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Master Thesis

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Net Zero climate alliances of financiers and carbon emission in the real world

submitted by

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List of Abbreviations

CCUS Carbon capture, utilisation and storage

ESG environmental, social and governance

GCPFT Global Coal Project Finance Tracker

GCPT Global Coal Plant Tracker

GEM Global Energy Monitor

GHG greenhouse gas

GIIN Global Impact Investing Network

IAD Institutional Analysis and Development

SFI Sustainable Finance and Investment

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Abstract

In the context of the climate crisis and the prospect that the finance industry can guide a transition towards sustainability, research on the effectiveness of Sustainable Finance and Investment practices (SFI) in reducing real-world greenhouse gas (GHG) emissions is needed. To find indications for real-word impact of the finance industry, I investigate the influence of the membership of a financier in a climate alliance on the GHG emissions of a coal-fired power plant unit where the financier is invested in. Through conducting a regression analysis, i investigate correlations between the membership in a climate alliance and the emissions or the lifetime of a coal-fired power plant unit financed by an alliance member. The results are unexpected, puzzling and contradicatory to a certain degree. While the membership in climate alliances still has potential, there is no proof for real-world emission reductions so far. These findings are in line with recent literature and highlight the difficulties of measuring impact and the need for accurate and robust data. More research is needed to unambiguously classify the possibilities of the finance industry to guide a transition of our economies towards sustainability.

1 Introduction

We live in an age of multiple crises, and the climate crisis is one of the biggest challenges of all. The IPCC report (2023) clearly reveals the necessity for a global shift towards more sustainable economies, otherwise the goal of the Paris Agreement, to keep global temperature rise well below 2°C compared to preindustrial levels, cannot be achieved (UNFCCC, 2015). In recent years, the financial sector gained attention as a possible contributor to a green transformation. Transformations are characterised by multi-level perspectives (Geddes & Schmidt, 2020) and as systematic intermediaries, financial institutions can drive this transformation through Sustainable Finance and Investment (SFI) practices (Dordi et al., 2022). SFI represents different concepts of investing with (an additional) non-financial purpose that is oriented towards environmental, social and governance (ESG) criteria (Cunha et al., 2021; Busch et al., 2021; Kölbel et al., 2020).

One of the core questions for research on SFI is whether financial institutions can really have an impact in the real world through their investment choices or not. This question is the subject of an ongoing scientific, practitioners and public debate:
Whereas many financial institutions claim to have a positive impact on climate change, a (causal) relation between the financial system and greenhouse gas (GHG) emission reductions in the real-world is not yet established convincingly. The main problem is that most instruments provably green the portfolios of the investors, but not necessarily reduce emissions in the real world. When investors divest from high emitting companies, for example, other capital sources might step in to finance the polluting company, allowing it to continue to emit. The underlying emissions have not been reduced but are attributed to another polluter. Practitioners call this "virtual impact" (Koliaï et al., 2022), as the difference in emission output is solely virtually in the portfolios of the investors. To have a real impact, financial decisions must lead to measurable GHG emission reductions in the real world. The lack of scientific contributions elaborating on virtual vs. real-world impact exacerbates the blurriness of the field and the need for more research in this regard. Unfortunately, publicly available data on GHG emission is rare and the methodology how it was gathered is often untransparent, as emission reporting is still voluntary. Moreover, there are no well-established frameworks to measure and compare impact of SFI practices and make it ponderable.

As increasing numbers of stakeholders in the SFI sector have recognized the urgency with which climate change must be combated, new initiatives emerged to promote SFI: So-called Net Zero climate alliances address the climate change through promoting sustainability among their members and enhancing cooperation and coordination. They advocate for a whole economy strategy that prioritizes integrating ESG considerations into the core of finance. To do so, the alliances provide their members with resources and guidance on the possibilities of the SFI sector to guide a just transition towards greener economies (Caldecott et al., 2022b).
Stakeholders, such as financial institutions or investors, become alliance members by signing a commitment that demonstrates their motivation. As members, they are then obliged to align their portfolios with the alliance's commitments. Commitments often represent international Net Zero targets that require to reduce GHG emissions as drastically as possible by 2050 or 2030 and compensate for the emissions that remain (Caldecott et al., 2022a). Most climate alliances promote that their members are generating an impact and contribute to real-world emission reduction. Unfortunately, proof for this real-world impact of those climate alliances is limited to reports published by the alliances themselves (UNEP, 2022, 2023; Climate Action 100+, 2023). External verification is missing.

So far, there is little research on the impact of SFI practices and literature still focuses a lot on definitions. Following Schoenmaker & Schramade (2021), SFI practices can be divided into four stages: The status quo is finance as usual, where the only value created by an investment is the shareholder value. In SFI 1.0 individual investors avoid companies with a very negative impact. During the second stage, SFI 2.0, social and environmental externalities are explicitly considered by financial institutions. The value created also includes stakeholders (not only shareholders). And in the third phase, SFI 3.0, finance is understood as an instrument to nourish a sustainable development creating value as a common good. The important change between SFI 2.0 and SFI 3.0 is the shift from avoiding negative externalities towards the idea of having an impact in the real world leading to more sustainable economies. In SFI 3.0 investors foster changes in the performance of an enterprise through their investment practices. These changes lead to more eco-friendly production patterns and GHG emission reductions (Busch et al., 2021). This form of investing with (an additional) non-financial impact is called impact investing.

Still, general frameworks to classify investments as impact generating or not are rare. This thesis is motivated by the lack of evidence in this regard. Research on the effectiveness of climate alliances and other SFI practices is needed to be transparent to investors and the public and to give financial institutions the opportunity to act in an impact-oriented way (Koliaï et al., 2022).

While not claiming any causal effect, my thesis provides a further understanding of the issue by addressing the question: **What influence does the membership of a financier in a climate alliance have on the GHG emissions of a coal-fired power plant unit that the financier finances?** I contribute to the field by elaborating a way to measure the impact of SFI in the real-world through a quantitative study. Even if the word 'impact' communicates a causal and measurable relation between an action and an outcome, I aim to identify correlations. A causal relation between investments and real world GHG emissions is hard to establish. Identifying correlations is a first step in examining whether there are any relationships at all between the actions of financiers and GHG emissions in the real economy.
Using multiple linear regression, I perform a cross sectional analysis to identify if there is a significant correlation between the membership of a financier in a climate alliance and lower GHG emissions or a shorter lifetime of a coal-fired power plant unit the financier invested in. As database I use two data-sets provided by the Global Energy Monitor. They provide information on worldwide coal-fired power plant units producing 30 megawatts and above and their finances. Additionally, I build up a data-set including information on the membership of financial institutions in climate alliances.

The remainder of this thesis is structured as follows: In section two, I assess the related literature, addressing important contributions to the research field, and clarifying definitions. Section three builds the theoretical basis of the analysis and names hypotheses. Section four presents the data and methods used for my analysis, followed by the results in section five. Then, I discuss my contributions to the state of the art and address limitations and weaknesses of the present analysis in section six, concluding in the last section.

2 Related Literature

The problem statement and the objectives of my thesis were outlined in the introduction. In order to deepen these aspects further, the following chapter on relevant literature provides a comprehensive overview of relevant terminologies and theories.

SFI represents different concepts of investing with (an additional) non-financial purpose that is oriented towards ESG criteria, without sacrificing returns (Cunha et al., 2021; Busch et al., 2021; Kölbel et al., 2020). In this thesis, I concentrate on green finance, investigating the influence of the SFI sector on climate change.
The scientific interest in this field grew with the urgency to make existing economic systems more sustainable to counteract a climate catastrophe. First scientific contributions were provided around 1990. According to Kumar et al. (2022), the first article on SFI was published in 1986 by Ferris & Rykaczewski. Kumar et al. (2022) elaborate in detail the different stages and the development of the research field through the use of machine learning techniques. In the earlier years, SFI focused mainly on divestment strategies, which were used against the apartheid regime in South Africa and the tobacco industry, for example (Kölbel et al., 2020). Since then the SFI sector has been growing continuously. In the past decade, several works have been written that trace and explain the development of the SFI field and provide overviews of basic concepts and theories (Schoenmaker & Schramade, 2021; Cunha et al., 2021; Kumar et al., 2022).
There are major differences about what is considered a sustainable investment: In the European context scholars refer to the European Taxonomy for a classification of (un)sustainable investments (Caldecott et al., 2022a), even though it is criticized for the decisions regarding gas and nuclear energy. In line with academic literature (Busch et al., 2021; Kölbel et al., 2020), by using the term sustainable investments or economy I refer to economic activities that embody ESG criteria. Following Busch et al. (2021) and Kölbel et al. (2020), instead of focusing on the evaluation of sustainability criteria, I aim at identifying whether sustainable investment practices really influence GHG emissions and create a real-world impact.
The term “impact investing” describes the idea of investing with an additional impact besides financial performance (SFI 3.0). Since its introduction in 2007 (Bugg-Levine & Emerson, 2011), the idea to use the financing sector to foster a transition towards a more

sustainable economy gained attention in science and business. The topic is relatively young and continuously developing and the concept of impact investing is not yet well specified. Literature still focuses a lot on definitions and terminology (Höchstädter & Scheck, 2015; Clarkin & Cangioni, 2016; Caldecott et al., 2022a; Schoenmaker & Schramade, 2021; Busch et al., 2021; Daggers & Nicholls, 2016).

Recent literature reviews that provide an overview of the development of the impact investing sector and different schools of thought are provided by Höchstädter & Scheck (2015) and Agrawal & Hockerts (2021). Both highlight that even if there are different approaches, some basic agreements exist on what is considered an "impactful investment". According to the Global Impact Investing Network (GIIN) (GIIN, 2019), an impactful investment consists of four basic elements: First, the positive non-financial impact on social or environmental measures generated should be intentional. Second, having some sort of financial return, which can vary between value-preserving and above market rates. Third, impact investments can take place across the whole range of all asset classes. And fourth, the investors are committed to measure and report the performance of their investments on social and environmental progress.

Applied to the framework by Schoenmaker & Schramade (2021), which classifies SFI into four typologies (finance as usual and SFI 1.0 to 3.0), the GIIN definition places impact investing somewhere between SFI 2.0 and 3.0, tending more towards 3.0. As mentioned above, the key difference between SFI 2.0 and 3.0 is the idea of investors having an impact, driving change, and leading their investee towards a more sustainable future. The GIIN requires impact investors to measure and report their social and environmental progress. This indicates that the GIIN believes that investors can have an impact and lead companies, and therefore our economies, in a more sustainable direction as described in SFI 3.0. So far, there is no consensus if any of the elements of the GIINs definition is more important (Agrawal & Hockerts, 2021). Additional terms have been introduced to distinguish between different approaches: Finance-first investors primarily pursue monetary goals, while generating impact is a secondary objective. Impact-first investors are socially motivated and particularly want to make a difference and accept lower monetary returns for it (Busch et al., 2021; Brest & Born, 2013; Höchstädter & Scheck, 2015).

Following Höchstädter & Scheck (2015) by using the term impact investing I refer to the concept of investing with social or environmental impact. The gradation between different approaches such as finance-first or impact-first is left aside for simplicity. More important, the word impact itself needs to be defined to avoid inconsistencies, which is missing in most contributions, making it difficult to compare results and draw conclusions for investors and policy.

The Oxford dictionary paraphrases impact as "the powerful effect that something has on somebody/ something" (Oxford University Press, 2023). Its meaning in the SFI context becomes clearer in delineation of the words output and outcome (see Fig. 1): At the beginning there is an action by investors or financial institutions with the ambition of e.g., meeting climate goals. If the action leads to a change, this is referred to as output. If the concrete activities are measurable, they are referred to as outcome. And if the outcome actually brings about the intended effect, this is referred to as impact (Soline Ralite, 2021).

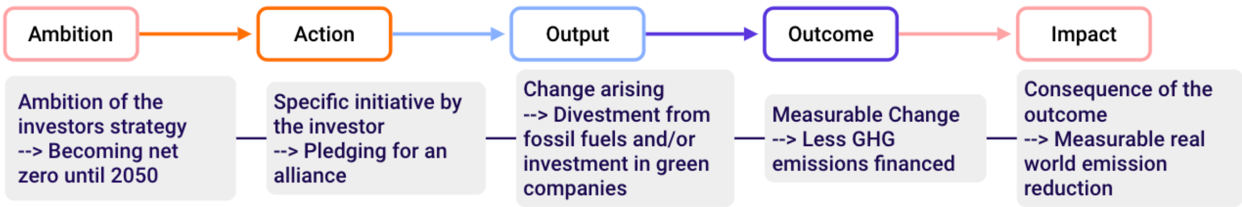

Figure 1: The stages of impact creation. Own representation based on 2Degrees Investing Initiative.

Impact can take place virtually or in the real economy: While real-economy or real-world impact actually has an impact on e.g., GHG emissions by reducing them (e.g. through the use of new technologies or more effective production processes), virtual impact does not have an effect in the real world through emission reductions. It solely reduces the emissions financed by a certain financial institution. With virtual impact, the same emissions are being produced, but they are attributed to a different polluter (Koliaï et al., 2022).

Moreover, a differentiation is drawn between impact-aligned and impact-generating investments. Investments are called impact-aligned when the financed companies are in line with e.g., Net Zero targets (Busch et al., 2022a). The impact has already been achieved by the financed company and was not achieved by the financier (Caldecott et al., 2022b). This is also called company or enterprise impact, as the changes in the real economy are realized by the company, through their products or by changing their production patterns (Kölbel et al., 2020). With impact-generating investments, financiers

themselves create provable effects in the real-economy (Busch et al., 2021). This is also called investor impact, as the investor achieves changes through their investment activities that would not have occurred otherwise (Brest & Born, 2013; Kölbel et al., 2020).
The distinction between different variations of impact is important to secure that effects are not counted twice by attributing them to the project itself and the underlying investment made (Busch et al., 2021). The crux for science and investors is that, whereas it is easier to track and measure the real GHG emissions of a company, it is hard to tell which changes are achieved by a financial institution and would not have occurred without their investment (Cunha et al., 2021). Therefore, SFI experiences the problem of impact washing. Like green washing for companies, impact washing describes the misuse of SFI for marketing purposes without providing investment possibilities that achieve changes in the real economy. This weakens the reputation of SFI (Caldecott et al., 2022a; Busch et al., 2021; Harji & Jackson, 2012; Findlay & Moran, 2019). Hence, it is important to analyse the role of the financial sector in the transformation of our economies and the impact of impact investing.

Research on how financial institutions can have impact on GHG emission reductions is still at the beginning and remains controversial: It is being discussed whether the financial system, whose institutions are designed to maintain existing systems, can foster changes and thus a transition of our economic systems (Schoenmaker & Schramade, 2021; Dordi et al., 2022; Naidoo, 2020).
Most research studies investigate the idea that financial institutions can provide or withdraw liquidity and thus control which companies are active on the market (Dordi et al., 2022; Geddes & Schmidt, 2020; Naidoo, 2020). But research focusing on what exactly this means for investors is rare. Caldecott et al. (2022a) elaborate three transmission mechanisms: Investors can exert influence by 1. Reducing/increasing the cost of capital for companies, 2. Reducing/increasing their access to liquidity, and 3. Influencing corporate practices. This indicates that investors are not able to directly impact ESG metrics: Investors either provide incentives for their investee companies so that these companies improve their measures to reduce GHG emissions. They can also steer the transformation of the economy by pushing the growth of green companies through providing them with liquidity and better financing options. Or, they can limit the success from polluting companies by withholding money (Brest & Born, 2013; Kölbel et al., 2020; IMP, 2019). In

almost all cases, the actual emission reduction is carried out by the company through its production patterns. But it is referred to as investor impact if the driving factor behind the emission reduction is the financial institution financing sustainable or less polluting companies and leading them in a more sustainable direction.

Still, new standardized and comparable schemes to classify impact are needed. According to Busch et al. (2022b), there are two commonly used systems for measuring impact, both developed by the GIIN: The COMPASS methodology (GIIN, 2021) is a tool for investors to assess their portfolio's impact using three analytical metrics: scale, pace, and efficiency. The second, IRIS+ (GIIN, 2023) is a system available for investors to analyse and compare their impact. Once investors identified their goals, IRIS+ provides metrics and indicators to track the development of the investments. The presented two systems are primarily aimed at investors in order to compare the effects of their different investments. Especially the IRIS+ system is suited to the individual goals of the investor and is not suitable to analyse the potential impact of the sustainable finance sector as a whole. Furthermore, neither the COMPASS methodology nor IRIS+ differentiate adequately between investor and company impact, which can lead to overestimation or double accounting of the effects (Busch et al., 2021). As highlighted by Busch et al. (2022a), external verification is needed to unambiguously classify investments as impact-generating and proof the effects of impact investing. Despite their importance for investors, the presented two systems by the GIIN are not suited for a sector analysis of the impact of SFI, which is why I do not use them for my analysis.

Scientific contributions investigating the effectiveness of impact investing are scarce and still primarily focus on how sustainable investment and ESG criteria influence economic performance, but not on their influence on real-world emissions or other ecological impact (Friede et al., 2015; Wagemans et al., 2013; Cunha et al., 2021; Schoenmaker & Schramade, 2021). The majority of studies and tools is addressing investors, leaving the public without any frameworks or devices to assess the impact of SFI. Moreover, studies often solely focus on performance measurement and ESG criteria without the crucial distinction between company impact and investor impact (Busch et al., 2022a). In consequence, financial institutions and investors cannot know if their investment has an impact in the real economy or not and so-called impact investments cannot promise real-world impact (Kölbel et al., 2020).

To analyse the potential effects of impact investing on real-world emissions, data is needed. But as sustainable finance is still a young phenomenon and not yet applied in many regions, it is difficult to find enough suitable data points (Kumar et al., 2022). Moreover, companies applying impact investing rarely track their performance on impact (Schoenmaker & Schramade, 2021). Furthermore, the data to estimate GHG emissions is poor (Hunt & Weber, 2019). In consequence, most studies on impact investing use qualitative assessment methods of investments, quantitative data analysis is rare (Agrawal & Hockerts, 2021).

More research is needed to make the potential effects of so-called impact investing transparent to investors and the public, and to enable financial institutions to act in an impact-oriented way. The majority of literature reviews and papers provide more questions than answers on the topic of impact investing and conclude with a call for research on the effectiveness of so-called green investments (Dordi et al., 2022; Cunha et al., 2021; Kumar et al., 2022; Busch et al., 2021; Kölbel et al., 2020; Caldecott et al., 2022a; Koliaï et al., 2022). According to (Cunha et al., 2021, 13) the main challenges for the field are "(i) the under-theorization of the SFI concept, (ii) the persistence of the traditional short-term financial logic, and (iii) the lack of evidence on the impacts of SFI on society and the environment". I leave the under-theorization of the SFI concept (i) open for future research and theoretical papers. The persistence of the traditional short-term financial logic (ii) is a problem that requires a multifaceted approach to be solved, involving the public, policymakers, and investors. A shift towards a more long-term oriented value approach is needed, which depends primarily on companies and the management of financial institutions (Schoenmaker & Schramade, 2023). In the following I address the third challenge, the lack of evidence on the impacts of SFI, by enriching the field with a quantitative study.

3 Theory and Hypotheses

Having explained common terminology and concepts in the previous chapter, I will now contextualise the main research gaps and challenges in the following theory section to derive my hypotheses.

As described in section 2, evidence on the effectiveness of so-called green investments is still sparse. There is a lack of frameworks and knowledge about integrating ESG criteria in investment choices (Schoenmaker & Schramade, 2021). As a result, even philanthropist impact-first investors cannot be sure whether they achieve a positive change in the environment through their investment choices, or not. To recognise the impact of the SFI sector and to guide a just transition towards greener economies it is indispensable to find evidence for GHG emission reductions through SFI practices.

Busch et al. (2022a) provide a detailed overview of the mechanisms of strategies for investors to invest with a non-financial impact. According to them, possible pre-investment strategies are:
First, the exclusion of companies, sectors or countries that are classified as non-investable. The best-known example of exclusion strategies is called divestment: Selling shares of misaligned companies for moral reasons (rather than financial decisions) is an important research topic in the SFI field. There is a whole body of literature on the so-called divestment strategy (Ansar et al., 2013; Berk & van Binsbergen, 2021; Busch et al., 2021; Caldecott et al., 2022a; Hunt & Weber, 2019; Kaempfer et al., 1987; Ritchie & Dowlatabadi, 2015) – the main unsolved problem of that strategy is that it primarily greens the portfolios of investors and not necessarily the real world. A second pre-investment strategy is the norm-based screening of investees. By doing so, investors control if possible investees comply with international norms, such as the Paris Agreement (UNFCCC, 2015). Third, the integration of ESG risks and opportunities in investment analyses. Fourth, the best-in-class approach, where the ESG performance of an investee is considered relative to its competitors. And fifth, sustainability themed screening where investees are chosen that work related to ESG issues like climate change. As mentioned for the first strategy divesting, the problem with pre-investment strategies is that their impact is limited. Other capital sources who do not prioritise environmental issues may step in and the polluting company keeps emitting (Ritchie & Dowlatabadi, 2015; Ansar et al., 2013; Hunt & Weber, 2019; Caldecott et al., 2022a). The drawback of exclusion strategies is that they rely on a majority of investors restricting their capital sources companies integrating ESG criteria.
Busch et al. (2022a) also provide post-investments strategies: Instead of withholding money from polluting companies, post-investment strategies intend to change production processes and the company's ecologic footprint in the long-term. Investors either engage through discussions or direct communication with their investees to increase disclosure

and/or improve the production practices towards more ESG integration. Or they use their ownership rights for public or private equity by exercising voting, filling proposals or through memberships in committees and boards. Positive changes achieved through post-investment strategies have a higher chance for real-world impact. It is not just the investor's portfolio that becomes greener, but the investee company modifies their habits and produces more environmentally friendly. Therefore, the focus of my analysis is on post-investment strategies, and I am researching investors who still retain coal-fired power plants.

Engagement of stakeholders, such as investors, either through pre- or post-investment strategies, is a powerful mechanism to steer companies to improve their environmental standards (Schoenmaker, 2017). Reasons for this engagement are diverse: Investors may want to act more sustainably due to the peer effect (to avoid disadvantages), outside pressure (of consumers, NGOs, or public policy), reputation (as marketing operation), risk avoidance (of stranded assets), collective advocacy (to reduce the uncertainty of changing policies), or collective engagement (Schoenmaker & Schramade, 2021).

As increasing numbers of stakeholders in the SFI sector have recognized the urgency with which climate change must be combated, they have set themselves goals of achieving varying climate targets. Over the last few years several initiatives emerged to promote SFIs through pre- or post-investment strategies. The so-called climate alliances are initiatives that address global issues like climate change through promoting sustainability among their members. They are typically established by organizations like the United Nations[1]. The finance initiative of the United Nations environment program for example, forms networks and alliances of different financial institutions to facilitate communication and steer their action. They also provide frameworks and principles to guide and unify SFI practices[2]. Stakeholders, such as financial institutions, can become members by signing a commitment to enhance cooperation and coordination. By forming coalitions and coordinate actions, financial institutions have a higher potential to foster a change in the economy and counteract a tragedy of the commons.

The concept "tragedy of the commons" was first introduced by Garrett Hardin in 1968. It describes the problem, that common pool resources, such as (clean) air, are easily exploited by individuals acting in their self-interest, ignoring that in the long-term they

[1] such as the Net Zero Banking Alliance for example.

[2] e.g. Principles for sustainable banking by the United Nations

overuse the natural resources they themselves depend on. If no property rights are being established, it causes the detriment of all stakeholders. This pessimistic view was challenged by Eleanor Ostrom in 1990: She developed the so-called system approach or Institutional Analysis and Development (IAD) framework. The IAD is an interdisciplinary concept to understand complex social-ecological systems. It describes that a common good can be provided by private coalitions working together. Ostrom argues that a community can govern common pool resources in a sustainable way, by engaging in coalitions whose members follow self-imposed rules.

The IAD also applies for the SFI context: Net Zero climate alliances are a form of coalitions in which investors can engage to counteract the tragedy of the commons. Through collective action and established self-governance mechanisms (not only carbon) emissions can be reduced and the SFI sector can transform into a more sustainable one.

Ostrom argues in favour of polycentric governance, where decentralized decision making through networks is applied. This ideal of polycentric governance can be identified in the SFI context: There are different organisation forms and centres of decision-making and resource-sharing. The most prominent organisation types are climate alliances, frameworks, and networks. All types have in common that they share (science-based) resources, provide guidance to promote SFI and that they aim to increase the impact of their members to contribute to a (real-world) emission reduction. Nevertheless, there are some differences between the organisations, which arise from their structure and the requirements for their members:

Frameworks offer investors certain guidelines or principles to which they can subscribe in order to publicly represent their commitment. They often do not have members, but partners with whom they cooperate, including other organisation types. An example are the UNEP FI Principles for Responsible Banking. Networks are superordinate initiatives that stimulate and facilitate communication, and coordinate action. Networks do not necessarily have investors as members, but also other organisations such as alliances. The GIIN is an example for a network. Alliances are the most frequently form of organisation used, as the individual alliances address investors directly and make more specific demands. They have a commitment that must be signed, or members must formulate an individual one. In addition, members often have to submit reports at set intervals documenting their compliance with their goals. An example is the Net Zero Banking Alliance. In line with the IAD (Ostrom, 1990), those alliances are nested within the larger organisation like networks. Which allows important forms of self-governance at the smaller level, whereby decisions are still coordinated at the larger level.

In my statistical analysis I focus on alliances, as they are the form of organisation that have investors as direct members and control them the tightest (see section 4 for a detailed explanation of the reasons). As Caldecott et al. (2022b) elaborate, most alliances have a more differentiated view of impact and place particular emphasis on real-world emission reductions. As the difference between industries is difficult to portray in one analysis, I focus on a single sector (Kumar et al., 2022): The energy sector plays a crucial role in our economies and heavily relies on fossil fuels. Fossil fuels are the largest source of global GHG emissions (Heede & Oreskes, 2016). In order to reduce GHG emissions and comply with the 2°C scenario, financial institutions must move away from fossil fuels (Dordi et al., 2022). As over a third of global electricity is still generated by burning coal, coal-fired power plants contribute significantly to climate change. For our industries to become Net Zero by 2050, emissions from coal-fired power plants need to be reduced annually by around 9% through 2030 (IEA, n.d.). Given the magnitude of the coal industry and its significant negative environmental impact, companies that generate their profits with fossil fuels play a crucial role in the transition of our economies (Dordi et al., 2022). This is why I focus my analysis on investors of coal-fired power plants. By limiting financial support (pre-investment strategy) for or by influencing corporate practices (post-investment strategy) of coal-fired power plants financial institutions can take a leading role in shifting the energy supply away from fossil fuels towards more sustainable generation methods (McGlade & Ekins, 2015). The importance of a transition away from coal-fired power plants is also highlighted by Ansar et al. (2013); Cui et al. (2019); Goodkind (2022) and the IEA (2021).

The commitments of the climate alliances also reflect the need to reduce carbon emissions drastically. A coal phase-out is not explicitly mentioned in most of the commitments of the alliances, but they all agree to meet Net Zero targets in 2030 or 2050. Achieving Net Zero automatically involves a transition from fossil fuels towards renewable energy sources. Due to the immense emissions associated with coal production and use (IEA, n.d.; Meinshausen et al., 2009; Cui et al., 2019) a coal phase-out is implicitly required from the members of all considered climate alliances.

This suggests that signatories of climate alliances phase out coal by 2030 or by 2050 at latest and do not finance coal-fired power plant units after 2050. I assume that signatories will only finance coal-fired power plants that will be taken off the grid by 2050 at the latest anyway. Or that the investors use post-investment strategies to influence the owner of the power plant to shut down the units they are financing by 2050 at the latest. Either way, the data should reveal that units financed by signatories of climate alliances are taken off the grid between 2030 and 2050. Whereas the power plant units financed by investors who are not members of a climate alliance will continue to burn coal and emit GHG beyond 2050. Accordingly, the power plant units of signatories have a shorter remaining lifetime than the units financed by non-signatories. This leads to my first hypothesis:

Hypothesis 1 (H_1): Coal-fired power plants whose financiers are signatories of a climate alliance have a lower remaining lifetime than coal-fired power plants financed by non-signatories.

To comply with the commitments and to achieve Net Zero goals emissions of coal-fired power plant units need to be drastically reduced. Either real emissions must be reduced, or emitted GHGs emissions must be compensated. The fewer the emissions, the easier this is. If financial institutions are members in a climate alliance and have ongoing financing of coal-fired power plants, I assume that the investors intend to influence the corporate practices of financed power plants to reduce the CO2 emissions. As elaborated above, this can be done by influencing corporate practices trough post-investment strategies like engagement or voting (Busch et al., 2022a). In the case of coal-fired power plant units there are different ways to reduce GHG emissions:
An economical option reducing net emissions would be to apply Carbon capture, utilisation and storage (CCUS) technologies. CCUS technologies capture CO2 that is emitted from large sources like power plants. Either the CO2 is reused by other companies that need it for their production process (usage). Or it is pressed into a storable form so that the CO2 is taken out of the cycle and does not simply end up in the atmosphere (storage). An option to reduce overall emissions is to make production processes greener: There are different types of coal, which differ in their energy output, characteristics, and emission factors. The two main types of coal are lignite and hard coal (in the quality levels anthracite, bituminous, sub-bituminous), whereby lignite (also referred to as brown coal) is considered more polluting than hard coal. Table 11 in the appendix shows the varying

emission factors of different coal types. Depending on the coal-type used for the energy production, the emissions of the power plant unit increase or decrease. To green their portfolio and the real world, investors financing coal-fired power plant units can use post-investment strategies to influence the production processes and the coal type burned in their unit. By modifying the plant to burn less polluting coal types, the power plant continues to generate energy, but with a lower adverse environmental impact. A more radical option to reduce emissions is to curb the production to a set maximum (that can be compensated for example).

I assume that signatories of a climate alliance choose one of the elaborated strategies to green the coal-fired power plant units they finance and comply with Net Zero goals. This reduces the annual CO2 emitted by the units and brings me my second hypothesis:

Hypothesis 2 (H_2): Financiers that are signatories hold lower emitting coal-fired power plant units than non-signatories.

The first hypothesis suggests a shorter lifetime of coal-fired power plant units held by signatories (H_1). The second proposes greener production processes of coal-fired power plant units held by signatories (through lower production volumes, less polluting raw materials, or compensation technologies, H_2). By combining these two, a positive picture for the impact of climate alliances emerges: Being signatory resolves in less overall emissions. But there are drawbacks if only one hypothesis is correct:

The Green Paradox is a concept by Hans Werner Sinn published in 2012 (Sinn, 2012). It describes that environmental policy measures to reduce GHG emissions can lead to increased short-term use of fossil fuels, to maximise financial profit. A more recent study on this phenomenon is provided by Jensen et al. (2015). Applied to the coal sector, the green paradox describes that an earlier coal phase-out (H_1 approved) leads to an increase in annual CO2 emissions. The plant owning companies burn more coal in the shorter time period left to generate the maximum profit possible. According to the Green Paradox, a coal phase-out does not reduce overall GHG emissions, but only the time horizon in which they are emitted.

To detect effects that arise when only one of the two hypotheses above is correct, I control not only for annual emissions, but also for total emissions. These can be derived by multiplying the remaining lifetime by the annual emissions. Contrary to what the Green Paradox predicts, I assume that both (H_1) and (H_2) will be approved. As a logical consequence, the total emissions of a coal-fired power plant will also be reduced if the investor is a member of a climate alliance. Which resolves in the third hypothesis:

Hypothesis 3 (H_3): Coal-fired power plant units hold by signatories have lower total lifetime emissions than units hold by non-signatories.

To build and run coal-fired power plants money is needed, which is often not provided by the owner of the plant, but by large institutions that have better financial resources. As with every other business model, there are different financial institutions investing in the power plants (such as governmental or non-governmental institutions) and different types of investments made (e.g., loans, grants, or equities). The most common types are equities and loans.

There is growing evidence that sustainability issues are more important to equity investors than most of them realise (Schoenmaker & Schramade, 2021): Equity investors are particularly affected by the company's performance. They have not only granted a loan, which must be repaid, but they have bought shares in the company. This makes them dependent on the success of the company to achieve economic profit, which is why they are more likely to invest in companies that pursue a strategy of long-term value creation (Schoenmaker & Schramade, 2021; Dordi et al., 2022).

In the present example of coal-fired power plants, sustainability issues can lead to the units being less economical: The introduction of certificate trading (e.g. as done in the EU) makes energy from fossil fuels more expensive and less lucrative compared to other (more sustainable) energy sources (Pietzcker et al., 2021). As equity investors are more oriented towards long-term value creation, I assume that they intend to green their portfolios and the investee company to better adapt to a future of rigid sustainability norms and regulations. Through applying a strategy of active ownership, equity investors can achieve changes in the production processes of the financed enterprises (Busch et al., 2021). Moreover, they can intend to reduce emissions by applying other post-investment strategies.

I assume that equity investors being signatories in a climate alliance are especially interested in financing companies with sustainable production processes and lower GHG emissions. This derives in my fourth hypothesis:

Hypothesis 4 (H_4): Coal-fired power plants of signatories that provide equity

investments have lower carbon emissions.

In the following, I test the presented hypotheses through a quantitative analysis to get a clearer picture of the influence of the membership of a financier in a climate alliance on the GHG emissions of a coal-fired power plant unit that it finances. This helps to better understand the real-world impact of SFI practices.

4 Data and Methods

To approach the influence of climate alliances on the GHG emissions of a coal-fired power plant unit I do a quantitative analysis by conducting a multiple regression using OLS. In this section I explain the material and method I used to measure the impact of the membership of investors in climate alliances.

4.1 Data

The basis of the statistical analysis is formed by two publicly available asset-level data-sets of the Global Energy Monitor (GEM). GEM is a non-profit organisation that develops information on the international energy landscape and provides open data-sets, reports, and tools[3]. As the focus of my thesis lies on coal-fired power plants, I use the data-set Global Coal Plant Tracker (GCPT) for my analysis. It provides detailed information about worldwide coal-fired power units, generating at least 30 megawatts. Thus, my analysis enriches the field with a global regression analysis for the coal sector. As most research on SFI focuses on single countries and developed economies, I enrich existing research on SFI with a global analysis (Kumar et al., 2022). The GCPT includes variables like the technology used, the plant lifetime and the emission factor of the coal-type used. To get an impression of the real-world impact of climate alliances and the SFI sector, I also need information on the finances of coal-fired power plants. Therefore, I include the Global Coal Project Finance Tracker (GCPFT) data-set. It surveys financial transactions of public and private funding for coal-fired power plant projects from 2010 onwards and provides information such as the amount of invested money and the type of financial institution that is financing the plant.

There is no data-set available that provides information about different financial institu-

[3]https://globalenergymonitor.org

tions and their membership in climate alliances. So, I compile this information myself. Starting from the paper by Cunha et al. (2021, Tab 1), I include initiatives presented in their literature review that focus on the finance sector. Furthermore, I check on the websites of those initiatives for related initiatives and partners of the alliances I already included. To have a comparable set of alliances and to avoid differences in my data that are caused by country specific conditions I only take alliances into account that work internationally and whose activities are not exclusively confined to individual countries. The alliances are easier to compare if they are aimed at the same international players than if they focus on financial institutions from a specific country. In addition, I exclude initiatives that focus on a specific topic within the SFI category. Alliances focusing on a single aspect of SFI are left aside, because they often have more ambitious plans in the sector they represent than broader-based alliances. Members of fossil free finance alliances, for example, should be much less likely to be invested in coal-fired power plants than members of more general climate alliances, or alliances operating in the blue finance sector[4], for example.

With the information gathered through my search strategy, I create a data-set of climate alliances working in the finance sector at a global scale (see appendix A.1, Fig. 7). Then, I establish screening criteria to filter the climate alliances and only include effective alliances in my analysis, as shown in Figure 2 and elaborated below. The established criteria are inspired by the design principles of Ostrom (1990). The design principles were defined to guide the management of (sustainable) resources, improve community-based governance and secure a proper functioning of a coalition. In the context of climate alliances, these principles ensure that the selected alliances contribute to enhancing the effectiveness of their members' sustainability measures. Additionally, the criteria set applied ascertains the comparability of the climate alliances for my analysis.

The first criterion applied is the area. In the analysis, only globally active groups are taken into account, as regional differences can result in different levels of ambition. For example, China permitted two new coal-fired power plant units per week in 2022 (Myllyvirta et al., 2023). It can be assumed, that alliances focusing on Asia have other (less strict) commitments than alliances focusing for example on the EU states. Therefore, I ex-

[4]Blue finance describes an area within SFI that focuses among other on protection of the oceans, underwater environments and clean (drinking) water.

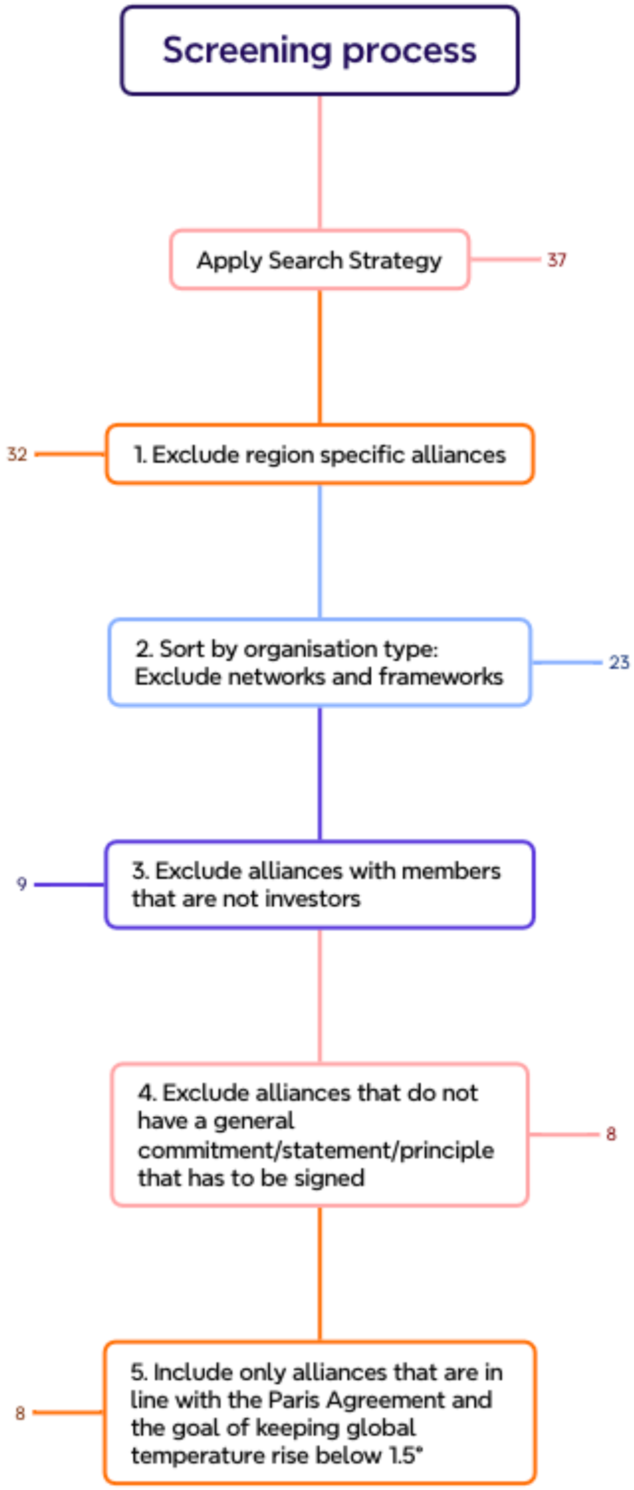

Figure 2: Screening process applied to filter the climate alliances. The numbers next to the process steps indicate the number of alliances that remain to be considered. Own representation based on Cunha et al. 2021

clude region specific networks.

The second criterion is the organisation type. According to Ostrom's design principles, alliance members should be able to actively participate in the decision-making process regarding rules and their monitoring. This is only the case for alliances, and not for frameworks or networks. Whereas the alliances are the core organisations in which financial institutions can actively participate, frameworks and networks are more like the infrastructure around them. Alliances refer to frameworks when justifying or specifying their commitments and are members in networks to communicate with other alliances. Both are considered superior to alliances as they act as intermediaries and create environments that facilitate communication between stakeholders. Therefore, I exclude networks and frameworks from my analysis.

The third criterion is the membership. In my analysis I exclude alliances with members that are not financial institutions but other stakeholders. In some alliances, not only financial institutions, but also universities or countries can become members. But those non-financial institutions might have other interests and focuses than investors. Alliances that address those different interests are not easily comparable to alliances that focus on one stakeholder group and are not included.

The fourth criterion is the commitment. Ostrom's design principles require clear boundaries from organisations. A uniform statement makes it clear which goals the alliance is pursuing and how the signatories are expected to implement them. This makes the goals more binding and facilitates monitoring of members' compliance. Additionally, it enables easier comparison of alliances with each other. Allowing institutions to join solely based on self-defined goals may result in significant disparities already within the alliance, so that the alliance as a whole is not comparable to others. Hence, I discard alliances without some sort of commitment, statement, or principle that has to be signed or adopted.

The fifth and last criterion is the Paris Agreement. I check if the initiatives considered in the analysis spur investors on achieving Net Zero targets as called for in the Paris Agreement (UNFCCC, 2015). The Paris Agreement is a legally binding instrument on climate change, adopted in 2015 by 196 governments. It's aim is to keep global temperature rise well below 2°C compared to pre-industrial levels. This obliges economies, and therefore investors to nearly half emissions until 2030 and have their portfolio Net Zero by 2050. Since its launch, the Paris Agreement characterizes the research on SFI. Its importance for the field is emphasized by various researchers (Kumar et al., 2022; Thomä et al., 2019)

The screening criteria applied secure that the studied alliances are effective in achieving their goals and are comparable with each other. This is important as I do not analyse the data for each specific alliance but aggregate the information in the process, as explained in detail in the following. See appendix A.1, Fig. 7 for a list of all considered alliances and the screening criteria applied.

To include the alliances in my statistical analysis I proceed as follows:

All selected climate alliances provide membership lists on their websites[5]. To use this information in my analysis, I manually compare the members list with the financiers of the coal-fired power plants shown in the GCPFT data-set. From this, I create a list for each alliance naming the alliance members that provide financial support for at least one coal-fired power plant unit (see Appendix A.1, Fig. 8). As the depiction of the members

[5]For the Net Zero Banking Alliance, there is only a list of signatories available that have already published their targets for 2025 meeting the requirements of the alliance commitment. Signatories that have publication due dates later than 12/2022 are not included in my analysis.

and the names of the financial institutions in the GEM data-set sometimes differ, I check for every alliance member if there is a financier with at least three consecutive identical letters in the name. If completely identical names occur, I include the financier in the data-set and in my analysis. If the names are similar, I include the financier in the data-set. Then, I look for other information that proves if the same financial institution is meant, to decide whether to include the financier also in my analysis. To do so, I first check if the financier's country, as given in the GCPFT data-set, is the same as the home country of the respective alliance member. If not, I do not include the alliance member in my analysis. If the countries match, I examine further why the names differ by investigating on the financial institutions' website. For synonymously used names like short forms I include the financial institution in the analysis. Same for financial institutions that names have changed over time. If the different names stand for different companies, but the similarity stems from the fact that one of them is a subsidiary, I take a closer look at the case. The alliance The Equator Principles explicitly recommends that the commitment be signed by the highest possible level of the company, e.g., the group holding company, as it translates the pledge to its subsidiaries (The Equator Principles Association, 2023). But if a subsidiary signs the pledge, its commitment to SFI practices does not affect other subsidiaries or the parent company. So, provided that the highest company level signed the commitment of a climate initiative, and the subsidiary financed a unit of a coal-fired power plant, I include the financial institution in my analysis. If it was the other way around, I do not. The created lists and data-sets are given in the appendix A.1.

To use the gathered information on the membership of financiers in climate alliances for my analysis, I create a new variable. It indicates whether the financier of a coal-fired power plant unit is a member of a climate alliance or not. To do so, I generate a dummy variable called signatory that equals one if the financier of a coal-fired power plant unit is a member of any of the considered climate alliances and 0 otherwise. Then, I include it in the GCPFT data-set. I call the variable signatory, and not member, to highlight that the members signed a commitment that outlines the (Net Zero) goals of the alliance.

4.2 Methodology

So far, scientific research mainly focuses on the financial performance of green investments, instead of on their impact on ESG criteria (Friede et al., 2015; Wagemans et al., 2013; Cunha et al., 2021; Schoenmaker & Schramade, 2021). The following analysis is a start to change this.

Given the structure of the data-sets, I perform a cross sectional analysis. Unfortunately, panel data on finance information of coal-fired power plants and their GHG emissions does not exist in an accessible way, so that alternative analysis techniques are limited. To identify correlations between different influential variables, I conduct a multiple regression analysis. The estimation method used is ordinary least squares (OLS).

For the analysis I need information that is solely given in the GCPT and information that is solely given in the GCPFT data-set. Therefore, I need to combine both data-sets. As every unit of a coal-fired power plant has a so-called tracker ID which is provided in both data-sets, the matching process is straight forward on the first look. However, there is a small hurdle: In the GCPT data-set, there is one observation per tracker ID. But as the finance information is more dynamic, the GCPFT data-set shows several observations for some units. This is for example the case, when multiple financiers finance a unit. When joining the data-sets in R, coal-fired power plant units are duplicated if there are several financiers, so that one tracker ID may end up with more than one observation. Thus, units with more than one financier gain more importance in the analysis, leading to a bias I want to avoid. There are several ways to address this issue. I decided to aggregate the information in the GCPFT data-set, so that it ends up with one observation per tracker ID, just like the GCPT data. This option ensures that the observation level of the units is not further subdivided into several observations per tracker ID. It also secures that the observations are independent from each other, and at the same time offers the possibility to include all variables of interest. What is lost is the information whether the financier is a member in one or in several climate alliances, and the information on which climate alliance it is. However, the aim of this thesis is not to investigate the effectiveness of particular alliances, but to identify correlations between the membership in any alliance and financed GHG emission. The screening criteria applied (as explained in section 4.1) secure that the alliances are comparable. Hence, the aggregation of the information on the membership is reasonable. I explain in more detail how the merging process choice affects the results in Section 6. To consider that the investors hold different shares of the total investment in the coal-fired power plant units, I weight the (control) variables proportionally to the investment made. This is done by calculating the average value of the variable of interest proportionally to the financial share of the financier in the financing of the project. For example, for the dummy variable signatory the merging proceeds as follows: If there are several investors for one coal-fired power plant unit, the dummy variable signatory is weighted proportionally based on the financial contribution of the financier to the plant's funding. This creates a new variable called weighted signatory. Weighted signatory takes a value between 0 and 1 and depicts the proportion of the financier's investment in the total investment made in the power plant unit.

As elaborated in section 2, the topic of impact investing is understudied and there is no criteria set available to unambiguously classify an investment as impact generating or not. The above presented systems for measuring impact (COMPASS methodology and IRIS+, see section 2) are directed at investors. My research is not directed at individual investors and their portfolios but aims to investigate the real-world impact of the whole SFI industry. To do so, I conduct a quantitative analyse of the lifetime and the CO2 emissions of coal-fired power plant units looking for correlations with the membership of financiers in climate alliances. There are also other sectors and variables that could be considered to analyse impact. I chose to focus on fossil fuels as their usage needs to be drastically reduced to counteract a climate catastrophe (IPCC, 2023). The GHG CO2 is also centre of the Race to Zero campaign by the United Nations and the Paris Agreement to achieve Net Zero until 2030 (or at least 2050).

4.2.1 Derivation of the regression models

To test the hypotheses H_1, H_2, and H_3, as presented in section 3, I run three regressions with different dependent variables:
The first hypothesis (H_1) assumes that signatories of a climate alliance hold coal-fired power plant units with a lower remaining lifetime than financial institutions not being signatory. In the GCPT data-set, the GEM provides a variable called remaining lifetime, that indicates the number of years a unit of a coal-fired power plant will continue to generate energy until it is taken off the grid. The average retire-age of the units is 38

years, but this varies between the different regions, ranging from 22 years in China to 53 in Eurasia (Champenois (2023), see appendix A.5, Tab. 12). However, the GCPT dataset only includes averages: Generally, the GEM assumes a 40-year lifetime of coal-fired power plants. If the plants are older than 40 years, the GEM assumes five more years of operation. In case a retire date is announced, the remaining lifetime of the plant is shortened to this year. The fact that averages for the remaining lifetime are used is visible in the data. The histogram shown on the left side in Figure 3 illustrates that most coal-fired power plant units have a remaining lifetime of 30-40 years. To get a first impression on H_1, I also create a histogram in which only the remaining lifetime of coal-fired power plant units financed by signatories are included (see Fig. 3, right). The distribution in both histograms looks similar and does not indicate an effect that signatories generally hold units with a shorter remaining lifetime or that signatories phase out coal before 2030 (see Fig. 3). To get a clearer picture and test H_1, I run a regression with remaining lifetime as dependent variable. This allows to identify whether the membership in a climate alliance influences the remaining lifetime of coal-fired power plant units financed by alliance members. From this, assumptions can be drawn regarding whether coal-fired power plants will be phased out earlier if the invested financial institutions are signatories of climate alliances.

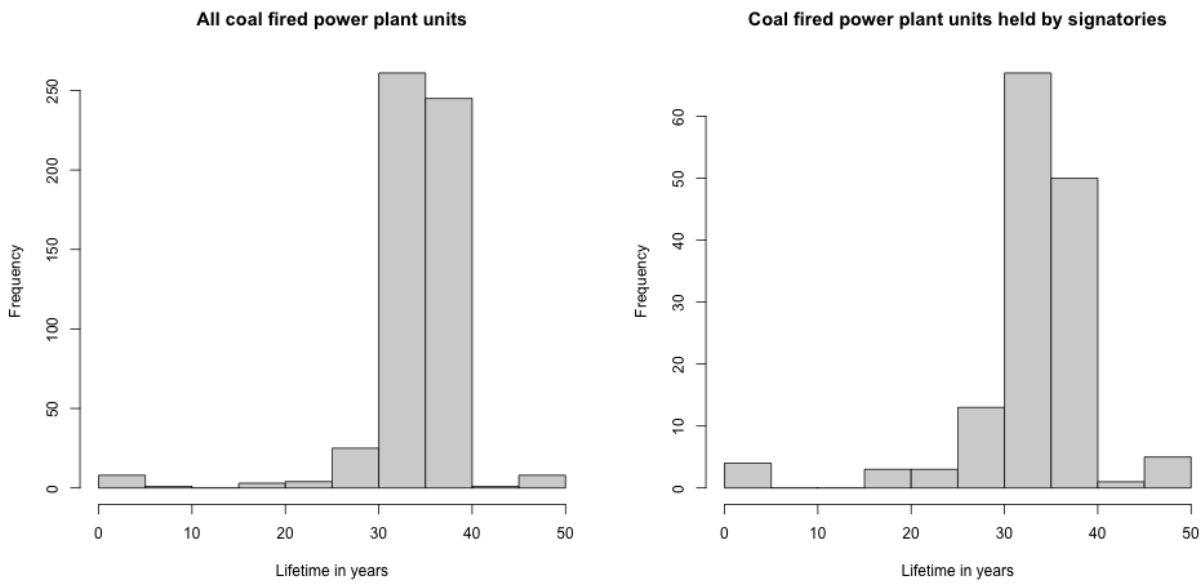

Figure 3: Lifetime distribution of all coal-fired power plant units compared to those units hold by signatories.

The second hypothesis (H_2) assumes, that financiers that are signatories hold lower emitting coal-fired power plant units than non-signatories. The GCPT data-sets includes information on the coal-types burned in a power plant and their respective emissions. It also provides a variable called annual CO2 that indicates how much CO2 is emitted annually by a coal-fired power plant unit. This reveals how dirty a power plant unit is and how much emissions are financed by the investor every year.

The GCPT estimates annual CO2 emissions by using the following formular (Champenois, 2023):

$$\begin{aligned} \text{Annual CO2 (in million tonnes)} = &\ \text{capacity} \cdot \text{capacity factor} \cdot \text{heat rate} \\ &\cdot \text{emission factor} \cdot 9.2427 \cdot 10^{-12} \end{aligned} \tag{1}$$

I briefly present the values that are used to calculate the annual CO2 emissions: The capacity depends on the size of the power plant unit and is provided for the analysis trough an own variable. The capacity factor is fixed for all units at the global average of 51%, regardless of the great differences that exist between countries. Values range from 37.8% in Russia to 82.2% in Japan (Champenois (2023), see appendix A.5, Tab. 8). The parameter heat rate measures the effectiveness of a power plant to convert the energy of the coal burned into electricity, whereby a low heat rate signifies high efficiency. The GCPT only respects averages for the heat rates but a bit more differentiated as for the capacity factor by calculating the heat rate according to the combustion technology and taking plant age and size into account. This is done by applying penalties depending on the size and age into the calculation. The resulting values vary between 7,528 and 13,724 (Champenois (2023), see appendix A.5, Tab. 9 for the different heat rates according to the combustion technology and appendix A.5, Tab. 10 for the penalty factors). For the carbon dioxide emission factor, the GCPT uses averages according to the different coal types. In 1994, the US government used the high heat value approach to calculate the carbon dioxide emission factor. By now, GEM refers to a study by the IPCC from 2006 using the low heat value (i.e. net calorific) approach IPCC (2006), leading to different results. The values calculated by the IPCC range from 94,600 to 101,000. Appendix A.5, Tab. 11, shows how different the results for carbon oxide emissions are according to the different calculations.

To test H_2, I run a regression with annual CO2 as dependent variable. This allows to identify correlations between being signatory of any climate alliance(s) and lower GHG emissions. Assumptions can be drawn whether the membership in a climate alliance influences the annual CO2 emissions of power plants financed by alliance members. This allows to infer whether coal-fired power plants will phase-out coal earlier if the invested financial institution is signatory of one or more climate alliances.

The third hypothesis (H_3) assumes, that coal-fired power plant units hold by signatories have lower total lifetime emissions than units hold by non-signatories. By solely analysing annual emissions or the remaining lifetime, effects could be overlocked, such as increased emission in a shorter period of time as predicted by the Green Paradox (as explained in section 3). To investigate real-world impact, it is necessary to also analyse the total emissions of coal-fired power plants. By multiplying the remaining lifetime with the annual CO2 emissions, the GCPT creates a variable called lifetime CO2, specifying how much CO2 is going to be emitted by the unit in total (Champenois, 2023). To avoid possible distortions and improve the model fit, I add further control variables to the regression equation:

The first control variable included is the type of investment made, to analyse whether the investment form influences the dependent variable. To do so, I create a dummy variable that equals one if the finance type of the investment is equity and 0 otherwise. Then, the dummy variable equity is weighted proportionally to the financial share of the financier in the financing of the power plant unit. This is necessary as I aggregate the information to prepare the merging process. Last, the weighted variable weighted equity is converted back into a dummy (weighted equity dummy) that equals one if the proportion of equity investments is > 0.5 and 0 otherwise.

The same procedure is followed to create the second control variable weighted loan dummy. This leaves every coal-fired power plant unit with only one type of investment, either equity, loan or other. Since there are other forms of investments (bond, government subsidy, insurance, refinancing loan, refinancing capital, refinancing bond), the two dummies weighted loan and weighted equity are not perfectly collinear. However, I do not include the other investment types as they are not as relevant. There are only a few observations of coal-fired power plant units that are financed by any other investment type than loan or equity.

The third control variable included is the capacity of the unit. The capacity of the coal-fired power plant units is a parameter in the calculation for the dependent variable annual CO2 and lifetime CO2 and therefore closely linked to them. The size of a coal-fired power plant is also related to the amount of money invested, and presumably to the size of the investing company and its membership in a climate alliance. This makes it a confounding variable that needs to be included.

The fourth and fifth controls are the status of the coal-fired power plant unit. The variables forthcoming or cut-off are included as control variables (ongoing is the default option). It is important to differentiate if an investor finances a currently operating coal-fired power plant unit, did finance one that already phased-out and is no longer emitting, or is financing the construction of new coal-fired power plant units.

Moreover, I control for the retire date, specifically if retirement until 2050 is announced. I chose 2050 as it is the less rigid Net Zero goal. It includes those that are more ambitious and retire until 2030, but those that do not plan to retire (or plan to retire far in the future) are left out.

I also included the variable weighted financing, which indicates whether the financing of the power plant unit is still ongoing or not. Investors with ongoing financing have the potential to influence the company, its liquidity and management. If the financing is closed, the investors tend to have less interest and influence in the investee, which makes an important difference for the analysis.

Lastly, I control for the different regions considering political and geographical boundaries. An important factor for the CO2 emissions, the remaining lifetime, and the total emissions (lifetime CO2) of coal-fired power plants are the policies of the countries where the units are based. Net Zero regulations through governmental climate coalitions and other factors like carbon pricing or the availability of alternative (green) energy sources affect production processes of local power plants (see section 2 and 3). I intend to approach this policy effect through controlling for the regions, to monitor whether an outcome solely appears in specific locations (with certain regulations and laws). Those regions are set in the GCPT and namely are Canada and the US, Latin America, the 27 EU states, non-EU Europe, Eurasia, East Asia, Southeast Asia, and South Asia.

The GCPT data-set includes 21 observations using CCS technologies. Unfortunately, there is no financial information available for the majority of those observations. After combining the GCPT with the GCPFT data set and dropping observations that do not include information for weighted signatory there is only one observation left where a coal-fired power plant is using CCUS technology. This is not enough to consider it in the regression. Therefore, the following analysis does not take CCUS technologies into account and leaves the subject to further studies.

The regression model is thus as follows:

$$\text{Dependent variable}_i = \beta_0 + \beta_1 \cdot \text{weighted signatory}_i + \vec{\delta}\vec{x} + \epsilon_i \tag{2}$$

Where $\vec{\delta}$ is the vector of coefficients for the control variables $\vec{x}$. Depending on the specifications of the model $\vec{x}$ contains the following controls: *weighted loan dummy, weighted equity dummy, capacity, forthcoming, cut-off, retire until 2050, weighted financing, region* (See Annex A.2 for a detailed explanation of the variables).

The fourth hypothesis (H_4) assumes, that coal-fired power plants hold by signatories that provide equity investments have lower carbon emissions than plants financed through other investment forms. As elaborated in section 3, equity investors have a higher possibility to influence their investees as they hold shares of the company. Through active ownership, they can influence production processes and can pressurize the company to reduce its emissions. As equity investors depend on the performance of their investee to gain economic profit they are more likely to lead the company in a more sustainable direction (through the use of their ownership rights). This is especially prominent in regions where emission output is getting more expensive through policy instruments such as certificate trading. To understand the possibilities and limitations of SFI and impact investing, it is important to analyse if and how the investment type affects the dependent variable (remaining lifetime, annual CO2, or lifetime CO2), and thereby the outcome of the analysis. To do so, I include the type of investment made (loan or equity) as control variable in the regression.

To test H_4 I include an interaction term in the regression model. The interaction term controls whether the effect of the dependent variable weighted signatory depends on the size of the explanatory variable weighted loan dummy. This reveals whether the type of investment has an interaction effect on the dependent variable remaining lifetime, annual CO2 or lifetime CO2 (Wooldridge, 2013). An interaction term for weighted equity is not included, as there are not enough units with a majority of signatories and a majority of equity investments to calculate an interaction of weighted equity with weighted signatory.

The regression model is thus as follows:

$$\begin{aligned}\text{Dependent variable}_i = \beta_0 + \beta_1 \cdot \text{weighted signatory}_i \\ +\beta_2 \cdot \text{weighted signatory} \times \text{weighted loan dummy} \\ +\beta_3 \cdot \text{weighted loan dummy} + \vec{\delta}\vec{x} + \epsilon_i\end{aligned} \tag{3}$$

Where $\vec{\delta}$ is the vector of coefficients for the control variables $\vec{x}$. Depending on the specifications of the model $\vec{x}$ contains the following controls: *weighted equity dummy, capacity, forthcoming, cut-off, retire until 2050, weighted financing, region* (See Annex A.2 for a detailed explanation of the variables).

In order to provide a clear picture of the significance of the regression models, the results recorded must be interpreted in the light of the regression diagnostic tests and other characteristics of the regression. To test the assumptions for a multiple linear regression and find the best linear unbiased estimator (BLUE), I did a graphical analysis following the Gauss-Markov theorem (see appendix A.3, Fig. 9-17). Among other assumptions, the Gauss-Markov Theorem requires that the standard errors are heteroskedasticity-robust. Visual inspection of the residual's vs fitted plots (see appendix A.3, Fig. 9-17) leads me to the conclusion that heteroskedasticity is present in the data. Thus, I do the Breusch-Pagan test to proof heteroskedasticity (Wooldridge, 2013), and it responds in the present case. The Breusch Pagan test is very sensitive and quickly flags at high sample numbers. However, introducing heteroskedasticity robust standard errors has no negative effects and does not change the direction of the effects, so to avoid bias in the results, I apply them here (Hayes & Cai, 2007).

5 Results

This section presents the main results of the statistical analysis. I start with a first glance at the regression lines: Figure 4 shows the bivariate regression line for remaining lifetime. Figure 5 shows the bivariate regression line for annual CO2. And figure 6 shows the bivariate regression line for the lifetime CO2.

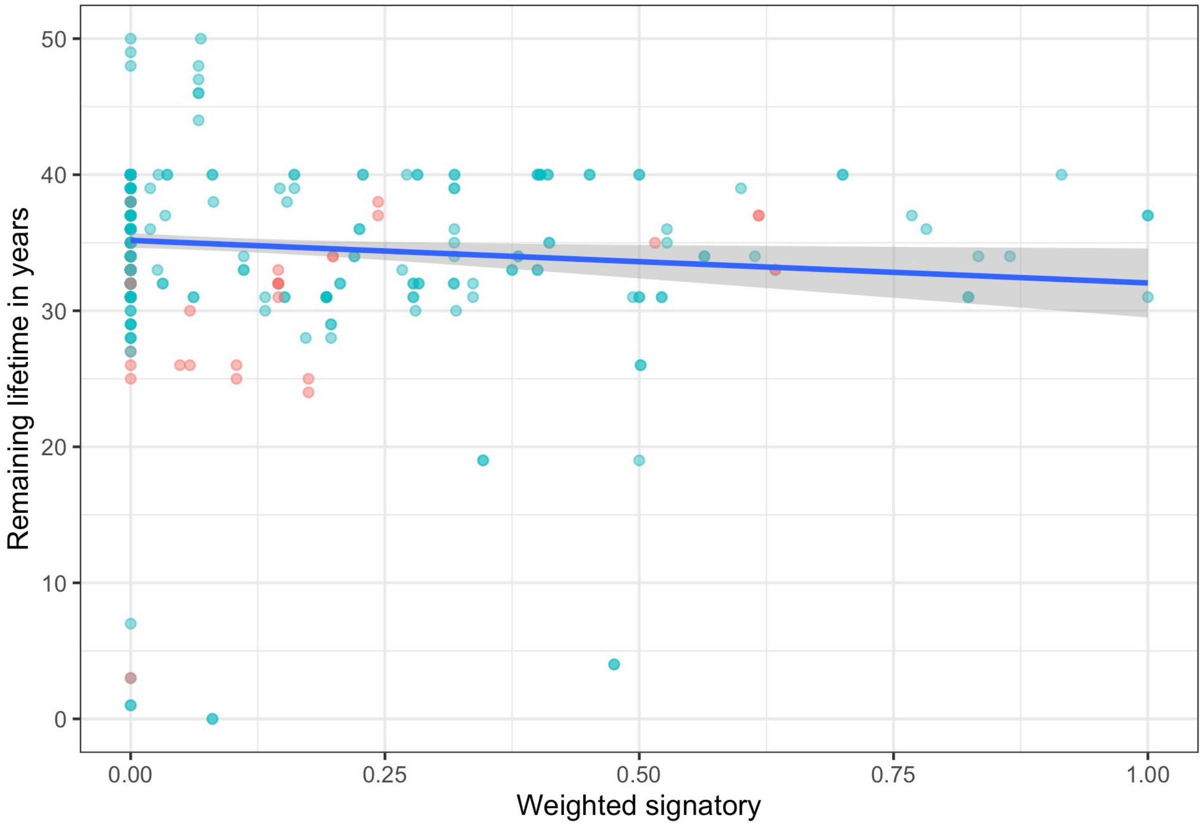

Figure 4: Bivariate regression line for the dependent variable *remaining lifetime*. The main investment types equity and loan are colour coded, whereby equity investments are highlighted in blue, loan in red.

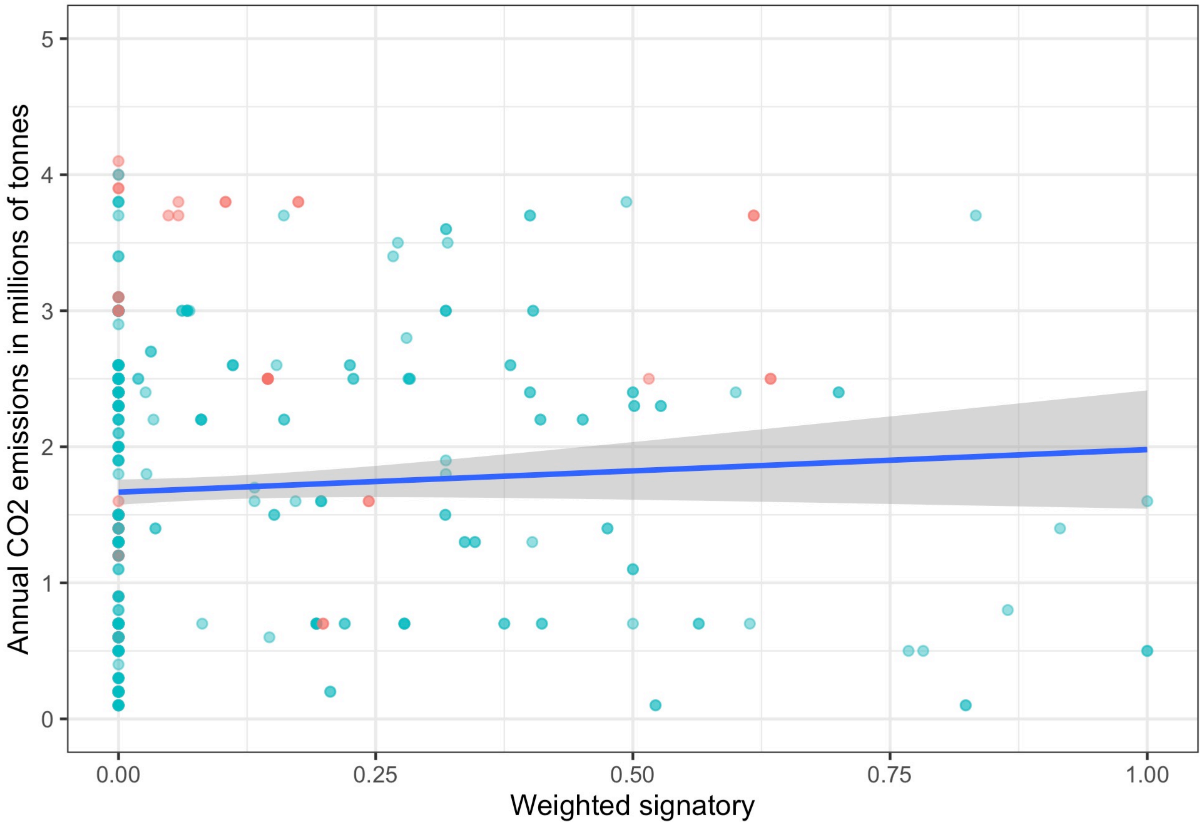

Figure 5: Bivariate regression line for the dependent variable *annual CO2*. The main investment types equity and loan are colour coded, whereby equity investments are highlighted in blue, loan in red.

The bivariate regression line for the remaining lifetime (Fig. 4) shows a slightly mathematically negative effect. In the context of the analysis of fossil fuels and climate change, this can be interpreted positively: The remaining lifetime of coal-fired power plant units slightly decreases when the financier is member in at least one climate alliance (H_1). For the dependent variables annual CO2 and lifetime CO2, there is a very slightly mathematically positive effect. Annual and lifetime CO2 emissions tend to increase when the investor is a member in a climate alliance (H_2, H_3). In the context of my analysis, this trend is to be interpreted negatively. However, all three graphs have nearly horizontal regression lines, indicating a null effect. This leads to the assumption, that there are no or only really small effects of being signatory in a climate alliance.

Overall, a first look on the bivariate regression lines suggests that the GEM data probably cannot proof a correlation between the lifetime or the emissions of coal-fired power plant units and the investors membership in one or more climate alliances.

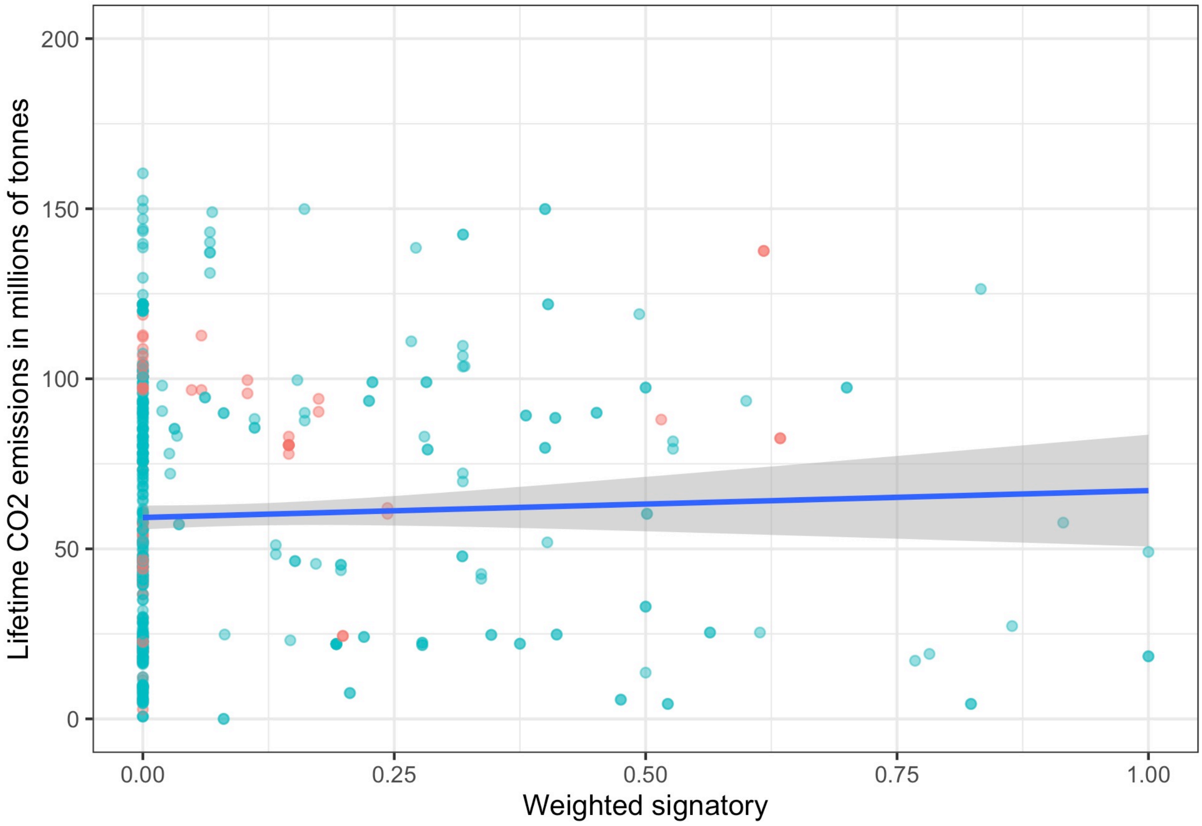

Figure 6: Bivariate regression line for the dependent variable *lifetime CO2*. The main investment types equity and loan are colour coded, whereby equity investments are highlighted in blue, loan in red.

The graphs showing the bivariate regression lines can also be used to get a first impression on H_4. To identify the interaction effect between investment type and being signatory in a climate alliance, the most frequent investment types equity and loans are colour coded. Equity investments are highlighted in blue, loan in red. Again, at first glance, no correlation between the investment type and the dependent variable can be discerned.

As described in the section 4.2, I run regressions with three dependent variables, namely remaining lifetime, annual CO2, and lifetime CO2. For each dependent variable, I estimate four models: First, I present bivariate regression results (1). Second, control variables are added to the regression (2). Third, the fixed effects for the regions are included to control for regional differences such as policy regulations (3). And fourth, I include an interaction term (weighted signatory x weighted loan dummy) to identify how the investment type interacts with the share of financiers being signatories (4). Tables 1, 2, and 3 provide the regression results for the main variables of interest. The provided tables do not display all estimated coefficients for all controls, but only indicate whether the control variables

are included in the model or not. I am merely interested in how the inclusion of control variables changes my dependent variable, the outcomes for the individual control variables are not the focus of the analysis. The complete regression output showing all controls are added to appendix A.4, Tables 5, 6 and 7.
The results I find are puzzling:

For the dependent variable remaining lifetime (Tab. 1) the regression presents a mathematically negative effect for the treatment group: Being signatory of a climate alliance is associated with a decrease of the remaining lifetime of the coal-fired power plant unit financed by about 1.6 to 3.1 years (depending on the model). In light of this master thesis, this can be interpreted positively. At the first look, those results confirm H1, but must be interpreted carefully.

	(1)	(2)	(3)	(4)
Weighted signatory	-3.1272^{**}	-0.6824	-3.1518^{***}	-2.5152
	(1.3791)	(0.9759)	(1.0318)	(3.4009)
Weighted loan dummy		-0.6884	-0.0521	0.0671
		(0.7926)	(0.7598)	(0.9730)
Weighted signatory x Weighted loan dummy				-0.6974
				(3.5496)
(Intercept)	35.1713^{***}	33.8825^{***}	35.6262^{***}	35.5141^{***}
	(0.2754)	(0.8804)	(1.0457)	(1.1922)
Controls	*no*	*yes*	*yes*	*yes*
Regions FE	*no*	*no*	*yes*	*yes*
R^2	0.0092	0.5288	0.5924	0.5924
Num. obs.	556	556	556	556

Note: OLS-estimates. Standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 1: Remaining lifetime

Most results are not significant: For the bivariate regression (1), the p-value of the F-statistic is too high (p-value of the model: 0.3777). This indicates that the first model (1) as a whole is not significant, even if the values for the single parameters are. The results of the models (2) and (4) for the independent variable weighted signatory are not significant either. So, only model (3) provides significant results that can be used for interpretations. Second, the effect size varies with the controls. Primarily it decreases when applying controls in the analysis (2), but when taking the region fixed effects into account (3) it increases again and becomes significant. However, the effect decreases again and is not significant anymore when the interaction term is included (4). This does not allow a straightforward interpretation.

The analysis of the dependent variable annual CO2 (Tab. 2) displays both, positive and negative effects for the treatment group, depending on the model. The results of model (1) and (4) can be interpreted in such a way that signatories of climate alliances hold coal-fired power plants with higher annual CO2 emissions. This contradicts H_2. The results of model (2) and (3) suggest that signatories of climate alliances hold coal-fired power plants with lower annual CO2 emissions. Which approves H_2. In other words, the results of the different models suggest contradicting effects. Again, these results must be interpreted carefully.

	(1)	(2)	(3)	(4)
Weighted signatory	0.3129	−0.0291	−0.0338	0.0126
	(0.2369)	(0.0212)	(0.0221)	(0.0729)
Weighted loan dummy		0.0247	0.0233	0.0319
		(0.0172)	(0.0163)	(0.0209)
Weighted signatory x Weighted loan dummy				−0.0508
				(0.0761)
(Intercept)	1.6667***	0.1396***	0.0890***	0.0808***
	(0.0473)	(0.0191)	(0.0224)	(0.0256)
Controls	*no*	*yes*	*yes*	*yes*
Regions FE	*no*	*no*	*yes*	*yes*
R^2	0.0031	0.9924	0.9936	0.9936
Num. obs.	556	556	556	556

Note: OLS-estimates. Standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 2: Annual CO2

The coefficients for weighted signatory in all three models are not significantly different from zero. Second, and more important, the results are decreasing when applying more controls and approach zero. This indicates a null effect which can also be seen in the graph displaying the bivariate regression lines for annual CO2 (Fig. 5). A null effect suggests that being signatory in a climate alliance does not have an effect on the annual CO2 emissions of the financed power plant unit.

Moreover, the values for R^2 are extremely high after applying the controls. This is very unusual and indicates that the model is overfitted and not able to predict the dependent variable correctly. Therefore, the regression results should be interpreted with caution.

A possible reason for high R^2 values is multicollinearity. Considering formular (1), that estimates the annual CO2 emissions of a coal-fired power plant unit in the GCPT, it is possible that the capacity of the coal-fired power plants strongly correlates with the annual CO2 emissions. I explore this issue more in detail in the discussion section. Overall, the second analysis for the dependent variable remaining lifetime shows no substantial treatment effect that can be interpreted.

The third model (Tab. 3) for the dependent variable lifetime CO2 shows a mathematically positive effect for the treatment group. The lifetime CO2 emissions of a coal-fired power plant unit increase when the financier is signatory of one or more climate alliances compared to financiers that are not members. This contradicts all hypotheses: Being signatory of a climate alliances does not lower the lifetime CO2 emissions of the financed coal-fired power plant unit. Instead, being a signatory of a climate alliance is associated with emitting more CO2 over the lifespan of a coal-fired power plant unit. This suggest that other assumptions apply, such as the Green Paradox.

	(1)	(2)	(3)	(4)
Weighted signatory	7.9035	1.1608	-2.0037	12.8987
	(8.9515)	(2.3097)	(2.4752)	(8.1310)
Weighted loan dummy		7.6777^{***}	7.7630^{***}	10.5548^{***}
		(1.8757)	(1.8227)	(2.3264)
Weighted signatory x Weighted loan dummy				-16.3250^{*}
				(8.4866)
(Intercept)	59.2133^{***}	-3.9651^{*}	-1.5197	-4.1450
	(1.7875)	(2.0835)	(2.5086)	(2.8503)
Controls	*no*	*yes*	*yes*	*yes*
Regions FE	*no*	*no*	*yes*	*yes*
R^2	0.0014	0.9369	0.9439	0.9443
Num. obs.	556	556	556	556

Note: OLS-estimates. Standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 3: Lifetime CO2

But again, the results of this analysis must be interpreted carefully. The magnitude of the effect varies extremely, depending on the model and the controls that are added to the regression. The results for the independent variable weighted signatory are not significant, indicating that the model cannot provide an answer to the research question. Moreover, the values for R^2 are again conspicuously high. This was to be expected, since the problems that arise for the variable annual CO2 also apply to the variable lifetime CO2 (since lifetime CO2 results from the multiplication of annual CO2 and remaining lifetime). Therefore, the results of this third regression analysis should also be taken with a grain of salt and no definite conclusions can be drawn.

Based on the data collected, no clear patterns can be identified. All in all, it is not possible to identify and interpret effects of being signatory in a climate alliance. Neither on the carbon emissions financed by a financial institution, nor on the lifetime of a coal-fired power plant unit. Therefore, the presented hypotheses (section 3) can neither be confirmed, nor rejected. As already mentioned, the results of the analysis are rather strange and should be seen in a more differentiated way. In the following discussion section, I go into more detail about the limitations and weaknesses of my analysis and provide an outlook to future research.

6 Discussion

In this section, I discuss the analysis and its results as presented above. To do so, I first summarize the results and contextualize them within the framework of this thesis. Then, I explore the limitations and weaknesses of the material and the methods used as well as those of the specifications applied in the regression analysis. I close this section with a discussion of the implications for research and policy.

As denoted in section 5, the present data analysis does not reveal a correlation between the membership of financial institutions in climate alliances and the GHG emissions or the lifetime of coal-fired power plant units financed by them. The multiple regression applied using OLS does not deliver significant, nor clear results. As the bivariate regression lines (Fig. 4-6) foreshadowed, the regression outputs for the different models indicate only minimal effects. The fact that no patterns can be detected, and different conclusions can be drawn from different regression models suggests that the explanatory power of the analysis is limited.

The hypotheses presented in section 3 neither can be confirmed nor rejected through the analysis applied. However, the results are still in line with previous research. So far, there is no clear and independently verified evidence that SFI practices have an impact on real world GHG emissions. Instead, the literature mainly emphasises how difficult it is to measure real-world impact and attribute successful emission reductions (exclusively) to the true responsible parties (Dordi et al., 2022; Cunha et al., 2021; Kumar et al., 2022; Busch et al., 2021; Kölbel et al., 2020; Caldecott et al., 2022a; Koliaï et al., 2022). This master thesis emphasises these problems and highlights the difficulties of research on impact.

Still, the regression results are rather puzzling. The main problem of the analysis is that the results of the individual models do not fit together. As explained in section 4.2, the variable lifetime CO2 is composed of the variables remaining lifetime and annual CO2. So, the results of the first two models should be reflected in the third. According to the first model (Tab. 1) being signatory of a climate alliance is associated with a decrease of the remaining lifetime of the coal-fired power plant unit financed by about 1.6 to 3.1 years. The second model (Tab. 2) suggest that there is no effect of being signatory on the annual CO2 emissions. Combining these findings suggests that the third model shows decreased total emissions: Lower remaining lifetime and constant annual emissions resolve in lower total emissions. But this is not the case in my analysis.
As mentioned in section 3, the concept of the Green Paradox (Sinn, 2012; Jensen et al., 2015) could explain why the remaining lifetime of coal-fired power plant units financed by signatories is lower (H_1 approved), but their annual CO2 emissions are higher compared to those of non-signatories (H_2 rejected). The Green Paradox could also explain why the overall lifetime CO2 emissions of the coal-fired power plants do not significantly differ between signatories and non-signatories or are even higher. But neither effect can be detected on the basis of the present analysis. The results for the annual CO2 emissions and lifetime CO2 emissions are barely interpretable and do not show higher (annual) CO2 emissions in a shorter period of time for signatories compared to non-signatories.
There is no concept or framework that is able to explain the strange results of this statistical analysis. In the following, I identify the limitations and weaknesses of the material, the methods and the specifications to explore reasons for the strange results.

6.1 What the data tells us and what it hides

The basis of the statistical analysis is the data used as input for the regressions. Namely, the GCPT and the GCPFT, and the information on financiers of climate alliances that I conducted myself. Since the data is the most determining factor for the results of a statistical analysis, I will first take a closer look at the limitations of the material.

The GCPT contains a vast amount of data on worldwide operating coal-fired power plant units producing at least 30 MW. It also includes proposed units from 2010, and units retired since 2000. The data is collected from private and public sources, such as companies, governments, and non-governmental organisations, and then cross checked against five additional sources: Government data on individual power plants, company reports, news and media reports, local NGOs specialising in coal, and first-hand information about a power plant project (Global Energy Monitor, 2023). To organise the information, a two-level system is used: It consists of data-sets (the GCPT and the GCPFT) containing information on each observation unit, and a wiki page for each coal-fired power plant containing further information on the history of the project and opposition (Global Energy Monitor, 2023). While this methodology is practical and clear, the fact that not all information is included in the data-sets leaves some information unrepresented in the statistical analysis. To provide information about coal-fired power plants in the GCPT, the GEM estimates values using different factors. Both, for the variable annual CO2 emissions and for the variable remaining lifetime different parameters are used to approximate the real values. As described in section 4.2 the variable annual CO2 is calculated by using the following formula:

$$\begin{aligned} \text{Annual CO2 (in million tonnes)} &= \text{capacity} \cdot 0.51 \cdot \text{heat rate} \\ &\quad \cdot \text{emission factor} \cdot 9.2427 \cdot 10^{-12} \end{aligned} \tag{4}$$

Whereby all parameters used are fixed averages or approximations, despite the fact that more detailed and recent data exists for most of them. The GEM makes decisions about the averages utilised and the method of calculation applied when approximating a parameter. As mentioned earlier, those choices greatly affect the values of the variables and therefore also the results of my analysis. To get a clearer picture of the effects of the membership in climate alliances and its correlation with the emissions and the lifetime of a coal-fired power plant unit, it is necessary to calculate the respective variables more specifically. As more (recent) data is available for the parameters, the specific regions, and the technologies used, it is possible to do a more precise analysis (see Champenois (2023), and appendix A.5, Tab. 8-12). Unfortunately, this goes beyond the scope of this thesis, and I leave it open for further research.

Another problem that remains is the weakness of research on GHG emissions and the uncertainty of carbon data. Despite the knowledge of the impact of GHG emissions on our climate, there is no framework or guideline on how to collect, report and share data on emissions. Emission reporting is still voluntary, leading to a general lack of data. Data that does exist is not necessarily available to the public. In addition, data-sets from different institutions are difficult to compare as it is not always clear how the information was gathered. Lack of data and transparency leads to inaccurate and unreliable information. Stronger regulations and standardised models are needed to better capture GHG emissions and draw valid conclusions (Hunt & Weber, 2019). In addition to the data basis, the techniques of data evaluation must also be improved and standardised to make studies and results comparable (Busch et al., 2021).

6.2 Conceptualization and specification issues

Not only the database used in an analysis, but also the methods chosen to analyse it determine its outcome. This subsection focuses on the limitations of the methods applied and the conceptualization made. In the following I discuss which specifications I used for the regression analysis and what could be done differently in an exploratory way to uncover relationships between the dependent variables and the membership of a financier in a climate alliance.

An important factor influencing the data and the results of the regression analysis is the merging process applied right at the beginning to combine the GCPT and the GCPFT data-sets. As described in section 4.2., I aggregate the information of each variable if there is more than one observation for one unit (and tracker ID). To do so, I weight the variable proportionally based on the financier's share in the total financing of the plant unit. Thereby, I end up with one observation per tracker ID. This preserves the observation units, and the observations are still independent of each other. At the same time, information is lost if a unit has several financiers who differ in their membership status. This missing information may cause some effects to be lost. Especially, when the different alliances vary in their effectiveness. As elaborated later, the majority of climate alliances only have a small number of members financing coal-fired power stations, but there are some outliers (see Tab. 4). Of the eight alliances studied, three[6] have no coal financing

[6]NZFSPA, NZICI and PAAO

members and other three[7] have less than 3%. But in the NZIA 10% of the members finance coal-fired power plant units and the NZBA has the highest score with 33% of its members financing coal. This illustrates that the merging process that aggregates information on the different alliances and treats them all the same may cause some effects to be lost.

Possible spill-over effects of being member in several alliances for example, cannot be identified after aggregating the information. But zero times zero is still zero. So, when being a signatory does not show any effect, being signatory in multiple alliances probably does not show an effect either.

Instead of aggregating the information one could only keep the observation units with the investor holding the biggest share of the coal-fired power plant unit, leaving all other investors aside. Still, information is lost, but the individual investors could be viewed at more differentiated, providing the possibility of checking for each individual alliance. I decided against this because I am not investigating what makes a good alliance or how alliances differ. I generally want to investigate whether the intended positive effects of SFI practices do have measurable effects in the real world. My research aim is to identify patterns of impact of membership in any climate alliance. The aim is not to control if a special climate alliance has an impact or not. Nevertheless, as Schoenmaker & Schramade (2021) emphasize, more research on the design of organizations and coalitions promoting SFI is needed to address environmental externalities, but this goes beyond the scope of this thesis. The screening process applied in the data generating process (see Section 4.1) secures that all alliances included in the analysis are comparable, which legitimatises that I summarize the information. Another possibility is to duplicate the information and give each investor per unit an own observation unit. On the one hand, no information is lost, which leaves room for several different analyses. On the other hand, units with several investors gain more importance as the observation units are multiplied, leading to a bias I want to avoid.

I took a statistical perspective and decided to apply the most straightforward and clean approach, as the alternative methods of combining the data-sets also have their disadvantages (as explained in section 4.2). Future research should elaborate more in detail on the merging process and try out different methods in an exploratory way to find out if other

[7]Climate100, NZAMI, NZAOA

conclusions can be drawn from the data when applying different merging techniques.

After applying the merging process, more specifications are chosen to run the regression. The decision about which control variables to include and to exclude in the model also shape the results. For example, through the so called omitted variable bias. It is a well-known problem in quantitative research which causes a bias in regression results by the (un)aware exclusion of variables from the regression that have an effect on the dependent variable. This results in the model being underspecified, which may lead to wrong conclusions. There is no way to test if a model is biased by omitted variables (Wooldridge, 2013).

As mentioned in section 4.2, an important factor for the lifetime of a coal-fired power plant unit and its emissions are the policies of the countries where the units are based. To avoid the omitted variable bias, I intend to approach this policy effect through adding region fixed effects into the model. This allows me to monitor whether an outcome solely appears in specific locations (with certain regulations and laws). But as elaborated above, in the GCPT data-set averages are used to calculate the values of the variables remaining lifetime and annual CO2, smoothing out possible regional effects. Existing variables need to be calculated more precisely to be able to control for regional differences and the effect of local conditions (see section 6.1). Moreover, future research needs to explore other mechanisms to reflect regional and political differences.

Another factor that could have an impact on the emissions and the lifetime of coal-fired power plants is how well alternative energy generation options can substitute for the coal plant's electricity. Possible omitted variables could be the technological readiness of alternative energy sources (such as solar, water and wind energy), the geographic conditions for the use of these, as well as economic conditions and the willingness to transform towards more sustainable energy generation methods in the country of operation. The hypothesis could be that countries with access to the sea or many hours of sunshine, as well as countries with high GDP, can switch more easily to green energy supply and reduce both annual emissions and the lifetime of coal-fired power plants in their country. The GCPT does not provide information on those factors and it was beyond the scope of the paper to collect the information myself. So, I approximated the effects of those omitted variable by including the variable region. But this is far too imprecise. Future research should rather consider regional differences at the country level or even more precisely and also include other variables like the technological readiness.

It is also possible that the present model is over specified by the variable capacity. I include the capacity of the units as control in my analysis because it is a confounding variable that is related to the dependent and to the independent variable (see section 4.2.). However, the variable annual CO2 is calculated by multiplying capacity with other factors as described above (see formular (1)). And as many factors in the calculation of formular (1) are fixed values and averages, the variable annual CO2 could be seen as a linear transformation of the capacity. This resolves in high correlation between the dependent variable annual CO2 and the control variable capacity. The correlation between the dependent and the control variable could explain the high values for the R^2 in the regression analysis of annual CO2 in Table 2. As the variable lifetime CO2 is calculated by multiplying annual CO2 emissions with the remaining lifetime of a coal-fired power plant, the high R^2 in the regression analysis of lifetime CO2 in Table 3 could also be explained by the overspecification of the model. However, excluding capacity as control variable from the regression analysis would lead to considerable omitted variable bias. Future research should have a closer look on this and run different regressions in an exploratory way to uncover relationships between the capacity of a coal-fired power plant unit, the membership status of a financier and the dependent variables.

Beyond the regression results, there is more information that can be gleaned from the data: One observation that is not represented in my analysis so far is the distribution of signatories investing in coal-fired power plants at all. To generate this information, I count how many of the members of each alliance are financiers of coal-fired power plant units. Then I calculate the share (Tab. 4). This reveals, that out of 1335 alliance members, only 8% (53) are invested in coal-fired power plants. Whereby great differences exist between the alliances. This indicates an effect of being signatory that is not visible in my analysis: It can be assumed, that signatories of climate alliances hold less shares of coal-fired power plant units compared to the group of financial institutions that are not members in such alliances. Alliance members either sold their shares or never invested in coal-fired power plants. These forms of pre-investment strategies or divestment green the portfolio of the investor, but not necessarily the real world as other capital sources might step in and the polluting company keeps emitting (see section 3, and Ritchie & Dowlatabadi (2015); Ansar et al. (2013); Hunt & Weber (2019); Caldecott et al. (2022a)). Therefore, leaving

Climate alliance	**Total members**	**Not financing coal**	**Financing coal**	**Share**
Climate100	700	697	3	0.43%
NZAMI	301	298	3	1.00%
NZAOA	84	82	2	2.38%
NZBA	126	84	42	33.33%
NZFSPA	27	27	0	0.00%
NZIA	30	27	3	10.00%
NZICI	11	11	0	0.00%
PAAO	56	56	0	0.00%
Total	**1335**	**1282**	**53**	
Total %	**100%**	**92%**	**8%**	

Table 4: Signatories financing coal-fired power plants.

the information of the distribution of signatories investing in coal-fired power plants aside does not cause a selection bias for my analysis. The aim of this paper is to find proofs of impact in the real world through lowered CO2 emissions of coal-fired power plants. The positive effect of being signatory in a climate alliance that leads to less signatories financing coal-fired power plants is a sign for virtual impact that greens the portfolios of the investors and not necessarily the world. To unambiguously proof an impact in the real world, panel data is needed with information about investors and emissions of coal-fired power plants at different points in time in order to see whether investors become members of a climate alliance and then disinvest. And to see if the GHG emissions of the coal-fired power plant that has been sold lower as a consequence of the divestment. Unfortunately, this data does not exist in an accessible way at the moment. I leave this topic open for future research.

Last, it is noteworthy that a substantial number of weighted signatory observations equal zero, which can be easily seen in the graphs showing the bivariate regression lines (see Fig. 4-6). This means that the majority of financiers investing in coal-fired power plants are not members of any climate alliance. Those observations could be excluded by using a dummy variable. I decided to include them for several reasons: First, the graphs showing the bivariate regression lines and the observation points (see Fig. 4-6) demonstrate that the observations of weighted signatory $\neq 0$ are uniformly distributed. It can be assumed that the bivariate regression line does not change significantly even if the zero observations are removed. Secondly, and more important, the observations where no financier is signatory do not distort the results, but are important for answering my research question: By removing weighted signatory = 0, I would be investigating whether the share of signatories among the financiers has an influence, not whether the fact of being signatory at all has an influence. So, I would discard a significant number of observations that interest me. This would result in a selection bias as I would only look at the data points that appear to have an effect rather than including all observations in my analysis.

6.3 Implications for research and policy

Now that I have discussed the statistical procedure in detail, I would like to contextualize it in the following to understand the implications of the findings.

The public, practitioners and policy institutions need to be aware, that not enough proof exists on the real-world impact of SFI practices. We do not know if the SFI sector is able to foster a just transition towards more sustainable economies. The problem of impact washing remains and needs to be addressed through more research on impact investing. This is important to be transparent to (philanthropic) investors and the public and to find ways to counteract a climate catastrophe. To conduct more and better research data availability needs to be improved through standardised frameworks for measuring real-world impact, and more data collection and processing on GHG emissions.
So far, there is also not enough evidence to argue against any real-world impact of the SFI sector. As long as there is the possibility that SFI can guide a just transition towards more sustainability, it is important to find out how this can be accomplished, advanced, and augmented to benefit from the advantages of the sector. The climate crisis is a real threat, and the financial sector is large and powerful. If there is an opportunity to harness it to drive a green transformation, this should be taken advantage of. More research needs to be done to understand the possibilities and ways of financial institutions to exert impact. As elaborated in section 3, collective action is needed to counteract the tragedy of the commons and lead the SFI sector into a more sustainable direction. To achieve real-world impact, it is not enough for individual investors to adjust their behaviour. The success of SFI practices depends on achieving a critical mass of investors using the same or a similar strategy. The public and policy insitutions should elaborate on ways to encourage as many financial institutions as possible to work in an impact-oriented manner. For

example, by making green investments more lucrative. The Target Setting Protocol of the NZAOA (United Nations Environment Programme, 2022) highlights, that the costs for implementing sustainable reforms in the production processes need to be reasonable. In our current system, a transformation of the economies towards more sustainability still needs to be cost-effective for investors, otherwise it will not take place.

In line with recent literature (Kölbel et al., 2020; Kumar et al., 2022; Nykvist & Maltais, 2022), all climate alliances state in their commitments and reports that SFI practices and financial institutions alone cannot transform our economies. Policy makers need to be aware of their crucial role in unifying frameworks and guidelines for measuring emissions and evaluating progress and their role in diffusing greener business practices.

7 Conclusion

The climate crisis is becoming more severe every day and studies as the IPCC report (2023) highlight the critical need for immediate action. Besides other measures, the finance industry gains momentum in becoming a leading instrument to transform our economy towards a more sustainable one. But although demand for SFI is rising and the sector is growing, there is, so far, no evidence that the financial industry actually can reduce real-world emissions through its investments.

Especially since the launch of the Paris Agreement, increasing numbers of financial institutions set themselves goals of achieving climate targets. Simultaneously, climate alliances emerged that provide a platform for financiers to share guidance and resources on Net Zero goals. Unfortunately, there is no proof that the membership in those alliances contributes to real-world emission reductions and even (philanthropist) impact-first investors do not know if their investments green the world. To approach the real-world impact of the SFI sector, I investigated the question: **What influence does the membership of a financier in a climate alliance have on the GHG emissions of a coal-fired power plant unit that it finances?** To do so, I enriched the mainly qualitative research on sustainable finance and investment with a linear regression model using ordinary least squares (OLS).

To provide a clear picture of the contributions to GHG emission reductions by financiers I differentiated between real-world and virtual impact, between investor and company impact, and impact-generating and impact-aligned investments. This secures, that detected emission reductions are not counted twice and are attributed to the right party responsible.

Interestingly, the regression output of my analysis cannot reveal a correlation between the membership of an investor in a climate alliance and lower emissions or a decreased lifetime of coal-fired power plant units. However, it does not refute possible positive influence either. The results join existing research and highlight the difficulties of measuring impact. To avoid impact washing and to be transparent to investors and the public, there needs to be clear proof of which mechanisms actually reduce GHG emissions in the real economy and which do not. The present analysis cannot provide the desired evidence.

To combine the two data-sets GCPT and GCPFT provided by the Global Energy Monitor, I aggregated information on alliances. In this way, I only looked at whether membership in an alliance has any effect at all and did not control for the individual alliances. However, my analysis suggests that there are large differences between different alliances and that it is worthwhile to control for the individual alliances. Also, the data-sets used provided by the GEM only represent averages or approximations for most of the variables. For the sake of simplicity, I run my regressions using these averages, even though more accurate data is available. Thus, future research should take this into account to obtain more precise results.

Still, more data is needed for a better understanding of SFI and the possibilities of so-called green investments. Reliable carbon data is scarce and hardly comparable. More research on GHG emissions needs to be done to create a viable base for further analyses. Moreover, panel data including finance information and emissions of the investee companies is needed to prove real-world impact.

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A Appendix

A.1 Alliances and their members

Name	Short	Inter-national	Type	Com-mitment	Paris aligned	Took in
Asia Investor Group on Climate Change	AIGCC	no				no
Climate Action 100+	C100	yes	Alliance	yes	yes	yes
Climate Bonds Initative	CBI	yes	Alliance	no		no
Coalition for Environmentally	Ceres	no				no
DivestInvest		yes	Other	no		no
Finance Watch		yes	Other	no		no
G20 Sustainable Finance Working Group		no				no
Glasgow Financial Alliance for Net Zero	GFANZ	yes	Network			no
Global Impact Investing Network	GIIN	yes	Network			no
Global Reporting Initiative	GRI	yes	Other	no		no
Global Sustainable Investment Alliance	GSIA	yes	Alliance	no		no
Intentional Endowments Network	IEN	yes	Network			no
Interfaith Center on Corporate Responsibility	ICCR	yes	Alliance	no		no
International Network of Financial Centres for Sustainability	FC4S	yes	Network			no
Investor Decarbonisation Initiative		yes	Other	no		no
Investor Group on Climate Change	IGCC	no				no
Net Zero Asset Managers Initiative	NZAMI	yes	Alliance	yes	yes	yes
Net Zero Asset Owner Alliance	NZAOA	yes	Alliance	yes	yes	yes
Net Zero Banking Alliance	NZBA	yes	Alliance	yes	yes	yes
Net Zero Financial Service Providers Alliance	NZFSPA	yes	Alliance	yes	yes	yes
Net Zero Insurance Alliance	NZIA	yes	Alliance	yes	yes	yes
Net Zero Investment Consultants Initiative	NZICI	yes	Alliance	yes	yes	yes
Network of Central Banks and Supervisors for Greening the Financial System	NGFS	yes	Network			no
Paris Aligned Asset Owners	PAAO	yes	Alliance	yes	yes	yes

Paris Aligned Investment Initiative	PAII	yes	Network			no
Say on Climate	SoC	yes	Other	no		no
Sustainable Banking and Finance Network	SBFN	yes	Alliance	yes	no	no
Task Force on Climate-related Financial Disclosures	TCFD	yes	Framework			no
Task Force on Nature-related Financial Disclosures	TNFD	yes	Framework			no
The Equator Principles	EP	yes	Alliance	yes	yes	yes
The Institutional Investors Group on Climate Change	IIGCC	no				no
The Investor Agenda	IA	yes	Framework			no
Toniic		yes	Community	no		no
UNEP FI Principles for Responsible Investment	PRI	yes	Framework			no
UNEP FI Principles for Responsible Banking	PRB	yes	Framework			no
UNEP FI Principles for Responsible Sustainable Insurance	PSI	yes	Framework			no

Figure 7: List of all climate alliances in the financial sector found through the search strategy.

Financier	climate100 Member	Difference	Included	Reason
Caixa Geral de Depósitos	CaixaBank Asset Management SGIIC, S.A.U.	yes	no	Member is a subsidiary of the financier
Bancolombia	Bancolombia	no	yes	
BNP Paribas	BNP Paribas	no	yes	
BNP Paribas Fortis	BNP Paribas	yes	no	Two different companies
Credit Suisse	Credit Suisse Asset Management	yes	no	Member is a subsidiary of the financier
Goldman Sachs	Goldman Sachs Asset Management	yes	no	Member is a subsidiary of the financier
HSBC	HSBC Bank (UK) Pension Scheme	yes	no	Member is a subsidiary of the financier
HSBC	HSBC Global Asset Management	yes	no	Member is a subsidiary of the financier
Investec	Investec Wealth & Investment	yes	no	Member is a subsidiary of the financier
KBC Bank	KBC Asset Management	yes	no	Member is a subsidiary of the financier
Macquarie SBI Infrastructure Fund	Macquarie Asset Management	yes	no	Two different companies
Mitsubishi UFJ Trust and Banking	Mitsubishi UFJ Trust & Banking	yes	yes	Corporation indicates company form
Raiffeisen Banking Group	Raiffeisen Capital Management	yes	no	Member is a subsidiary of the financier
Raiffeisen Banking Group	Raiffeisen Pensionskasse Genossenschaft	yes	no	
Sumitomo Corporation	Sumitomo Mitsui DS Asset Management	yes	no	Two different companies
Sumitomo Mitsui	Sumitomo Mitsui DS Asset Management	yes	no	Two different companies
Sumitomo Mitsui Banking	Sumitomo Mitsui DS Asset Management	yes	no	Two different companies
Sumitomo Mitsui Financial Group	Sumitomo Mitsui DS Asset Management	yes	no	Member is a subsidiary of the financier
Sumitomo Mitsui Trust Holdings	Sumitomo Mitsui Trust Asset	yes	no	Member is a subsidiary of the financier
T&D Holdings	T&D Asset Management	yes	no	Member is a subsidiary of the financier

Financier	EP Member	Difference	Included	Reason
ABSA Bank	ABSA Group Limited	yes	yes	Financier is a subsidiary of the member
Aozora Bank	Aozora Bank	no	yes	
Bradesco	Banco Bradesco, S.A.	yes	yes	
Banco de Brasil	Banco de Brasil	no	yes	
Santander	Banco Santander S.A.	yes	yes	
Banco Votorantim	Banco Votorantim SA	yes	yes	

Bancolombia	Bancolombia S.A.	yes	yes	
Barclays	Barclays plc	yes	yes	
BNP Paribas	BNP Paribas	no	yes	
BNP Paribas Fortis	BNP Paribas	yes	no	Two different companies
BTG Pactual	BTG Pactual	no	yes	
Caixa Geral de Depositos	Caixa Bank	yes	no	Two different companies
Caixa Geral de Depositos	CAIXA Econômica Federal	yes	no	Two different companies
Cathay United Bank	Cathay United Bank Co., Ltd	yes	yes	
Citibank	Citigroup Inc.	yes	yes	Financier is a subsidiary of the member
Citigroup	Citigroup Inc.	yes	yes	
Credit Suisse	Credit Suisse Group	yes	yes	
Crédit Agricole Corporate and Investment Bank (CALYON)	Crédit Agricole Corporate and Investment Bank	no	yes	
CTBC Bank	CTBC Bank Co., Ltd	yes	yes	
DBS Bank	DBS Group Holdings Ltd	yes	yes	Financier is a subsidiary of the member
DekaBank	DekaBank Deutsche Girozentrale	yes	no	Member is a subsidiary of the financier
Deutsche Bank	Deutsche Bank AG	yes	yes	
Development Bank of Japan	Development Bank of Japan	no	yes	
DZ Bank	DZ Bank AG	yes	no	
First Abu Dhabi Bank	First Abu Dhabi Bank (FAB)	yes	yes	
FMO	FMO (Netherlands Development Finance Company)	yes	yes	
Hana Bank	Hana Bank	no	yes	
HSBC	HSBC Holdings plc	yes	yes	
IDFC Infrastructure Fund	IDFC FIRST Bank	yes	yes	
Industrial Bank of Korea	Industrial Bank of Korea	no	yes	
Intesa Sanpaolo	Intesa Sanpaolo SpA	yes	yes	
Itau-Unibanco	Itaú Unibanco S.A.	yes	yes	
JP Morgan	JP Morgan Chase & Co.	yes	yes	JP Morgan is a shortform for JP Morgan Chase & Co

KB Kookmin Bank	KB Kookmin Bank	yes	yes	
KBC Bank	KBC Group N.V.	yes	yes	Financier is a subsidiary of the member
KFW	KfW IPEX-Bank GmbH	yes	no	Member is a subsidiary of the financier
Korea Development Bank	Korea Development Bank	no	yes	
Bank Mega	Mega Bank	yes	no	Two different companies
Mizuho Financial Group	Mizuho Bank, Ltd. / AMOAI	yes	no	Financier is a subsidiary of the member
Mizuho Bank	Mizuho Bank, Ltd. / AMOAI	yes	yes	
Mizuho Corporate Bank	Mizuho Bank, Ltd. / AMOAI	yes	yes	
MUFG Bank	MUFG Bank, Ltd	yes	yes	
MUFG's banking arm Bank of	MUFG Bank, Ltd	yes	no	
Natixis	Natixis	no	yes	
NIBC Bank	NIBC Bank N.V.	yes	yes	
Nippon Life Insurance	Nippon Life Insurance Company	yes	yes	
Nonghyup Bank	NongHyup Bank	no	yes	
NongHyup Life Insurance	NongHyup Bank	yes	no	Member is a subsidiary of the financier
Nonghyup Group	NongHyup Bank	yes	no	Member is a subsidiary of the financier
Nonghyup Property and Casualty Insurance	NongHyup Bank	yes	no	Member is a subsidiary of the financier
OCBC NISP	OCBC	yes	no	OCBC owns 85% of OCBC NISP, but its a different company
Oversea Chinese Banking	OCBC	yes	yes	OCBC is the shortform
Samsung Life Insurance	Samsung Life Insurance	no	yes	
Samsung Fire & marine Insurance	Samsung Life Insurance	yes	no	
Shinhan Bank	Shinhan Bank	no	yes	
Shinhan Life Insurance	Shinhan Bank	yes	no	
Shinsei Bank	Shinsei Bank Limited	yes	yes	
Siam Commercial Bank	Siam Commercial Bank	no	yes	
Skandinaviska Enskilda Banken	Skandinaviska Enskilda Banken AB	yes	yes	
Societe Generale	Société Générale	yes	yes	
Standard Bank South Africa	Standard Bank Group	yes	yes	Two different companies

Standard Chartered Bank	Standard Chartered Plc	yes	yes	
Sumitomo Corporation	Sumitomo Mitsui Banking Corporation	yes	no	Two different companies
Sumitomo Mitsui	Sumitomo Mitsui Banking Corporation	yes	yes	
Sumitomo Mitsui Banking	Sumitomo Mitsui Banking Corporation	yes	yes	
Sumitomo Mitsui Financial Group	Sumitomo Mitsui Banking Corporation	yes	no	Member is a subsidiary of the financier
Sumitomo Mitsui Trust Holdings	Sumitomo Mitsui Trust Bank, Limited	yes	no	Member is a subsidiary of the financier
Norinchukin Bank	The Norinchukin Bank	yes	yes	
UniCredit	UniCredit SpA	yes	no	
United Overseas Bank	United Overseas Bank Limited (UOB)	yes	yes	
Woori Bank	Woori Bank	no	yes	

Financier	NZAMI Member	Difference	Included	Reason
Ashmore Energy International	Ashmore Group Plc	yes	yes	Financier is a subsidiary of the member
BNP Paribas	BNP Paribas Asset Management	yes	no	Member is a subsidiary of the financier
BNP Paribas Fortis	BNP Paribas Asset Management	yes	no	Two different companies
Caixa Geral de Depósitos	Caixa Gestão de Ativos	yes	no	Member is a subsidiary of the financier
Credit Suisse	Credit Suisse asset Management	yes	no	Member is a subsidiary of the financier
Deka Bank	Deka Investment GmbH Deka Vermögensmanagement GmbH	yes	no	Member is a subsidiary of the financier
Bancolombia	Grupo Bancolombia	yes	yes	Financier is a subsidiary of the member
HSBC	HSBC asset Management	yes	no	Member is a subsidiary of the financier
JP Morgan	JP Morgan asset Management	yes	no	Member is a subsidiary of the financier
Macquarie SB Infrastructure	Macquarie Asset Management	yes	no	Member is a subsidiary of the financier
Mirae Asset Life Insurance	Mirae Asset	yes	yes	Financier is a subsidiary of the member
MUFG Bank	MUFG asset Management	yes	no	Member is a subsidiary of the financier
MUFG's banking arm Bank of Tokyo-Mitsubishi	MUFG asset Management	yes	no	Two different companies
SMBC Nikko Securities	Nikko Asset Management Co. Ltd.	yes	no	Two different companies
Santander	Santander Asset Management	yes	no	Member is a subsidiary of the financier
Shinhan Bank	Shinhan Asset Management	yes	no	Member is a subsidiary of the financier

Societe Generale	Societe Generale Private Wealth Management	yes	no	Member is a subsidiary of the financier
Sumitomo Mitsui	Sumitomo Mitsui DS Asset Management Company, Limited	yes	no	Two different companies
Sumitomo Mitsui Trust Holdings	Sumitomo Mitsui Trust Asset Management	yes	no	Two different companies
Sumitomo Corporation	Sumitomo Mitsui DS Asset Management Company, Limited	yes	no	Two different companies
Sumitomo Mitsui Financial Group	Sumitomo Mitsui DS Asset Management Company, Limited	yes	no	Member is a subsidiary of the financier
Sumitomo Mitsui Banking Corporation	Sumitomo Mitsui DS Asset Management Company, Limited	yes	no	Two different companies

Financier	NZAOA Member	Difference	Included	Reason
Nippon Life Insurance	Nippon Life	yes	yes	Nippon Life is a shortform for Nippon Life Insurance
BNP Paribas	BNP Paribas	no	yes	
BNP Paribas Forits	BNP Paribas	yes	no	Two different companies
Prudential Capital Group	Prudential plc	yes	no	Two different companies
Credit Agricole Group	Crédit Agricole Assurances	yes	no	Member is a subsidiary of the financier
Crédit Agricole Corporate and Investment Bank (CALYON)	Crédit Agricole Assurances	yes	no	Two different companies
Société Générale	Société Générale Assurances	yes	no	Member is a subsidiary of the financier
Intensa Sanpaolo	Intesa Sanpaolo Vita Group	yes	no	Member is a subsidiary of the financier
Caixa Geral de Depósitos	VidaCaixa S.A.U.	yes	no	Member is a subsidiary of the financier

Financier	NZBA Member	Difference	Included	Reason
Bancolombia	Bancolombia SA	yes	yes	SA indicates company form
Barclays	Barclays Group plc	yes	yes	Financier is a subsidiary of the member
BNP Paribas	BNP Paribas	no	yes	

BNP Paribas Fortis	BNP Paribas	yes	no	Two different companies
Bradesco	Banco Bradesco S.A.	yes	yes	Bradesco is a shortform for Banco bradesco S.A.
Caixa Geral de Depósitos	Caixa Geral de Depósitos (CGD)	no	yes	
CIMB Group	CIMB Bank Berhad	yes	yes	Company profile on the NZBA Website
Citibank	Citi	yes	yes	Financier is a subsidiary of the member
Citigroup	Citi	yes	yes	Citi is a shortform for Citigroup
Commerzbank	Commerzbank AG	yes	yes	AG indicates company form
Credit Agricole Group	Crédit Agricole S.A.	yes	yes	Credit Agricole Group is linked on the NZBA Website
Credit Suisse	Credit Suisse	no	yes	
Deutsche Bank	Deutsche Bank AG	yes	yes	
Erste Bank	Erste Group Bank AG	yes	no	Two different companies
First Abu Dhabi Bank	First Abu Dhabi Bank P.J.S.C.	yes	yes	
Garanti Bank	Garanti Bank	no	yes	
Goldman Sachs	The Goldman Sachs Group, Inc.	yes	yes	Goldman Sachs is a shortform for The Goldman Sachs Group, Inc
HSBC	HSBC Holdings plc	yes	yes	Company profile on the NZBA Website shows both names
IBK Affiliates	Industrial Bank of Korea (IBK)	yes	no	Two different companies
Industrial Bank of Korea	Industrial Bank of Korea (IBK)	no	yes	
ING Group	ING	yes	yes	ING is a shortform for ING Group
Intesa Sanpaolo	Intesa Sanpaolo	no	yes	
Investec	Investec group	yes	yes	Investec is a shortform for Investec Group
Itau-Unibanco	Itaú Unibanco Holding S.A.	yes	yes	
Mitsubishi Corporation	Mitsubishi UFJ Financial Group, Inc	yes	no	Two different companies
Mitsubishi UFJ Financial Group	Mitsubishi UFJ Financial Group, Inc	yes	yes	
Mitsubishi UFJ Trust and Banking	Mitsubishi UFJ Financial Group, Inc	yes	yes	Financier is a subsidiary of the member
Mizuho Financial Group	Mizuho Financial Group, Inc.	no	yes	

Mizuho Bank	Mizuho Financial Group, Inc.	yes	yes	Financier is a subsidiary of the member
Mizuho Corporate Bank	Mizuho Financial Group, Inc.	yes	yes	Name changed over time
NLB Bank	NLB Group	yes	yes	Financier is a subsidiary of the member
NongHyup Bank	NongHyup Financial Group	no	yes	Listet on website
NongHyup Group	NongHyup Financial Group	yes	yes	NongHyup Gorup is a shortform for NongHyup Financial Group
NongHyup Life Insurance	NongHyup Financial Group	yes	yes	Financier is a subsidiary of the member
NongHyup Property and Casualty Insurance	NongHyup Financial Group	yes	yes	Financier is a subsidiary of the member
Santander	Banco Santander S.A.	yes	yes	Santander is a shortform for Banco Santander S.A.
Shinhan Bank	Shinhan Financial Group	yes	yes	Financier is a subsidiary of the member
Shinhan Life Insurance	Shinhan Financial Group	yes	yes	Financier is a subsidiary of the member
Skandinaviska Enskilda Banken	Skandinaviska Enskilda Banken (SEB)	no	yes	
Societe Generale	Société Générale	no	yes	
Standard Chartered Bank	Standard Chartered plc	yes	yes	Financier is a subsidiary of the member
Sumitomo Corporation	Sumitomo Mitsui Financial Group, Inc.	yes	no	Financier is a subsidiary of the member
Sumitomo Mitsui	Sumitomo Mitsui Financial Group, Inc.	yes	yes	Financier is a subsidiary of the member
Sumitomo Mitsui Banking Corporation	Sumitomo Mitsui Financial Group, Inc.	yes	yes	Financier is a subsidiary of the member
Sumitomo Mitsui Financial Group	Sumitomo Mitsui Financial Group, Inc.	no	yes	
Sumitomo Mitsui Trust Holdings	Sumitomo Mitsui Trust Holdings, Inc.	no	yes	
UniCredit	UniCredit	no	yes	
Woori Bank	WOORI FINANCIAL GROUP	yes	yes	Financier is a subsidiary of the member

Financier	NZFSPA Member	Difference	Included	Reason
BDO Unibank	BDO International	yes	no	Two different companies

Financier	NZIA Member	Difference	Included	Reason
Intensa Sanpaolo	Intensa Sanpaolo Vita	yes	no	Member is a subsidiary of the financier

Samsung Fire & Marine Insurance	Samsung Fire & Marine Insurance	no	yes	
Shinhan Life Insurance	Shinhan Life Insurance	no	yes	
Shinhan Bank	Shinhan Life Insurance	yes	no	Two different companys

Financier	NZICI Member	Difference	Included	Reason
Janata Bank	Jana	yes	no	Two different companies

Financier	PAAO Member	Difference	Included	Reason
Barclays	Barclays Bank UK Retirement Fund	yes	no	Member is a subsidiary of the financier
HSBC	HSBC Bank Pension Trust (UK) Ltd.	yes	no	Member is a subsidiary of the financier

Figure 8: List of the alliance members considered as signatories for the analysis.

A.2 Regression - Included variables

1. *Weighted loan*: A former dummy variable that took the value 1 if over 50% of the investors in a coal-fired power plant unit invested in loans. It was then weighted by the financiers share of the overall funding.

2. *Weighted equity*: A former dummy variable that took the value 1 if over 50% of the investors in a coal-fired power plant unit invested in equities. It was then weighted by the financiers share of the overall funding. Since there are other forms of investments (bond, government subsidy, insurance, refinancing loan, refinancing capital, refinancing bond), the two dummies (weighted loan and weighted equity) are not perfectly collinear. However, I do not include the other investment types as they are not relevant. There are only a few observations of coal-fired power plant units that are financed by any other investment type than loan or equity.

3. *Capacity*: Indicates the capacity of the power plant unit in megawatts.

4. *Forthcoming*: A dummy variable that takes the value 1 if the power plant unit is under construction, permitted, pre-permited or shelved.

5. *Cut-off*: A dummy variable that takes the value 1 if the power plant unit is cancelled, mothballed or retired.

6. *Retire until 2050*: A dummy variable that takes the value 1 if the power plant retires until 2050.

7. *Weighted financing*: A dummy variable that takes the value 1 if the financing for the power plant unit ist still ongoing, weighted by the financiers share of the financing.

8. *Region*: To avoid the omitted variable bias, I control for the regions as a reflection of policy regulations.

A.3 Graphical analysis of the regression models

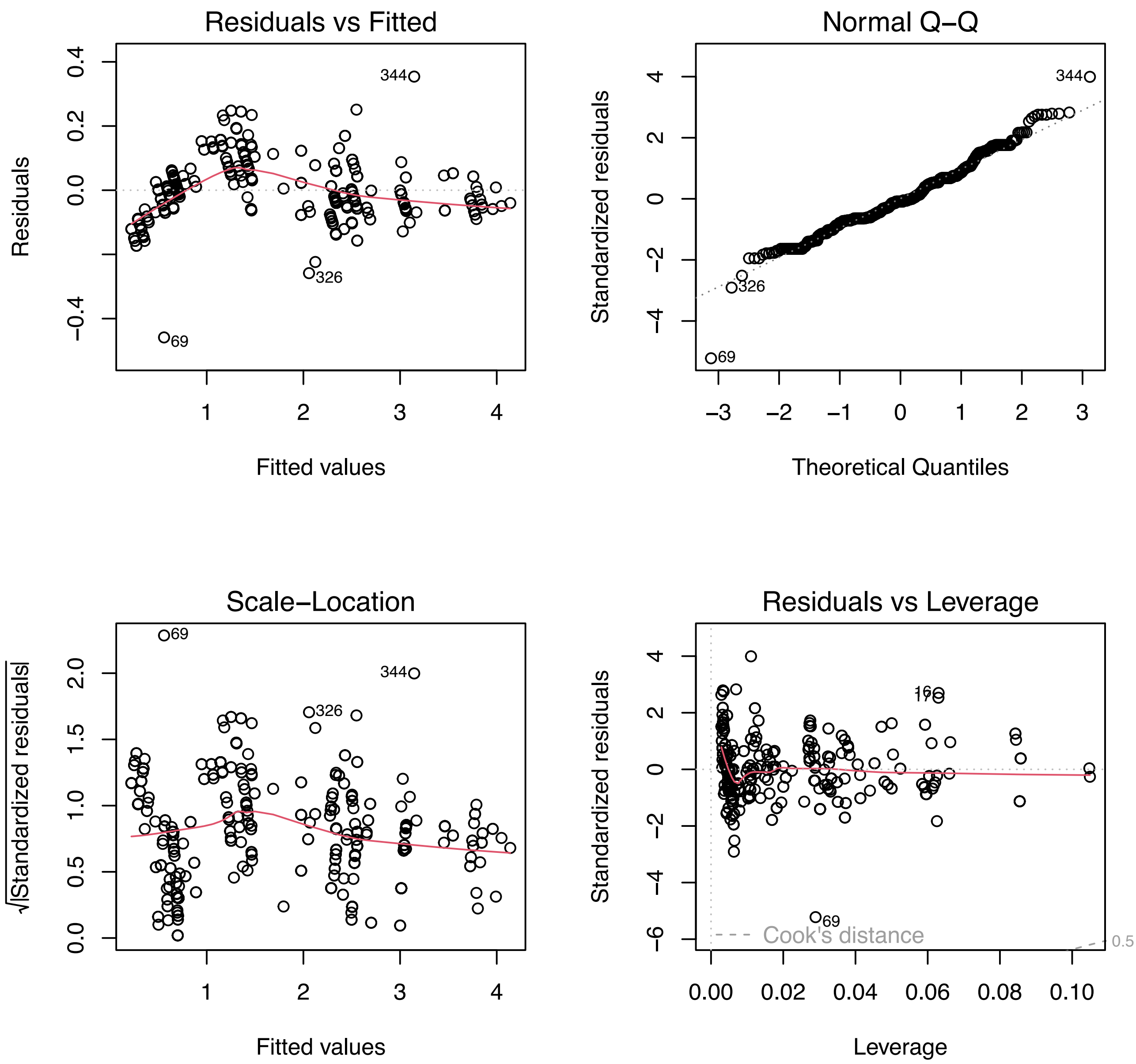

Figure 9: Graphical test of the Gauss-Markov Theorem for *annual CO2*.

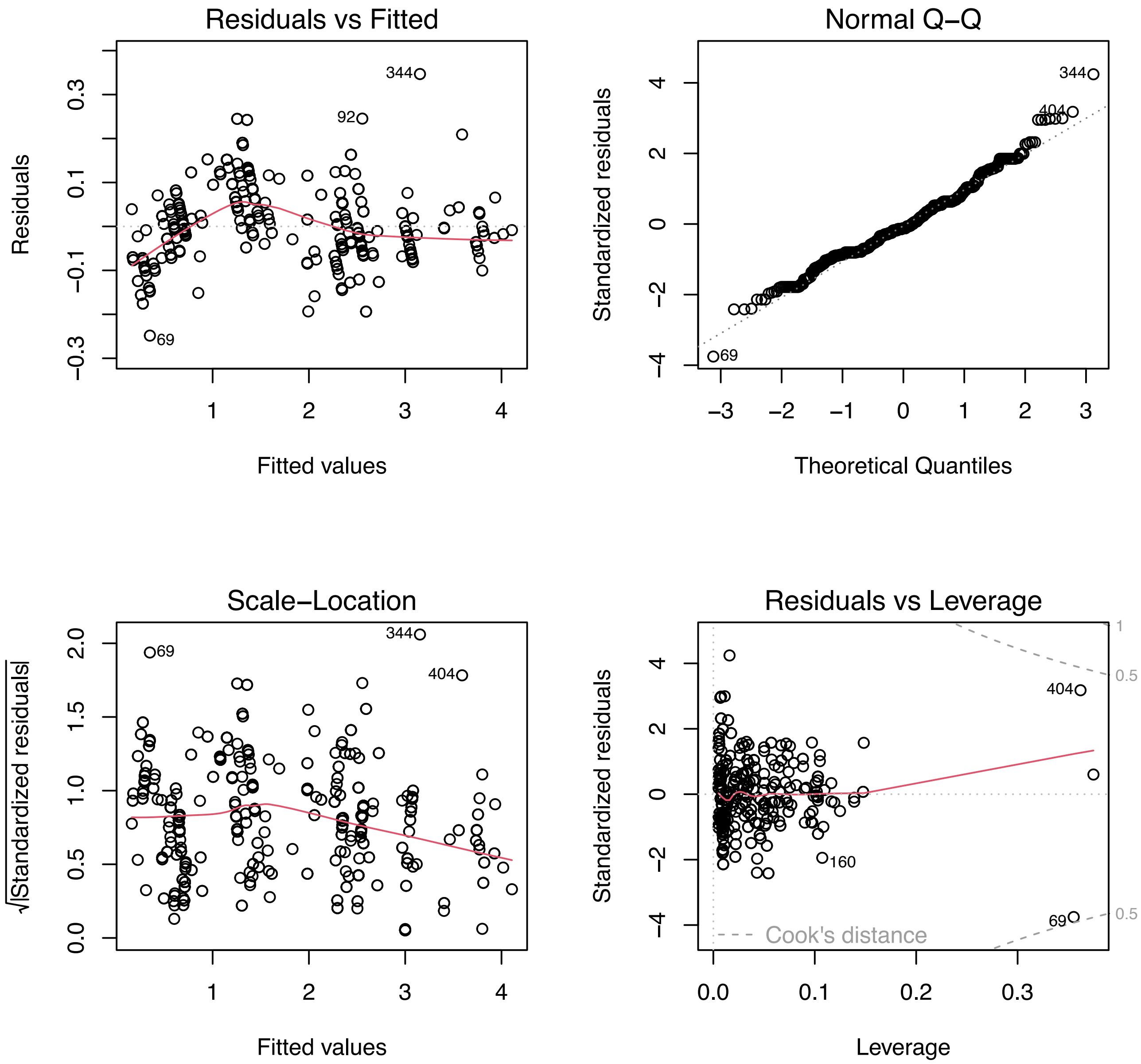

Figure 10: Graphical test of the Gauss-Markov Theorem for *annual CO2* with regions.

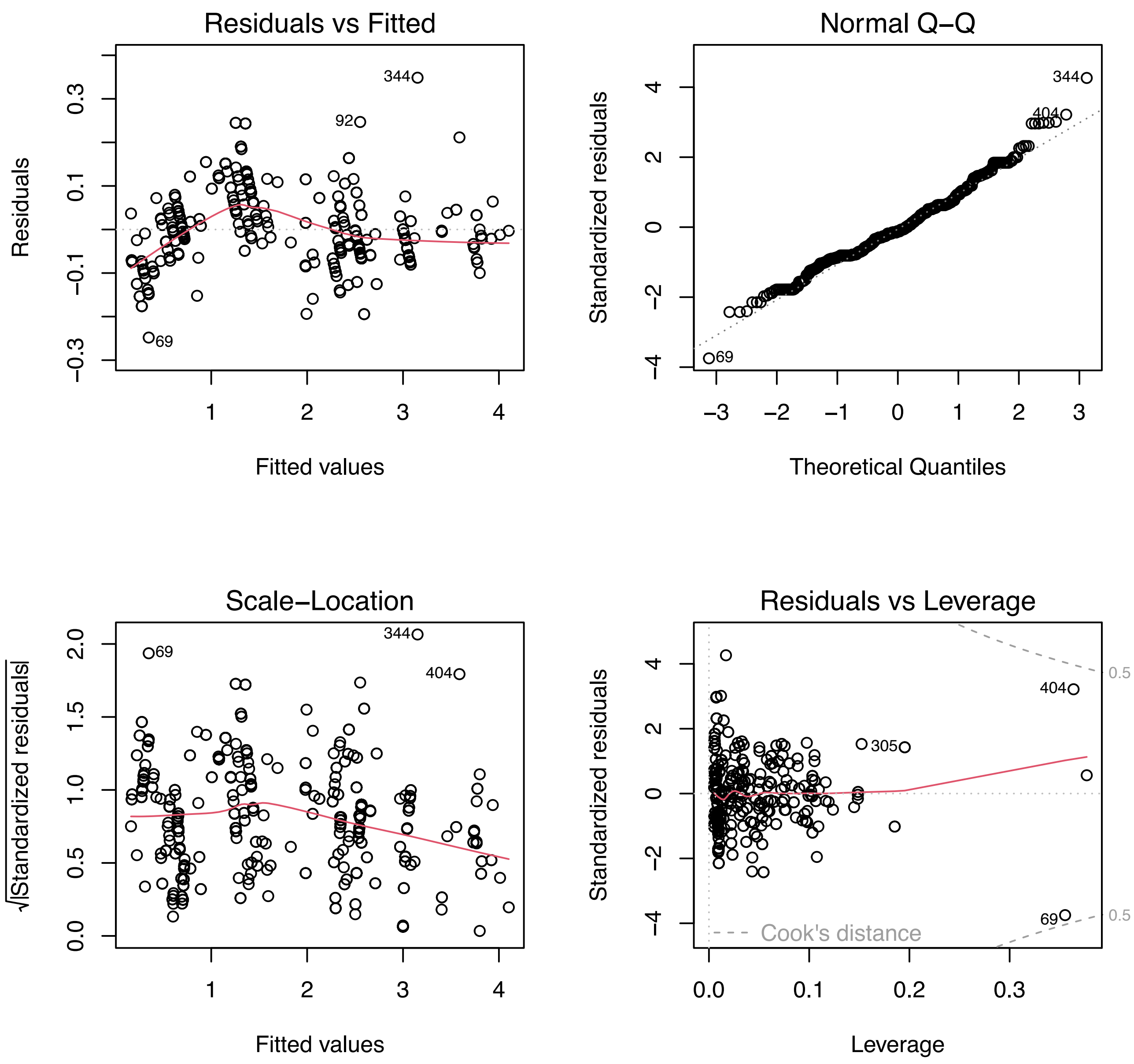

Figure 11: Graphical test of the Gauss-Markov Theorem for *annual CO2* with regions and interaction term.

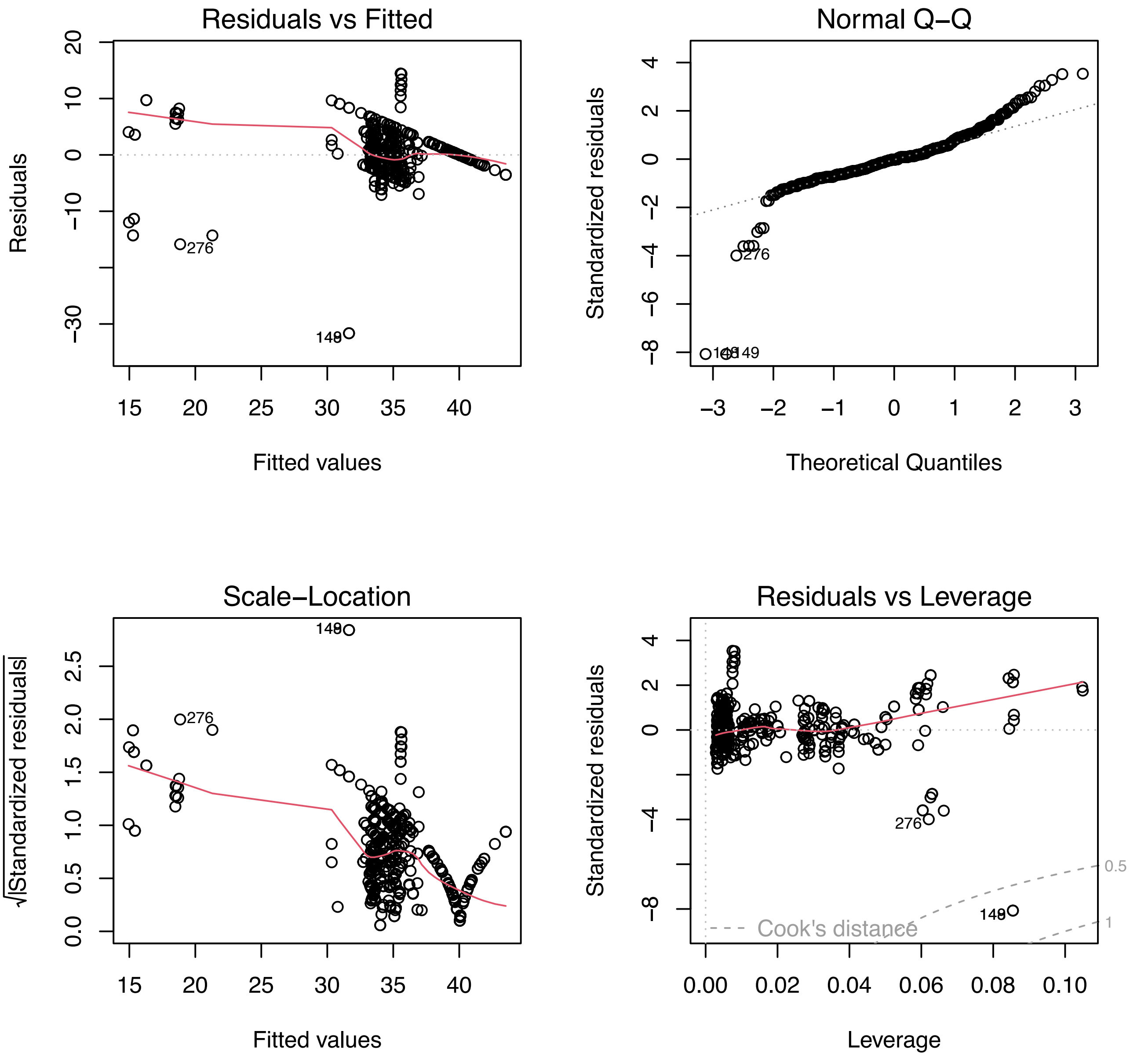

Figure 12: Graphical test of the Gauss-Markov Theorem for *remaining lifetime*.

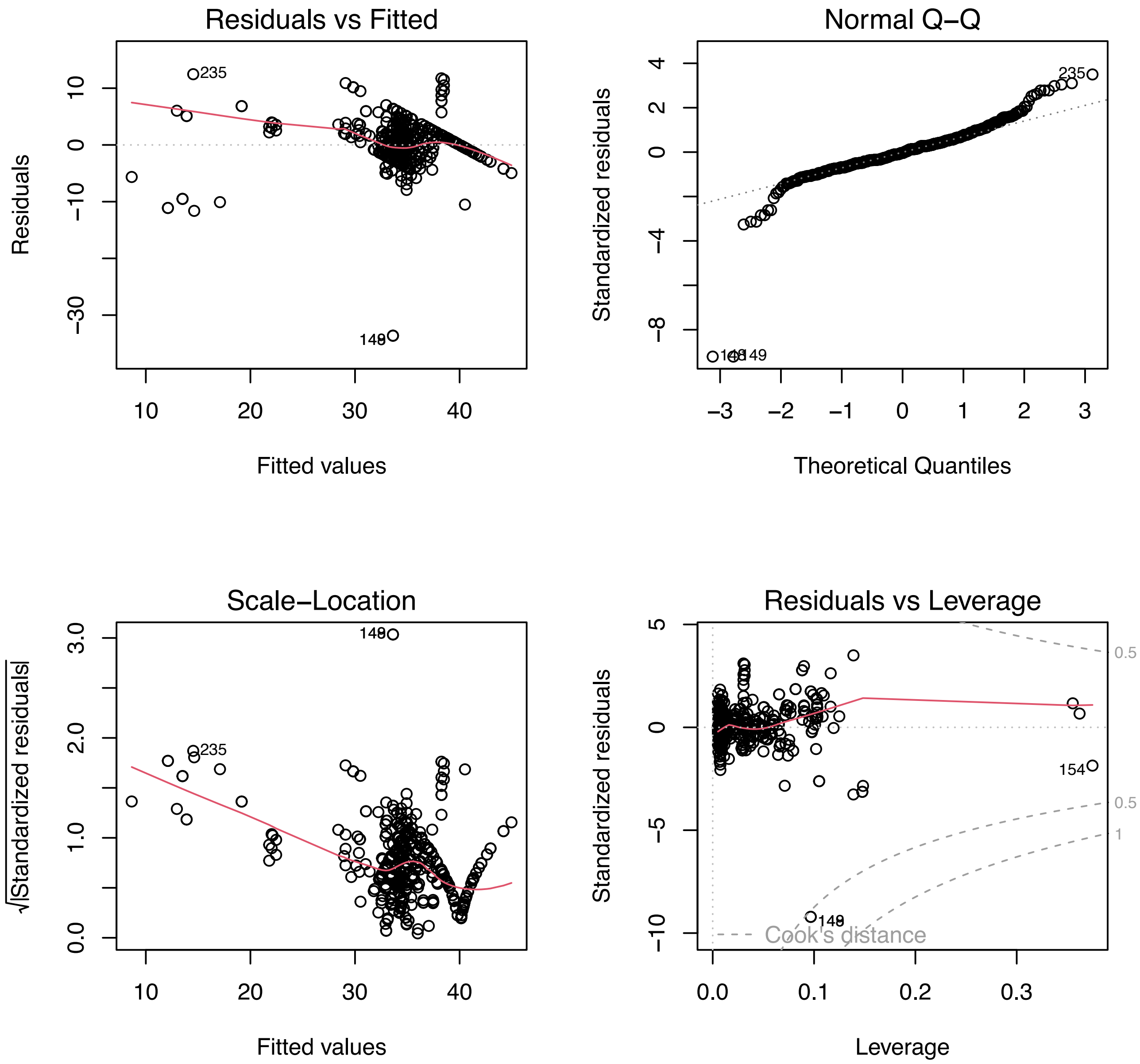

Figure 13: Graphical test of the Gauss-Markov Theorem for *remaining lifetime* with regions.

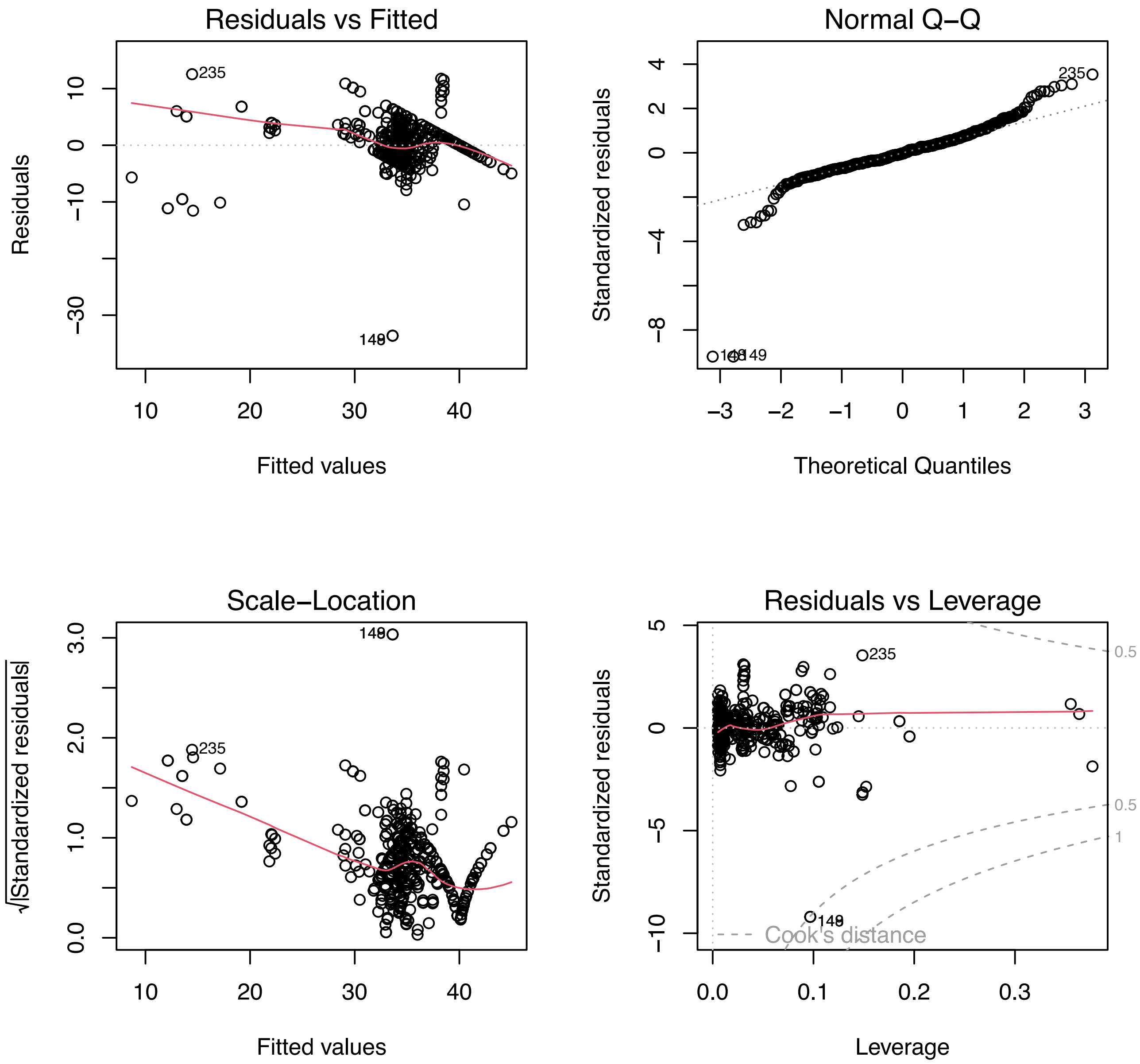

Figure 14: Graphical test of the Gauss-Markov Theorem for *remaining lifetime* with regions and interaction term.

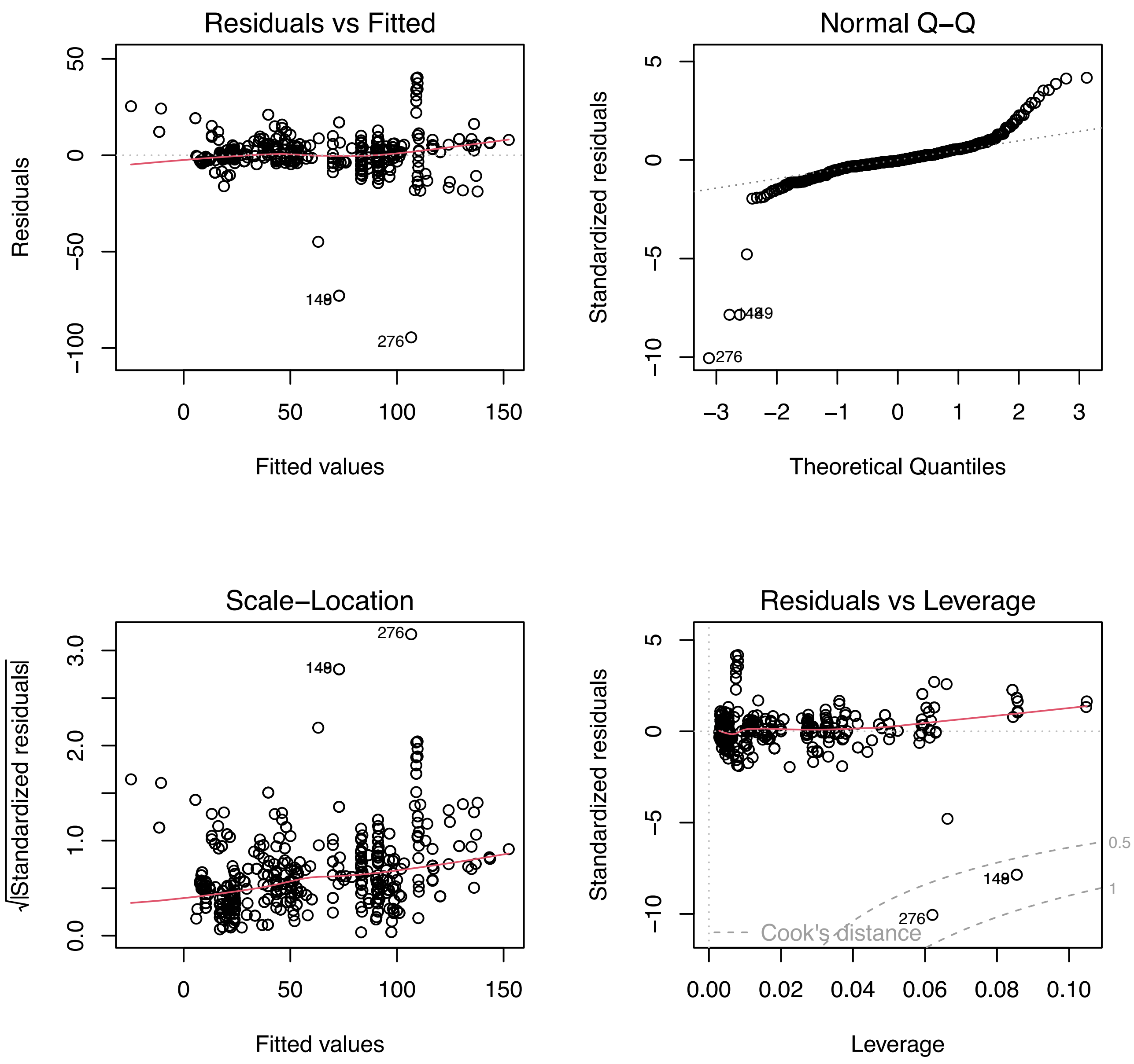

Figure 15: Graphical test of the Gauss-Markov Theorem for *lifetime CO2*.

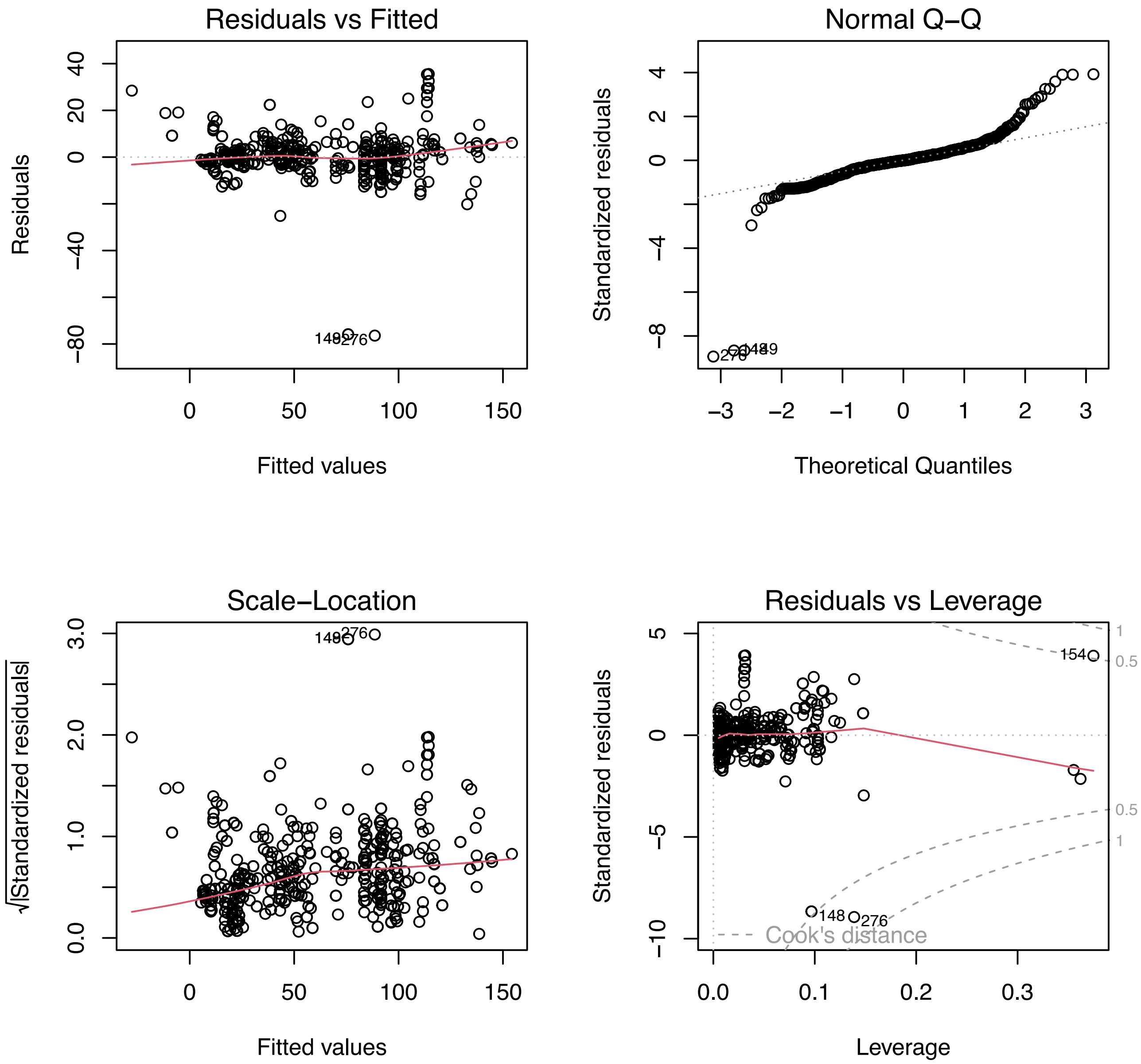

Figure 16: Graphical test of the Gauss-Markov Theorem for *lifetime CO2* with regions.

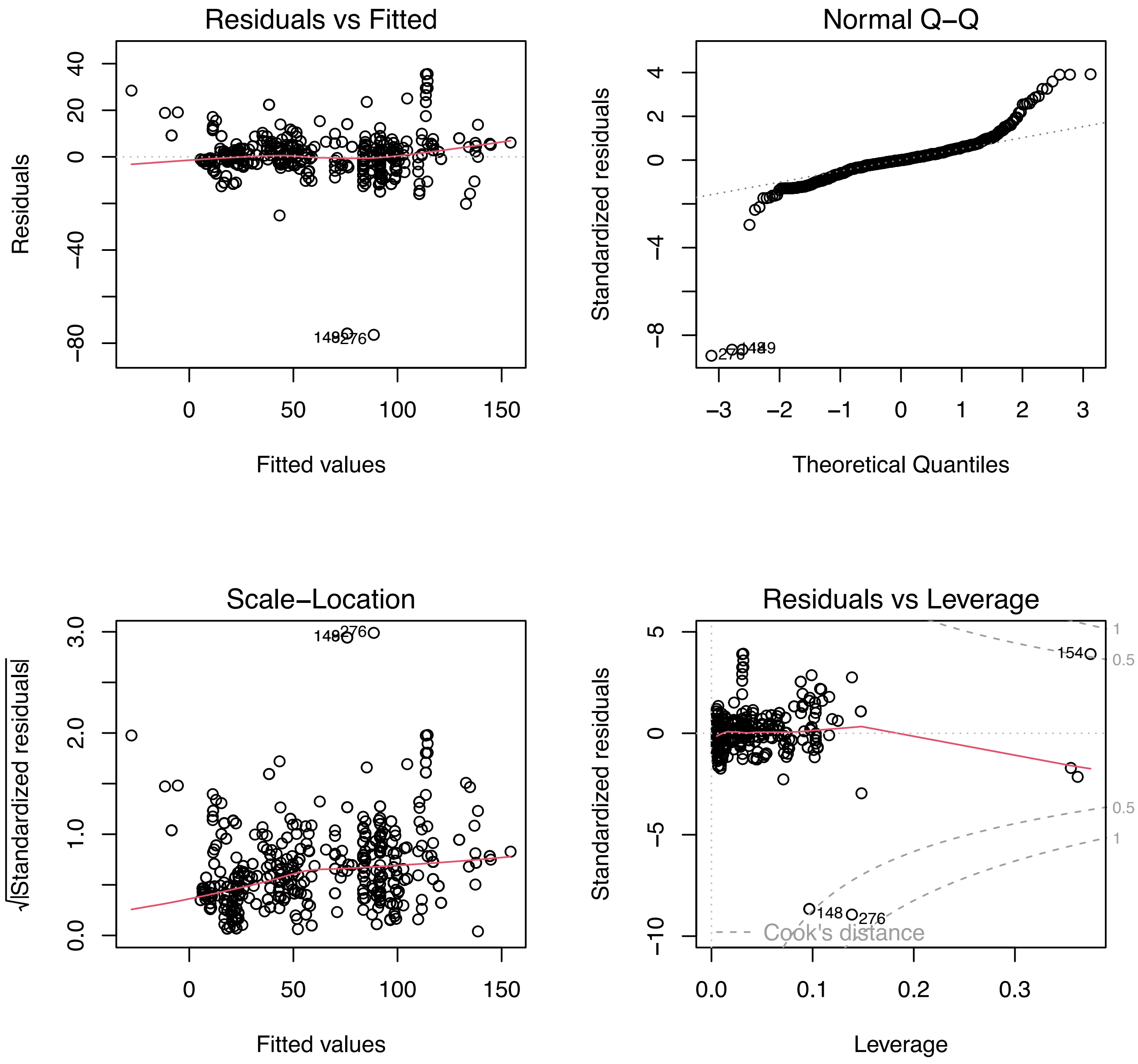

Figure 17: Graphical test of the Gauss-Markov Theorem for *lifetime CO2* with regions and interaction term.

A.4 Regression output

The following tables display the regression outputs for all estimated coefficents.

	Model 1	Model 2	Model 3	Model 4
Weighted signatory	0.3129	−0.0291	−0.0338	0.0126
	(0.2369)	(0.0212)	(0.0221)	(0.0729)
Weighted equity dummy		0.0203	0.0291	0.0373
		(0.0224)	(0.0209)	(0.0242)
Weighted loan dummy		0.0247	0.0233	0.0319
		(0.0172)	(0.0163)	(0.0209)
Capacity		0.0036***	0.0036***	0.0036***
		(0.0000)	(0.0000)	(0.0000)
Forthcoming		−0.0521***	−0.0513***	−0.0513***
		(0.0103)	(0.0096)	(0.0096)
Cut-off		−0.0410	−0.0242	−0.0245
		(0.0263)	(0.0248)	(0.0248)
Retire until 2050		0.0124	0.0364	0.0387*
		(0.0213)	(0.0225)	(0.0227)
Weighted financing		0.0298*	0.0294*	0.0296*
		(0.0158)	(0.0151)	(0.0151)
Region Canada/US			−0.1697***	−0.1699***
			(0.0501)	(0.0502)
Region East Asia			−0.0170	−0.0155
			(0.0214)	(0.0215)
Region EU27			−0.0165	−0.0156
			(0.0290)	(0.0290)
Region Eurasia			0.0004	−0.0005
			(0.0297)	(0.0297)
Region Latin America			0.1669***	0.1673***
			(0.0258)	(0.0258)
Region non-EU Europe			0.0818***	0.0822***
			(0.0217)	(0.0217)
Region South East Asia			0.0522***	0.0517***
			(0.0143)	(0.0143)
Region South Asia			0.0542***	0.0543***
			(0.0139)	(0.0139)
Weighted signatory x Weighted loan dummy				−0.0508
				(0.0761)
(Intercept)	1.6667***	0.1396***	0.0890***	0.0808***
	(0.0473)	(0.0191)	(0.0224)	(0.0256)
R^2	0.0031	0.9924	0.9936	0.9936
Num. obs.	556	556	556	556

Note: OLS-estimates. Standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 5: Annual CO2

	Model 1	Model 2	Model 3	Model 4
Weighted signatory	−3.1272**	−0.6824	−3.1518***	−2.5152
	(1.3791)	(0.9759)	(1.0318)	(3.4009)
Weighted equity dummy		0.5206	1.1241	1.2364
		(1.0292)	(0.9720)	(1.1282)
Weighted loan dummy		−0.6884	−0.0521	0.0671
		(0.7926)	(0.7598)	(0.9730)
Capacity		0.0030***	0.0037***	0.0036***
		(0.0007)	(0.0007)	(0.0007)
Forthcoming		4.4673***	4.1247***	4.1252***
		(0.4733)	(0.4460)	(0.4464)
Cut-off		−3.3143***	−3.8853***	−3.8901***
		(1.2087)	(1.1539)	(1.1552)
Retire until 2050		−18.3704***	−18.3560***	−18.3250***
		(0.9774)	(1.0471)	(1.0598)
Weighted financing		2.2279***	1.4224**	1.4252**
		(0.7256)	(0.7044)	(0.7052)
Region Canada/US			−8.7513***	−8.7542***
			(2.3369)	(2.3390)
Region East Asia			1.3506	1.3710
			(0.9956)	(1.0019)
Region EU27			−6.6655***	−6.6527***
			(1.3507)	(1.3535)
Region Eurasia			−5.6536***	−5.6660***
			(1.3840)	(1.3866)
Region Latin America			−3.2310***	−3.2263***
			(1.2031)	(1.2044)
Region non-EU Europe			−0.7872	−0.7814
			(1.0121)	(1.0135)
Region South East Asia			−1.7382***	−1.7452***
			(0.6657)	(0.6672)
Region South Asia			−3.1415***	−3.1400***
			(0.6478)	(0.6484)
Weighted signatory x Weighted loan dummy				−0.6974
				(3.5496)
(Intercept)	35.1713***	33.8825***	35.6262***	35.5141***
	(0.2754)	(0.8804)	(1.0457)	(1.1922)
R^2	0.0092	0.5288	0.5924	0.5924
Num. obs.	556	556	556	556

Note: OLS-estimates. Standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 6: Remaining lifetime

	Model 1	Model 2	Model 3	Model 4
Weighted signatory	7.9035	1.1608	−2.0037	12.8987
	(8.9515)	(2.3097)	(2.4752)	(8.1310)
Weighted equity dummy		8.2650***	8.8697***	11.4971***
		(2.4356)	(2.3319)	(2.6974)
Weighted loan dummy		7.6777***	7.7630***	10.5548***
		(1.8757)	(1.8227)	(2.3264)
Capacity		0.1324***	0.1353***	0.1351***
		(0.0016)	(0.0016)	(0.0016)
Forthcoming		7.0105***	6.4952***	6.5064***
		(1.1202)	(1.0700)	(1.0673)
Cut-off		−10.4127***	−11.3807***	−11.4919***
		(2.8606)	(2.7681)	(2.7618)
Retire until 2050		−35.0443***	−33.9720***	−33.2466***
		(2.3130)	(2.5118)	(2.5338)
Weighted financing		3.0197*	1.5908	1.6569
		(1.7171)	(1.6898)	(1.6859)
Region Canada/US			−6.7828	−6.8506
			(5.6060)	(5.5922)
Region East Asia			−3.1657	−2.6875
			(2.3885)	(2.3955)
Region EU27			−24.6693***	−24.3700***
			(3.2404)	(3.2360)
Region Eurasia			−1.0368	−1.3263
			(3.3201)	(3.3152)
Region Latin America			2.6726	2.7822
			(2.8863)	(2.8796)
Region non-EU Europe			−1.4056	−1.2695
			(2.4281)	(2.4230)
Region South East Asia			−2.8796*	−3.0442*
			(1.5969)	(1.5952)
Region South Asia			−3.8758**	−3.8416**
			(1.5540)	(1.5502)
Weighted signatory x Weighted loan dummy				−16.3250*
				(8.4866)
(Intercept)	59.2133***	−3.9651*	−1.5197	−4.1450
	(1.7875)	(2.0835)	(2.5086)	(2.8503)
R^2	0.0014	0.9369	0.9439	0.9443
Num. obs.	556	556	556	556

Note: OLS-estimates. Standard errors in parentheses. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Table 7: Lifetime CO2

A.5 Supplementary tables

Country or region	**Coal-fired generating capacity in 2017 (GW)**	**Capacity factor**
China	981	51.7%
US	277	54.4%
India	224	60.8%
EU	170	47.5%
Japan	50	82.2%
South Africa	42	61.4%
Russia	52	37.8%
World	2130	52.8%

Table 8: 2017 Capacity factors of important coal producing regions.
(Source: Champenois 2023)

Combustion Technology	Heat rate (Btu per kWh)
Subcritical	8702
Supercritical	8409
Ultra-super	8272
CFB	8702
IGCC	7528
Unknown	8605
IGCC/CCS	10505
Supercritical/CCS	12534
Subcritical/CCS	13724
Unknown/CCS	12534
IDGCCLignite	7742
Subcritical/CCSBituminous(CCS90)	13724
Subcritical/CCSSub-bit(CCS90)	13724
Subcritical/CCSLignite(CCS90)	13724
Subcritical/CCSUnknown(CCS90)	13724
unknown/CCSLignite(CCS90)	12534
unknown/CCSBituminous(CCS90)	12534
Oxyfuel/CCSBituminous(CCS90)	10505
Oxyfuel/CCSUnknown(CCS90)	10505

Table 9: Heat rate (Btu per kWh) of widely used combustion technologies. (Source: Champenois 2023)

	0 - 349 MW	350 - 449 MW	450+ MW
0-9 years	20%	10%	0%
10-19 years	30%	20%	10%
20-29 years	40%	30%	20%
over 39 years	45%	35%	25%

Table 10: Penalty factors for older and smaller coal-fired power plants used to calculate the heat rate. (Source: Champenois 2023)

	US Department of Energy	IPCC
	pounds of carbon dioxide per million Btu	kg of carbon dioxide per TJ
Lignite	216.3	101,000
Subbituminous coal	211.9	96,100
Bituminous coal	205.3	94,600
Anthracite	227.4	98,300

Table 11: Emission factors according to the different calculations of the US government and the IPCC. (Source: Champenois 2023)

Region	**Average age of retirement (years)**
Africa and Middle East	48
Australia/ New Zealandl	42
Canada/ United States	51
East Asia	23
Eurasia	53
Latin America	34
EU28	43
non-EU Europe	46
Southeast Asia	28
South Asia	42
China	22
India	42
United States	51
World	38
World without China	47

Table 12: Average age of retirement of coal-fired power plant units by region. (Source: Champenois 2023)

Declaration of Authorship

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbstständig verfasst habe und sämtliche Quellen, einschließlich Internetquellen, die unverändert oder abgewandelt wiedergegeben werden, insbesondere Quellen für Texte, Grafiken, Tabellen und Bilder, als solche kenntlich gemacht habe.

Ich versichere, dass ich die vorliegende Abschlussarbeit noch nicht für andere Prüfungen eingereicht habe.

Mir ist bekannt, dass bei Verstößen gegen diese Grundsätze ein Verfahren wegen Täuschungsversuchs bzw. Täuschung gemäß der fachspezifischen Prüfungsordnung und/oder der Fächerübergreifenden Satzung zur Regelung von Zulassung, Studium und Prüfung der Humboldt-Universität zu Berlin (ZSP-HU) eingeleitet wird.

Potsdam, 31.01.2024

Ort, Datum Unterschrift