe alternative and thus want to buy it. As obvious by the falling demand curve, demand ceases to be perfectly elastic in this model. The fixed supply of shares will then be ‘distributed’ to those investors who have the highest expectations regarding the stock’s returns. The price of the stock under heterogenous expectations will hence be determined by the most optimistic investors’ willingness to pay. Note that this price will always be

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50 More concretely, estimated probability distributions of returns.
51 Imagine a situation in which the shares were distributed to investors who do not have the highest expectations. Then, investors with higher expectations would buy the stocks from these investors at a higher price.
higher than the average expectation on the stock’s prospect. In line, it will also always be higher than the one under the assumption of homogenous expectations. This is the case as the supply of one single stock will never be high enough to be bought by at least 50% of the investor base.

Miller’s framework sheds new light on divestment’s impact on the share price: All existing stock must be held by someone. Divesting institutions thus sell their fossil fuel shares to investors who were not willing to buy the shares at their previous price. Consequently, the stock price must fall to make those investors include the stock in their portfolio. This prediction is consistent with the empirical analyses of price effects of institutional trading (Dewenter, Han, and Malatesta 2010). The higher the fraction of shares divested, the more pronounced should this price effect be.

In equilibrium, each individual stock will only be held by a tiny minority of all investors. This implies that the stock price is determined by the evaluation of a small fraction of market participants who happen to be most optimistic about its future. Assuming that investors make unbiased estimates on average, the market price will exceed the willingness to pay of a hypothetical investor with perfect information. Reflecting the opinion of the optimists, the equilibrium does not produce a pareto optimum (Miller 1977: 1158).

Holding the average opinion constant, an increase in divergence of opinion about a stock will increase its market clearing price. As shown in figure 6, dispersed expectations about a stock’s prospects are associated with a less elastic demand (i.e. a steeper demand curve) resulting in stronger price effects.

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52 The demand in Miller’s model could quite as well be represented by a straight, downward sloping line. In figure 5, a curve is used to show that the price exceeds the average investor’s expectation.

53 For example, Chen, Noronha, and Singal (2004) estimate that an average institutional sell depresses the stock price by 0.35%.

54 As investors’ estimations are assumed to be unbiased, their future predictions are right, on average. The (non-existent) “average investor” will therefore approximately decide like a hypothetical investor with full information.

55 In this situation, the Efficient Market Hypothesis ceases to hold. Applying skilled analysis, i.e. a conservative investment strategy which avoids purchasing or sells occasional overvalued securities, should outperform the market.
According to Miller, disagreement tends to be stronger for more risky stocks. In consequence, they will be more heavily overpriced. Miller (1977: 1155) notes: “where there are numerous events which can make the return higher or lower than expected (risk), there will be widely differing evaluations on how likely these events are and a divergence of opinion. This leads to the surprising result, that with risk neutral investors that the expected market price for the security will increase with the risk. Indeed, even a moderate degree of risk aversion by investors might be offset.” With limited short selling, a “badly informed or excessively optimistic small group of investors can bid up a stock up to a value that most investors regard as unreasonable” (ibid.: 1154). Thus, physical investment of a company may be financed even if most investors have negative expectations about it.

According to some scholars, the current situation in the fossil fuel market is exactly as described by Miller’s framework (Carbon Tracker Initiative 2014; Critchlow 2016; Meyer, N., & Brinker, L. 2014; Baron and Fischer 2015). If they are right and assets are heavily overpriced, divestment’s impact could be substantial in the medium to long term. Before medium and long-term effects are discussed however, the results of this section will shortly be summarized to formulate hypotheses for the empirical assessment.

4.3.6 Divestment’s Short-Term, Direct Effects: Summary and Hypotheses
Following the LOP, the CAPM and the APT the direct effect of fossil divestment on share prices should be negligible. This is because divestment will not directly impact (expected) future cash flows, systematic risk or macroeconomic conditions. Merton’s model of »segmented markets« and Miller’s model under divergence of opinion abandon the two unrealistic assumptions of full information respectively homogenous expectations. Relying on these two models, divestment should depress share prices. In Merton’s model, this depression is a compensation for limited risk sharing of shunned stocks. In Miller’s framework, divested assets will only find buyers if their price is lowered. In both models, divestment will more seriously affect share prices, the larger the fraction of divested shares. Following Miller, divestment’s impact should further be more pronounced the higher the disagreement about a stock’s intrinsic value.
For later empirical assessment, the following hypotheses are derived:

\[ H_1: \text{In the short term, divestment has a small negative effect on the share price on targeted firms} \]  
(Miller and Merton)

\[ H_2: \text{If the stock price of a targeted firm is depressed by divestment, it will be quickly bid up again} \]  
(CAPM and APT)

Two further hypotheses could be derived which I will not be able to test in my framework. They are left to later work:

\[ H_{99}: \text{The negative, short term effect of divestment on the share price is more pronounced, the higher the fraction of divested capital (Miller).} \]

\[ H_{999}: \text{Divestment’s negative effect on the share price is stronger, the more dispersed the opinion about a stock (Miller).} \]

4.4 Fossil Fuel Divestment’s Indirect Effect: Divestment as a Signal in the Context of the Fossil Fuel Industry’s Overvaluation

In the following section, divestment’s role in the long-term development of fossil fuel asset prices is analyzed. I first give some context on the probable overvaluation of the fossil fuel sector, a phenomenon that has been termed the »carbon bubble«. I then build on theories of rational bubbles to argue that divestment could send an important signal to raise awareness of the »carbon bubble« and catalyze its burst. This would depress share prices in a substantial and long-lasting manner and create serious damage to the fossil sector.

4.4.1 The Context of Fossil Fuel Capital Markets: The »Stranded Assets« Debate

As has been pointed out, the fossil fuel sector differs from other ‘sin industries’ in that its future is extremely uncertain. In a world facing climate change as one of its most serious challenges, the sector is exposed to three types of risk: First, a technological breakthrough could make clean energy more competitive challenging the sector’s cost competitiveness. Second, public policies fighting climate change will most probably impede the companies’ continuation with ‘business as usual’. Third and associated, social factors, such as a societal transformation towards a low-carbon society, could break down demand for fossil energy (Mathieu 2015: 7).

If by technological progress, political action or societal change; there is vast agreement that global warming needs to be limited to 1.5°C or 2°C to circumvent disastrous consequences (Pachauri et al. 2014). To limit the risk of exceeding the 2°C goal by 2050 to 20%, it is estimated that 565 Gt carbon dioxide (CO₂) may be emitted (the so-called »carbon budget«). However, if the earth’s proven reserves of coal, oil and gas were burned, carbon emissions would amount to 2795 Gt CO₂. Hence, to avoid only the most drastic consequences of climate change, merely a fifth of the proven reserves may be burned (Allen et al. 2009; Meinshausen et al. 2009; Carbon Tracker Initiative 2014).

\[ \text{65% of this is from coal, 22% from oil and 13% from gas.} \]
Reserves held by the 100 largest listed coal, oil and gas companies (even though they are tiny players as compared to the biggest state-owned companies) already exceed the safe budget by 180 Gt. If all fossil fuel companies (including state-owned companies) reduced their reserve usage uniformly, 80% of the listed companies’ reserves would have to stay in the ground\(^\text{57}\) (Carbon Tracker Initiative 2014). These unburned oil, gas and coal resources would become »stranded assets« namely “lose[] [their] value well ahead of [their] anticipated useful life because of the impact of various transformational changes” (Eastman: 10). Note that ‘assets’ here can both refer to physical assets, i.e. the fuels that cannot be extracted and monetarized, and to financial assets, i.e. financial investments that lose value because of the lower cash flows generated when fuels are forced to stay in the ground.

The market value of listed coal, oil and gas companies in the literature is perceived to be based on a maintenance of today’s economy (Apfel 2015: 930; Baron and Fischer 2015: 9; see also Exxon Mobile 2014; Shell 2014). This means that, assuming at least slightly ambitious action on climate change in the future\(^\text{58}\) (for example the activities which have been agreed on by 195 states in the Paris agreement) fossil fuel companies’ financial assets today are considerably overvalued. As soon as climate action will be incorporated in financial markets, prices might fall tremendously. This “strong and sustained departure of the price of [fossil fuel] assets from their fundamental value followed by a strong decline.” (Critchlow 2016: 13) is called a »carbon bubble«.

**Empirical Estimations of the Value of Stranded Assets**

The International Energy Agency (IEA) (2014) estimates stranded assets to be in the order of USD 304 billion\(^\text{59}\). This includes USD 180 billion for upstream oil and gas investments, USD 120 billion for new fossil fuel capacity in the power sector, and USD 4 billion for coal mining\(^\text{60}\). An alternative estimate by the Climate Policy Initiative (CPI) quantifies the losses in a 2°C scenario in power generation, coal and gas with USD 1.05 trillion\(^\text{61}\) (Nelson et al. 2014). Less conservative estimates by the bank Barclays forecast a loss in revenues from stranded assets of USD 33 trillion over the next 25 years (Ryan 2016). The Citigroup’s estimate for a scenario with global regulations to reduce carbon emissions even quantifies losses as adding up to USD 100 trillion (Citi GPS 2015).

Differences in estimates can be attributed to diverging policy assumptions, methodologies and definitions of assets (Baron and Fischer 2015: 8). In any case, many scholars and analysts agree that we actually do face a carbon bubble with the potential to disrupt financial markets (Bank of England; Byrd and Cooperman 2016: 3; Bloomberg New Energy Finance; Caldecott, Lomax, and Workman 2015; Carbon Tracker Initiative 2014; Krosinsky 2016; Paulson 2014; Silver 2016; Spedding, Mehta, and Robins 2013).

These warnings have by no means only been delivered by university researchers or environmental organizations: Alerting voices further come from prominent political and economic figures and organizations like Mark Carney,

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\(^{57}\) Older estimates state that a third of proven reserves can be consumed prior to 2050 (International Energy Agency 2012). However, most recent publications refer to the number of one fifth of reserves to be burned to, more or less safely, stick to the 2°C target.

\(^{58}\) Some people perceive climate policies to be already largely implemented with the growing subsidies for green energy and carbon taxation in many countries. However, an IMF working paper puts this perception in perspective. It shows that fossil fuels are still subsidized by USD 5.3 trillion globally. German subsidies for example have amounted to € 21.6 billion in 2010. A removal of global fossil fuel subsidies could reduce CO\(_2\) emissions by over 20% (Kiyar and Wittneben 2015: 9626–9627)

\(^{59}\) By 2035, assuming a 2°C compatible scenario.

\(^{60}\) The estimates for coal are relatively low as most mines have already recovered their initial investment costs.

\(^{61}\) USD 50 billion in power generation, USD 600 billion in coal and USD 400 billion in gas.
Governor of the Bank of England and Chairman of the G20’s Financial Stability Board (Carney 2015), the OECD (Baron and Fischer 2015, 2015), the World Bank (Byrd and Cooperman 2016: 2), the IMF (ibid.), the Citigroup (Citi GPS 2015) and the German WestLB (Garz and Volk 2003).

Quantitatively, it is still disputed how strongly share prices will be affected by a bubble’s burst. Following Spedding, Mehta, and Robins (2013), unburnable fuels combined with reduced prices resulting from lower demand places at risk 40% to 60% of Europe’s biggest oil and gas companies’ market capitalization.

Based on these considerations, the present paper will build on the assumption that fossil assets are currently overvalued. It will further be assumed that the sector faces a »carbon bubble« as defined above. No assumptions will be made however on the seriousness of the overvaluation, the size of the bubble and the severity of the bubble’s burst. These quantitative details are of limited importance for the general argument.

The Financial Community’s Reaction to the »Stranded Assets« Debate

As a result of the stranded assets debate many have argued that incorporating climate risks should be considered part of all investors’ fiduciary duty (Arabella Advisors 2016: 8). For example, the World Bank President Jim Yong Kim at the 2014 World Economic Forum has pledged investors to take climate risks seriously (Alexander, Nicholson, and Wiseman 2014: 5). In 2015, France has enacted the first law that requires large institutional investors to disclose climate risks of their investments from June 2017 on. The 2017 G20 Summit has mandated its Financial Stability Board63 to develop recommendations for financial actors and businesses on how to evaluate and report risks from climate impacts, reputational and litigation risk as well as resilience to ambitious climate policy (Christoph Bals, Gerrit Hansen, Lutz Weischer 2017: 12).

As a response to the increasing awareness, some institutional investors have divested fossil fuel assets. Others have introduced climate risks into their assessment. Yet others have demanded fossil fuel companies to discuss climate risks in public statements (Apfel 2015: 931; Arabella Advisors 2016; Baron 2001: 13)

Notwithstanding the amounting concerns, fossil fuel companies’ public reports still offer almost nothing about climate risk. Notwithstanding the Paris Agreement, Exxon, BP and Shell aim to increase oil drilling by 25-30% in the next decade (Byrd and Cooperman 2016: 2).

Similarly, a large portion of investors still ignores the risks associated with climate change. The Asset Owners Disclosure Project’s (AODP) Global Climate 500 Index reports that in 2017, 201 of the world’s 500 biggest asset owners (who manage USD 12.5 trillion of assets) still ignore climate risks in their investments completely (Asset Owners Disclosure Project 2017: 15–16).

This is an improvement as compared to last year when the majority of investors disregarded climate risks. However, still in 2017, less than half of the asset owners incorporate climate change into their policy frameworks. Only one in five asset owners has staff to integrate climate risk into investment. Only 6% assess the risk of stranded assets on their portfolio and a mere 0.5% of assets are identified as low-carbon investment. Taken all indicators together, 14% of asset owners are classified by the AODP as »Leaders« or »Challengers« which at least “show action in a variety of capabilities”63 of incorporating climate risk (ibid.: 2; 5; 49). Of the world’s top 50 asset

63 More concretely, the Financial Stability Board’s industry-led Task Force on Climate related Financial Disclosures.

63 »Leaders« (A-AAA) “Demonstrate strong/excellence/elite performance across capabilities”, »Challengers« (B-BBB) “are (at least) progressing to a wider variety of capabilities” regarding their disclosure and management of climate risk. 14% of asset
managers, more than 50% are classified by the AODP as part of the two bottom groups who show “limited disclosure on financial implications of climate change in investments” (implying no action) or “no evidence of considering financial implications of climate change in investments” (ibid.: 7–8).

Reasons for Investor’s Inertia

Investors’ inertia is sometimes justified indicating the improbability that effects of climate change policies will overshadow those of economic and demographic growth over the next 10-15 years (Mathieu 2015: 7). Notwithstanding the “lip-service being paid to a 2°C temperature target” (Davidson 2014: 3), so far governments efforts have remained timid and erratic. The “belief that the companies in this industry are correctly evaluated [could therefore] be justified since a large proportion of proved reserves controlled by them will have been exploited” before strong regulation is implemented (Mathieu 2015: 7)\(^4\), so the argument goes.

In a similar vein, Shell and Exxon have responded to shareholders enquiries about »unburnable carbon« that their proven reserves will not become stranded (Shell 2014; Exxon Mobile 2014). However, the companies’ calculation is based on a scenario in which the world fails to limit global warming to 2°C (Baron and Fischer 2015: 8).

More moderate opponents of the bubble hypothesis admit that there might be some devaluation of assets which would however not be strong enough to compromise finance stability. Instead, average losses would stay at around 3% of total asset value of European pension funds, 2% of European insurance companies and 0.4% of the big European banks (Green European Foundation 2014; Mathieu 2015: 8).

It is a valid assumption that global governance will fail in limiting global warming to 2°C. However, as Mercer’s (2015) abovementioned simulation demonstrates, a future scenario of little climate action and strong fragmentation would hit investors even harder than strong policy action. Incorporating climate change risk in their assessment should hence be investors’ very self-interest.

Mercer (2015: 21) argues that an important reason for neglecting this interest is that risk assessments normally only cover between one and three years. Climate change, a risk in the more distant future, then goes by the board. An alternative explanation for investors inertia is that the financial community is simply unwilling to accept the fact that it should deal with climate issues. The founder of the Carbon Tracker Initiative who works for the Henderson group, for example, describes how his London colleagues were reluctant towards even talking about stranded assets: “The city is populated with people who... it’s not that they can’t get it – it’s that they don’t want to get it. My own experience of talking to mining and oil analysts [...] was their struggle with the idea you couldn’t burn all the fossil fuels. That was incomprehensible. [...] Even some of the top sustainability folks would not sit down and discuss it. They just weren't interested in it.” (Climate Change News 2015).

\(^4\) Byrd and Cooperman (2016) support this claim by an empirical analysis in which they find a positive stock price reaction to breakthroughs in carbon capture and sequestration (CSS) but no negative reaction on setbacks. They conclude that investors have already incorporated stranded asset risk into their valuations and that the fear of a carbon bubble is unjustified at least for the coal sector.
Critchlow (2016) describes a similar pattern when she diagnoses investor’s lack of action as ‘Irrational Apathy’ (c.f. Shiller 2015). In her framework, behavioral biases induce investment professionals to under-react to climate change information. Investment professionals with little concern about the climate are deceived by confirmation biases. They irrationally select climate change information in such a way that they underestimate climate risks and governmental and technological responses to these risks. In their valuation, investors therefore under-price the risks associated with the 2°C compatible strong policy or technology scenario and hence overvalue fossil fuel assets. Critchlow supports her theoretical analysis with data on London’s investment officials who are more apathetic towards climate change than the general public. Investors of her sample moreover have a poor knowledge of market relevant climate change information. They further question governments’ ability to meet the 2°C target and underestimate existing levels of climate change policies and technologies.

Notwithstanding the limited information and knowledge of investors surveyed by Critchlow, it is somewhat premature to conclude from her small and nonrandom sample (N=65) that all investors in fossil fuel asset market behave irrational. Moreover, the fact that investors are less concerned than the public does not reveal anything about the former’s rationality.

In the following theoretical analysis of divestment in the context of a carbon bubble, investors will thus be assumed to be rational, at least in parts. For the purpose of this paper, following Chamley (2004: 1), the “usefulness of this assumption goes beyond the standard ‘benchmark’ justification”. Instead, the theories which will be used show that “despite the rationality of individual behavior, and often because of that rationality, the process of social learning may be inefficient or fail completely” (ibid.).

I will provide a framework in which the carbon bubble can persist even if fossil fuel investors were rational. Introducing divestment in this framework shows how the campaign, in the medium to long term, could affect share prices in an indirect but strong way.

4.4.2 Divestment in the Context of a »Carbon Bubble«

In the context of a »carbon bubble«, divestment can influence share prices in two important ways:

First, it can act as a signal to other investors hinting on the existence or on a probable burst of the bubble. Second, the divestment campaign could exacerbate the bubble and trigger its early bursting by increasing future risks of the fossil fuel sector. I will concentrate on the first mechanism as the second is nearly impossible to separate from the political and social impacts presented. Further, the second mechanism has already been covered in detail by Ansar, Caldecott, and Tilbury (2013).

Divestment’s role as signal in the bubble context will be explained with the help of two models, Bikhchandani, Hirshleifer, and Welch’s (1992) insights on informational cascades and Abreu and Brunnermeier’s (2003) theory of bubbles and crashes in a setting of rational investors who try to “beat the gun” (Keynes 1973 [1936]: 99).

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65 The public could be irrational just as well.
66 The idea that market actors act rational and nevertheless create an inefficient outcome is in line with Samuelson’s (1998: 36) claim that modern financial markets are micro-efficient but macro-inefficient.
67 Adding irrationality to the models would, most probably, not impede the predictions made.
4.4.3 »Informational Cascades«, the »Carbon Bubble« and Divestment

One reason for the persistence of a »carbon bubble« despite investors’ rationality is given by Bikhchandani, Hirshleifer, and Welch’s (1992) model of »informational cascades«. In the model, investors decide sequentially if to invest in an asset. The private information they have about this asset diverges and investors are well aware of this disagreement. Decisions to invest or not invest in an asset are made based on public and private information, i.e. investors take into account the observed action of all other agents and their own private signal.

The simplest form of an informational cascade occurs if the first and the second investor have positive information or opinion on a stock. They both invest in the asset. The third agent is now equipped with three signals: She knows about the decision of the first agent from which she infers a positive signal, the decision of the second agent, from which she also infers a positive signal and her own information. If she values all signals equally, the third agent will invest in the stock, even though her own information might be negative; she is herding. The fourth agent, again, will invest, regardless of her own personal information. In this setting, social learning between agents with private information stops completely; an »informational cascade« emerges.

Due to the cessation of social learning, a situation can occur in which all agents invest in a stock, even though the majority has a negative signal and considers it to be incorrectly valued. The public belief is mistaken as it is based on a small fraction of the available information only. The equilibrium achieved is societal ineffective.

This equilibrium is moreover very fragile: An asset price might be incorrect for quite a while as investors are guided by a particular interpretation of history. However, after a time, this line of thinking might suffer from an increasing lack of supporting evidence. Agents will then switch to an alternative interpretation which results in a price jump (Chamley 2004: 11). This alternative interpretation will only be accepted after the observation of new, contrasting signals. “When a ‘black sheep’ breaks away from the herd, he reveals a piece of strong private information. That information is then incorporated in the public belief, which makes a quantum jump” (ibid.: 6). All agents know that only someone who is fully sure of her own signal would ever act differently than the rest of the group. If an investor does, her signal will thus be heavily weighted provoking a renewal of social learning.

Adopting the model to the case of fossil fuel investment, it is possible that many, maybe even a majority of investors, are skeptical towards the future of fossil fuel assets and think that assets are overvalued. However, they observe that most other investors keep investing in fossil fuels. Investors conclude that their skepticism, at least in the short run, is unjustified and consequently keep their investments in fossil fuels (in turn resolving the doubt of other investors).

This ‘vicious circle’ could be broken up by divestment: If divestors manage to be the ‘black sheep’ who break the herd, even small divested sums could induce a change in public belief and cause a ‘quantum jump’ in asset prices. This signaling effect should be most significant for financially motivated divestment (or, divestment that is considered as financially motivated by the market) and for large, well-known institutions.

An apparent shortcoming of Bikhchandani, Hirshleifer, and Welch’s model is the unrealistic assumption that agents do not communicate. If they do (and if they are willing to reveal their information), investors should quickly find out that only some minority beliefs in the future profitability of fossil fuels. To defend the model, it has been observed that, even when allowing for communication between agents, they often withhold personal information. For instance, investors are often reluctant to express an opinion countering the mainstream because

68 Or other agents as their model is not only applicable to the financial market.
they fear a loss of reputation. Indeed, Ottaviani and Sørensen (2006) show that reputational herding follows an identical path as the one suggested by Bikchandani, Hirshleifer, and Welch.

As has been argued, the discussion about the »carbon bubble« has remained overly quiet for a long time. Divestment can foster debate about stranded assets and support it with the credible signal of financial divestment. Its long-term effect should hence be more influential if it is accompanied by public statements related to the stranded assets debate.

4.4.4 How Can a Bubble Can Persist Even Though Most Rational Investors Know about it and Communicate

Abreu and Brunnermeier (2003) show how a bubble can persist, even if investors are rational and communicate. Investors in Abreu and Brunnermeier’s model, from a certain point in time, know as a matter of fact that they face a bubble. For their decision to buy or sell, they however do not rely on their own evaluation of the stock’s intrinsic value. Instead, they invest based on the market price expected in the future. This expected price, in turn, depends on other investors’ perception. To use Keynes’ (1973 [1936]: 156) words:

“[P]rofessional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one’s judgement, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be.”

Abreu and Brunnermeier (2003) assume that rational arbitrageurs interact with boundedly rational behavioral traders69. The latter bid up the price of an asset driven by ‘irrational exuberance’ (Shiller 2015). Hence, like depicted in figure 7 the asset price increases by a larger rate than the asset’s fundamental value does.

Rational traders subsequently gain knowledge about the existence of a bubble. They also know that the bubble must necessarily burst at some point, i.e. when enough traders who are aware of the bubble decide to sell. Traders however do not know how many other investors already know about the bubble’s existence. A rational investor therefore keeps her investment until the temptation to ‘ride the bubble’ is dominated by her fear of immediate collapse. As soon as a critical mass sells their assets, all rational arbitrageurs who know about the bubble sell immediately. This causes the bubble to burst and brings down the asset price to its fundamental value. In Abreu and Brunnermeier’s model, “[t]he resilience of the bubble stems from the inability of arbitrageurs to temporarily coordinate their selling strategies70. This synchronization problem together with the individual incentive to time the market results in the persistence of bubbles over a substantial period.” (Abreu and Brunnermeier 2003: 173).

69 Bounded rationality means that a person’s rationality in decision making is limited by the tractability of the decision problem, cognitive limitations, and time restrictions. Deciding agents are assumed to content themselves with satisfying outcomes rather than always seeking the optimum (Simon 1972).
70 If all traders had the same opinion about the bubble’s bursting time, each trader would try to sell before the others do. This would result in a situation in which (similar to the neoclassical model in which bubbles do not emerge) each trader would sell immediately which would prevent the asset price to rise above its fundamental value.
Using a metaphor of Keynes (1973 [1936]: 156) again:

“For it is, so to speak, a game of Snap, of the Old Maid, of Musical Chairs - a pastime in which he is a victor who says Snap neither too soon nor too late, who passed the Old Maid to his neighbour before the game is over, who secures a chair for himself when the music stops...”

Like the games mentioned by Keynes, the bubble in Abreu and Brunnermeier’s model produces winners and losers: Arbitrageurs who sell at the bubble’s peak will gain most, late sellers gain less, and behavioral traders lose⁷¹.

As all rational traders try to seize the right moment to benefit from the bubble as much as possible, they vigilantly look for signals which indicate a soon burst of the bubble. Some news events enable traders to synchronize and facilitate coordination of the bubble’s burst. They can hence have a disproportionate impact as compared to their intrinsic informational content. These ‘synchronizing events’ can be news, specific dates⁷² or market movements.

⁷¹ Note that, in contrast to other models (e.g. Milgrom and Stokey (1982) and Tirole (1982)) investors face a zero-sum game. In the end, every profit made through the bubble will be paid off by another market participant, i.e. by behavioral traders (or, in some cases, by rational arbitrageurs who do not know about the bubble yet or who are slow in selling the asset).

⁷² Abreu and Brunnermeier frequently use the example of Friday 13th which however, in my opinion, contrasts their assumption of rational traders.
The most remarking ‘synchronizing event’ is a visible price movement. Inducing many informed investors to sell, a moderate price decline can hence lead to a full-blown crash\(^\text{73}\).

The carbon bubble differs from other historical bubbles in the sense that the fossil fuel sector has not experienced a strong rise of asset prices in the last years. However, even though the market price of assets has increased only slightly, its growth rate is higher than the rate of the assets’ fundamental value. The latter, following the «stranded assets» argument, has decreased over time. The situation in the fossil fuel market is thus consistent with Abreu and Brunnermeier’s assertion that the fundamental value grows at a smaller rate than the price (see figure 9, next page).

Following the Abreu and Brunnermeier, some investors in the fossil fuel market (the ones described by Critchlow (2016) as ‘irrationally apathetic’) trade behaviorally and are unaware of the current overvaluation of fossil fuel assets. However, other (and maybe even a majority of) fossil fuel investors trade rationally and have become aware of the bubble over the years. Against the backdrop of climate change and associated policies to protect the climate, they know that the bubble will have to burst and fossil fuel asset prices will fall at some time in the future.

However, before this burst, they want to benefit as long as possible from the decent investment opportunity in fossil fuels. As has been outlined, investors have only recently started to incorporate climate change in their risk management. The quick increase of investors’ sensibility for climate risks in the last few years shown in figure 8 is consistent with the claim that more and more rational investors have ‘learned’ about the bubble and perceive its burst to come closer.

In this context, divestment has the potential for a »synchronizing event« which signals the market that investors start leaving the overvalued sector. This could alarm other traders and facilitate their coordination to burst the bubble, a scenario depicted in figure 9.

\(^{73}\) If the price drop is too weak, it can also lead to the bubble’s rebound temporarily strengthening the bubble. This is because leaving and reentering the market in case of no burst is costly as prices are higher when the investor reenters. Arbitrageurs will thus only leave if they are sufficiently sure that the bubble will burst.
In this setting, divestment, again, should be most powerful if the market considers it to be on financial grounds, if the divesting institution is prominent and if the decision to divest is publicly promoted.

4.4.5 Divestment Dynamics as a Risk Factor for Fossil Fuel Investors

In the long run, divestment cannot only serve as a signal. It can further influence the bubble’s context and shape by increasing uncertainty about the sector’s future prospect. Ansar, Caldecott, and Tilbury (2013) show that this uncertainty can be induced through stigmatization.

Stigmatization will firstly increase the expectations that governments will act to restrict fossil fuels. Secondly, it will reduce linkages between politics and the fossil sector as politicians fear a reputation loss when collaborating with stigmatized industries. Stigmatized companies will thus have reduced access to state subsidies, public contracts and procurement. Stigmatization will thirdly scare away suppliers, subcontractors, potential employees and customers. It can fourthly result in multiple depression which, in turn, hurts the share price. Taken together, stigmatization manages to increase legislative and economic uncertainty. For investors, this translates into higher risk which lowers asset valuation and might accelerate the carbon bubble’s burst.

These mechanisms have been well-analyzed by Ansar, Caldecott, and Tibury (2013). I consider the effects to be part of divestment’s broader political and societal impact. They will therefore not be part of my analysis and are just shortly covered for the sake of completeness.
4.4.5 Divestment’s Long Term, Indirect, Effects: Summary and Hypotheses

In the context of the overvaluation of fossil fuel assets, divestment can serve as an important signal:

This signal can firstly serve to break down informational cascades: The »carbon bubble« could be kept alive through each single investor’s conviction that the financial community cannot be wrong. Divesting institutions then give a strong market signal when breaking away from the herd. Their credible step of selling assets can motivate skeptical investors to leave the sector as well. Divestment further stimulates the debate on the valuation of the sector and reawakens social learning. Especially if financially motivated and promoted by well-known, high reputation institutions, it can accelerate the bubble’s burst resulting in a downward jump in prices.

In a slightly different setting, divestment can secondly serve as a »synchronizing event«: In a situation in which rational arbitrageurs try to benefit from ‘riding the »carbon bubble«’ and sell before its burst, divestment can send a signal that the bubble’s burst is near. This signal, induced by market exit or a small price decline, could lead rational investors to sell and thus synchronize their trading strategies towards the bubble’s burst. Inflated asset prices in turn would fall to the assets’ intrinsic values.

Following these two lines of reasoning, some hypotheses can be derived for divestment’s indirect, medium to long-term impacts:

\( H_3 \): Fossil fuel divestment has an indirect, medium to long term negative effect on asset prices which outperforms the direct, short term effect.

\( H_4 \): The indirect, medium to long term negative effect of fossil fuel divestment on asset prices is stronger for financially motivated divestment.

\( H_5 \): The indirect, medium to long term negative effect of fossil fuel divestment on asset prices is stronger for divestment which is promoted publicly.

5. Survey of Divesting Institutions

To test these relationships between divestment and stock prices of fossil fuel companies empirically, data on the two variables (and important third variables which will be discussed later) is needed. In particular, detailed data on fossil fuel divestment is indispensable. A comprehensive data set would have to include the exact dates when funds were withdrawn, how many assets were sold of which particular firm, if the motivation for divestment was purely ethical or, at least partially, financial, and if the decision to divest was publicly promoted.

As this kind of data was not available, I conducted a survey which was spread among all divesting organizations listed at the »Fossil Free« website (gofossilfree.org). As by March 2017, this list encompassed 706 organizations which have committed to divestment.

The most important information gathered by the survey was the date of the organization’s divestment decision, when the decision to divest was made public, the date and the amount divested and, in the best case, from which specific company money was withdrawn.

The survey entailed 15 questions and was conducted web-based. Alternatively, respondents could fill a PDF and return it by e-mail or postal mail. Respondents were reminded up to five times by e-mail (as suggested by Schnell 2012: 248–254; see also Dillman, Smyth, and Christian 2014: 19–55).
In the following, I will first explain how the survey and the survey process were designed before presenting an overview of the gathered data in the next chapter. The contacted institutions, all e-mails sent to respondents, the questionnaire and the gathered dataset can be found in Appendix B.

5.1 Survey Design

5.1.1 »Taylored Design Method« and Social Exchange Theory
The survey was called »2017 Fossil Fuel Divestment Survey« and designed following Dillman et al.’s (2014) »Taylored Design Method« (TDM). The TDM gives insights on how to design a survey to reduce the risk of different errors which could lead to a wrong depiction of relevant population aspects by our data. These errors are coverage error\(^{74}\), sampling error\(^{75}\), nonresponse error\(^{76}\) and measurement error\(^{77}\) (ibid.: 3–4)\(^{78}\).

Dillman et al. build on Social Exchange Theory (SET) to reduce these errors (Blau 1964; Homans 1961; Thibaut and Kelley 1967). SET analyses the behavior of people when interacting with each other and the social norms which emerge to guide these interactions (Dillman, Smyth, and Christian 2014: 24). One central claim of the theory is based on a cost-benefit analysis: If a person believes that complying with someone else’s request will bring more rewards than costs she will be ready to comply (ibid.). Applying these insights to survey design, a surveyor can raise the willingness of people to respond by increasing the respondent’s benefits, reducing his or her potential costs and creating trust that the benefits will actually be substantialized both during the response process and afterwards (ibid.: 21).

Considering a survey’s benefits, its costs and trustworthiness is especially important when surveying organizations as I do. For organizations including businesses the time spent to respond a survey translates into actual labor costs and trust is essential to secure that confidential data will not be misused. An employee should only respond to a survey if she sees a benefit for her own organization (otherwise she would be wasting her working time).

Building on empirical evidence, Dillman et al. (2014) summarize the most important ways to increase benefits, decrease costs and increase trust. I applied the suggested strategies during the whole survey process. The process involved several decisions i.e. the timing of the survey, response modes, invitation e-mails and reminders, which questions to include, which choice options to give, how to word questions, how to program the questionnaire

74 Coverage error describes the misestimation resulting from a difference in the list from which sample members are drawn and the actual population regarding relevant study characteristics (Dillman, Smyth, and Christian 2014: 3).
75 Sampling error describes the divergence between the estimate produced by a sample and the estimate which would hypothetically be generated when everybody on the list of the full population was surveyed (Dillman, Smyth, and Christian 2014: 3).
76 Nonresponse error occurs when respondents and non-respondents vary in a characteristic relevant to the study. It measures the difference between the estimate which would have been produced if all members of the sample had answered and the actual estimate produced (Dillman, Smyth, and Christian 2014: 3).
77 Measurement error describes the difference between the true sample value and the estimates produced when respondents have answered inaccurately (no matter if willingly or unwillingly due to e.g. ambiguous question wording or choice options) (Dillman, Smyth, and Christian 2014: 3).
78 The method is mainly designed for sample surveys. In my case, all organizations on the Fossil Fuel list were contacted. Nevertheless, I will treat my data as sample data as the generated responses can be interpreted as a sample of all organizations who have committed to fossil fuel divestment.
and, finally, which layout and design to use. Dillman et al.’ strategies and their application to my survey are summarized in figure 10.

Figure 10: Survey Design build on Social Exchange Theory

<table>
<thead>
<tr>
<th>Increase benefits</th>
<th>Decrease costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tell how results will be used: importance for divestment campaign and fight against climate change is stressed in invitation, reminders and questionnaire</td>
<td>• Reduce length and complexity: just 15 questions, simple wording and smart filters</td>
</tr>
<tr>
<td>• Ask for help: in invitation and reminders respondents are asked for help, in the questionnaire they are thanked for their help</td>
<td>• Use good visual design</td>
</tr>
<tr>
<td>• Ask interesting questions: questions about moral reasons for divestment and financial assessment of fossil fuel assets in the beginning</td>
<td>• Make responding convenient: respondents just click on link and enter code, easy to send around within organization</td>
</tr>
<tr>
<td>• Convey that others have responded (in reminders)</td>
<td>• Avoid uncomfortable modes: web-based or fillable PDF options</td>
</tr>
<tr>
<td>• Use a legitimate and trusted sponsor: University of Kassel and International Center for Development and Decent Work with logos</td>
<td>• Avoid offering choice of modes: PDF option introduced as a later offer to facilitate response</td>
</tr>
<tr>
<td>• Stress that opportunities are limited: in reminders</td>
<td>• Minimize request for sensitive information: two sensitive questions in the end of questionnaire</td>
</tr>
<tr>
<td>• Do not deny benefits</td>
<td>• Avoid subordinating people: adult-to-adult communication style</td>
</tr>
</tbody>
</table>

Establish Trust

• Show authenticity and legitimacy of request: Postal address provided, contact opportunity by e-mail and phone
• Sponsorship by legitimate authority: Reference to University of Kassel and International Center for Development and Decent Work
• Assure confidentiality and data protection: in invitation, questionnaire and elaborated in second reminder
• Professionalism: in communication and design of questionnaire

5.1.2 Increase Benefits for Respondents

Thibaut and Kelley (1967) suggest that people are willing to assist others, even in a time consuming manner, simply because their help is appropriately recompensed by verbal appreciation or a small favor returned later (Dillman, Smyth, and Christian 2014: 28). Social psychological studies find that most people feel good when contributing to something which generates benefits to others. They like being asked for advice. They further like to feel as part of a group and enjoy doing interesting tasks (ibid.).

I used these insights for my survey design: First, I specified how the results will be helpful for the overall divestment campaign. In the invitation e-mail, my study was set in context of the fight against climate change. This was assumed to be in the interest of all contacted organizations as they had voluntarily joined the fossil free campaign. Respondents were explicitly asked for help in the different e-mails.
Questions which were considered of divesting organizations’ interest were placed prominently in the first part of the survey (c.f. ibid.: 28–29). As my sample comprises non-profit organizations on the one hand and profit seeking banks and funds on the other, I decided to start with questions about the moral importance of divestment and on the over- or undervaluation of fossil fuel assets.

The sponsorship by a legitimate organization (which has been found to increase benefits, see Dillman, Smyth, and Christian 2014: 29) was emphasized by referring to the Corporate Finance department of the University of Kassel and the International Center for Development and Decent Work Kassel in the invitation e-mail, the reminders and the questionnaire itself. The survey was sent out in the time of documenta exhibition, maybe the only time in many years when someone of an US-based organization could have heard of the city of Kassel. Thereby, I hoped to raise respondents’ interest in supporting the Kassel based institutions.79

Especially in the later reminders it was stressed that opportunities to respond are limited, a fact that has been found to encourage people to respond to surveys due to the feeling of exclusive selection (ibid.: 29–30). In later reminders, it was further stressed that other institutions had already responded. As it is rewarding to behave like other group members, this should encourage normatively oriented actors to follow the group of divesting institutions and respond (ibid.: 30). Finally, I avoided to deny the existence of benefits of responding, which is counterproductive but often done in surveys. Contrary to the suggestions of survey research (Dillman, Smyth, and Christian 2014: 30; Schnell 2012: 251) it was unfortunatly impossible to send material incentives due to financial limitations.

5.1.3 Decreasing Costs for Respondents
To decrease the costs of responding, first of all, the survey was kept very short entailing only 15 questions (c.f. Dillman, Smyth, and Christian 2014: 32–33). Even though it was tempting to ask everything that could be valuable any time in the future, the decision was made for a very brief survey to keep up the response rate. Regarding the perceived length of the interview a graphical process indicator has been found to have a rather discouraging effect (ibid.: 326) and was therefore not included. Instead, a subtle indicator of progress was introduced by informing the respondents about current and total question numbers (e.g. “question 3 of 15”). To further facilitate responding, complexity was reduced by asking short questions and using filters (ibid.: 33–34). This made the questions understandable for respondents in different settings (e.g. questions for organizations which have never owned fossil fuel related assets had a slightly different wording than questions for those organizations which had owned fossil fuel assets and divested them).
Starting the survey did not demand any effort from respondents. They just needed to click on a link provided in the email and enter a code that could be copy pasted. Visual design principles supported the respondent when clicking through and finally completing the survey (ibid.: 34).

I offered the possibilities to submit answers either through a web-based questionnaire or by returning a fillable PDF to provide respondents with a survey mode they felt comfortable with (ibid.: 35–36). The two modes were chosen as web-based surveys are easy and quick to respond while fillable PDFs can be easily passed around in an institution and printed copies can be kept for the records (ibid.: 306). Further, a PDF returned by e-mail or postal mail was expected to raise less data concerns when providing sensitive information on the organization or company (see also next section). As the explicit offer of a choice of response mode has been found to lower

79 Some respondent who contacted me by email even commented on the documenta.
response rates however (ibid.: 36), in the first invitation I only presented the web-based questionnaire. In the second e-mail, the opportunity to respond by PDF was offered as an alternative.

A preferred survey mode would have been a paper questionnaire. This was found to be most popular among responding companies and increase response rates while reducing data concerns (Dillman, Smyth, and Christian 2014: 251; Snijkers 2013: 251). However, sending out paper questionnaires to about 700 institutions all over the world was not possible due to financial constraints.

To decrease costs for respondents, in particular for employees responding in charge of an organization or company, requests to obtain sensitive information should be minimized (Dillman, Smyth, and Christian 2014: 36; Snijkers 2013: 41–42). In my survey, there were two questions central to my analysis that required the disclosure of such information, i.e. the amount divested by an organization and the question how much was divested from which coal, oil or gas company. These questions were strategically posed in the end of the interview as respondents tend to be more willing to answer sensitive questions after having answered several other questions and after having established trust and rapport (Dillman, Smyth, and Christian 2014: 36). Finally, subordinating language was avoided as in general people do not like to feel dependent on or commanded by others (ibid.: 34–35). Instead, an adult-to-adult communication style was used.

5.1.4 Establishing Trust
The question of how to establish trust is essential when interviewing organizations about financial issues and inviting them by e-mail.

To decrease concerns of respondents, possibilities were provided to evaluate the authenticity of the survey and ask questions about it (ibid.: 39). A physical address was given both in the invitation e-mail and in the questionnaire. Both an e-mail address and a phone number were provided to ask questions which several respondents made use of (to ask questions, raise criticism and suggest changes). The sponsorship of the University of Kassel was emphasized (ibid.: 41) by designing the questionnaire in line with the University’s corporate design and including the logo of both the Chair of Corporate Finance and the International Center for Development and Decent Work.

Confidentiality and the protection of data was assured (ibid.: 40). The measures taken to secure data protection were elaborated in one of the reminders. However, it was avoided to go too much into detail as this has been found to increase data concerns rather than reducing them (ibid.: 41). As has been explained, the possibility to submit the survey by e-mail or postal mail was introduced to reduce remaining data concerns. To ensure integrity, communication was kept professional (ibid.).

5.2. Survey Responses
Of the 706 organizations from the list provided by 350.org, 591 were contacted via email (preferred method), online contact forms or Facebook (if no other contact information could be found). The remaining 115 organizations could either not be found in the internet at all or the information which was found did neither include an email address nor a contact form nor a Facebook contact. After excluding double entries and those organizations who, by self-assertion, are not part of the campaign80, 582 divesting institutions remain. 131

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80 Note that, only of those answering to my emails, five institutions were highly surprised to be listed as divestors on the »Fossil Free« list. These institutions had neither divested nor joined the campaign. There might be some more non-campaign-members of those who did not answer and of those whose contact could not be found.
institutions completed the survey (22.5 % of those contacted). Their responses over time are depicted in figure 11:

**Figure 11: Survey Reponses over Time**

Including those institutions who worked on the survey but did not finish it, responses add up to 155 (26.6%). To benefit from all given information, I incorporated 18 further surveys in my analysis who had not completed the interview but filled it in a meaningful way to a considerate extent\(^1\) to end up with a sample size of 149. This makes for 25.6% of all contacted institutions or 21.1% of all listed institutions\(^2\).

Like shown in figure 12, my sample consists of faith-based organizations (26.5%), city, state and federal governments (16.5%), philanthropic foundations (11.9%), educational institutions (9.9%), pension funds (4.0%), NGOs (6.0%), For-profit corporations (in particular insurance companies, 2.6%), and cultural institutions (2.6%). Regarding institution type, it depicts the true population relatively well except for the underrepresentation of philanthropic foundations. Of the surveyed institutions, 64% have divested from fossil fuels while the remaining 36% have never owned fossil fuel assets and have joined the campaign out of solidarity. Note that, as my unit of analysis are targeted firms rather than divesting institutions, for my later analysis, it is relatively unimportant how

\(^1\) These cases, in particular, include institutions who filled the survey up to the point where specific information regarding the firms divested from was asked.

\(^2\) It is reasonable to assume that many of the institutions whose contact could not be found at all either do not exist anymore or are not part of the campaign (see foot note 5) or are very small. It should hence not be too problematic not to have contacted them.
well my sample depicts the real divestor population. Instead, divestment announcement dates and dollar sums divested are of main interest for the later analysis. The gathered data will be presented in the next section.

Figure 12: Responding Institutions as Compared to all Divesting Institutions

6. Data
Fossil fuel divestment, my explanatory variable, can take two forms: First, in both analyses, divestment announcements of institutions joining the »Fossil Free« campaign are used. Second, dollar sums divested by these institutions are included in the long-term analyses. The main independent variable are stock prices of targeted companies, i.e. of the biggest oil, gas and coal companies. In the following, the data on these variables as well as on control variables is briefly described.

6.1 Main Explanatory Variable: Divestment Announcement Dates and Dollar Sums Divested
From the 149 responses of the survey, 76 divestment announcement dates, i.e. the date when an institution publicly announced the decision to divest, were extracted. 125 dates of divestment from a specific fossil fuel

83 Dates were only used if they at least gave month and year of the announcement. If no specific day of the month was given, the first of a month was set as a date. If the decision to divest was given but not the announcement date, the decision date was used under the assumption that an institution’s decision would also spread news. After these changes, 76 divestment dates remained.
company were given. Of those, 59 were used as the other dates were either not specific enough or no sufficient return data was available for the targeted firm at the given date. Divestment announcements are reported between 2012 and 2017. If the announcement was made at a weekend, the subsequent Monday was set as the announcement date to be able to evaluate its stock-price impact.

In addition to divestment dates, 48 respondents gave the detailed sum of their total divestment. Divested sums are transformed into dollar returns. The sums range from 20,000 USD to 232.4 Mio USD. The data set also entails sums divested from a specific company. These sums are not used in my analyses however as they are only reported for very few firms.

6.2 Dependent Variable: Stock Prices and Returns of Targeted Companies

The main dependent variable of the different analyses is the stock price or return of companies targeted by the divestment campaign. A company is considered a ‘targeted company’ when (1) it was named by respondents of the survey among the firms they divested from, or (2) it is part of the »Carbon Underground 200« i.e. one of the companies which »Fossil Free« suggests to divest from most urgently (Fossil Free 2017b, companies are listed in Appendix).

Stock price data was gathered via Datastream. For each stock, I use the price at the market at which it is mainly traded. To control for stock splits and similar actions as well as for dividend payments, the Total Return Index (RI) was used instead of the price. For the event study, the index was transformed into log returns. Returns were used from 2000 to 2017 depending on the event date (see methods section).

For the latent growth curve model, stock prices (rather than returns) are analyzed from June 2007 to June 2017. I transform them into log share prices to be able to assess percental price (and thus the market value) changes and to eliminate size effects.

All Saturdays and Sundays were deleted from the data as they are non-trading days. Excluding all other bank holidays was a little trickier as the stocks are traded at different markets. For a non-trading day, Datastream reports the exact same return index as the previous day. Hence, the return or price was set to missing for these days.

84. Note that there are more dates of divestment from a specific company as general divestment announcement dates. This is because one divestment announcement could comprise the (planned) divestment from several specific companies, i.e. some respondents giving one announcement date gave more than one dates of divestment from a specific company.

85. Setting all weekend divestments to Monday could possibly bias results as a general day-of-the-week-effect has been reported (e.g. Zhang, Lai, and Lin 2017). To account for this pattern robustness was checked including a binary variable for Mondays which did not change the results.

86. By the way, University of Kassel is apparently unable to properly install Datastream. From April to August 2017, the responsible did not manage to install the excel-add-in without which it is nearly impossible to properly gather a larger amount of data and which cannot be installed without administrator rights. I was frequently told that they are sorry, but “no one has needed this so far”.

87. As the return index used is independent of currencies (see next sentence), no transformation into one single currency was necessary.

88. Note that, despite being called return index, the RI reports the corrected stock price rather than its change over time.

89. The default price index of Datastream P (‘adjusted price’) takes stock splits and similar corporate actions into account, but does not adjust for dividends.

90. It was checked that this procedure did not produce too many missings.
6.3 Control variables
For the event study, control variables are used to obtain ‘normal returns’ (a detailed description will be provided in the next chapter). To estimate normal returns I follow Griffin et al.’s (2015) study on the fossil fuel sector’s stock price reaction on a Nature article about the carbon bubble. I use a three-factor Fama-French model extended by the oil price. The three-factor model is commonly used to estimate normal returns in event studies (Kothari and Warner 2004). It includes the excess return on the market\(^9\), the performance of small stocks relative to big stocks ("Small-minus-Big, SMB\(^6\)”, and the performance of value stocks relative to growth stocks ("High-minus-low, HML") (c.f. Fama and French 1992). Data is obtained from Kenneth French’s website and explained in detail there (French 2017). The oil price is used in addition as it is a crucial determinant for stock prices in the fossil fuel sector. The West Texas Intermediate (WTI) crude oil spot price is obtained from Datastream. For the event study, daily price changes are used.
In the latent growth curve model, I use the same control variables, i.e. the three Fama French factors and the (absolute) WTI crude oil spot price. I further control for time what will be explained in the next chapter in greater detail.

6.4 Missing Data
To handle missing data in the event study, multiple imputation (predictive mean matching, m=5) was used to create probabilistic values. Multiple imputation approximates a full information, maximum likelihood estimation of missing values and has been found to be superior to list-wise deletion. The latter (which R applies per default in ordinary least square (OLS) regression) is criticized for biasing results (Schafer and Olsen 1998). In the latent growth curve setting, the applied software Mplus uses full information maximum likelihood procedures for all endogenous and list-wise deletion of exogenous variables. The former is considered the most thorough way to avoid bias caused by missing values (ibid.).

7. Methods
7.1 Event Study to Estimate Fossil Fuel Divestment’s Short-Term Impact
To account for the short-term impact of fossil fuel divestment, I apply two event studies: The first one investigates the stock price reaction of a fossil fuel stock following an announcement to divest from exactly this company. It will henceforth be referred to as ‘firm-specific analysis’. An institution’s announcement to divest could, however, not only affect the companies from which assets are actually withdrawn. In addition, divestment announcement could affect the whole fossil fuel sector (see theory). Therefore, in a second analysis, the effect of an institution’s announcement to divest from fossil fuels on all targeted companies, (i.e. the »Carbon Underground 200« plus firms named by the repondents) will be estimated. This second event study will be referred to as ‘sector-wide analysis’.

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\(^{9}\) The market return is a “value-weight return of all CRSP firms incorporated in the US and listed on the NYSE, AMEX, or NASDAQ that have (i) a CRSP share code of 10 or 11 at the beginning of month \(t\), (ii) good shares and price data at the beginning of \(t\), and (iii) good return data for \(t\)” (French 2017). The risk-free interest rate is the Federal Reserve’s one-month treasury bill rate (French 2017).
In the following, I will shortly present the event study methodology and elaborate on the specific design applied in the present paper.

**Event Studies: Identifying Abnormal Returns (AR) after a news event**

Event studies are a statistical tool to estimate the short-term impact of news events on a company’s stock price. The method disentangles the stock price effect of an information of interest from those price variations which can be traced back to other, mostly market wide, determinants (Corrado 2011: 209).

To extract the fraction of the price change the news release can be made responsible for, abnormal returns (AR) are calculated (1). ARs are the observed returns (R) in the time of an event minus normal returns (NR). NRs are the returns that would be expected based on the current market situation and the stock’s former development.

\[ \hat{AR}_t^i := R_t^i - \hat{NR}_t^i \]

where
\[ \hat{AR}_t^i \] is stock i’s estimated abnormal returns in period t;
\[ R_t^i \] is stock i’s observed return in period t;
\[ \hat{NR}_t^i \] is stock i’s estimated normal returns in period t.

The main distinction between the firm-specific and the sector-wide analysis lies in the events for which ARs are investigated: In the firm-specific analysis, a company experiences an event at the day when a divesting institution announces to withdraw money from exactly this company. This means that every firm has idiosyncratic event days and some firms do not experience an event at all (and are thus not analyzed). In the sector-wide analysis, all companies of the sector experience an event when a divesting institution announces to divest from fossil fuels in general, i.e. when it joins the divestment campaign. That means that, in the sector-wide analysis, the events are the same for all fossil fuel companies. Every company experiences several events, i.e. on each day of the 76 captured divestment announcements.

**Underlying Assumption: The Efficient Market Hypothesis**

Event studies rely on the efficient market hypothesis (EMH). This hypothesis postulates that security prices reflect all relevant market information at any given point in time. The EMH builds on the claim that investors exploit every piece of available data in their quest to benefit from trading. The release of new information should consequently bring about an immediate and appropriate price adjustment. This adjustment, in turn, can be detected within the event study framework (Kliger and Gurevich 2014: 5; Fama 1970; Fama et al. 1969).

Market efficiency can be assumed to be in place to different degrees: The weak form of the EMH assumes prices to reflect all information embedded in previous prices. This implies that investors cannot earn above-market profits from analyzing former price patterns. The semi-strong form of the EMH postulates that all publicly available information, including information on former prices, is reflected by the market. Investors in this scenario would be able to generate trading profits only if they access private information which is hidden to other market participants. The strong form of the EMH states that even private information is incorporated in the prices which...

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92 To a certain extent event studies can also be used to investigate longer term effects of specific events. The validity of long-term estimates is however subject of a controversial debate (c.f. Kothari and Warner 2007).

93 The implications this has for the testing procedure will be discussed in some sections.
makes them reflect all information available. Consequently, no market participant could generate above-market profits, not even with the help of private information (Kliger and Gurevich 2014: 16).

The EMH, especially in its strong form, is highly contested (see for example Grossman and Stiglitz 1980). Even the hypothesis’ originator Eugene Fama acknowledges that “the extreme version of the market efficiency hypothesis is surely false” (Fama 1991: 1575). Conclusions from event studies however remain valid if the EMH’s semi-strong version is in place. Semi-strong market efficiency has shown empirically defendable according to several studies (Kliger and Gurevich 2014: 16–17; Aharony and Swary 1980; Keown and Pinkerton 1981, 1981). It will therefore be assumed in my analysis for the short term.\(^{94}\)

**Event Windows**

According to the EMH, after an information release prices should adjust instantly without any delay. In case of information leakage, prices should react even prior to the announcement date (Kliger and Gurevich 2014: 20). Abnormal returns are hence tracked over a period of a few days, during the so-called ‘event window’.

In my analysis, event windows of three and seven days are applied. They start one resp. three working days before the divestment announcement and finish one resp. three working days after the event. McWilliams and Siegel (1997) strongly recommend to avoid long event windows and only extend them to more than two days if there is a specific reason to do so. The gathered announcement data reveals two peculiarities which call for a longer event window: Firstly, the data shows that many divesting institutions had decided to divest several days before they made their decision public. A leakage even before the pre-event day is hence highly likely. Secondly, several institutions only indicated the month rather than the exact day of their divestment announcement. Considering a longer event window increases the probability that the applied window in fact captures the date of the announcement.\(^{95}\) The relatively long event windows however raise the risk of wrongly assigning the effect of confounding events to divestment. To reduce the risk of confounding events, large (positive or negative) abnormal returns during the event window were identified and excluded when they were obviously due to confounding events (which was the case for all identified large abnormal returns).\(^{96}\)

**Estimation Windows**

To generate NRs, event studies rely on past return developments of a security and current market patterns. These past return developments are analyzed during an ‘estimation window’ which is assumed to be representative for the return process and unaffected by the event. As shown in figure 13, the estimation window for the firm specific analysis starts five years and 30 days before the respective divestment announcement. It ends 30 days before the announcement. For the sector-wide analysis, the estimation window is the same for all events and firms. It starts

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\(^{94}\) Even a violation of the semi-strong version of the EMH would not necessarily render the analysis useless. For example, if prices were biased upwards, consistently over the whole period, divestment news could nevertheless be found to induce price jumps on top of the ‘biased’ price.

\(^{95}\) When only a month was given, the first working day of that month was treated as the event day.

\(^{96}\) Two events were excluded from the analysis. The event window of the first included August 24, 2015, when a major stock crash took place. The second was a divestment from Anadarko Petroleum in July 2015 during which the company’s stock experienced heavy price jumps.
in the beginning of 2009 and lasts to the end of 2012. The first investigated event of the sector-wide analysis takes place in January 2013\(^{97}\).

**Figure 13: Estimation and Event Windows for the Two Event Studies**

![Table showing estimation and event windows](image)

**Estimating Normal Returns (NR)**

‘Normal’ price patterns are estimated by a time series regression which accounts for a security’s sensitivity to different market patterns. The NR is then predicted for the days of the event window based on the specific market situation in place. The benchmark model to estimate NRs can assume very different forms. A frequently applied model is the Fama-French three-factor model (Fama and French 1992, 1993; Kothari and Warner 2004). It includes the excess return on the market over a risk-free interest rate, the performance of small stocks relative to big stocks (‘Small-minus-Big, SMB’), and the performance of value stocks relative to growth stocks (‘High-minus-low, HML’) (see data section for further details). As the fossil fuel sectors’ stock prices are crucially dependent on the oil price, I follow Griffin et al. (2015) and include oil price changes in addition. For each security, the following regression model was run to predict normal returns.

\[
\hat{NR}_t^i = R_t^f + \hat{\beta}_{0,i} + \hat{\beta}_{1,i}(R_t^m - R_t^f) + \hat{\beta}_{2,i}HML_t + \hat{\beta}_{3,i}SMB_t + \hat{\beta}_{4,i}oilpricechange
\]

where

- \(\hat{NR}_t^i\) is stock i’s estimated NR at time t;
- \(R_t^f\) is the risk-free interest rate at time t;
- \(R_t^m - R_t^f\) is the excess market return (over the risk-free interest rate) at time t;
- \(HML_t\) is the book-to-market equity factor at time t;
- \(SMB_t\) is the size factor at time t;
- \(\hat{\beta}_i\) coefficients are the estimated model’s firm-specific parameters;
- \(oilpricechange\) is the percental change in oil prices from time (t-1) to time t.

The company-specific beta estimates measure sensitivity to market wide changes in market excess return, SMB, HML and the oil price. They are obtained by ordinary least square (OLS) estimation. Under the assumption that returns are jointly normal, independently and identically distributed over time, NRs should be consistently predicted. If returns are non-normally distributed (as also the case in my data), NRs are still consistently predicted.

---

\(^{97}\) To extend the estimation window to the end of 2012 one event had to be deleted which otherwise would have occurred during the estimation window. However, this was considered reasonable to avoid a far distance between the estimation window and the studied events (the last studied events took place in June 2017). A far distance between estimation and event window might worsen the exactness of the estimates.
standard errors are however biased. As I am not interested in testing the significance of the regressors predicting NRs, this is only of limited importance for this paper.98

Calculating Abnormal Returns (AR), Average Abnormal Returns (AAR) and Cumulative Average Abnormal Returns (CAAR)

After calculating ARs for every security over the event window (see equation (1)), ARs are averaged over securities for each day of the event window (arithmetic mean). In other words, in a first step, the mean of the stock price reaction of all firms on their first event day is calculated. Note that these “first event days” can take place at different calendar days. The same is done for all following days of the event window. For the three-day event window, three average abnormal returns (AAR) are obtained in this manner, seven AAR are calculated for the seven-day event window respectively. Relying on the law of large numbers, the obtained AARs should reduce noise from the single AR estimates.

\[
\overline{AAR}_t = \frac{\sum_{i=1}^{n} \overline{AR}_i}{n} \quad (3)
\]

where
- \(\overline{AAR}_t\) is the estimated AAR at time \(t\);
- \(\overline{AR}_i\) is stock \(i\)'s estimated AR at time \(t\);
- \(n\) is the number of events.

To measure the total effect of the event, AARs are cumulated over the days of the event window. The cumulative average abnormal return (CAAR) is calculated for every day of the event window summing up the effect of divestment up to that specific date.99 The CAAR can be interpreted as the total stock price change induced by the event up to a specific day. Of specific interest is the CAAR of the full event window which estimates the total stock price reaction following a divestment announcement:

\[
CAAR_{s,t} := \sum_{\tau=s}^{t} \overline{AAR}_\tau \quad (4)
\]

where
- \(CAAR_{s,t}\) is the estimated CAAR for the period from time \(s\) to time \(t\);
- \(\overline{AAR}_\tau\) is the estimated AAR at time \(\tau\).

(c.f. Kliger and Gurevich 2014: 19-43; 51-61).

Significance Tests

To draw inference for the market reaction on divestment events, significance is tested100. Following McWilliams and Siegel (1997) parametric and non-parametric tests are obtained.

Parametric Tests

For the firm-specific analysis, simple t-tests are run to test if estimated CAARs significantly deviate from zero. In the firm-specific analysis, event windows do not overlap, and estimation windows vary between events and

---

98 If the regressors’ significance was of interest, heteroscedasticity-robust standard errors could be obtained. I do not do this as I do not find it important here and the R command I know would be very time-consuming for the 58 resp. 76 different regressions.

99 For example, to obtain the CAAR the second day of the event window, the AAR of the first and the second days are summed up. For the CAAR of the third day of the event window, the AAR of the first, second and third day are summed up and so on.

100 As I use self-reported divestment dates, my sample is not random. However, consistent with literature in the field, I still use inferential statistics.
It can thus be assumed that no clustering takes place between events and ARs are independent across stocks which is required to avoid biased t-estimates. The t-test further assumes ARs to be normally distributed with mean zero and a firm-specific variance of abnormal returns $\sigma_i^2$ ($AR_i^t \sim N(0,\sigma_i^2)$). This property can be assumed to hold approximately for large numbers, i.e. a large estimation window as applied in my case. The conditional variance of the estimated ARs $\sigma_i^2(\overline{AR}_i^t)$ can further be broken down into two components: Firstly, the error variance of the security’s stock return, secondly the variance which is caused by the sampling error in the parameter estimates of $\overline{AR}$. The latter component should however approach zero with a long estimation window. The conditional variance $\sigma_i^2(\overline{AR}_i^t)$ should thus approach the security’s AR variance $\sigma_i^2$ (c.f. Kliger and Gurevich 2014: 55). To estimate the variance of $\overline{CAAR}_{s,t}$, conditional variances $\sigma_i^2(\overline{AR}_i^t)$ are averaged across firms i and accumulated over event days:\[ \sigma_{s,t}^{CAAR} = \frac{t-s+1}{n^2} \sum_{i=1}^{n} \sigma_i^2 \] (5)

where
- $\sigma_{s,t}^{CAAR}$ is the estimated variance for each CAAR from time s to t;
- t is the day of the event window until which the CAAR is estimated;
- s is the start of the event window;
- n is the number of securities which have experienced an event in our sample;
- $\sigma_i^2$ is the estimated variance for security i’s ARs.

Test statistics (TS) are calculated for each $\overline{CAAR}_{s,t}$ over the event window by the following equation:

\[ TS_{s,t} = \frac{\overline{CAAR}_{s,t}}{\sqrt{\frac{t-s+1}{n^2} \sum_{i=1}^{n} \sigma_i^2}} \] (6)

where
- $TS_{s,t}$ is the test statistic (t-statistic) for a cumulative return from the start of the event window until the day at which the CAAR is estimated.

This test statistic (i.e. t-statistic) is asymptotically normally distributed for many events and long estimation windows. Significance is hence tested against the normal distribution (two-sided test)\[102\]. Both the test statistic and the p-values are reported (c.f. ibid.: 51–63).

For the sector-wide analysis, events and event windows are the same for each security and are hence clustered. This violates the t-test’s assumption of independence and would result in an upwards bias of the test statistics. Therefore, in the sector-wide analysis, standard errors are adjusted for clustering. Following Kliger and Gurevich (2014: 65–68), a simplified version of Brown and Warner’s (1980) ‘crude dependence adjustment’, Bernard’s (1987) ‘cross-sectional aggregation’ and MacKinlay’s (1997) ‘portfolio approach’ is used. The TS for clustered event windows is then estimated by

\[ \overline{\overline{\delta}_{s,t}^{CAAR}} \]

---

\[101\] To reach this formula, first consider the estimated variance for the cumulative AR (CAR) of one security $\overline{CAR}_{s,t}^i = (t - s + 1) \sigma_i^2$. This variance is then averaged across firms to estimate $\overline{\overline{\delta}_{s,t}^{CAAR}}$.

\[102\] Even though my hypothesis goes into a clear direction, it was decided for a two-sided test to avoid the artificial increase in significance associated with a one-sided test.
\[ T_{s,t}^{\text{clustered}} = \frac{CAAR_{s,t}}{\sqrt{(t-s+1)(t-s+2)\sum_{t=End}^{Start} (CAAR_{t}\bar{CAAR})^2}} \]  

where

- \( t_{\text{Start}}^{\text{EstWin}} \) and \( t_{\text{End}}^{\text{EstWin}} \) are the starting date resp. end date of the estimation window;
- \( \bar{CAAR} \) is the estimated average of AARs over the estimation window:

\[ \bar{CAAR} := \frac{\sum_{t=Start+1}^{End} CAAR_t}{\sum_{t=Start}^{End} CAAR_t} \]  

The test statistic is tested against the normal distribution. Both test statistics and p-values are reported. (Kliger and Gurevich 2014: 65–68)

Non-Parametric Tests

Even for long estimation windows, the normality assumption for returns is often violated (see for example Richardson and Smith 1993). This is also partly the case for the data of this paper. McWilliams and Siegel (1997) therefore suggest that t-tests should always be accompanied by nonparametric tests which do not require any distributional assumptions. Accordingly, I use Wilcoxon’s signed rank test (Wilcoxon 1945) as an alternative test for significance in both event studies. The test ranks the absolute value of ARs during the event window. It then sums up the ranks of those ARs which show the hypothesized direction, i.e. show a negative sign in my analysis. The more of the ARs are negative and the higher the absolute value of these ARs, the higher Wilcoxon’s test statistic. For large numbers of (in my case, many ARs) the Wilcoxon’s test statistic follows a standard normal distribution. It is therefore tested against the normal distribution. Test statistics and p-values are reported.

The complete code used for the event studies can be found in Appendix C1 and C2.

7.2 Latent Growth Curve Model to Account for Mid to Long-Term Effects of Divestment

Estimating the longer-term impact of divestment and including indirect effects comes along with several caveats: Firstly, divestment from one fossil fuel firm should impact the whole sector rather than only the targeted firm (as it provides a market-wide signal). Estimating the impact on one specific targeted firm in an OLS regression over the sample of the fossil fuel sector would thus provide biased estimates. In the data, then, the ‘treatment’ of divestment would only be assigned to the company which is directly targeted. In reality, however, the whole sector is under treatment. If the targeted firm is now compared to the sector, no effect would be found, even though all companies could be significantly impacted.

To acknowledge that the full sector is affected by every act of divestment, the divestment variable for all fossil fuel companies would have to change with every divestment announcement. Consequently, all fossil fuel firms would show the same values for divestment at each point in time. To run an OLS regression, the sample would thus have to be extended by non-fossil fuel firms to introduce variation in the independent variable. Fossil-fuel based firms’ asset prices do however follow idiosyncratic patterns. Including non-fossil fuel firms in the sample and estimating divestment’s impact entails the risk of assigning any fossil fuel sector-specific pattern mistakenly to divestment.
To be able to estimate the effect for the whole sector and restrict my sample to fossil fuel based companies, I use latent (growth) curve modeling (LGCM). LGCM allows me to estimate a ‘normal’ growth path for each company. On this basis, it can be assessed if the company-specific growth trajectory is affected by the accumulating level of divestment\(^{103}\).

LGCM (c.f. Bollen and Curran 2006; Meredith, W., Tisak, J. 1984) is used to investigate the form of change over time in a structural equation modeling (SEM) framework. With the help of longitudinal data, growth trajectories of different subjects, in my case fossil fuel firms, are estimated. The effect of outside interventions, in my case divestment, on their development can then be studied (Geiser 2011: 168). In practice that means that, first, the stock price development of fossil fuel assets is predicted as accurately as possible for the years between 2007 and 2017. Then, it is evaluated if this development is affected by the occurrence of ever more divestment announcements and higher sums divested.

The share price of each firm at a given point of time is modeled as a function of an underlying growth process described by a latent intercept and latent slope-factors. These factors are ‘latent’ as they describe how the stock market value evolves over time without pinning this evolution down to observed variables\(^{104}\).

As shown in figure 14, a linear, a quadratic and a cubic slope factor is introduced to describe the growth process of share prices from 2007 to 2017\(^{105}\). The functional form of growth is thus assumed to be the same for all companies. However, the parameters describing the growth curves differ between firms, i.e. each firm has its individual regression coefficients for the influence of time and hence its own growth curve. To model growth trajectories more accurately, in addition, control variables are introduced, i.e. the abovementioned three Fama-French model factors and the oil price. For these variables, firm-specific slopes are introduced when necessary\(^{106}\). Further, coal firms are assumed to follow a different path than oil and gas firms. The firm type variable ‘coal’ is hence used as a further predictor for slopes and intercepts.

To see if the fitted curves of this ‘baseline model’ of stock price development are affected by divestment, the divestment level of each day is introduced as a time-varying variable. Divestment is quantified by total divestment announcement at each point in time. In a second model, divestment is measured by the total sum divested at each point in time. Firms are assumed to be affected by divestment in a similar manner. As no significant difference of divestment’s effect was found between oil, gas and coal firms, divestment coefficients are estimated for all firms together. As can be seen in figure 14 and in the regression equations given below, error terms are included both in the full regression (\( \varepsilon_{t,i} \), company and time specific) and in the regressions to estimate firm-specific intercept and slopes (\( \zeta_{0-6,i} \), firm-specific). \( \varepsilon_{t,i} \) is assumed to be independent and identically normally

\(^{103}\) Note that in this framework, the divestment variable will be the same for all companies. However, as growth curves differ between companies, the impact on each curve can be different. The average impact of cumulated divestment announcement on the growth curves will be estimated.

\(^{104}\) In an SEM setting, variables are called ‘latent’ if they are not observed but inferred from other variables. Here these ‘other variables’ are points in time and their polynomials.

\(^{105}\) The decision to include polynomials of time up to degree three is based on goodness-of-fit tests which were ran with polynomials up to degree four. I chose the model with the lowest sample-size-adjusted Bayesian Information Criterion (BIC).

\(^{106}\) Slopes are designed as firm-specific when slope coefficients deviate significantly between firms (as it is the case for the risk-free interest rate, the market excess return and the oil price). Other control variables (namely HML and SMB) are introduced without firm-specific slopes.
distributed with variance $\sigma^2_\varepsilon$ and uncorrelated over time. It is further uncorrelated with the regression coefficients $\eta_{1,i} - \eta_{6,i}$. To make my analysis robust to, at least some violations of these assumptions, robust standard errors are estimated\(^{107}\).

**Figure 14: Latent Growth Model for Stock Price Development of Fossil Fuel Companies**

The figure shows the estimated model for 5 exemplary days. Latent variables are indicated by ellipses, non-latent variables are indicated by boxes. Arrows indicate the loadings on the dependent variable. $\varepsilon_t$ is the time-specific, firm-specific error term, FF are the Fama-French Factors $R_f$, $Mk-R_f$, $HML$ and $SMB$.

Source: Own representation based on Geiser (2011)

\(^{107}\) Certainly, robust standard errors are of little help when endogeneity problems or other serious misspecifications occur. However, other (mild) violations of the assumptions will most probably be compensated by the robust full information maximum-likelihood estimators for standard errors (see also later section on LGCM test procedures.).
The regression equations estimated are as follows (notation c.f. Hox and Stoel 2005):

\[ P_{i,t} = \eta_{0,i} + \eta_{1,i} \text{time} + \eta_{2,i} \text{time}^2 + \eta_{3,i} \text{time}^3 + \eta_{4,i} R^f + \eta_{5,i} (R_t^m - R_t^f) + \eta_{6,i} \text{oilprice} + \gamma_1 HML_t + \gamma_2 SMB_t + \gamma_3 \text{divestment}_t + \epsilon_{t,i} \]  

(9)

\[ \eta_{0,i} = v_0 + \beta_0 \text{coal}_i + \zeta_{0,i} \]
\[ \eta_{1,i} = v_1 + \beta_1 \text{coal}_i + \zeta_{1,i} \]
\[ \eta_{2,i} = v_2 + \beta_2 \text{coal}_i + \zeta_{2,i} \]
\[ \eta_{3,i} = v_3 + \beta_3 \text{coal}_i + \zeta_{3,i} \]
\[ \eta_{4,i} = v_4 + \zeta_{4,i} \]
\[ \eta_{5,i} = v_5 + \zeta_{5,i} \]
\[ \eta_{6,i} = v_6 + \zeta_{6,i} \]

where

- \( P_{i,t} \) is the share price of company \( i \) at time point \( t \);
- \( R^f \) is the risk-free interest rate;
- \((R_t^m - R_t^f)\) is the market excess return over the risk-free interest rate;
- \( HML_t \) is the book-to-market equity factor at time \( t \);
- \( SMB_t \) is the size factor at time \( t \);
- \( \text{divestment}_t \) is the level of divestment at time \( t \), measured by divestment announcements or total sum divested in million dollars;
- \( \text{coal}_i \) is a binary variable which takes the value 1 if company \( i \) is a coal company and 0 if company \( i \) is an oil or gas firm;
- \( \eta_{0,i} \) is the latent intercept of company \( i \);
- \( \eta_{1,i} - \eta_{3,i} \) are the latent slopes for the linear, quadratic and cubic growth curves of company \( i \);
- \( \eta_{4,i} - \eta_{6,i} \) are the firm-specific slope parameter for \( R^f \), \((R_t^m - R_t^f)\) and oilprice;
- \( \gamma_1 - \gamma_3 \) are the non-firm-specific regression coefficients;
- \( v_0 - v_6 \) are the expectations for the firm-specific intercept and slopes;
- \( \beta_i \) are the firm-specific regression coefficients to estimate firm-specific intercept and slopes;
- \( \epsilon_{t,i} \) is the time-specific and firm-specific deviation from the estimated value;
- \( \zeta_{0,i} - \zeta_{6,i} \) are the firm-specific deviations when estimating firm-specific intercept and slopes.

To analyze if divestment is more effective when financially motivated and/or publicly announced, interaction effects are included. Interaction is allowed (1) between divestment announcements at date \( t \) and the financial motivation \((\text{divestment}_t \times \text{financial motivation})\) and (2) between divestment announcement at date \( t \) and public promotion of the announcement \((\text{divestment}_t \times \text{public promotion})\). As the (binary) variables of financial motivation and public promotion can only take the value of 1 if divestment is announced (without divestment, they are always zero) they are only included in the interaction terms and not by themselves.
\[ EV_{i,t} = \eta_{0,i} + \eta_{1,i}time + \eta_{2,i}time^2 + \eta_{3,i}time^3 + \eta_{4,i}RF + \eta_{5,i}(R_m - R_f) + \eta_{6,i}oilpricechange + \gamma_1 HML_t + \gamma_2 SMB_t + \gamma_3 divestment_t + \gamma_4 (divestment_t \times financial\ motivation) + \gamma_5 (divestment_t \times public\ promotion) + \epsilon_{t,i} \] (10)

where

financial motivation is a binary variable that takes the value of 1 if financial considerations played a role in the decision to divest fossil fuels and 0 otherwise;

public announcement is a binary variable that takes the value of 1 if the decision to divest was publicly promoted and 0 otherwise.

All estimates are obtained using a full information maximum-likelihood (FML) procedure. FML includes both regression coefficients and variance components into the likelihood function and produces asymptotically efficient and consistent estimates (Hox 2010: 40–42). Heteroscedasticity-robust standard errors are used. Note that autocorrelation is taken account for by the design of the LGCM.

The baseline model for LGCM was chosen in accordance with measures of best fit, i.e. the sample-adjusted Bayesian Information Criterium (BIC). The model was estimated in Mplus, the data set was prepared in R. Scripts can be found in the appendix C3.

8. Results

8.1 Fossil Fuel Divestment's Short-Term Impact: Results from the Event Studies

8.1.1 The Short-Term Impact of a Divestment Announcement from a Specific Firm

An institution’s announcement to divest from a specific fossil fuel company is followed by a weak drop in this company’s market value: Stock price reactions on firm-specific divestment announcements for 58 fossil fuel companies are negative both in the three-day and the seven-day event window. As shown in figure 15 and 16, abnormal returns in both analyses reach their minimum on the event day and return to a less negative value afterwards. On the day of the announcement, returns are, on average, 0.43 percentage points lower than predicted by the benchmark regression in the three-day event window. For an event within the seven-day window, the downward deviation reaches 0.22 percentage points at the event day. In total, cumulative average abnormal returns (CAARs) are estimated to be -0.19 (three-day window) resp. -0.23 (seven-day window) percentage points for the two analyses.

According to the parametric t-test, none of these negative abnormal returns shows significance at the 5%-level. However, the non-parametric Wilcoxon signed rank test evaluates the price drop in the three-day event window to be significant for the cumulative effect of the pre-event and the event day (p=0.0105), but not for the cumulative effect over three days. For the seven-day event window, the Wilcoxon test shows significant for the period up to one day after the event (p=0.0075) and for the full period (p=0.0460).

\[ ^{108} \text{As latent growth model software does normally not allow as many time points as necessary for my analysis (more than 2600), the model was estimated in a two-level multilevel framework with random intercepts and random slopes which does result in exactly the same estimates as the latent growth specification (c.f. Hox and Stoel 2005).} \]
The reason for the inconsistent significance levels is that most abnormal returns during the event window are negative, albeit only weakly. However, they are counteracted by few, relatively large, positive reactions. The obtained mean reaction is thus ‘not negative enough’ to result in significant t-values. Nevertheless, the number of negative effects is high enough to result in a significant Wilcoxon signed rank test.

**Figure 15: CAAR for 58 Fossil Fuel Divestment Announcements**

*Event Window from 1 day before to 1 day after announcement of divestment*

<table>
<thead>
<tr>
<th>Event Day</th>
<th>-1</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>-0.0021</td>
<td>-0.0021</td>
<td>+0.0025</td>
</tr>
<tr>
<td>CAAR</td>
<td>-0.0021</td>
<td>-0.0042*</td>
<td>-0.0017</td>
</tr>
<tr>
<td>t-value of CAAR (p-value)</td>
<td>-0.767 (0.4434)</td>
<td>-1.267 (0.2053)</td>
<td>-0.448 (0.6541)</td>
</tr>
<tr>
<td>Wilcoxon statistic of CAAR (p-value)</td>
<td>308 (0.0736)</td>
<td>997 (0.0105)</td>
<td>1367 (0.1677)</td>
</tr>
</tbody>
</table>

* **p<0.01 in Wilcoxon test  * p<0.05 in Wilcoxon test   I p<0.1 in Wilcoxon test

AARs and CAARs are measured in total (not percental) deviations from the normal return, significance is only tested for CAARs
Figure 16: CAAR for 58 Fossil Fuel Divestment Announcements

Event Window from 3 days before to 3 days after announcement of divestment

<table>
<thead>
<tr>
<th>Event Day</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>0.0007</td>
<td>-0.0012</td>
<td>-0.0021</td>
<td>-0.0021</td>
<td>0.0025</td>
<td>0.0005</td>
<td>-0.0002</td>
</tr>
<tr>
<td>CAAR</td>
<td>0.0007</td>
<td>-0.0006</td>
<td>-0.0027</td>
<td>-0.0048**</td>
<td>-0.0023</td>
<td>-0.0018*</td>
<td>-0.0020*</td>
</tr>
<tr>
<td>t-value of CAAR</td>
<td>0.242 ( - )</td>
<td>-0.177 (0.8560)</td>
<td>-0.695 (0.4871)</td>
<td>-1.184 (0.2636)</td>
<td>-0.491 (0.6236)</td>
<td>-0.356 (0.7220)</td>
<td>-0.365 (0.7152)</td>
</tr>
<tr>
<td>Wilcoxon statistic of CAAR</td>
<td>187 (0.5249)</td>
<td>365 (0.7353)</td>
<td>874 (0.1400)</td>
<td>1092 (0.0075)</td>
<td>1312 (0.1013)</td>
<td>1308 (0.0975)</td>
<td>1236 (0.0460)</td>
</tr>
</tbody>
</table>

**p<0.01 in Wilcoxon test   * p<0.05 in Wilcoxon test   p<0.1 in Wilcoxon test

AARs and CAARs are measured in total (not percental) deviations from the normal return, significance is only tested for CAARs

The slightly negative effect which is only significant for some days aligns very well with hypotheses 1 and 2: Divestment has negative, but rather negligible effect on the directly targeted firm. The effect is quickly settled as soon as neutral investors jump in.

8.1.2 The Short-Term Impact of an Institution’s Divestment Announcement on the Fossil Fuel Sector

An institution’s announcement to join the campaign and divest from fossil fuels also results in a drop of the fossil fuel sector’s stock valuation. In a three-day event window, this effect is invisible however: The fossil fuel sector does not show any negative reaction to 76 divestment announcements. As visible in figure 17, CAARs are even slightly positive and approach the estimated normal returns in the end of the event window.
Figure 17: CAAR (Sector-Wide) for 76 Fossil Fuel Divestment Announcements
Event Window from 1 Day before to 1 Day after Announcement to Divest

<table>
<thead>
<tr>
<th>Event Day</th>
<th>-1</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>0.0003</td>
<td>-0.0001</td>
<td>-0.0000</td>
</tr>
<tr>
<td>CAAR</td>
<td>0.0003</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
<tr>
<td>t-value of CAAR (p-value)</td>
<td>2.812</td>
<td>1.300</td>
<td>1.228</td>
</tr>
<tr>
<td>Wilcoxon statistic of CAAR (p-value)</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
</tbody>
</table>

**p<0.01 in Wilcoxon test  * p<0.05 in Wilcoxon test  T p<0.1 in Wilcoxon test

AARs and CAARs are measured in total (not percental) deviations from the normal return, significance is only tested for CAARs. No p-value is given as ARs are positive countering the hypotheses. All positive effects are insignificant.

This picture changes drastically when the longer event window of seven days is considered (see figure 18): From the first event day on, AARs are significantly negative (both in the t-test and the Wilcoxon test) and continue significantly negative over the whole period. After the seven days of the event window, returns are 0.2 percentage points lower than predicted by the benchmark model.

The seven-day event window also uncovers why the effect was invisible over the three-day window: The stock price drops three to two days before the announcement, a period uncaptured by the three-day event window. It then keeps this (negative) level for the following three days without further decreasing, the only part of the reaction visible in the three-day event window. On the second and third day after the announcement (which, again, is not captured by the three-day event window) the stock price decreases even further.
To conclude, in the short term, a negative effect of divestment is found. The announcement to divest is followed by a drop in the share price, both of those companies who are directly targeted by a specific announcement and by the entire fossil fuel industry. Stock price reactions are however small and (for firm-specific announcements) sometimes insignificant. In case of the firm-specific divestment, the price drop is short-lived. The empirical assessment thus supports both

$H_1$: In the short term, divestment has a small negative effect on the share price on targeted firms (Miller and Merton)”, and, for the firm specific analysis also

$H_2$: “If the stock price of a targeted firm is depressed by divestment, it will be quickly bid up again (CAPM and APT)”. 
8.2 Fossil Fuel Divestment's Long-Term Impact: Results from the Latent Growth Curve Model

Modeling the latent growth curve for stock prices from June 2007 to June 2017 provides us with a more ambiguous picture.

Table 1 presents the estimated effects of the model. All included control variables are significant and show in the expected direction. This is partly because the baseline model was chosen in a way to fit the data best (according to the sample size adjusted BIC) and non-significant control variables and interactions were dropped from the outset.

### TABLE 1: DIVESTMENT'S IMPACT ON SHARE PRICES 2007 TO 2017: LATENT GROWTH CURVE MODEL

<table>
<thead>
<tr>
<th></th>
<th>(MODEL 1) LOG STOCK PRICE</th>
<th>(MODEL 2) LOG STOCK PRICE</th>
<th>(MODEL 3) LOG STOCK PRICE</th>
<th>(MODEL 4) LOG STOCK PRICE</th>
<th>(MODEL 5) LOG STOCK PRICE</th>
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<tbody>
<tr>
<td>Divestment announced</td>
<td>0.015***</td>
<td></td>
<td></td>
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<tr>
<td>Divestment announced (cumulated)</td>
<td>0.002*</td>
<td>0.003</td>
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<tr>
<td>Total sum divested (in million USD)</td>
<td>0.0003***</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Divestment*financial</td>
<td>-0.005**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divestment*public</td>
<td>0.001</td>
<td></td>
<td></td>
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<tr>
<td>Financially motivated divestment (cumulated)</td>
<td>-0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Time (in 1000 days)</td>
<td>0.48***</td>
<td>1.76***</td>
<td>0.29***</td>
<td>1.51***</td>
<td>0.20***</td>
</tr>
<tr>
<td>Time² (in 1000 days)</td>
<td>0.21***</td>
<td>-</td>
<td>0.17***</td>
<td>-1.22***</td>
<td>0.16***</td>
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<tr>
<td>Time³ (in 1000 days)</td>
<td>-0.11**</td>
<td>0.14**</td>
<td>-0.04**</td>
<td>0.20***</td>
<td>-0.02**</td>
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<td>Oil price</td>
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<td>0.20***</td>
<td>0.23***</td>
<td>0.15***</td>
<td>0.24***</td>
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<tr>
<td>Mkt-Rf</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
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<tr>
<td>HML</td>
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<td>-0.001***</td>
<td>-0.001***</td>
<td>-0.001***</td>
<td>-0.001***</td>
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<td>SMB</td>
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<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
<td>0.001***</td>
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<tr>
<td>Days</td>
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<td>2610</td>
<td>2610</td>
<td>2610</td>
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<td>Firms</td>
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<td>188</td>
<td>188</td>
<td>188</td>
<td>188</td>
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</tbody>
</table>

Notes: * p<0.05  ** p<0.01  *** p<0.001

Underlined regressors are estimated with random slopes (mean value is reported). Non-random slopes were estimated when slopes did not vary significantly between firms. All coefficients are estimated using a maximum likelihood.

Including cumulated divestment announcements in the model, its effect on the share price is surprisingly found to be positive (Model 1). According to the estimation, every additional announcement to divest goes along with a (significant) increase in share price of 1.5%\(^{109}\). Likewise, an increase in the total dollar sum divested shows a significantly positive effect (Model 2). For each additional million USD divested, the share price is estimated to

\(^{109}\) Note that no distinction was made between coal and oil/gas firms regarding for the effect for divestment. Models allowing for this distinction did not result in different coefficients (see methods part).

\(^{110}\) The rise in share price can be interpreted as a percental increase as log prices are analyzed and changes are relatively small.
increase by 0.03%. Keeping in mind that divested sums\textsuperscript{111} in the survey reach more than 230 million USD, this effect is also economically relevant.

To assess if divestment’s impact is stronger for financially motivated divestments and/or for divestors who promote their decision publicly, two interaction terms are included (Model 4). To be able to interpret the interaction in a meaningful way, divestment announcements were coded as a binary variable in this model\textsuperscript{112}. Without the interaction terms, the effect of every single divestment announcement is positive again (Model 3). Allowing for an interaction however (Model 4), the effect of purely morally motivated divestment becomes insignificant. Moreover, a significantly negative effect is reported for financially motivated divestment announcements. Every financially motivated divestment announcement is estimated to lead to a 0.5% decrease in share price.

To investigate if the negative effect of financially motivated divestment can be generalized for cumulated divestment announcements, an additional model was run for the subsample of financially motivated divestments (Model 5). Indeed, taking only the financially motivated divestment announcement into account, the coefficient for cumulated divestment announcements becomes negative, however insignificant.

The interaction with public promotion, i.e. the distinction between those divestors who promote their divestment decision publicly and those who do not, is insignificant (Model 4). Further (nonreported) analyses including the divesting institution’s size and an interaction between announcements and size are insignificant as well.

Taking the analyses together, in the long to medium term, a positive effect of divestment is found. However, this positive effect breaks down and sometimes becomes even negative for financially motivated divestment. The findings thus speak against \textit{H}\textsubscript{3} (“There is an indirect, medium to long term negative effect of fossil fuel divestment on asset prices which outperforms the direct, short term effect”) and \textit{H}\textsubscript{5} (“The indirect, medium to long term negative effect of fossil fuel divestment on asset prices is stronger for divestment which is promoted publicly”).

However, Hypothesis 4 is supported:

\textit{H}\textsubscript{4}: The indirect, medium to long term negative effect of fossil fuel divestment on asset prices is stronger for financially motivated divestment.

\textit{How to Explain the Positive Effect of Divestment?}

There is no convincing theoretical argument why divestment should impact stock values positively. A more likely explanation for the positive coefficients are problems with the applied method. The fact that all firms are assigned the same level of divestment makes the analysis highly sensitive to omitted variable bias. This risk is even exacerbated as cumulated divestment is growing over time and hence correlated with many other temporal developments (even though the model attempts to extract this temporal progress). Further, due to the long-time period, even weak effects easily become significant. The presented results should hence be interpreted with greatest caution.

These problems could be overcome by extending the sample by firms which are comparable to those targeted by the divestment campaign but unaffected by divestment. A particularly suitable group of such firms are non-public

\textsuperscript{111} Note that ‘divested sums’ are the actual sums divested from fossil fuels as reported in my survey and not the total holdings of divesting institutions as reported on the Fossil Free website.

\textsuperscript{112} This binary variable takes the value of one if divestment was announced on a specific day and the value of zero otherwise.
coal, oil and gas companies. State-owned fossil fuel companies should experience very similar developments as listed firms, but are unconcerned of divestment. Long term, direct and indirect effects of divestment could reliably be estimated by mimicking an experiment: For instance, by applying propensity score matching, the listed companies which experience the ‘treatment’ of divestment could be directly compared to the ‘non-treated’ control group of state-owned or other non-public firms. Unfortunately, it was impossible to incorporate such an approach in this paper as I did not have access to data of non-public fossil fuel firms.

9. Conclusion
The fossil fuel divestment campaign claims to “hit [the fossil fuel sector] where it hurts” (Fossil Free 2017d). So far, however, it lacks empirical evidence on divestment’s financial impact on the biggest oil, gas and coal companies. The present paper is an attempt to close this gap. Using new data on fossil fuel divestment, I seek to shed light on the campaign’s influence on share prices of targeted companies. Recognizing the campaign’s context of a possible »carbon bubble«, divestment’s impact on stock prices is estimated using an event study for the short term and latent growth curve modeling to account for indirect, medium to long term effects.

Existing literature focuses on the movement’s broader societal impact and emphasizes the campaign’s potential to raise awareness of the urgency of global warming. Other research estimates the costs incurred for divesting institutions (e.g. for universities) and counterbalances transaction and diversification costs with the costs of holding an asset which is exposed to serious regulation risk through climate policies.

In absence of research on the recent movement, to understand divestment’s financial implications for targeted companies one needs to draw on literature on previous campaigns: Notwithstanding the fact that divestment from South Africa is considered of political importance for the demise of apartheid, share price of attacked companies remained unaffected. However, firms collaborating with Sudan during genocide suffered from declining stock prices following divestment113. The avoidance of ‘sin stocks’ (e.g. tobacco) by ethical investors was likewise found to induce higher capital costs on ‘sin industries’. Concordantly, investors earn ‘sin premia’ on controversial stocks.

Findings from former campaigns can only partly be transferred to fossil fuel divestment: Though divesting from fossil fuels resembles the ‘sin stock’ setting, so far, no other divestment movement has reached the current campaign’s scope. Moreover, no other ‘sin industry’ has been questioned on basis of its ability to generate future earnings. Fossil fuel investment, by contrast, is heavily exposed to regulation risk in the context of climate change policies. This risk could soon be captured by a broad investor base driven by purely financial considerations. Therefore, the current campaign’s potential to hurt the sector financially should supersede previous stock boycotts’ capabilities. Further, higher capital costs for fossil fuel companies will not necessarily translate into a ‘sin premium’ for unscrupulous investors: If the share price is depressed substantially in the long term, fossil fuel investors will instead incur losses resulting from ever-decreasing stock values.

113 However, these results come from merely three studies of which one has serious methodological flaws.
Theoretical arguments can be put forward for both a short term, direct, and a long term, indirect, effect of divestment on share prices:

Admittedly, the Law of One Price (LOP), the Capital Asset Pricing Model (CAPM), and the Arbitrage Pricing Theory (APT) preclude divestment’s impact on asset prices: As neither future cash flows (LOP), nor systematic risk (CAPM), nor macroeconomic conditions (APT) are affected in the short term, stock prices should remain unchanged (c.f. Sharpe 1964; Lintner 1965; Ross 1976). Having said this, a stock price reaction on divestment becomes possible, as soon as two (unrealistic) assumptions of these models are loosened: Merton’s (1987) »segmented markets« model and Miller’s (1977) model under divergence of opinion imply that divestment should indeed induce a decline in share prices. Following Merton, the depression in asset prices is a compensation for limited risk sharing of shunned stocks. In Miller’s model, it occurs in consequence of other buyers’ lack of willingness to purchase the asset at its current price.

In the long run, divestment must be analyzed in the context of a probable overvaluation of fossil fuel assets, the so-called »carbon bubble«. In a world fighting climate change, fossil fuel investments face serious risk through technological breakthroughs, political decisions, and social transformations. Indeed, if the Paris agreement was to be implemented, for instance, 80% of the reserves of the biggest fossil fuel companies would be forced to stay in the ground. If the current value of fossil fuel companies’ is based on the burning of these reserves, a serious depreciation could be imminent in the coming years.

Against this background, divestment can send an important signal. It could, firstly, break down »informational cascades« (Bikhchandani, Hirshleifer, and Welch 1992): If the sector’s overvaluation is based on each single investor’s misconception that the financial community keeps fossil fuel assets for a reason, divesting institutions provide a strong market signal when breaking away from the herd. This signal could reinforce the debate on the sector’s misvaluation and motivate skeptical, ‘neutral’ investors to leave the market.

Divestment can secondly enable the synchronization of trading strategies to burst the bubble (c.f. Abreu and Brunnermeier 2003): Rational arbitrageurs, well-aware of the overvaluation, might try to benefit from ‘riding the bubble’ and sell before its burst. In such a situation, divestment sends a signal that the burst is about to come. Market exit or a (small) price decline induced by divestment could incentivize many rational investors to sell. Consequently, the bubble would burst and inflated asset prices would fall to their intrinsic values. The ‘signal effect’ of divestment should be most effective when divestment is financially motivated and promoted by well-known, reputable institutions.

To test the theoretical propositions empirically, I use new data from 149 divesting institutions. An event study is set up to capture short-term stock price responses on divestment announcements. I find that declarations to divest from fossil fuels are followed by a small drop in the share price. A reduction in the stock’s market value is detected both for the companies who are directly targeted by a specific announcement and for the entire sector. For companies targeted by a specific announcement, this effect is quickly offset and sometimes becomes insignificant. In the sector-wide analysis, the price depression is found to be persistent and significant.

Divestment’s potential to disrupt fossil fuel assets’ value enhancement over a longer period is investigated with the help of latent growth curve modeling. Countering theory, divestment is found to be conducive to stock price growth. However, the positive effect breaks down and sometimes turns negative for financially motivated divestment. The counterintuitive positive relationship between divestment and stock prices is most probably driven by omitted variable bias induced by the methodological design.
A promising approach to examine divestment’s long-term effect on stock prices in the future involves a comparison between listed and non-listed (i.e. state-run) fossil fuel companies. For instance, an experiment could be mimicked estimating the difference between firms who are exposed to the ‘treatment’ of divestment (i.e. listed firms) and those who are not (i.e. state-run firms).

Future research should, moreover, scrutinize the ‘signal effect’ of divestment. A question of crucial interest is how ‘neutral’ investors respond to the divestment movement.

Stock prices are only the very first part of the story. For a comprehensive understanding of divestment’s financial impact, it is essential to know what happens after a possible depreciation of the stock price.

The dataset provided in this paper could be of help when asking these and other divestment related questions.

At this juncture, it can be (cautiously) concluded that »Fossil Free«’s potential could go beyond being a hook for climate change debate. Already today, fossil fuel divestment demonstrates its ability to depress targeted companies stock prices, at least to a certain extent. If the movement maintains its current upward dynamics, this impact could be amplified in the coming years.
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— Our Theory of Change (2017d).


Declaration of Academic Integrity

I hereby insure that the following work is my own. I have not altered any other works or aid-materials completely or in part without proper indication. All aspects, which make use of other works in the wording or the sense, have been cited with the correct source information. This applies also to designs, sketches, figurative representations etc. as well as to sources from the Internet.

I am familiar with the methodology of proper citation.

Kassel, 23/10/2017
Alison Schultz
APPENDICES: Overview

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Appendix A:
Firms Targeted by Fossil Fuel Divestment: The »Carbon Underground 200«

»Fossil Free« asks to divest from the “200 publicly-traded companies [that] hold the vast majority of listed coal, oil, and gas reserves” (Fossil Free 2017b), i.e. the »Carbon Underground 200«.

The »Carbon Underground 200« is provided by the consultancy Fossil Free Indexes LLC. It lists the 100 oil and gas companies and the 100 coal companies who own the largest fossil fuel reserves as measured by their potential carbon emissions. All companies listed in the 2016 »Carbon Underground 200« are investible as of July 11, 2016. Rankings are based on carbon emissions associated to reserves reported as of May 31, 2016. The ranking was adjusted for mergers and acquisitions as of May 31, 2016 (c.f. Fossil Free Indexes 2016b).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Coal Companies</th>
<th>Coal Gt CO₂</th>
<th>Rank</th>
<th>Oil and Gas Companies</th>
<th>Oil Gt CO₂</th>
<th>Gas Gt CO₂</th>
<th>Total O&amp;G Gt CO₂</th>
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Appendix B: 2017 Fossil Fuel Divestment Survey

Appendix B1: Contacted Institutions
All institutions who had joined the fossil fuel divestment campaign by March 2017 (as according to gofossilfree.org) were contacted (if contact information could be found online). These institutions are listed below.

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<th>Institution</th>
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City of Münster
City of New London, CT
City of Newcastle
City of Northampton, MA
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City of Ōrebro
City of Oxford
City of Palo Alto, CA
City of Paris
City of Portland, OR
City of Providence, RI
City of Provincetown, MA
City of Ravoire
City of Richmond, CA
City of San Francisco, CA
City of San Luis Obispo, CA
City of Santa Fe, NM
City of Santa Monica, CA
City of Seattle, WA
City of Stirling
City of Stockholm
City of Strömstad
City of Stuttgart
City of Sudbury, MA
City of Swan
City of Sydney
City of Truro, MA
City of Uppsala
City of Venissieux
City of Vincent
City of Wodonga
City of Savernay
Clean Water Action
Climate Action Network Australia
College of the Atlantic
College of the Marshall Islands
Colorado Ratnashri Sangha
Columbia University in the City of New York
Comart Foundation
Community Friends Quaker Meeting in Cincinnati, OH
Community Impact Foundation
Compton Foundation
Conservation Breeding Specialist Group
Council of Canadians, The
Council of Progressive Rabbis of Australia, Asia, and New Zealand
Country of Ireland
County council of Loiret
Cranfield University
Dane County, WI
Daniel and Nina Carasso Foundation
Darwin Superannuation Fund
Davara Super Fund
Herriot-Watt University
Harriet-Watt University
HESTA Super Fund
Hidden Leaf Foundation
Huddersfield Quakers
Hull Family Foundation
Humboldt State University
Hunt Foundation, The
Hunter Hall Investment Management
Ian Somerhalder Foundation
Inspire Foundation for Business and Society
International Living Future Institute
Ircantec
Islamic Society of North America
Island Institute
Jacob & Valeria Langeloth Foundation, The
Jacobs Robinson Super Fund
Jalana Super Fund
Jamaica Plain Unitarian Universalist, NY
Janelia Foundation
Jennifer Altman Foundation
Jennie Di Blasi Super Fund
Jessie Smith Noyes Foundation
Joffe Charitable Trust, The
JMG Foundation
Joffe Charitable Trust, The
John & Marcia Goldman Foundation
John Merck Fund
Joseph Rowntree Charitable Trust
JRS Biodiversity Foundation
Jubitz Family Foundation
Just Money Super Fund
Kansas City, MO
Kerr Ratcliffe Super
Kestrelman Trust
King’s College London
Kirklees Council
KL Felicitas Foundation
Kollantai Super Fund
Kommunal Landspensjonskasse (KLP)
KR Foundation
Kristine and Will Catto Foundation
Kuhn’s Gold Super
La Trobe University
Laird Norton Family Foundation
Lake Country Unitarian Universalist Church, WI
Lansdowne Monthly Meeting
Laughing Gull Foundation
Laval University
Le Mans city
League of Conservation Voters
Lehigh Valley Monthly Meeting
Lemelson Foundation
Leonard and Sophie Davis Fund, The
Leonardo DiCaprio Foundation
Libra Foundation, The
Local Government Super
London Borough of Southwark Pension Fund
London School of Economics
London School of Hygiene & Tropical Medicine
Lookout Foundation
Lund University
Lutheran World Federation
Lydia B. Stokes Foundation, The
M & N West Pension Fund
Macedon Ranges Shire Council
Madden Sainsbury Foundation
Madirrinaya Foundation
Madison Monthly Meeting of the Religious Society of Friends (Quakers)
Maine Council of Churches, ME
Malbird Super Fund
Manchester Metropolitan University
Maree Kordonsky Super
Marist Sisters Australia
Mark Leonard Trust, The
Mary Babcock Foundation
Mary Robinson Foundation
Massachusetts United Church of Christ
McKenzie River Gathering Foundation
McKinnon Family Fund
McKinnon Super Fund
Medford Friends Meeting
Melbourne Unitarian Church
Melton Foundation
Mennen Foundation
Merck Family Fund
Methodist Church of Britain
Metropolitan New York Synod, Evangelical Lutheran Church in America
Meyer Family Enterprises
Miami Monthly Friends (Quaker) Meeting
Waynesville, OH
Miami Quarterly Friends (Quaker) Meeting of Ohio
Valley, OH
Millamac Super Fund
Missionary Society of St. Columban
Mize Family Foundation
Monash University
Montreal Quakers
Montreuil
Moomintroll Super Fund
Morning Star Foundation
Mount Alexander Shire Council
Mount Holly, New Jersey
Mountain Vista Unitarian Universalist Congregation, AZ
Mullum Trust
Multnomah County, OR
Naropa University
National Ethical Service
National Synod of Scotland
National Tertiary Education Union
National University of Ireland Galway
Natural Resources Defense Council
Neranie Super Fund
Nest Sammelstiftung / Nest Fondation Collective
Nevada Super Fund
New England Biolabs Foundation
New Priorities Foundation
New Progressive Alliance
New York Conference of The United Methodist Church
New York Quarterly Meeting
Newcastle University
Newton County Quaker Meeting, PA
Nia Community Fund
Nisie Student Relocation Commemorative Fund
Noorda Foundation
Nordea Bank AB
Nordic Enterprise
Norman Foundation
North Star Fund
Northeast Wilderness Trust
Northern Yearly Meeting – Quakers in the Upper Midwest
Norwegian Unitarian Universalist Church
Nottingham Trent University
NYC Teachers Pension Fund
NYCERS
Odense City Council
Ohio Valley Yearly Meeting, Society of Friends (Quakers), OH
Okeanos Foundation for the Sea
Old Haverford Monthly Meeting
Oregon Metro
Oregon State University
Orp Foundation
Ostergotland Region
Overbrook Foundation, The
Oxford Brookes University
Oxford University
Pace Foundation
Pacific Northwest Conference of The United Methodist Church
Pacific School of Religion
Paletum, The
Panahpur
Park Foundation, NY
Partnership for Change
Pax Fund
Pensionfonds Zorg en Welzijn (PFZW)
Peralta Community College District
Perpetual Ocean Super Fund
PFA Pension
Philadelphia Yearly Meeting
Phipps Conservatory and Botanical Gardens
Pi Investments
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Unitarian Universalist Congregation of South County, RI
Unitarian Universalist Fellowship of Ames
Unitarian Universalist Fellowship of Corvallis, OR
Unitarian Universalist Society of Amherst, MA
Unitarian Universalist Society of Bangor, Maine
United Church of Canada
United Church of Christ
United Church of Christ, Minnesota Conference
United Reformed Church of Scotland
United Church of Canada
United Church of Scotland
United Church of Australia Assembly
Unity College
Unity Temple Unitarian Universalist Congregation, IL
University of Abertay Dundee
University of Arts Bournemouth
University of Bedfordshire
University of Bristol
University of California
University of Cambridge
University of Copenhagen
University of Dayton
University of Edinburgh
University of Glasgow
University of Gloucestershire
University of Greenwich
University of Hawaii
University of Hertfordshire
University of Kent
University of Liège
University of Maryland
University of Massachusetts Foundation
University of Oregon Foundation
University of Otago
University of Portsmouth
University of Sheffield
University of Southampton
University of St. Andrews
University of Surrey
University of Sussex
University of Sydney
University of the Arts London
University of the West of Scotland
University of Wales Trinity Saint David
University of Warwick
University of Washington
University of Westminster
University of Worcester
Urban community of Cherbourg
Urban community of Hénin-Carvin
UU Church of Boulder, CO
UU Congregation of Binghamton, NY
V. Kann Rasmussen Foundation
Velux Foundations
Victoria University of Wellington
Village of Cooperstown Pension Fund
Vincent Wildlife Trust
Wahumba Super Fund
Wallace Global Fund
Waltham Forest Pension Fund
Warren Wilson College
Water Dragon Foundation
Waterloo Foundation
Wattle Blossum Super Fund
Wermuth Family Office
Werzalit Gruppe
Western Australian Local Government Association
Western Oregon University
Westtown Monthly Meeting
Whitley Fund for Nature
Wilburforce Foundation
Wilderness Society, The
Willows Investments
Winslow Foundation, The
Wolfson College
Wombat Super
Woodward Charitable Trust
World Council of Churches
World Medical Association
WWF-UK
Yale University
Appendix B2: E-Mail Invitation and Reminders to Respondents

In the following, all e-mails sent to the surveyed institutions are presented. An institution only received emails up to the date when it responded to the survey.

June 29th and June 30th, 2017: Invitation entailing hyperlink with survey

Sent: June 29th, afternoon (Emails)
     and June 30th, during day (contact forms on website)
Subject: Fossil Fuel Divestment Survey Invitation

Dear «name1» «surname1», («name2» «surname2» and «name3» «surname3»), / finance team of «organization»,

I am writing to ask for help with the 2017 Fossil Fuel Divestment Survey. You are part of a random sample of organizations who have committed fossil fuel divestment and who are listed on the website of the Fossil Free campaign. A goal of the survey is to investigate the economic and political impact of fossil fuel divestment. In particular, we want to find out if fossil fuel divestment can effectively put pressure on providers of “dirty” energy and improve the competitiveness of alternative energy sources.

To this end, we would greatly appreciate if you would answer a few questions for us. To do so, simply click on this link:

https://www.soscisurvey.de/2017FossilFuelDivestmentSurvey/

In order to begin the survey, you will need to enter this identification code: «ID_questionnaire»

The questionnaire is short, only 15 questions, and should take about ten minutes to complete. Once started, you can quit the survey any time you want and complete it later by entering your identification code.

The survey is confidential. Responses will not be connected to your organization in any reports of the data. Your participation is voluntary, and if you come to any question you prefer not to answer please skip it and go to the next. Should you have any questions or comments please contact Alison Schultz, the study director, at the chair of corporate finance, University of Kassel, +49 (1578) 3596939 or a.schultz@uni-kassel.de.

Many thanks,

Alison Schultz
Study Director, Chair of Corporate Finance, University of Kassel, Germany
International Center for Development and Decent Work, Kassel, Germany

Prof. Dr. Christian Klein
Chair of Corporate Finance, University of Kassel
Henschelstraße 4
D-34127 Kassel
Germany
July 10th and July 12th, 2017: First reminder entailing hyperlink and PDF questionnaire as alternative response mode

Sent: July 10th, afternoon (Emails) and July 12th, morning (contact forms on website on which attachment was possible)

Subject: Fossil Fuel Divestment Survey – Alternative Response Mode

Dear «name1» «surname1», («name2» «surname2» and «name3» «surname3»,) / finance team of «organization»,

Some days ago we sent an e-mail to you asking for your participation in the 2017 Fossil Fuel Divestment Survey. We are conducting this survey with organizations that have divested from fossil fuels to learn about the political and economic effects of fossil fuel divestment.

I am following up with this e-mail to provide you with the opportunity to submit your answers via e-mail or postal mail. I hope this makes it more convenient for you to respond. Simply complete the attached questionnaire. It should only take a few minutes to answer the 15 questions. You can submit your responses by pressing the ‘submit’ button in the attached form, by returning the form via e-mail or sending a printout by post.

In case you prefer to complete the questionnaire online, please use this link:
https://www.soscisurvey.de/2017FossilFuelDivestmentSurvey/

and enter your identification code to start the survey: «ID_questionnaire»

The result of this study will help us to better understand if fossil fuel divestment can be effective in transforming our energy systems and eventually fighting climate change. Your participation is very important, and we appreciate you considering our request.

Sincerely,

Alison Schultz
Study Director, Chair of Corporate Finance, University of Kassel, Germany
International Center for Development and Decent Work, Kassel, Germany

Prof. Dr. Christian Klein
Chair of Corporate Finance, University of Kassel
Henschelstraße 4
D-34127 Kassel
Germany
July 20th and July 21st, 2017: Second reminder entailing hyperlink and PDF questionnaire

Sent: July 20th, morning (contact forms that had not received the first reminder)  
and July 21st, morning (Emails and contact forms that had received the first reminder)

Subject: Fossil Fuel divestment of your organization

Dear «name1» «surname1», («name2» «surname2» and «name3» «surname3»,) / finance team of «organization»,

Recently we sent you an email asking you to complete a survey about fossil fuel divestment. If you have already completed the survey, we would like to thank you very much. We truly appreciate your help.

If you have not answered the questionnaire yet, we’d like to urge you to do so. It should only take a few minutes to complete. Simply click on the link below or open the questionnaire which you find attached to this e-mail. To start the questionnaire, please enter your digital access code: «ID_questionnaire»

https://www.soscisurvey.de/2017FossilFuelDivestmentSurvey/

The 2017 Fossil Fuel Divestment Survey is important. The organizations that have divested fossil fuel related assets are the only source we have for getting an image of divestment activity which has happened in the last years. If you have questions or comments, please contact Alison Schultz, the study director, at +49 (1578)3596939 or a.schultz@uni-kassel.de. Thank you for your help.

Sincerely,

Alison Schultz
Study Director, Chair of Corporate Finance, University of Kassel, Germany
International Center for Development and Decent Work, Kassel, Germany

Prof. Dr. Christian Klein
Chair of Corporate Finance, University of Kassel
Henschelstraße 4
D-34127 Kassel
Germany
July 31st, August 1st: Third reminder entailing hyperlink and PDF with questionnaire

Sent: July 31th, afternoon
      and August 1st, morning (Contact forms)
Subject: Help University of Kassel Investigate Fossil Fuel Divestment

Dear «name1» «surname1», («name2» «surname2» and «name3» «surname3»), / finance team of «organization»,

Some weeks ago, we contacted you asking you for your help with the 2017 Fossil Fuel Divestment Survey. We are writing to you again because our ability to accurately describe actual fossil fuel divestment depends on hearing from those who have not yet responded. As you are a part of the sample we took from organizations that are listed on the website of the Fossil Free campaign, we need your help to ensure the results are as precise as possible.

Even if you do not answer every single question your answers are very helpful to us. Please feel free to skip questions you are not willing or able to answer. To fill out the questionnaire, please complete the survey attached or click on the link below:

https://www.soscisurvey.de/2017FossilFuelDivestmentSurvey/

Digital Access Code: «ID_questionnaire»

Responses to the survey are confidential and will not be connected to your organization in any reports of the data. If you have any questions about the survey, please contact the study director, Alison Schultz. She can be reached via e-mail at a.schultz@uni-kassel.de or by telephone at +49 (1578) 3596939.

Thanks for considering our request.

Sincerely,

Alison Schultz
Study Director, Chair of Corporate Finance, University of Kassel, Germany
International Center for Development and Decent Work, Kassel, Germany

Prof. Dr. Christian Klein
Chair of Corporate Finance, University of Kassel
Henschelstraße 4
D-34127 Kassel
Germany
August 9th: Fourth and final reminder entailing hyperlink and PDF with questionnaire

Sent: August 9th, afternoon
Subject: Last chance to help University of Kassel investigate fossil fuel divestment

Dear «name1» «surname1», («name2» «surname2» and «name3» «surname3»,) / finance team of «organization»,

We are writing to follow up on the message we sent last week asking you to participate in the 2017 Fossil Fuel Divestment Survey. The assessment of the impacts of fossil fuel divestment is drawing to a close, and this is the last reminder we are sending about the study.

Please find the questionnaire attached or complete it on the website below. If you come to any question you prefer not to answer please you can simply skip it and go to the next.

https://www.soscisurvey.de/2017FossilFuelDivestmentSurvey/

Digital Access Code: «ID_questionnaire»

We also wanted to let you know that if you are interested in seeing a summary of results, we hope to be able to provide them by the end of summer. Please contact us if you would like to receive information about the results of this study. In the meantime, we want to wish you an enjoyable summer.

Sincerely,

Alison Schultz
Study Director, Chair of Corporate Finance, University of Kassel, Germany
International Center for Development and Decent Work, Kassel, Germany

Prof. Dr. Christian Klein
Chair of Corporate Finance, University of Kassel
Henschelstraße 4
D-34127 Kassel
Germany
Appendix B3: Questionnaire

The web-based questionnaire of the »2017 Fossil Fuel Divestment Survey« can be accessed by the following link (in preview mode without digital access code) up to November 22\textsuperscript{nd}, 2017. Please contact me if you need access after this date.

2017 Fossil Fuel Divestment Survey (Preview web-based questionnaire):
https://www.soscisurvey.de/2017FossilFuelDivestmentSurvey/?act=AAOAUpbZ7dlsxwkASZMiceSb

The alternative response mode (fillable PDF) is provided as a copy on the following pages. The fillable document can be found in the digital appendix: Appendix B3 – Questionnaire_Fillable PDF (.pdf)
Thank you very much for completing this questionnaire. This study will help us better understand the economic and political impact of fossil fuel divestment. Against the backdrop of global efforts to fight climate change, it is important to learn more about the potential of fossil fuel divestment and identify how divestment can effectively support these efforts. Throughout the questionnaire, “divestment” means the removal of investment assets including stock, bonds, credit and investment funds from companies involved in extracting or processing fossil fuels.

Your responses will be kept confidential. No information of your organization will be associated with your responses in any reports of the data. If you have any questions please feel free to contact Alison Schultz, the study director, by email at a.schultz@uni-kassel.de or by phone at +49 (1578) 3596939.

Question 1 of 15

What is the type of your organization?

Please choose

Question 2 of 15

Has your organization ever owned fossil fuel related assets?

Please choose “yes” if your organization has invested in stock, bonds, credit and investment funds from companies primarily involved in extracting or processing fossil fuels at any point in the past or today.

- Yes, my organization has owned fossil fuel related assets (in the past or today).
- No, my organization has never owned fossil fuel related assets.
**2017 FOSSIL FUEL DIVESTMENT SURVEY**

**Question 3 of 15**

Why did your organization decide to divest fossil fuel related assets and/or not to invest in them?

*You may choose more than one response. If joining the campaign was a symbolic act please give the reasons for this act.*

- [ ] Ethical reasons
- [ ] Stakeholder pressure
- [ ] Public pressure
- [ ] Reputation risk
- [ ] Financial risk
- [ ] Other (please specify) [ ]

**Question 4 of 15**

All in all, what was your organization’s **most important** reason to divest fossil fuel related assets and/or not to invest in them in the future?

- [ ] Financial considerations
- [ ] Ethical considerations
- [ ] Other (Please specify) [ ]

**Question 5 of 15**

*If your organization has divested fossil fuel related assets:*

Which fuels has your organization targeted in its divestment strategy?

*If your organization has never owned fossil fuel related assets:*

Which fuels has your organization decided not to invest in, even if only symbolically?

*You may choose more than one response.*

- [ ] Coal
- [ ] Crude oil
- [ ] Natural gas
- [ ] Oil sands / Tar sands
- [ ] Oil shale
- [ ] Other (please specify) [ ]

Contact us: a.schultz@uni-kassel.de | +49 (1578) 3596939

Alison Schultz, Department of Corporate Finance, University of Kassel
Question 6 of 15
In general, do you think that most fossil fuel related assets have a fair value or do you consider them to be undervalued or overvalued?

*Please choose 'fair valued' if you think that fossil fuel related assets will keep their value in the future, 'undervalued' if you think they will gain value and 'overvalued' if you think they will lose value in the future.*

- [ ] Strongly undervalued
- [ ] Undervalued
- [ ] Fair valued
- [ ] Overvalued
- [ ] Strongly overvalued
- [ ] Don’t know

Question 7 of 15
Do you think that the current fossil fuel divestment campaign hurts the fossil fuel sector financially?

- [ ] Yes
- [ ] No
- [ ] Don’t know

Question 8 of 15
Some organizations try to influence a company’s behavior by engaging as shareholders. They put pressure on a company’s management, e.g. in shareholder meetings or with the help of proxy votes, to enforce more sustainable management decisions.

*If your organization has divested fossil fuel related assets:*

Please consider your organization’s behavior as a shareholder of fossil fuel companies. Before, or in addition to divesting fossil fuel related assets, has your organization engaged as a shareholder to enforce more sustainable management decisions in the respective companies?

- [ ] Yes
- [ ] No

*If your organization has never owned fossil-fuel related assets:*

Has your organization engaged as a shareholder to enforce more sustainable management decisions?

- [ ] Yes
- [ ] No
2017 FOSSIL FUEL DIVESTMENT SURVEY

Question 9 of 15
When did your organization decide to divest fossil fuel related assets and/or not to invest in them in the future?
Please indicate the date when the decision to divest or not to invest was made (not the date when divestment did actually take place).

Month Day Year

Question 10 of 15
When did your organization declare publicly that fossil fuel related assets will be divested and/or not invested in in the future?

Month Day Year

☐ Decision was not made public

Question 11 of 15
If your organization has divested fossil fuel related assets:
When did your organization actually divest fossil fuel related assets?
Please indicate the date or the period during which fossil fuel related assets were sold. If all assets were sold at a single day, please leave the second field empty.

from: Month Day Year

to: Month Day Year

☐ All assets were sold at this day

☐ Divestment still ongoing

If your organization has never owned fossil fuel related assets:
Please skip this question.

Question 12 of 15
Several organizations who divested fossil fuel related assets have promoted this decision publicly. For example, some organizations have released press statements. Others have told customers about the divestment decision or have made the decision public on the organization’s website.

Has your organization promoted the decision to divest fossil fuel related assets and/or not to invest in them in the future and/or to join the campaign?

☐ Yes

☐ No
Question 13 of 15

If your organization has divested fossil fuel related assets:
Has your organization strategically reinvested the divested money in assets of companies with a climate-friendly business model, for example in companies providing "green energy" or alternative energy systems?

☐ Yes
☐ No
☐ In parts

If your organization has never owned fossil fuel related assets:
Has your organization strategically invested in assets of companies with a climate-friendly business model, for example in companies providing "green energy" or alternative energy systems?

☐ Yes
☐ No

Question 14 of 15

How much has your organization divested?
Please indicate the total value of fossil fuel related assets your organization has divested.
Please indicate total value Please choose currency

☐ My organization has never owned fossil fuel related assets.

If your organization has never owned fossil fuel related assets: Please skip question 15 and go to the end of the questionnaire.
Question 15 of 15

More specifically, which assets were divested by your organization?

Please give information on the companies whose assets were sold by your organization. For each company, please indicate the date of divestment, the amount divested and the asset type divested. You can either mark the companies in the list below or send us an excel file containing the requested information.

Please choose

- I will send an excel file with the requested data.
  
  Please skip question 15 and go to the end of the questionnaire.

- No excel file will be attached.
  
  Please give information on companies and funds divested from below.

Below, the most important coal, gas and oil companies are listed in alphabetical order. Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.

<table>
<thead>
<tr>
<th>Coal companies (A-Bu)</th>
<th>Divestment date/period</th>
<th>Amount divested</th>
<th>Currency</th>
<th>Asset type</th>
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<td>Adani Enterprises</td>
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<td>African Rainbow Minerals</td>
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<td>AGL Energy</td>
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<td>Alliance Resource Partners</td>
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<td>Alpha Natural Resources</td>
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<td>Anglo American</td>
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<td>ArcelorMittal</td>
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<td>Arch Coal</td>
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<td>Aspire Mining</td>
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### 2017 FOSSIL FUEL DIVESTMENT SURVEY

**Question 15 of 15 (coal companies Cc-Ka)**

Companies divested from

*Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.*

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<th>Coal companies (Cc-Ka)</th>
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Contact us: a.schultz@uni-kassel.de | +49 (1578) 3596939
Alison Schultz, Department of Corporate Finance, University of Kassel
Question 15 of 15 (coal companies Ki-Se)

Companies divested from

Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.

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<tr>
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Question 15 of 15 (coal companies Sh-Z, oil and gas companies A-Ca)

Companies divested from

Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.

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2017 FOSSIL FUEL DIVESTMENT SURVEY

Question 15 of 15 (oil and gas companies Ca-Gu)

Companies divested from

Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.

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Contact us: a.schultz@uni-kassel.de | +49 (1578) 3596939
Alison Schulte, Department of Corporate Finance, University of Kassel
### 2017 FOSSIL FUEL DIVESTMENT SURVEY

**Question 15 of 15 (oil and gas companies He-Pe)**

Companies divested from

*Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.*

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Alison Schultz, Department of Corporate Finance, University of Kassel
2017 FOSSIL FUEL DIVESTMENT SURVEY

Question 15 of 15 (oil and gas companies Pi-Z)

Companies divested from
Please choose all companies whose assets were sold by your organization to divest fossil fuels. Please further indicate for each company the date of divestment, the amount divested and the asset type sold. Later, you can add companies or investment funds which are not listed here.

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Alison Schultz, Department of Corporate Finance, University of Kassel
2017 FOSSIL FUEL DIVESTMENT SURVEY

Question 15 of 15 (more companies or investment funds)

Have you divested assets of more companies or investment funds?
Please give information on further companies or investment funds whose assets were sold by your organization. For each company, please indicate the date of divestment, the amount divested and the asset type divested.

Other companies or funds divested from

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<td></td>
<td>US dollars</td>
<td>Stock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>US dollars</td>
<td>Stock</td>
</tr>
</tbody>
</table>

In case you could not provide detailed information on the companies or funds divested from, please describe your organization’s divestment strategy here:

Contact us: a.schultz@uni-kassel.de | +49 (1578) 3596939
Alison Schultz, Department of Corporate Finance, University of Kassel
Thank you very much for your help!

Would you like to be informed about the results of this study?
If you would like to receive a summary of our results by fall 2017, please enter your e-mail address here. Your e-mail address is only saved to deliver the results of the 2017 Fossil Fuel Divestment Survey and is not passed on to a third party.

E-mail address:

Please submit the questionnaire by clicking the button. Please do not forget to attach the excel file (containing the companies divested from, the date of divestment, the amount divested and the asset type divested for each company) to the e-mail if necessary.

SUBMIT

If submission does not work with the button, please save the completed questionnaire and send it (with the excel file) electronically to a.schultz@uni-kassel.de

or a printed version via postal mail to:

Prof. Christian Klein
z.H. Alison Schultz

Universität Kassel,
FB 07 Wirtschaftswissenschaften
Henshelstr. 4
D-34127 Kassel
Germany

Contact us: a.schultz@uni-kassel.de | +49 (1578) 3596939
Alison Schultz, Department of Corporate Finance, University of Kassel
Appendix B4: Data Gathered with the 2017 Fossil Fuel Divestment Survey

Please find the gathered data and the codebook in the digital appendix.

Fossil Fuel Divestment Data: Appendix B3: Fossil Fuel Divestment Data.xlsx
Codebook: Appendix B3: Fossil Fuel Divestment Data Codebook.pdf

This is the raw data of the questionnaire. The full data including all contacted institutions that did not respond and the unfinished questionnaires can also be provided if of interest. Every analysis required a specific data preparation. The datasets prepared for the two presented event studies and the latent growth curve analysis are provided in the digital appendix.

Data for firm-specific event study: all_decla_klp.csv
Data for sector-wide event study: deci_decla_all_divestors.csv
Date for latent growth curve analysis: lgm_mp.dat

If you want to have a look at further data (e.g. other combination of divestment dates and targeted firms or the data set for any of the analyses run), please ask for it.
Appendix C: Analyses

The R codes and Mplus codes for my analyses are given in the following. In the digital appendix, the associated R-scripts and Mplus Input file is available:

Appendix C1 - Event Study_Divestment_Firm Specific Analysis.R
Appendix C2 - Event Study_Divestment_Sector-Wide Analysis.R
Appendix C3 - lgcm_cumulated announcements.inp
Appendix C4 - graphs.R

Appendix C1: Event Study, Firm Specific Analysis (R-Code)

rm(list=ls())
setwd("C:/Users/Alison Schultz/Documents/Studium/R/data")

# Loop with i firms

## Divestment declaration dates including KLP divestment
\n#read data
all_decla_klp=read.csv("all_decla_klp.csv",header = TRUE, quote="\", stringsAsFactors= TRUE, check.names=TRUE)
data=read.csv("divest_returns and FF.csv",header = TRUE, quote="\", stringsAsFactors= TRUE, check.names=TRUE)

returns=data[2:187]  
FF=data[188:193]  
date=as.Date(data$..date, format= "%Y-%m-%d")

# extract events for each targeted firm
events=NULL
for(i in 1:length(returns[[1]])) {
  events[[i]]=na.omit(event_dates[all_decla_klp$number==i])
}

# number of events for each targeted firm
number_events=NULL
for(i in 1:length(returns[[1]])) {
  number_events[[i]]=length(events[[i]])
}

# delete firms which do not have an event from return data
returns=returns[,number_events>0]

# number of firms with event: 58
length(returns[[1]])

#delete firms which do not have an event from events data
events=events[number_events>0]

#do we have the same number of firms?--> YESSS, finally...
length(events)==length(returns[[1]])

# delete firms which do not have return data for relevant period
#windowlength=1825 days
missing=NULL
for (i in 1:length(returns[[1]])) {
  missing[[i]]=sum(is.na(returns[min(events[[i]]-1855 < date & date < min(events[[i]])-30,i)]))
}
sum(missing>1700)
# no firm has too many missings in the relevant period

# see firms with their new id (IN.ADE for testing is 27)
names(returns)

# estimate normal returns (5 years before 30 days before first divestment of firm)
# as the missings are distributed in a way that lm is impossible, I use multiple imputation (predictive mean matching)
reg_data=data.frame(returns,FF)
library(mice)
impute=mice(reg_data, m = 5, method = "pmm")
reg_data=complete(impute)
sum(is.na(reg_data))
estimates=list()
for(i in 1:length(returns[,1])) {
estimates[[i]] <- lm(reg_data[min(events[[i]]):1855 < date & date < min(events[[i]])-30,i] ~
  reg_data$SR[min(events[[i]]):1855 < date & date < min(events[[i]])-30]
  + reg_data$Mkt.RF[min(events[[i]]):1855 < date & date < min(events[[i]])-30]
  + reg_data$HML[min(events[[i]]):1855 < date & date < min(events[[i]])-30]
  + reg_data$SMB[min(events[[i]]):1855 < date & date < min(events[[i]])-30]
  + reg_data$oilpricechange[min(events[[i]]):1855 < date & date < min(events[[i]])-30], na.action=na.omit)
}

##############################################################
## 7 DAYS EVENT WINDOW ##
##############################################################

# returns in event windows
event.returns=list()
event.returns0=list()
event.returns1=list()
event.returns2=list()
event.returns3=list()
event.returns_1=list()
event.returns_2=list()
event.returns_3=list()
index=1:length(date)
names(index)=date
events_num=list()
events_num1=list()
events_num2=list()
events_num3=list()
events_num_1=list()
events_num_2=list()
events_num_3=list()
for (i in 1:length(returns[,1])) {
  events_num[[i]]=index[as.character(events[[i]])]
  events_num1[[i]]=index[as.character(events[[i]]+1)]
  events_num2[[i]]=index[as.character(events[[i]]+2)]
  events_num3[[i]]=index[as.character(events[[i]]+3)]
  events_num_1[[i]]=index[as.character(events[[i]]-1)]
  events_num_2[[i]]=index[as.character(events[[i]]-2)]
  events_num_3[[i]]=index[as.character(events[[i]]-3)]
}
for (i in 1:length(returns[,1])) {
  event.returns0[[i]]=returns[events_num[[i]],i]
  event.returns1[[i]]=returns[events_num1[[i]],i]
  event.returns2[[i]]=returns[events_num2[[i]],i]
  event.returns3[[i]]=returns[events_num3[[i]],i]
event.returns_1[[i]]=returns[events_num_1[[i]],i]
event.returns_2[[i]]=returns[events_num_2[[i]],i]
event.returns_3[[i]]=returns[events_num_3[[i]],i]
}

for (i in 1:length(returns[,1])) {
    event.returns[i]=cbind(event.returns_3[i],
        event.returns_2[i], event.returns_1[i],
        event.returns0[i], event.returns1[i],
        event.returns2[i], event.returns3[i])
}

# predicted returns at event window
b0_=NULL
b1_=NULL
b2_=NULL
b3_=NULL
b4_=NULL
b5=NULL

for (i in 1:length(estimates)) {
    b0_[[i]]=estimates[[i]]$coefficients[1]
    b1_[[i]]=estimates[[i]]$coefficients[2]
    b2_[[i]]=estimates[[i]]$coefficients[3]
    b3_[[i]]=estimates[[i]]$coefficients[4]
    b4_[[i]]=estimates[[i]]$coefficients[5]
    b5_[[i]]=estimates[[i]]$coefficients[6]
}

pr.event.returns=list()
pr.event.returns0=list()
pr.event.returns1=list()
pr.event.returns2=list()
pr.event.returns3=list()

for (i in 1:length(returs[,1])) {
    pr.event.returns0[[i]]=b0_0[[i]]+
        b1_0[[i]]*FF$RF[events_num0[i]]+
        b2_0[[i]]*FF$Mkt.RF[events_num0[i]]+
        b3_0[[i]]*FF$HML[events_num0[i]]+
        b4_0[[i]]*FF$SMB[events_num0[i]]+
        b5_0[[i]]*FF$oilpricechange[events_num0[i]]
    pr.event.returns1[[i]]=b0_1[[i]]+
        b1_1[[i]]*FF$RF[events_num1[i]]+
        b2_1[[i]]*FF$Mkt.RF[events_num1[i]]+
        b3_1[[i]]*FF$HML[events_num1[i]]+
        b4_1[[i]]*FF$SMB[events_num1[i]]+
        b5_1[[i]]*FF$oilpricechange[events_num1[i]]
    pr.event.returns2[[i]]=b0_2[[i]]+
        b1_2[[i]]*FF$RF[events_num2[i]]+
        b2_2[[i]]*FF$Mkt.RF[events_num2[i]]+
        b3_2[[i]]*FF$HML[events_num2[i]]+
        b4_2[[i]]*FF$SMB[events_num2[i]]+
        b5_2[[i]]*FF$oilpricechange[events_num2[i]]
    pr.event.returns3[[i]]=b0_3[[i]]+
        b1_3[[i]]*FF$RF[events_num3[i]]+
        b2_3[[i]]*FF$Mkt.RF[events_num3[i]]+
        b3_3[[i]]*FF$HML[events_num3[i]]+
        b4_3[[i]]*FF$SMB[events_num3[i]]+
        b5_3[[i]]*FF$oilpricechange[events_num3[i]]
    pr.event.returns01[[i]]=b0_01[[i]]+
        b1_01[[i]]*FF$RF[events_num01[i]]+
        b2_01[[i]]*FF$Mkt.RF[events_num01[i]]+
        b3_01[[i]]*FF$HML[events_num01[i]]+
        b4_01[[i]]*FF$SMB[events_num01[i]]+
        b5_01[[i]]*FF$oilpricechange[events_num01[i]]
b3_[[i]]*FF$HML[events_num_1[[i]]]+
b4_[[i]]*FF$SMB[events_num_1[[i]]]+
b5_[[i]]*FF$oilpricechange[events_num_1[[i]]]+
pr.event.returns_2[[i]]=b0_[[i]]+
b1_[[i]]*FF$RF[events_num_2[[i]]]+
b2_[[i]]*FF$Mkt.RF[events_num_2[[i]]]+
b3_[[i]]*FF$HML[events_num_2[[i]]]+
b4_[[i]]*FF$SMB[events_num_2[[i]]]+b5_[[i]]*FF$oilpricechange[events_num_2[[i]]]
pr.event.returns_3[[i]]=b0_[[i]]+
b1_[[i]]*FF$RF[events_num_3[[i]]]+b2_[[i]]*FF$Mkt.RF[events_num_3[[i]]]+b3_[[i]]*FF$HML[events_num_3[[i]]]+b4_[[i]]*FF$SMB[events_num_3[[i]]]+b5_[[i]]*FF$oilpricechange[events_num_3[[i]]]
pr.event.returns[[i]]=cbind(pr.event.returns_3[[i]],
pr.event.returns_2[[i]],pr.event.returns_1[[i]],
pr.event.returns0[[i]],pr.event.returns1[[i]],
pr.event.returns2[[i]],pr.event.returns3[[i]])

# abnormal returns
ar=list()
for (i in 1:length(returns[1,])) {
ar[[i]]=event.returns[[i]]-pr.event.returns[[i]]
}

#replace NAs with zeros to be able to show graph later
#(justified as abnormal returns are expected to be zero)
ar_adj=list()
for (i in 1:length(returns[1,])) {
ar_adj[[i]] = ar[[i]]
ar_adj[[i]][is.na(ar[[i]])] = 0
}

# change observation unit from firm level to event level
all_ars=NULL
all_ars_adj=NULL
for(i in 1:length(returns[1,])) {
all_ars=rbind(all_ars, matrix(t(ar[[i]]), ncol=7, byrow=T))
all_ars_adj=rbind(all_ars_adj, matrix(t(ar_adj[[i]]), ncol=7, byrow=T))
}

# look at abnormal returns to identify if some could bias the estimates too much
library(plyr)
library(ggplot2)
df <- melt(ldply(ar, data.frame))
df2 <- ddply(df, .variable, function(x) { x$index <- 1:nrow(x); x})
ggplot(df2, aes(index, value, color = variable)) +
  geom_point(size=3) + scale_x_continuous(breaks = seq(1:max(df2$index)))

which(all_ars<-(-0.1), arr.in=TRUE)
which(all_ars>0.1, arr.in=TRUE)
all_ars=c(-41,60)
#-> event nr 60, 41 are outliers (<-0.1), event nr 60 is an extreme outlier (<-0.4)-> delete event 60
all_ars=all_ars[-60]
all_ars_adj=all_ars_adj[-60]

# Cumulative abnormal returns
car=rowSums(all_ars_adj)
car1=all_ars_adj[,1]
car2=rowSums(all_ars_adj[,1:2])
car3=rowSums(all_ars_adj[,1:3])
car4=rowSums(all_ars_adj[,1:4])
car5=rowSums(all_ars_adj[,1:5])
car6=rowSums(all_ars_adj[,1:6])
car7=rowSums(all_ars_adj[,1:7])
car_daily=cbind(car1,car2,car3,car4,car5,car6,car7)

# Average abnormal return
aar=colMeans(all_ars_adj)
aar

# cumulative average abnormal return
caar=sum(aar)
caar2=mean(car)
caar==caar2 # should be the same. Returns FALSE nevertheless (rounding error)
caar

# calculate cumulative abnormal return over days (for graph)
caar1=aar[1]
daily_caar=c(caar1,caar2,caar3,caar4,caar5,caar6,caar7)
daily_caar

# significance tests, Kliger/Gurevich, p.55 ff.:
# variance of CAR_i: (t-s+1)sigma2_i (t-s = event window days)
# variance of CAAAR=((t-s+1)/(n^2))*SUM(sigmahat2_i)
# sigma from sample variance of benchmark model
# TS= CAAAR_hat/((1/n)*sqrt((t-s+1)*SUM(sigmahat2_i)))-- standard normal distribution
# note: ARs over estimation window equal residuals (their mean is zero per definition)
# for full CAAAR
n=length(all_ars[,1])
t=7
s=0
sigma2hat=NULL
for (i in 1:length(returns[,1])) {
  sigma2hat[[i]]=(1/(length(estimates[[i]]$residuals)-1))*(estimates[[i]]$residuals^2)
}
sigma2hat_sum=do.call(sum, sigma2hat)
TS = caar/((1/n)*sqrt((t-s+1)*sigma2hat_sum))
TS
p=2*pt(TS, estimates[[1]]$df.residual)
p
# caar for sumulative days of event window
t_v=1:7
caar_v=daily_caar
TS_v=caar_v/((1/n)*sqrt((t_v-s_v+1)*sigma2hat_sum))
TS_v
p_v_positive=2*pt(TS_v,estimates[[1]]$df.residual, lower.tail=FALSE)
p_v_negative=2*pt(TS_v,estimates[[1]]$df.residual)
p_v_negative

# Wilcoxon signed-rank test (non-parametric), Holler p.124 f
# omit zeros of cars as wilcoxon signed rank test is wrongly specified with zeros
car1[car1==0]<-NA
car2[car2==0]<-NA
car3[car3==0]<-NA
car4[car4==0]<-NA
car5[car5==0]<-NA
car6[car6==0]<-NA
car7[car7==0]<-NA

wilcox1= wilcox.test(car1)
wilcox2 = wilcox.test(car2)
wilcox3= wilcox.test(car3)
wilcox4= wilcox.test(car4)
wilcox5= wilcox.test(car5)
wilcox6= wilcox.test(car6)
wilcox7= wilcox.test(car7)
c(wilcox1$p.value,wilcox2$p.value,wilcox3$p.value,wilcox4$p.value,wilcox5$p.value,wilcox6$p.value,wilcox7$p.value)
c(wilcox1$statistic,wilcox2$statistic,wilcox3$statistic,wilcox4$statistic,wilcox5$statistic,wilcox6$statistic,wilcox7$statistic)

# plot of daily CAARs
time=seq(-3,3)
plot(time,daily_caar,type="l",
    xlab="",ylab="Cumulative average abnormal return",
    axes=F, col="blue")
lines(c(-4,3),c(0,0),lty="dotted")
mtext("Figure 16: CAAR for 58 Fossil Fuel Divestment Announcements",cex=1.2,line=1.5,adj=0.55,font=2)

# confidence intervals for plot
sigma_caar_v=sqrt(((t_v-s_v+1)/(n^2))*sigma2hat_sum)
confidence = -1.64*sigma_caar_v
lines(c(0,0),c(-0.015,0.01),lty="dotted")
text(0,0.0207,"Event day",xpd=TRUE)

# returns in event windows
event.returns=list()
event.returns0=list()
event.returns1=list()
event.returns2=list()
event.returns3=list()
event.returns_1=list()
event.returns_2=list()
event.returns_3=list()

index=1:length(date)
names(index)=date
events_num=list()
events_num1=list()
events_num2=list()
events_num3=list()
events_num_1=list()
events_num_2=list()
events_num_3=list()

for (i in 1:length(returns[1,])) {
    events_num[[i]]=index[as.character(events[[i]])]
    events_num1[[i]]=index[as.character(events[[i]]+1)]
    events_num2[[i]]=index[as.character(events[[i]]+2)]
    events_num_1[[i]]=index[as.character(events[[i]]-1)]
    events_num_2[[i]]=index[as.character(events[[i]]-2)]
    events_num_3[[i]]=index[as.character(events[[i]]-3)]
}
events_num3[[i]]=index(as.character(events[[i]]+3))
events_num_1[[i]]=index(as.character(events[[i]]-1))
events_num_2[[i]]=index(as.character(events[[i]]-2))
events_num_3[[i]]=index(as.character(events[[i]]-3))
}
for (i in 1:length(returns[1,])) {
    event.returns0[[i]]=returns[events_num[[i]],i]
    event.returns1[[i]]=returns[events_num1[[i]],i]
    event.returns2[[i]]=returns[events_num2[[i]],i]
    event.returns3[[i]]=returns[events_num3[[i]],i]
    event.returns_1[[i]]=returns[events_num_1[[i]],i]
    event.returns_2[[i]]=returns[events_num_2[[i]],i]
    event.returns_3[[i]]=returns[events_num_3[[i]],i]
}
for (i in 1:length(returns[1,])) {
    event.returns[[i]]=cbind(event.returns_1[[i]],
        event.returns0[[i]],event.returns1[[i]]))
}

# predicted returns at event window
b0_=NULL
b1_=NULL
b2_=NULL
b3_=NULL
b4_=NULL
b5_=NULL
for (i in 1:length(estimates)) {
    b0_[[i]]=estimates[[i]]$coefficients[1]
    b1_[[i]]=estimates[[i]]$coefficients[2]
    b2_[[i]]=estimates[[i]]$coefficients[3]
    b3_[[i]]=estimates[[i]]$coefficients[4]
    b4_[[i]]=estimates[[i]]$coefficients[5]
    b5_[[i]]=estimates[[i]]$coefficients[6]
}
pr.event.returns=list()
pr.event.returns0=list()
pr.event.returns1=list()
pr.event.returns2=list()
pr.event.returns3=list()
pr.event.returns_1=list()
pr.event.returns_2=list()
pr.event.returns_3=list()
for (i in 1:length(returns[1,])) {
    pr.event.returns0[[i]]=b0_[[i]]+
        b1_[[i]]*FF$RF[events_num[[i]]]+
        b2_[[i]]*FF$Mkt.RF[events_num[[i]]]+
        b3_[[i]]*FF$HML[events_num[[i]]]+
        b4_[[i]]*FF$SMB[events_num[[i]]]+
        b5_[[i]]*FF$oilpricechange[events_num[[i]]]
    pr.event.returns1[[i]]=b0_[[i]]+
        b1_[[i]]*FF$RF[events_num1[[i]]]+
        b2_[[i]]*FF$Mkt.RF[events_num1[[i]]]+
        b3_[[i]]*FF$HML[events_num1[[i]]]+
        b4_[[i]]*FF$SMB[events_num1[[i]]]+
        b5_[[i]]*FF$oilpricechange[events_num1[[i]]]
    pr.event.returns2[[i]]=b0_[[i]]+
        b1_[[i]]*FF$RF[events_num2[[i]]]+
        b2_[[i]]*FF$Mkt.RF[events_num2[[i]]]+
        b3_[[i]]*FF$HML[events_num2[[i]]]+
        b4_[[i]]*FF$SMB[events_num2[[i]]]+
        b5_[[i]]*FF$oilpricechange[events_num2[[i]]]
    pr.event.returns3[[i]]=b0_[[i]]+
}
\begin{verbatim}
# abnormal returns
ar=list()
for (i in 1:length(returns[1,])) {
    ar[[i]]=event.returns[i]-pr.event.returns[i]
}

# replace NAs with zeros to be able to show graph later
# (justified as abnormal returns are expected to be zero)
ar_adj=list()
for (i in 1:length(returns[1,])) {
    ar_adj[[i]] = ar[[i]]
ar_adj[[i]][is.na(ar[[i]])] = 0
}

# change observation unit from firm level to event level
all_ars=NULL
all_ars_adj=NULL
for(i in 1:length(returns[1,])) {
    all_ars=rbind(all_ars, matrix(t(ar[[i]]), ncol=3, byrow=T))
    all_ars_adj=rbind(all_ars_adj, matrix(t(ar_adj[[i]]), ncol=3, byrow=T))
}

# look at abnormal returns to identify if some could bias the estimates too much
library(plyr)
library(ggplot2)
library(reshape2)
df <- melt(ldply(ar, data.frame))
df2 <- ddply(df, .(variable), function(x) { x$index <- 1:nrow(x); x})
ggplot(df2, aes(index, value, color = variable)) +
  geom_point(size=3) + scale_x_continuous(breaks = seq(1:max(df2$index)))

which(all_ars<-(-0.1))
which(all_ars>0.1)
all_ars[41,]

#-- event nr 60, 41 are outliers (<-0.1), event nr 60 is an extreme outlier (<-0.4)-- delete event 60
\end{verbatim}
all_ars=all_ars[-60,]
all_ars_adj=all_ars_adj[-60,]

# Cumulative abnormal returns
car=rowSums(all_ars_adj)
car1=all_ars[,1]
car2=rowSums(all_ars_adj[,1:2])
car3=rowSums(all_ars_adj[,1:3])
car_daily=cbind(car1,car2,car3)
car_daily

# Average abnormal return
aar=colMeans(all_ars_adj)
aar

# cumulative average abnormal return
caar=sum(aar)
caar2=mean(car)
caar==caar2 # should be the same. Returns FALSE nevertheless (rounding error)
caar

# calculate cumulative abnormal return over days (for graph)
caar1=aar[1]
daily_caar=c(caar1,caar2,caar3)
daily_caar

# significance tests, Kliger/Gurevich, p.55 ff.:
# variance of CAR_i: (t-s+1)sigma2_i (t-s = event window days)
# variance of CAAR=((t-s+1)/(n^2))*SUM(sigmahat2_i)
# sigma from sample variance of benchmark model
# TS= CAAR_hat/((1/n)^sqrt((t-s+1)*SUM(sigmahat2_i)))-- standard normal distribution
# note: ARs over estimation window equal residuals (their mean is zero per definition)
# for full CAAR
n=length(all_ars[,1])
t=3
s=0
sigma2hat=NULL
for (i in 1:length(returns[,1])) {
    sigma2hat[[i]]=(1/(length(estimates[[i]]$residuals)-1))*(estimates[[i]]$residuals^2)
}
sigma2hat_sum=do.call(sum, sigma2hat)
TS = caar/((1/n)^sqrt((t-s+1)*sigma2hat_sum))
TS
p=2*pt(TS, estimates[[1]]$df.residual)
p

# caar for cumulative days of event window
t_v=1:3
s_v=rep(0,3)
caar_v=daily_caar
tS_v=caar_v/(1/n)^sqrt((t_v-s_v+1)*sigma2hat_sum)
TS_v
p_negative=2*pnorm(TS_v)
p_v_positive=2*pt(TS_v,estimates[[1]]$df.residual, lower.tail=FALSE)
p_v_negative=2*pt(TS_v,estimates[[1]]$df.residual)
p_v_negative

# Wilcoxon signed-rank test (non-parametric), Holler p.124 f.
# delete zero values as wilcoxon signed rank test does not allow for zeros
car1[car1==0]<-NA
car2[car2==0]<-NA
car3[car3==0]<-NA
wilcox1=wilcox.test(car1)

XXXIV
wilcox2 = wilcox.test(car2)
wilcox3 = wilcox.test(car3)
c(wilcox1$p.value, wilcox2$p.value, wilcox3$p.value)
c(wilcox1$statistic, wilcox2$statistic, wilcox3$statistic)

# plot of daily CAARs
time = seq(-1, 1)
plot(time, daily_caar, type = "l",
     xlim = c(-1.1, 1), ylim = c(-.01, .0075),
     lwd = 2, xlab = "",
     ylab = "Cumulative average abnormal return",
     axes = F, col = "blue")
lines(c(-1, 1), c(0, 0), lty = "dotted")
mtext("Figure 15: CAAR for 58 Fossil Fuel Divestment Announcements", line = 1.5, adj = -.53, font = 2, cex = 1.2)

# confidence intervals for plot
sigma_caar_v = sqrt(((t_v - s_v + 1) / (n^2)) * sigma2hat_sum)
confidence = -1.96 * sigma_caar_v
lines(c(-1:1, confidence), col = "red", lty = 2)
lines(c(0, 0), c(-0.015, 0.005), lty = "dotted")
mtext("Event Window from 1 day before to 1 day after announcement of divestment", adj = -.5, font = 2)
axis(1, at = c(-1, 0, 1), cex.axis = .9)
axis(2, at = c(-0.01, -0.005, 0, 0.005),
     lab = c("-1pp", "-5pp", "0", "5pp"), las = 1,
     cex.axis = .9)
text(0, -.013, "Event day", xpd = TRUE)

Appendix C2: Event Study, Sector-Wide Analysis (R-Code)

# loop with i firms
# Divestment declaration dates including KLP divestment
# read data
declarations = read.csv("deci_decla_all divestors.csv", header = TRUE, quote = "", stringsAsFactors = TRUE, check.names = TRUE)
data = read.csv("divest_returns and FF.csv", header = TRUE, quote = "", stringsAsFactors = TRUE, check.names = TRUE)
returns = data[, 2:181]
FF = data[, 188:193]
date = as.Date(data$..date, format = "%Y-%m-%d")
event_dates = as.Date(declarations$declaration, format = "%Y-%m-%d")[-49]

# estimate normal returns (2009 to end of 2012)
# as the missings are distributed in a way that lm is impossible, I use multiple imputation (predictive mean matching)
reg_data = data.frame(returns, FF)
library(mice)
impote = mice(reg_data, m = 5, method = "pmm")
reg_data = complete(impote)
colSums(is.na(reg_data))

# delete returns of firms who still have missings
reg_data = reg_data[,-c(104, 131, 146)]

# delete the same columns in the return dataset (dataset without imputation) to have same columns
returns = returns[,-c(104, 131, 146)]
estimates = list()
for(i in 1:length(returns[1,])) {
    estimates[[i]] <- lm(reg_data[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d"), i) ~
                 reg_data$RF[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d")]) +
                 reg_data$SHM[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d")) +
                 reg_data$Mkt_RF[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d")]) +
                 reg_data$HML[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d")]) +
                 reg_data$SMB[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d")]) +
                 reg_data$oilpricechange[, Date("2009-01-01", format="%Y-%m-%d") < date & date < as.Date("2013-01-01", format="%Y-%m-%d")])
}

# create a variable which gives the row of the event date in the return dataset
index=1:length(date)
names(index)=date
events_num=list()
for (i in 1:length(event_dates)) {
    events_num[[i]]=index[as.character(event_dates[i])]
}

# check--works
event_dates[76]==date[events_num[[76]]]
events_num=unlist(events_num, use.names=FALSE)

# creating matrices for the event window returns around all events
# (i= event dates, column=firm, row=return at day of event window for all divestment events)
event.returns=NULL
event.returns0=NULL
event.returns1=NULL
event.returns2=NULL
event.returns3=NULL
event.returns_1=NULL
event.returns_2=NULL
event.returns_3=NULL
for (i in 1:length(retu

# predicted returns at event window
b0_=NULL
b1_=NULL
b2_=NULL
b3_=NULL
b4_=NULL
b5_=NULL

for (i in 1:length(estimates)) {
    b0_[[i]]=estimates[[i]]$coefficients[1]
    b1_[[i]]=estimates[[i]]$coefficients[2]
    b2_[[i]]=estimates[[i]]$coefficients[3]
for (i in 1:length(returns[1,])) {
    pr.event.returns0[[i]]=b0_0[i]+b1_0[i]*RF[index[as.character(event_dates)]]+
    b2_0[i]*Mkt.RF[index[as.character(event_dates)]]+
    b3_0[i]*HML[index[as.character(event_dates)]]+
    b4_0[i]*SMB[index[as.character(event_dates)]]+
    b5_0[i]*oilpricechange[index[as.character(event_dates)]]
    pr.event.returns1[[i]]=b0_1[i]+b1_1[i]*RF[index[as.character(event_dates+1)]]+
    b2_1[i]*Mkt.RF[index[as.character(event_dates+1)]]+
    b3_1[i]*HML[index[as.character(event_dates+1)]]+
    b4_1[i]*SMB[index[as.character(event_dates+1)]]+
    b5_1[i]*oilpricechange[index[as.character(event_dates+1)]]
    pr.event.returns2[[i]]=b0_2[i]+b1_2[i]*RF[index[as.character(event_dates+2)]]+
    b2_2[i]*Mkt.RF[index[as.character(event_dates+2)]]+
    b3_2[i]*HML[index[as.character(event_dates+2)]]+
    b4_2[i]*SMB[index[as.character(event_dates+2)]]+
    b5_2[i]*oilpricechange[index[as.character(event_dates+2)]]
    pr.event.returns3[[i]]=b0_3[i]+b1_3[i]*RF[index[as.character(event_dates+3)]]+
    b2_3[i]*Mkt.RF[index[as.character(event_dates+3)]]+
    b3_3[i]*HML[index[as.character(event_dates+3)]]+
    b4_3[i]*SMB[index[as.character(event_dates+3)]]+
    b5_3[i]*oilpricechange[index[as.character(event_dates+3)]]
    pr.event.returns_1[[i]]=b0_1[i]+b1_1[i]*RF[index[as.character(event_dates-1)]]+
    b2_1[i]*Mkt.RF[index[as.character(event_dates-1)]]+
    b3_1[i]*HML[index[as.character(event_dates-1)]]+
    b4_1[i]*SMB[index[as.character(event_dates-1)]]+
    b5_1[i]*oilpricechange[index[as.character(event_dates-1)]]
    pr.event.returns_2[[i]]=b0_2[i]+b1_2[i]*RF[index[as.character(event_dates-2)]]+
    b2_2[i]*Mkt.RF[index[as.character(event_dates-2)]]+
    b3_2[i]*HML[index[as.character(event_dates-2)]]+
    b4_2[i]*SMB[index[as.character(event_dates-2)]]+
    b5_2[i]*oilpricechange[index[as.character(event_dates-2)]]
    pr.event.returns_3[[i]]=b0_3[i]+b1_3[i]*RF[index[as.character(event_dates-3)]]+
    b2_3[i]*Mkt.RF[index[as.character(event_dates-3)]]+
    b3_3[i]*HML[index[as.character(event_dates-3)]]+
    b4_3[i]*SMB[index[as.character(event_dates-3)]]+
    b5_3[i]*oilpricechange[index[as.character(event_dates-3)]]
    pr.event.returns[[i]]=cbind(pr.event.returns_3[[i]],
                      pr.event.returns_2[[i]],pr.event.returns_1[[i]],
                      pr.event.returns1[[i]],pr.event.returns2[[i]],pr.event.returns3[[i]])
}
for (i in 1:length(returns[1,])) {
    ar[[i]] = event.returns[[i]] - pr.event.returns[[i]]
}

# replace NAs with zeros to be able to show graph later
# justified as abnormal returns are expected to be zero
ar_adj = list()
for (i in 1:length(returns[1,])) {
    ar_adj[[i]] = ar[[i]]
    ar_adj[[i]][is.na(ar[[i]])] = 0
}

# AARs
sum_ar_firms = Reduce('+', ar_adj)
aar_matrix = sum_ar_firms / 177

# look at abnormal returns to identify if some could bias the estimates too much
library(plyr)
library(ggplot2)
library(reshape2)
df <- melt(lapply(aar_matrix, data.frame))
df2 <- ddply(df, .(variable), function(x) { x$index <- 1:nrow(x); x })
ggplot(df2, aes(index, value, color = variable)) + geom_point(size=3) + scale_x_continuous(breaks = seq(1:max(df2$index)))

which(aar_matrix < (-0.03), arr.in=TRUE)

# event 46 (divestment of City of Münster) has an overly negative abnormal
# return as compared to the rest of the dates on the last event day (24.8.2015, general stock market crash)

# --> event nr 46 is an extreme outlier --> delete it
aar_matrix = aar_matrix[-46,]
aar = colMeans(aar_matrix)
aar = sum(aar)

# CARS (used for wilcoxon test later)
# also delete 46th event
ar[[46]] <- NULL
ar_adj[[46]] <- NULL
all_ars_m = NULL
all_ars_adj_m = NULL
for (i in 1:176) {
    all_ars_m = rbind(all_ars_m, matrix(t(ar[[i]]), ncol=7, byrow=T))
    all_ars_adj_m = rbind(all_ars_adj_m, matrix(t(ar_adj[[i]]), ncol=7, byrow=T))
}

car = rowSums(all_ars_adj_m)
car1 = all_ars_m[,1]
car2 = rowSums(all_ars_adj_m[,1:2])
car3 = rowSums(all_ars_adj_m[,1:3])
car4 = rowSums(all_ars_adj_m[,1:4])
car5 = rowSums(all_ars_adj_m[,1:5])
car6 = rowSums(all_ars_adj_m[,1:6])
car7 = rowSums(all_ars_adj_m[,1:7])
car_daily = cbind(car1, car2, car3, car4, car5, car6, car7)

# calculate cumulative abnormal return over days (for graph)
caar1 = aar[1]

daily_caar = c(caar1, caar2, caar3, caar4, caar5, caar6, caar7)
daily_caar

# significance tests, clustered standard errors based on a simplified version
# of "crude dependence adjustment" (Brown Warner 1980), "cross-sectional aggregation" (Bernard 1987)
# and "portfolio approach" MacKinley 1997, see Kliger/Gurevich, p.66 ff. and Kothari/Warner 2007

# generate series of estimated ARs over event and estimation window
ar_event.window = ar
ar_estimation.window = list()
for (i in 1:length(estimates)) {
  ar_estimation.window[[i]] = estimates[[i]]$residuals
}

ar_estimation.window.adj = list()
for (i in 1:length(returns[1,])) {
  ar_estimation.window.adj[[i]] = ar_estimation.window[[i]]
  ar_estimation.window.adj[[i]][is.na(ar_estimation.window[[i]])] = 0
}

aar_event.window = aar_matrix
# firm number 127 somehow does not have estimates for all residuals and is hence excluded
aar_estimation.window.adj = ar_estimation.window.adj[-127]

aar_bar = sum(aar_estimation.window[length(aar_estimation.window)]

sigma2 = 1/length(aar_estimation.window)*sum(aar_estimation.window-aar_bar)^2
sigma = sqrt(sigma2)

caar_hat = daily_caar
t.minus.s = -1:7
sigma2_caar = (t.minus.s + 1)*sigma2
sigma_caar = sqrt(sigma2_caar)

# test statistics which is normally distributed for long estimation window (which I have)
TS = caar_hat/sigma_caar

p = 2*pnorm(TS)
p

# wilcoxon signed rank test
# delete zeros as wilcoxon test does not allow for zeros
# (and those zeros stand for NAs anyways)

wilcox1 = wilcox.test(car1)
wilcox2 = wilcox.test(car2)
wilcox3 = wilcox.test(car3)
wilcox4 = wilcox.test(car4)
wilcox5 = wilcox.test(car5)
wilcox6 = wilcox.test(car6)
wilcox7 = wilcox.test(car7)
c(wilcox1$statistic, wilcox2$statistic, wilcox3$statistic, wilcox4$statistic, wilcox5$statistic, wilcox6$statistic, wilcox7$statistic)
c(wilcox1$p.value, wilcox2$p.value, wilcox3$p.value, wilcox4$p.value, wilcox5$p.value, wilcox6$p.value, wilcox7$p.value)

# plot of daily CAARs

time = seq(-3, 3)
plot(time, daily_caar, type = "l",

XXXIX
# confidence intervals for plot
confidence = -1.96*sigma_caar
lines(c(-3.3:3.confidence),col="red",lty=2)
lines(c(0,0),c(-0.01,0.003),lty="dotted")

ttext(3.confidence[7]-0.004,labels="95% confidence interval",col="red")

ttext(0,0.0067,"Event day",xpd=TRUE)
axis(1,at=c(-3,-2,-1,0,1,2,3),las=1, cex.axis=.9)
axis(2,at=c(-.5,-.4,-.3,-.2,-.1,0,.1,.2,.3),las=1, cex.axis=.9)

# 3 DAY EVENT WINDOW ##
# Predicted returns at event window
b0_ =NULL
b1_ =NULL
b2_ =NULL
b3_ =NULL
b4_ =NULL
b5_ =NULL

for (i in 1:length(estimates)) {
   b0_[[i]] = estimates[[i]]$coefficients[1]
b1_[[i]] = estimates[[i]]$coefficients[2]
b2_[[i]] = estimates[[i]]$coefficients[3]
b3_[[i]] = estimates[[i]]$coefficients[4]
b4_[[i]] = estimates[[i]]$coefficients[5]
b5_[[i]] = estimates[[i]]$coefficients[6]
}

pr.event.returns=NULL
pr.event.returns0=NULL
pr.event.returns1=NULL
pr.event.returns2=NULL
pr.event.returns3=NULL
pr.event.returns_1=NULL
pr.event.returns_2=NULL
pr.event.returns_3=NULL

for (i in 1:length(returns[1,])) {
   event.returns0[i]=returns[index(as.character(event_dates)),i]
event.returns1[i]=returns[index(as.character(event_dates+1)),i]
event.returns2[i]=returns[index(as.character(event_dates+2)),i]
event.returns3[i]=returns[index(as.character(event_dates+3)),i]
event.returns_1[i]=returns[index(as.character(event_dates-1)),i]
event.returns_2[i]=returns[index(as.character(event_dates-2)),i]
event.returns_3[i]=returns[index(as.character(event_dates-3)),i]
event.returns[[i]]=cbind(event.returns_1[[i]],event.returns0[[i]],
event.returns1[[i]])
}

XL
for (i in 1:length(returns[1,])) {
    pr.event.returns0[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates)]]
    pr.event.returns1[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates+1)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates+1)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates+1)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates+1)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates+1)]]
    pr.event.returns2[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates+2)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates+2)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates+2)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates+2)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates+2)]]
    pr.event.returns3[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates+3)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates+3)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates+3)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates+3)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates+3)]]
    pr.event.returns_1[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates-1)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates-1)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates-1)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates-1)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates-1)]]
    pr.event.returns_2[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates-2)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates-2)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates-2)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates-2)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates-2)]]
    pr.event.returns_3[[i]] = b0[[i]] +
    b1[[i]] * FF$RF[index[as.character(event_dates-3)]] +
    b2[[i]] * FF$Mkt.RF[index[as.character(event_dates-3)]] +
    b3[[i]] * FF$HML[index[as.character(event_dates-3)]] +
    b4[[i]] * FF$SMB[index[as.character(event_dates-3)]] +
    b5[[i]] * FF$oilpricechange[index[as.character(event_dates-3)]]
    pr.event.returns[[i]] = cbind(pr.event.returns_1[[i]],
    pr.event.returns0[[i]], pr.event.returns1[[i]])
}

# abnormal returns: create a list of matrices, one matrix per targeted company
# each matrix entails 7 columns for the 7 days of the event window and 77 rows for the 77 announcements
ar = list()
for (i in 1:length(returns[1,])) {
    ar[[i]] = event.returns[[i]]- pr.event.returns[[i]]
}

# replace NAs with zeros to be able to show graph later
# justified as abnormal returns are expected to be zero
ar_adj = list()
for (i in 1:length(returns[1,])) {
...
ar_adj[i] = ar[i]
if(is.na(ar[i])) = 0
}

for (i in 1:length(returns[1,])) {
car[i] = sum(ar_adj[i])
}

sum_ar_firms=Reduce('+',ar_adj)
aar_matrix=sum_ar_firms/177

# look at abnormal returns to identify if some could bias the estimates too much
library(plyr)
library(ggplot2)
library(reshape2)
df <- melt(ldply(aar_matrix, data.frame))
df2 <- ddply(df, .(variable), function(x) { x$index <- 1:nrow(x); x})
ggplot(df2, aes(index, value, color = variable)) + geom_point(size=3) + scale_x_continuous(breaks = seq(1:max(df2$index)))

which(aar_matrix<-0.03, arr.in=TRUE)
aar=colMeans(aar_matrix)
aar
caar=sum(aar)
caar

# CARS (used for wilcoxon test later)
# also delete 46th event
ar[46]<-NULL
ar_adj[46]<-NULL
all_ars_m=NULL
all_ars_adj_m=NULL
for(i in 1:176) {
all_ars_m=rbind(all_ars_m, matrix(t(ar[i]), ncol=3, byrow=T))
all_ars_adj_m=rbind(all_ars_adj_m, matrix(t(ar_adj[i]), ncol=3, byrow=T))
}

car=rowSums(all_ars_adj_m)
car1=all_ars_m[,1]
car2=rowSums(all_ars_adj_m[,1:2])
car3=rowSums(all_ars_adj_m[,1:3])
car_daily=cbind(car1,car2,car3)

daily_caar=aar[1]
daily_caar

daily_caar

daily_caar

daily_caar

# significance tests, clustered standard errors based on a simplified version
# of "crude dependence adjustment" (Brown Warner 1980), "cross-sectional aggregation" (Bernard 1987)
# and "portfolio approach" MacKinley 1997, see Kliger/Gurevich, p.66 ff. and Kothari/Warner 2007

# generate series of estimated ARs over event and estimation window
ar_event.window=ar
ar_estimation.window=list()
for(i in 1:length(estimates)) {
ar_estimation.window[[i]]=estimates[[i]]$residuals
}
ar_estimation.window.adj=list()
for (i in 1:length(returns[1,])) {

XLII
ar_estimation.window.adj[[i]] = ar_estimation.window[[i]]
ar_estimation.window.adj[[i]][is.na(ar_estimation.window[[i]])] = 0
}

aar_event.window=aar_matrix

# firm number 127 somehow does not have estimates for all residuals and is hence excluded
ar_estimation.window.adj=ar_estimation.window.adj[-127]
ar_estimation.window=ar_estimation.window[-127]

sum_ar_estimation.window=Reduce('+',ar_estimation.window)
aar_estimation.window=sum_ar_estimation.window/length(ar_estimation.window)
aar_bar=sum(aar_estimation.window[-1]/length(aar_estimation.window))
sigma2=1/length(aar_estimation.window)*sum(aar_estimation.window-aar_bar)^2
sigma=sqrt(sigma2)
aar_hat=daily_caar
t.minus.s=1:3

sigma2_caar=(t.minus.s+1)*sigma2
sigma_caar=sqrt(sigma2_caar)

# test statistics which is normally distributed for long estimation window (which I have)
TS=aar_hat/sigma_caar
TS
p=2*pnorm(TS)
p

# wilcoxon signed rank test
# delete zeros as wilcoxon test does not allow for zeros
(and those zeros stand for NAs anyways)
car1[car1==0] <- NA
car1[car2==0] <- NA
car1[car3==0] <- NA
car1[car4==0] <- NA
car1[car5==0] <- NA
car1[car6==0] <- NA
car1[car7==0] <- NA

wilcox1=wilcox.test(car1)
wilcox2=wilcox.test(car2)
wilcox3=wilcox.test(car3)
wilcox4=wilcox.test(car4)
wilcox5=wilcox.test(car5)
wilcox6=wilcox.test(car6)
wilcox7=wilcox.test(car7)
c(wilcox1$p.value,wilcox2$p.value,wilcox3$p.value,wilcox4$p.value,wilcox5$p.value,wilcox6$p.value,wilcox7$p.value)

# plot of daily CAARs

time=seq(-1,1)
plot(time,daily_caar,type="l", xlim=c(-1,1.2),ylim=c(-.003,.004), lwd=2, xlab="", ylab="Cumulative average abnormal return", axes=F, col="blue")
lines(c(-1.2,1),c(0,0),lty="dotted")
mtext("Figure 17: CAAR (Sector-Wide) for 76 Fossil Fuel Divestment Announcements",line=1.5,adj=2.15,font=2,cex=1.2)

# confidence intervals for plot
confidence = -1.96*sigma_caar
lines(-1:1,confidence, col="red",lty=2)
lines(c(0,0),c(-0.01,0.003),lty="dotted")
text(1,confidence[3],"95% confidence interval",col="red",xpd=TRUE)
text(1,confidence[4],"Event Window from 1 Day before to 1 Day after Announcement to Divest", font=2,adj=-.45)
axis(1,at=c(-1,0,1),cex.axis=.9)
axis(2, at=c(-0.003,-0.002,-0.001,0.001,0.002,0.003), las=1, cex.axis=.9)
Appendix C3: Latent Growth Curve Model (Mplus Code)

The code is provided for Model 1. The code of the other models just exchanges the variable dec (= cumulated divestment announcement) with the cumulated dollar sum divested or includes further variables.

TITLE: Latent Growth Analysis Divestment
DATA: file = C:\Users\Alison Schultz\Documents\Studium\R\data\lgm_mp.dat;
VARIABLE: names = id coal
time time2
time3 time4
ri ril
de dec
am amc
si sic
fin pub
rf mkf
hml smb
oil;
usevar = ril
time time2
time3 rf
mkf
hml smb
oil coal
dec;
cluster = id;
within = time time2
time3 rf
mkf
hml
tsmb
oil
dec;
between = coal;
missing = all(-999);
ANALYSIS: type = twolevel random;
estimator = mlr;
processors = 4;
MODEL: %within%
b_time | ril on time;
b_time2 | ril on time2;
b_time3 | ril on time3;
b_rf | ril on rf;
b_mkf | ril on mkf;
b_oil | ril on oil;
ril on hml;
ril on smb;
ril on dec;
%between%
rii with b_time;
rii with b_time2;
rii with b_oil;
b_time on coal;
b_time2 on coal;
b_time3 on coal;
b_oil on coal;
OUTPUT: sampstat;
modindices(3.84);
SAVEDATA: RESULTS ARE "C:\Users\Alison Schultz\Documents\Studium\Mplus\data\res2.csv";