Rotterdam School of Management
Erasmus University

Erasmus Platform for Sustainable Value Creation

Thesis working paper

The Signaling Role of Science-Based Targets

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October 2023

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Executive summary

The growing significance of ESG disclosure for investors means that the problem of asymmetry of ESG information between firms and investors is becoming more pronounced. Firms can potentially use ESG disclosure initiatives to reduce information asymmetry with investors, thereby reducing the perceived risk and improving firm valuation. This study aims to determine whether science-based targets are a type of ESG disclosure which can reduce information asymmetry, by analysing the effect that science-based targets adoption, as well as target achievement and difficulty, have on a firm's market-based financial performance. The theoretical framework of signaling theory is applied, which draws on concepts such as signal honesty and signal cost to determine the necessary elements of a good signaling strategy. This research sheds light on the signaling effect of ESG disclosure and helps to determine whether targets are a useful medium for signaling.

The study uses a quantitative research design, using both financial and non-financial data from publicly-listed firms around the world. Data from the Science-Based Targets initiative (SBTi) is used to formulate the independent and moderating variables. The cross-industry multi-year panel data is analysed using regression analysis, while considering firm-effects and using control variables to account for the influence of other financial and non-financial indicators. Next to the overall sample, further samples are studied which are characterized by the level of industry emission intensity, the ambition level of targets, and the number of firm-year observations. The analysis is moderately constrained by the lack of longitudinal data and the premature nature of existing science-based targets. Finally, to support the quantitative analysis, a number of expert interviews are conducted to deepen the understanding of the observed phenomena.

The results from the analysis indicate that the adoption of science-based targets does not significantly influence the firm's market-based financial performance. This indicates that science-based targets are not a type of ESG disclosure which reduces information asymmetry to the extent to which investors consider them in investment decisions. Furthermore, the investment required to set science-based targets, which includes acquiring intellectual and human capital as well as developing decarbonization plans, is seemingly not valued by investors. Another finding is that the progress towards achieving science-based targets, both on an absolute and relative basis, does not influence firm valuation. This means that the probability of (not) achieving the target, and what this says about a firm's ability to decarbonize, is not expected to be taken into account by investors. Under certain conditions, where the sample consists of either high- or low-emitting industries, the difficulty of targets is found to have a positive moderating effect on the relationship between target achievement and market-based financial performance. This shows that, while the adoption or achievement of the targets are not influential, the level of ambition of targets is a relevant factor considered by investors.

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It also highlights the importance of focusing on specific firm- and industry-level characteristics to determine whether ESG disclosure can have a signaling effect. Supported by findings from the interviews with experts, the results indicate that investors potentially use science-based targets adoption as a 'hygiene factor', or negative screening tool.

From a theoretical perspective, the application of signaling theory to science-based targets explores the potential for targets as a medium for signals and the signaling of information of intent rather than quality, as well as the role of third-party verification in improving signal honesty. Despite the strong theoretical fit, the results do not support either notion. From a practical standpoint, the findings allude to a potential lack of concern from investors towards corporate decarbonization efforts and could cause firms to reconsider their reasons for adopting such ESG disclosure initiatives.

The conclusion from the research is that adoption of science-based targets does not lead to an improvement in firm valuation. Furthermore, while the progress towards achieving science-based targets is generally not considered by investors, the difficulty of targets does influence the level of relevancy, with more ambitious targets having a stronger relationship between target achievement and firm valuation. Based on the findings, the signaling effect of science-based targets is found to be negligible and science-based targets currently should not be considered as a type of ESG disclosure useful for reducing information asymmetry between firms and investors.

Within the current academic landscape, this research elevates the understanding of the signaling role of ESG disclosure and the usefulness of science-based targets in informing investors. The study supports the theoretical development of signaling theory in the ESG context, while also arguing that targets could be a medium for signals which contain information of intent. The findings further our knowledge on investor's perception of ESG disclosure and hint towards a lack of concern towards corporate decarbonization efforts. Finally, the study opens up the possibility to further enhance our understanding of the role of ESG disclosure, specifically science-based targets, and under which circumstances they are considered relevant by investors.

Future research should continue to explore this topic by conducting qualitative analysis aimed at gaining insights from investors, firms, and other stakeholders about the importance of ESG disclosure. Other avenues for future research include the studying of private companies' ESG disclosure, the direct effect of SBT adoption on stock performance and focusing on the effect of ESG disclosure on internal accounting-based financial performance. Lastly, revisiting data on science-based targets once they have matured will allow for deeper insights and could lead to different conclusions than the present data.

In conclusion, this study explores the asymmetry of ESG information between firms and investors in the theoretical context of signaling theory, by focusing on the effect of the adoption, achievement, and difficulty of science-based targets on market-based financial performance. The main findings reveal an insignificant signaling effect of science-based targets on investor's firm valuation. This study makes a significant contribution to the existing theory and literature, whilst also exposing the market's apparent indifference towards ESG disclosure initiatives. Looking into the future, it remains to be seen whether the global decarbonization efforts will be reached, and whether this will be in spite or because of pressure from investors and the market as a whole.

Preface

I hereby present the master thesis titled 'The Signaling Role of Science-Based Targets', written as part of the curriculum for the MSc Global Business & Sustainability program of the Rotterdam School of Management (RSM) at the Erasmus University Rotterdam.

The author declares that this work is original and that no sources other than those referenced have been used during the development of this thesis. The copyright of the master thesis rests with the author. The author is responsible for its contents. RSM is only responsible for the educational coaching and cannot be held liable for the content.

Victor van der Velde
Rotterdam, 29 June 2023

Acknowledgements

I would like to thank my thesis coach, Tony Choi, for his critical and effective criticism and for guiding me, particularly in the early stages, towards a research topic which is both theoretically and practically relevant.

I would also like to thank my co-reader, Martin Fuchs, for his reassuring and supportive feedback.

A special thank you to both prof.dr. Dirk Schoenmaker and Dieuwertje Bosma for sharing their knowledge and allowing me to use their network to reach out to experts in the field.

Furthermore, I would like to thank the participants in my interviews for sharing their valuable time and providing me with the insights necessary to take this thesis to the next level.

Finally, I would like to thank my family and friends for their support and much-appreciated moments of distraction.

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1. Introduction

Investors are increasingly taking into account environmental, social and governance (ESG) information when making investment decisions, reflected in the continued growth of sustainable investment in global markets, reaching $35.3 trillion in 2020 (GSIA, 2020). With demand for such information, the problem of information asymmetry between companies and investors becomes prevalent. In other words, companies have information on its ESG performance, which is valuable but not disclosed to investors. Compared to financial information, which is subject to legal disclosure requirements for listed companies, sustainability performance is more challenging to evaluate for investors due to limited and less standardized reporting requirements, despite the growing number of sustainability reporting standards. As a result, information asymmetry is often more pronounced in the area of sustainability, making it difficult for investors to make informed decisions.

Literature on ESG disclosure has highlighted its value for investors in terms of reducing information asymmetry, which can lead to reduced perceived risk and increased firm valuation (Dhaliwal, et al., 2011), but research also indicates that the disclosure of comparable, concise, and credible information is still lacking according to investors (Cohen, et al., 2015; Amel-Zadeh & Serafeim, 2018; Bernow, et al., 2019). Moratis' (2018) study explored the signaling role of sustainability standards in reducing information asymmetry, therein drawing on signaling theory, which posits that entities can reduce information asymmetry between them and receiving parties by signaling their unobservable, underlying quality (Connelly, et al., 2011). Besides sustainability standards, there are other ESG disclosure initiatives, including science-based targets, which can both help improve ESG performance by setting ambitious forward-looking targets and reduce information asymmetry between firms and investors in terms of the desired future state of the company. The characterization of science-based targets in extant literature, in particular the aspect of third-party verification, leads to the assumption that they are useful ESG disclosure tools in answering to the demands from investors (Andersen, et al., 2021). Similar to Moratis (2018), this study will aim to use signaling theory to determine whether science-based targets, as a type of ESG disclosure, are useful signals by firms to reduce information asymmetry with investors.

This study contributes to the literature in several ways. First, the study adds to the literature on signaling theory by studying it in the context of ESG disclosure. Earlier studies have implemented signaling theory when performing a qualitative review of sustainability standards (Moratis, 2018) or a quantitative analysis of the impact of overall ESG performance on financial performance (Carnini Pulino, et al., 2022), while the present study focuses on science-based emission reduction targets, specifically the effect of their adoption, their achievement, and their difficulty on financial performance. Second, to the author's best knowledge of the extant literature, this study is the first to perform quantitative analysis using data on science-based targets set by firms, by studying its effect on market-based financial performance.

Although earlier literature has studied the progress of early SBT adopters (Giesekam, et al., 2021) and studied the effect of environmental performance on financial performance for firms with SBTs (Bendig, et al., 2022), this study specifically incorporates the quantitative targets set, as reported by the Science Based Targets initiative (SBTi). Third, according to the author's best knowledge, this study is the first to make the case for corporate targets being potential signaling tools for firms. While previous literature has hinted towards the applicability of targets as signals (Connelly, et al., 2011), no study has explicated this idea and tested it using quantitative analysis.

By finding out whether science-based targets can reduce information asymmetry to the extent to which investors will consider them in their investment decisions, much can be learned from both a theoretical and practical perspective. Regarding signaling theory, increasing the focus on the signaling role of ESG disclosure creates a new perspective on theoretical concepts such as signal honesty and signal cost and could offer new insights into the relevance of signaling ESG information for managers. Similarly, the signaling potential of targets furthers our understanding of theoretical concepts such as information of intent, as well as highlighting the usefulness of ambitious target-setting in corporate strategy, specifically to satisfy the demands from investors.

In summary, the existing literature on ESG disclosure highlights the demand from investors for information on firm's ESG performance (Amel-Zadeh & Serafeim, 2018), while signaling theory literature posits that sustainability initiatives could be used as a signaling strategy by firms (Connelly, et al., 2011). Currently missing from this literature is a focus on science-based targets as a useful type of ESG disclosure for investors, as well as a consideration for such targets to be a good medium for signaling information of intent. To increase our understanding of the signaling role of science-based targets, this study aims to answer the following question:

Research question: are firms' science-based targets strong signals for investors?

First, in the 'Literature Review' section, the extant literature on ESG disclosure and specifically science-based targets is discussed, before explaining the theoretical framework behind signaling theory and applying its theoretical concepts to the scenario of firms setting science-based targets to signal to investors. The section is concluded by synthesizing the literature and developing the hypotheses that are tested in this study. Second, in the 'Methods' section, the quantitative research method used to investigate the hypotheses is explained by first describing the data, sample, and variables and then describing the initial and subsequent analyses. Third, in the 'Results' section, the results from the analyses are presented and explained, both in tables and textually. Fourth, in the 'Discussion' section', the findings from the results are interpreted and the implications, limitations and avenues for future research are discussed, before drawing final conclusions.

2. Literature Review

2.1 ESG Information and Disclosure

The growing prevalence of sustainable development in the last 30 years has led to significant growth in investor demand for nonfinancial information, otherwise known as environmental, social and governance (ESG) information (Tsang, et al., 2023). Literature on ESG disclosure has studied the effectiveness of disclosure from the perspective of investors, and results indicate that most information disclosed is lacking in terms of comparability and credibility (Cohen, et al., 2015; Amel-Zadeh & Serafeim, 2018; Bernow, et al., 2019). Investors require more concise, comprehensive, and credible information, coupled with less variation in applied sustainability-reporting standards, to allow for comparisons to be drawn between firms. By adopting a single standard and having ESG disclosures audited, firms can reduce information asymmetry and convey information about their long-term performance (Tsang, et al., 2023; Clarkson, et al, 2008). In addition, Dhaliwal, et al. (2011) found that ESG disclosure leads to reduced cost of equity capital, thereby positively impacting market value. These findings indicate the immense value of accurately disclosing ESG information.

ESG disclosure regards information about organizational performance on material ESG issues and criteria (Peterdy, 2022). To measure this performance and to compare ESG performance between firms and within firms across time, specific ESG indicators are used (Moldan, et al., 2012). Most ESG disclosure is focused on the current ESG performance of firms. ESG standards, such as those developed by the Sustainability Accounting Standards Board (SASB) and the Global Reporting Initiative (GRI), help companies in reporting on its material ESG issues (Christensen, et al., 2021). However, besides disclosing current ESG performance, firms also use ESG indicators to indicate their ambition to improve its performance. Such ESG indicators rely on a baseline and a target. Baselines serve as a reference point for measuring change across time, while targets measure the distance from the baseline or serve as a threshold value. For example, in the 2015 Paris Agreement the goal was set to “hold the increase in the global average temperature to well below 2°C above pre-industrial levels” (UN, 2015), where ‘pre-industrial levels’ serves as the baseline and ‘well below 2°C’ as the target for the global warming indicator. Similarly, in Johan Rockström et al.’s (2009) Planetary Boundaries framework nine boundaries were set that aimed to define a safe operating space for humanity. In 2017, Kate Raworth (2017) extended the framework to include social foundations as derived from the UN’s Sustainable Development Goals, thus forming the Doughnut framework indicating the boundaries for an ecologically safe and socially just operating space for humanity. In these frameworks, the boundaries serve as threshold values and thus as targets if a boundary has been crossed. Both the Paris Agreement and the Doughnut framework are important for setting the overarching goal for the global economy but provide

limited guidance for individual firms in setting their own targets to align with that overarching goal. Bringezu (2017) therefore argues for a distinction between 'targets of the desired state' and 'management targets' which can be applied for effective action. Such management targets are increasingly expected of corporations, such as in a recent UN Report recommending the setting of science-aligned net zero targets by non-state entities (UN, 2022) and in the draft of the European Sustainability Reporting Standards (ESRS), where Disclosure Requirement E1-4 refers to disclosing "targets related to climate change mitigation and adaptation" and, more specifically, "whether the GHG emission reduction targets are science-based and compatible with limiting global warming to 1.5°C" (EFRAG, 2022, p. 9). Such 'science-based targets' are a specific type of ESG disclosure which refer to firm-level ESG targets aligned with the scientific consensus on acceptable levels of impact on environmental and social issues (Walenta, 2019; Andersen, et al., 2021).

2.2 Science-Based Targets

The term 'science-based targets' (SBTs) is commonly associated with carbon emission reduction targets, such as in Rockström, et al.'s (2017) paper, where the authors mention the necessity for adopting SBTs to achieve decarbonization goals. Additionally, the Science-Based Targets initiative (SBTi), set up by the United Nations Global Compact (UNGC), Carbon Disclosure Project (CDP), World Resource Institute (WRI) and World Wildlife Fund (WWF), focuses exclusively on guiding companies to set carbon emission reduction targets and providing verification on those targets. However, the term can be applied more broadly to targets that address other environmental issues such as biodiversity loss and desertification (Andersen, et al., 2021). To this end, a collection of global organizations, including the founding organizations of SBTi, created the Science-Based Targets Network (SBTN), which focuses on setting targets on environmental issues such as biodiversity, climate, ocean, land, and freshwater systems (SBTN, n.d.). However, fewer targets have been set through SBTN when compared to SBTi and these targets are not publicly disclosed, making it difficult to study its results so far. SBTs could also be developed for social issues by aligning with the social dimensions in Raworth's (2017) Doughnut framework, although measurements and indicators for those dimensions are currently less clearly defined and subject to academic debate (Moldan, et al., 2012). Therefore, for the purpose of this study, SBTs will be studied through the carbon emission reduction targets set by firms under the guidance of SBTi, since this subset of SBTs is most developed and contains the most publicly available information. Bear in mind that, when illustrating points on SBTs using carbon emissions as an example in subsequent sections of this study, carbon emissions could be interchanged with different ESG issues such as biodiversity and freshwater use.

Andersen, et al. (2021) characterize SBTs as theoretically achievable, quantifiable, and supported by a scientific rationale. Similarly to the distinction created by Bringezu (2017), Andersen, et al. (2021) differentiate between overall SBTs for the world (e.g., Paris Agreement, Doughnut framework, etc.) and specific SBTs for individual entities, such as those set through SBTi. Freiberg, et al. (2021) found that SBTs set by firms have higher target difficulty than non-SBTs, also referred to as 'internal targets' by Bjørn, et al. (2022). This increase in target difficulty was found to be coupled with reduced emissions and increased investment in carbon-reduction projects. These findings are consistent with the results found by Dahlmann, et al. (2017), who found that ambitious and long-term targets, as opposed to symbolic "greenwashing" targets, were related to significant emissions reductions. Additional literature on SBTs has found that most targets set by early adopters of SBTi were on track to be achieved (Giesekam, et al., 2021) and that improved carbon performance for SBTi-aligned firms is associated with improved financial performance (Bendig, et al., 2022). To sum up, literature on SBTs explains that such targets can be considered ambitious (more so than internal targets), long-term, comparable, and are assured by a third party (SBTi).

Considering these characteristics and the information asymmetry between firms and investors in terms of ESG information, as explained in the opening paragraph of this section, SBTs could be deemed as a valuable type of ESG disclosure for investors. As stated by Cohen, et al. (2015, p. 129): "… investors prefer nonfinancial information that is streamlined, but wide in scope and content, consistent from one company to the next, and assured by neutral third parties". In line with this reasoning, Piper and Longhurst (2021) found that the two main motivations for firms to use SBTs were credibility and standardization. Thus, through signaling credible and standardized ESG information, SBTs are expected to reduce information asymmetry between firms and investors (Tsang, et al., 2023). This rationale is central to signaling theory, which has served as a theoretical explanation for the importance of ESG disclosure in earlier literature (Moratis, 2018; Carnini Pulino, et al., 2022). In this study, the argument is put forward that signaling theory can explain how SBTs, as a type of ESG disclosure with targets as the medium for signals, reduce information asymmetry between firms and investors and therefore are expected to lead to improved firm valuation.

2.3 Signaling Theory

Signaling theory (ST) focuses on the dynamics in a relationship between two parties when there is information asymmetry (Spence, 2002). Before George A. Akerlof (1970) introduced the concept of information asymmetry into academic discourse, economic models worked under the assumption that information was perfect (Stiglitz, 2001). However, through using the example of used cars, where sellers of used cars are more informed on the car quality than buyers of used cars, Akerlof (1970) explained

how information asymmetry exists in markets and how it could lead to suboptimal market performance. Following this finding, Michael Spence (1973) first studied the phenomenon he described as "market signaling" through showing how job applicants can reduce information asymmetry between them and employers by signaling their quality through investing in education. Since those initial studies, literature on ST has grown exponentially and has been applied in countless contexts, including many management disciplines such as corporate governance, entrepreneurship, and human resource management (Connelly, et al., 2011). Nevertheless, the application of ST in the research context of SBTs has been limited, notably on two dimensions: ST literature focusing on sustainability and ST literature focusing on targets as a medium for signals.

As part of their recommendations on future research focused on ST, Connelly, et al. (2011) propose studying sustainability initiatives, since partaking in those initiatives requires significant investments and non-compliance would lead to penalty costs. Therefore, sustainability initiatives should signal a firm's credibility and expectation that it will improve its ESG performance. The notion that signals are strong because of the cost associated with signaling is related to the concept of signal costs, which is explained later on in this section.

Connelly, et al. (2011) further state that increased concern about sustainability raises the question of how companies should signal their ambition to stakeholders such as employees, customers, and investors. Following these recommendations, Moratis (2018) has applied ST to the sustainability standard ISO 26000 by qualitatively investigating whether there is congruence between ST and the sustainability standard. The study identified several signaling problems and concluded that the standard emitted signals that compromised, rather than enhanced, the external visibility of firms' sustainability performance. Another application of ST in the sustainability field is the study by Carnini Pulino, et al. (2022), who argue that firms use sustainability initiatives to signal their commitment to stakeholders. Other studies make references to ST in the context of ESG disclosure, such as Wong and Zhang (2022), Alsayegh, et al., (2020), Khan (2022) and Reber, et al. (2022), but only do so to a limited extent or in combination with other theories such as legitimacy theory or agency theory.

While some studies have studied ST in the sustainability context since Connelly's (2011) paper, a research context which has seemingly received no academic attention so far is the management topic of corporate target setting and the potential signaling role that targets could play. Although never explicitly stating that targets could be a potential medium for signals, Connelly et al. (2011) mention that firms could use signals to inform stakeholders about a firm's future profitability and that signals may indicate future action. In addition, the authors explain that the interpretation of signals depends on receiver's expectations about the future, which is applicable to targets since the value of targets also

depends on stakeholders' belief that the targets accurately predict firms' future ability. Therefore, there are references in extant literature that indicate that targets could potentially be considered as a viable signaling tool, particularly in signaling information of intent, since it reduces the information asymmetry between firms and investors in terms of the firm's future ambitions.

The lack of literature studying targets as a medium for signals and the limited research on ESG disclosure in the context of ST can be leveraged and researched in unison when focusing on SBTs as the relevant research context. This makes the concept of SBTs particularly interesting to research, since it could provide evidence towards the signaling role of ESG disclosure and simultaneously introduce targets as a viable medium for signaling information of intent.

To understand how SBTs can serve as viable signals, the relevant aspects of ST will be explained and applied to the context of the expected investor demand for signals of SBTs. The scenario of firms signaling to investors using SBTs contains three elements which are linked to the primary constructs of ST: the signaler, the signal, and the receiver (Connelly, et al., 2011). First, the firm is the signaler, which is the party holding information unavailable to the receiver(s). In the application of ST to management literature, firms are frequently considered as the signaling entity. Second, SBTs are the signal, which is the information shared with the receiver(s). Third, investors are the receiver, which is the party lacking but desiring information. In management literature, particularly in entrepreneurship and strategy research, investors are often used as the receiving party. Using Connelly, et al.'s (2011) extensive synthesis of literature on ST as a framework, the following paragraphs will explain key concepts of the theory. Their synthesis covers additional concepts (i.e., signal fit, signal reliability, signal frequency, signal consistency and receiver interpretation), but this research will focus exclusively on concepts that play a central role in defining the signaling potential of SBTs.

2.3.1 Information and Quality

Information is a fundamental concept in ST which can be divided into information of quality, focusing on characteristics, and information of intent, focusing on behavior (Stiglitz, 2000). In Spence's (1973) study, job applicants indicate their ability through investing in their education, thereby signaling information of quality by showing the applicant's commitment and ability to put time and effort into completing that level of education. An example of signaling information of intent is when entrepreneurs approach angel investors to invest in their start-up, which is a type of behavior that could signal to investors that the entrepreneur intends to 'cash out' (Elitzur & Gavious, 2003).

To determine which type of information most accurately describes SBTs, the notion of quality within ST needs to be elaborated upon further. The definition of quality proposed by Connelly, et al. (2011, p. 43)

will be applied in this study, which is that "quality refers to the underlying, unobservable ability of the signaler to fulfill the needs or demands of an outsider observing the signal". Importantly, quality is a characteristic of the signaler rather than the signal in this theoretical context, and it is used to create a distinction between high-quality entities that are able to truthfully signal information and low-quality entities that are unable to truthfully signal the same information (Kirmani & Rao, 2000). The element of truthfulness is related to the concept of signal honesty, which will be explained in the following section and is highly relevant in the context of signals of SBTs.

For SBTs, quality refers to the ability of firms to decarbonize their operations and thereby achieve their targets. Taking into account this definition of quality, SBTs signal future ability rather than current ability when the targets are being set, and as such signal information of intent. At the moment when targets are achieved, SBTs instead signal current ability, and as such signal information of quality. Therefore, the information signaled using SBTs is dynamic and dependent on the timing of the signal. The notion that a signal can contain both information of quality and information of intent, particularly when exploring targets as the medium for signaling information, has not been explored in earlier literature and could prove a valuable contribution to ST. Considering the time period used in this study, which is before any long-term SBTs have matured, this study only studies signals containing information of intent.

2.3.2 Signal Honesty

As mentioned earlier, the truthfulness of the signal is a fundamental characteristic of signals in ST. This concept is defined as signal honesty, which refers to the extent to which the underlying quality of the signal is present in the signaler (Connelly, et al., 2011). If signals are not perceived as honest it may lead to both signalers and signals having a dishonest reputation, which decreases the value of the signal perceived by investors (Cohen & Dean, 2005). For disclosure on current ESG performance, the truthfulness or validity of the signaled information is high since this disclosure typically has to comply with (regulatory) standards and is validated by third-party auditors. The signal honesty of ESG targets is less straightforward, with it being impossible to provide factual information about a firm's future ESG performance. Instead, the honest signaling of SBTs depends on the current resources of the firm, including available human and intellectual capital and detailed decarbonization plans, which provide strong arguments in favor of the firm's ability achieve the signaled targets. To be able to set SBTs through SBTi, firms are required to commit considerable resources for an extended period of time and will need to supply detailed information (Henderson, 2019). This is intended to give the experts working at SBTi the strongest chance to correctly validate targets with a realistic chance of achievement. However, the underlying quality of decarbonizing operations will only become clear to investors further in the future, either when the actual level of decarbonization is significantly different from the SBT trajectory of after

the SBT is (not) reached. Therefore, the extent to which early adopters of SBTs are genuinely able to reach their respective targets will largely determine the reputation and signal honesty of SBTs. From their analysis of early adopters of SBTs, Giesekam, et al. (2021) found that most targets were on track to be achieved, thus providing an early indication that signal honesty of SBTs is adequate and that the target submission process of SBTi accurately screens for companies with the necessary resources to achieve SBTs.

2.3.3 Signal Cost

In an ideal world, all companies should eventually possess the ability to make the transition to net-zero emissions and thus be able to signal using SBTs, which would mean there are no low-quality firms. However, given historical evidence, such as in the cases of Eastman Kodak and Blockbuster Inc. (Gershon, 2013), and established theory, such as Schumpeter's (1942) principle of creative destruction or Rogers' (1995) diffusion theory, industries and firms will have different levels of ability to make the transition, also referred to as transition preparedness by Schoenmaker and Schramade (2023). Hence, with respect to decarbonization there are also sectors and companies that are unwilling or unable to make the necessary transition (The World Bank, 2021). As such, there will be both high-quality firms and low-quality firms.

Considering some firms are in a better position to decarbonize than others, the investment costs associated with making the transition are different for high- and low-quality firms. This refers to the concept of signal cost, which is central to ST, with some even referring to it as the "theory of costly signaling (Bird & Smith, 2005). Signal cost refers to the assumption that some signalers are better equipped to bear the costs associated with the signaled information. For SBTs, there are costs involved in acquiring the required resources to develop SBTs and subsequent investment (i.e., in innovation) is necessary to actually achieve the decarbonization target (Bonifant, et al., 1995). As discussed, firms differ in terms of transition preparedness, and thus differ in terms of additional investment needed to increase preparedness. Therefore, assuming that SBTs are honest signals, they can be considered more costly for low-quality firms, who require more investment to improve their ability to decarbonize, than for high-quality firms.

The effectiveness of signaling is heavily dependent on the cost of signaling, as explained by Connelly, et al. (2011, p. 45): "If a signaler does not have the underlying quality associated with the signal but believes the benefits of signaling outweigh the costs of producing the signal, the signaler may be motivated to attempt false signaling". To prevent false signaling using SBTs, the signal must be costly enough that low-quality firms are not incentivized to profit of the benefits of signaling. Taking into account the stringent process associated with setting SBTs through SBTi, the ability of firms to signal using SBTs

becomes difficult unless they have the adequate resources in place. Additionally, if firms are unable to meet their SBTs, they may incur penalty costs as a result of illegitimate signaling (Connelly, et al., 2011). These penalty costs will only be incurred in the future, which could mean the firm underestimates such costs when setting SBTs. The actual penalty costs associated with not achieving SBTs will only be observed once the first SBTs reach their target date, which could lead to firms becoming more hesitant to adopt SBTs if the costs are believed to be too high. Both the investment costs required to develop SBTs and the potential penalty costs for not achieving targets should prevent low-quality firms from signaling, which would provide support for the notion that SBTs are a viable signaling tool for high-quality firms, since it could be used to differentiate them from low-quality firms in the eyes of investors.

2.3.4 Signal Observability and Receiver Attention

The final two ST concepts that are relevant to this study focus on whether signals are visible to receivers, defined as signal observability, and whether receivers are looking for signals, defined as receiver attention. First, signal observability is a particularly relevant concept, because "if actions insiders take are not readily observed by outsiders, it is difficult to use those actions to communicate with receivers" (Connelly, et al., 2011, p. 45). Since firms typically disclose SBTs in their reporting, approved SBTs are presented on the SBTi website, and significant media attention is given to firms setting SBTs, the observability of SBT-signals can be considered high (Freiberg, et al., 2021; Trexler & Schendler, 2015). Furthermore, SBTs have a considerably higher observability compared to internal targets. This provides additional motive to study SBTs, rather than internal corporate targets, in the context of ST.

Receiver attention is defined as the degree to which receivers are actively searching for the signal (Connelly, et al., 2011). For investors, as described in the beginning of this section, ESG information is increasingly valuable, particularly when it is concise, comparable, and credible (Cohen, et al., 2015). As such, considering the information it holds about the future of the firm and what it tells about the firm's resources due to the strict requirements for developing SBTs through SBTi, investors are expected to be vigilant for firms disclosing SBTs, particularly when they have been validated by a credible third-party.

ST posits that effective signals require high observability, which SBTs provide due to extensive disclosure and media exposure, and high attention, which investors have indicated to be high for relevant ESG information such as that provided through SBTs. As such, the stage is set for SBTs to influence the behavior of investors with regards to their analysis of firms' ESG information.

2.4 Synthesis of Theory & Literature

In summary, the literature on ESG information and disclosure indicates a high appetite from investors for concise, comprehensive, and credible information on a firm's ESG performance. Besides disclosure on current ESG performance, such as provided by regulations and standards, another type of disclosure focuses on ESG targets. With previous literature predicting ESG disclosure to be an effective signaling tool (Moratis, 2018; Carnini Pulino, et al., 2022) but a lack of exploration with respect to the signaling role of targets, a focus on SBTs as potential signals could provide useful contributions to both theory and practice.

The relevant concepts of ST that explain the signaling role of SBTs are signaler quality, signal honesty, signal cost, signal observability and receiver attention. Considering the different levels of ability between firms and the costs involved in developing and achieving decarbonization targets, SBTs are expected to be more difficult to signal with for low-quality firms than for high-quality firms, with a limited potential for false signaling using SBTs due to the rigorous process of developing targets through SBTi. Furthermore, both the observability of SBT-signals is high, due to the level of reporting and media attention it receives, and investors' attention to SBT-signals is high, due to their appetite for information that signals strong (future) ESG performance.

ST posits that signalers use signals to disclose information about the signaler's underlying, unobserved quality to the receiver, and thereby reduce the information asymmetry between the two parties. As thoroughly explained in this section, this theory is applicable to the scenario of firms using SBTs to signal the firm's intent, and the availability of resources, to improve its ESG performance to investors. The relevant concepts associated with ST according to Connelly, et al. (2011) have been applied to this scenario and illustrate a strong fit with the theory.

2.5 Hypothesis Development

To prove the fit between ST and the SBT-investor scenario, several assumptions have to be tested. First and foremost, investors have to positively perceive the disclosure of SBTs in terms of market valuation. According to previous research, investors are increasingly considering ESG information and especially value comparable, consistent, and credible information (Amel-Zadeh & Serafeim, 2018; Cohen, et al., 2015; Bernow, et al., 2019). Additional research on the impact of ESG disclosure found that it reduced perceived risk and decreased the firm's cost of capital, thus positively impacting market valuation (Dhaliwal, et al., 2011). This last study finds that the disclosure of value-relevant information, either financial or non-financial (i.e., ESG), reduces information asymmetry between firms and investors. To be specific, investors that are "informationally disadvantaged … become less willing to trade", which leads

to lower liquidity, subsequently resulting in a higher required rate of return or cost of capital (Dhaliwal, et al., 2011, p. 62). These findings indicate that more (ESG) disclosure lowers the cost of capital by reducing information asymmetry.

The expectation in this study is that the information provided through SBTs reduces information asymmetry between firms and investors as it signals a previously unobserved and underlying quality, which is that firms have both the intent and the necessary resources to decarbonize and align themselves with scientific pathways. Furthermore, these SBT-signals allow investors to distinguish between high-quality firms, who possess the required resources and are thus able to decarbonize and achieve their set SBTs, and low-quality firms, who do not possess the same quality in terms of resources. Next, the truthfulness of SBT-signals is expected to be high enough for investors to trust that firms truly possess the required resources, and the cost of signaling is high enough such that low-quality firms are not incentivized to falsely signal that they also have the required resources and intent to decarbonize. Finally, both the observability of signals of SBTs and the attention given to such signals by investors is high enough such that investors are able to take SBTs into account during their investment decisions. Relating these notions to the findings of Dhaliwal, et al. (2011), the assumption is that signals of SBTs lower a firm's cost of capital, since it reduces the risk perceived by investors as they become more informed about the firm's ESG performance, specifically the intention and available resources to transition to a low-carbon economy. As such, this decreased risk should have a positive impact on a firm's market valuation, leading to the expectation that SBT adoption, as a type of ESG disclosure, has a positive effect on firm's market-based financial performance.

Hypothesis 1: science-based target adoption has a positive effect on market-based financial performance

According to ST, only firms with the necessary underlying quality are able to benefit from signaling the desired information. Moratis (2018) refers to this as 'the efficacy of signaling by high-quality and low-quality firms' (p.4), meaning that the signal is only effective for firms that possess the quality associated with the signal. Kirmani and Rao (2000) illustrate the concept of signaling efficacy by assessing signaling payoffs along two dimensions: first, the quality of the firm (high-low), and second, whether the firm signals or not. These dimensions lead to four payoffs: payoff A, when a high-quality firm signals, payoff B, when a high-quality firm does not signal, payoff C, when a low-quality firm signals, and payoff D, when a low-quality firm does not signal. The authors argue that a signaling strategy is viable when both payoff A exceeds payoff B for high-quality firms (A > B) and payoff D exceeds payoff C for low-quality firms (D > C) (Kirmani & Rao, 2000). The assumption that D > C refers to the expectation that a signal sent by a low-quality signaler would make receivers aware of the signaler's low-quality and that this would have an adverse effect on the receiver's perception of the signaler.

With regards to SBTs, the assumption is that only high-quality firms will be able to adopt SBTs since there is a need to possess the required resources to get their targets validated by SBTi. As such, this assumption would mean no low-quality firms could signal using SBTs, or at least not with third-party verification. Continuing this line of thinking, that would assume that firms with the required resources to decarbonize according to SBTi would all actually manage to reach the SBTs that they set, which is considered highly implausible. Therefore, the notion of quality in this research context could be reconsidered to reflect the actual ability of firms to reach their targets, instead of only having the necessary resources according to SBTi. This would mean also low-quality firms could signal but would experience a negative effect of signaling when they do not reach their target as investors would become aware of their low quality, namely their inability to decarbonize and reach their targets. The negative effect of signaling could entail incurring penalty costs such as a higher cost of capital due to the increased risk associated with the firm as perceived by investors (Connelly, et al., 2011; Dhaliwal, et al., 2011).

To determine whether SBTs can act as a viable signaling strategy, the framework developed by Kirmani and Rao (2000) should be applied. More specifically, do high-quality firms benefit from signaling (A > B) and do low-quality firms suffer from signaling (D > C)? As outlined in the previous paragraph, whether a firm possesses the underlying quality associated with SBTs can be determined through its progress in terms of target achievement. For example, if recent reporting shows the firm is not in line to achieve the SBTs, investors can start to question whether the firm possesses the underlying quality which was signaled, and which is needed to reduce its emissions to the extent which it has previously signaled. This scenario would lead to penalty costs and ultimately a reduced valuation by the investor, potentially even below the valuation before the signal. On the other hand, signaling the achievement of SBTs to investors would lead to reduced risk for high-quality firms compared to its low-quality peers. Assuming that SBTs pose as a viable signaling strategy, this study therefore expects that target achievement has a positive effect on market-based financial performance.

Hypothesis 2: science-based target achievement has a positive effect on market-based financial performance

In their study, Freiberg, et al. (2021) determined that an increase in target difficulty is related to a more significant emissions reduction. Assuming these findings would also apply to SBTs, alongside the assumption that firms would truthfully signal such ambitious targets and would possess the necessary resources to achieve them, the expectation is that investors would more strongly value targets which are more ambitious. Additionally, the level of ambition of SBTs would likely impact the extent to which an investor takes that information into account for investment decisions, especially if the amount of firms setting SBTs continues to increase and the market could become saturated with “standard” SBTs.

In other words, if a firm sets a highly ambitious target, it would stand out compared to other targets set by other firms and thus receive comparatively more attention from investors (i.e., increased receiver attention). In contrast, a less difficult SBT is less useful to investors, and would therefore have less impact on investor's valuation of the firm. The expectation is thus: if firms are showing that they possess the necessary resources by (being on track to) achieving the SBT, the difficulty of the SBT will determine the effect this has on investor's firm valuation. Therefore, this study expects target difficulty to moderate the relationship between SBT achievement and market-based financial performance.

Hypothesis 3: the relationship between science-based target achievement and market-based financial performance is moderated by target difficulty

See Appendix 1 for the Conceptual Research Model including Hypothesis 1, 2 and 3

3. Methods

3.1 Data and Sample

To determine the impact of SBT adoption on firms' market-based financial performance as stated in Hypothesis 1, this study analyzes financial and non-financial data on a global and cross-industry sample of publicly listed firms derived from the Refinitiv Eikon database. By filtering for firms with data on annual Scope 1 and Scope 2 emissions, the initial sample consists of panel data covering 1,348 individual firms across a time series from 2015 until 2022. After removing missing values which were necessary to determine the dependent variable, the final sample consists of an unbalanced panel of 9,920 firm-year observations for 1,291 individual firms.

To determine which firms have set SBTs, the sample is cross-checked with the database provided by SBTi alongside its Annual Progress Report 2021. The number of firms in the sample that were found to have set absolute targets on Scope 1 and Scope 2 emissions was 284 out of a total 1,291. Of that subset, which counts 2,084 observations, a share of observations is of financial years before the firm has adopted the SBT. The number of firm-year observations where the firm has approved SBTs is 919. Since the data required for the measurement of the variables in Hypothesis 2 and Hypothesis 3 is only available for firms that have adopted SBTs, the subset of firm-year observations with adopted SBTs will be used for Hypothesis 2 until 4. Henceforth, the complete sample will be referred to as Sample 1 and the SBT-subset will be referred to as Sample 2.

To ensure correct representation of Sample 1 in Sample 2, both are compared based on the industry and country representation. Following the ICB's industry classification, both Sample 1 and Sample 2 contain firms in all 11 industries. The distribution of industries is relatively similar between both samples, with the most represented industries being 'Industrials' (22.4%), 'Consumer Discretionary' (15.6%) and 'Basic Materials' (11.1%) for Sample 1, and 'Consumer Discretionary' (22.1%), 'Industrials (18.7%) and 'Consumer Staples' (17.4%) for Sample 2. Sample 1 contains firms from 52 countries, while Sample 2 consists of 30 countries. The countries which are not represented in Sample 2 do not cover a significant share of Sample 1, with the most represented countries in Sample 1 being the U.S. (19.4%), the U.K. (13.3%), Japan (10.0%) and France (4.3%), which are similarly represented in Sample 2: the U.S. (26.7%), Japan (21.3%), the U.K. (10.5%) and France (8.5%). Comparing Sample 1 and Sample 2 in terms of industry and country finds that Sample 2 is appropriately representative of Sample 1.

3.2 Measures

3.2.1 Dependent Variable

To measure market-based financial performance of firms, the measurement of *Tobin's Q* is used since this measures a firm's market value relative to the value of its tangible assets (King & Lenox, 2001). *Tobin's Q* is frequently used in literature focused on the impact of environmental performance on financial performance, since it takes into account the expected future cash flows of a firm from the investor's perspective and takes into account long-term benefits of investment in improving environmental performance (Misani & Pogutz, 2015). Analyzing market-based performance is preferred over accounting-based performance measures such as ROA, since this study specifically studies the investor's perspective on the firm's current and future performance. While there are various, often complex, methods to determine *Tobin's Q*, this study follows the same approach as Bendig, et al. (2022) by measuring it as a firm's market capitalization relative to the book value of its assets. To account for skewness in the data, the logarithm of *Tobin's Q* is used to normalize the distribution of values. Other variables with skewed data are also defined using logarithmic transformations.

3.2.2 Independent Variables

For Hypothesis 1, the independent variable is *SBT Adoption*, which is a binary variable (where no adoption = 0 and adoption = 1) and indicates whether the year in which the firm first adopted SBTs is less than or equal to the actual year. As such, the independent variable compares SBT-adopted firms with a control group of firms which are yet to adopt SBTs as of their actual year or have not currently adopted SBTs at all.

For Hypothesis 2, the independent variable, *SBT Achievement,* is another binary predictor variable (where not being on track = 0 and being on track = 1) which determines whether a firm is on track to achieve its adopted SBT. The notion of being 'on track' to achieve the SBT is adapted from the study by Giesekam, et al. (2021), who assume that firms are on track if their actual emissions for a given year are lower than the emissions a firm should have if it wants to achieve its SBT, based on a straight-line depreciating pathway from the base year until the final target year.

3.2.3 Moderating Variable

For Hypothesis 3, the moderating variable is *SBT Difficulty*, which is a continuous variable based on the quantitative reduction target set by firms for their SBTs. For example, a 40% reduction target translates to a *SBT Difficulty* measurement of 0.4. As such, the higher the value the more difficult the target, where a value of 0 means zero reduction.

3.2.4 Control Variables

Considering the broad range of variables that could impact a firm's market valuation and a firm's ability or desire to set SBTs, several additional variables are included to control for potential unobserved effects. Consistent with prior literature (Bendig, et al., 2022), the following financial variables are included: *firm size*, defined as the logarithm of total assets, *firm growth,* defined as the year-on-year growth of total assets, *revenue,* defined as the logarithm of total revenue, *number of employees,* defined as the logarithm of total number of employees, *leverage*, defined as the logarithm of total debt divided by total assets, and *capital intensity,* defined as the logarithm of total capital expenditures divided by total assets. The variable *cash* was initially included, but later removed due to a large amount (around 50%) of missing values.

In addition to the potential impact of financial factors, other non-financial factors are also likely to impact the dependent and independent variables. Therefore, several variables are included to control for such effects, namely: *emission size,* defined as the logarithm of total Scope 1 and 2 emissions, and *ESG Score,* defined as Refinitiv's ESG Score (measuring a firm's overall environmental, social and governance performance). *ESG Score* is included to account for other, non-emission-related factors, as well as social and governance factors.

3.3 Initial Analysis

As both samples consist of unbalanced panel data, a Hausman (1978) test is conducted to determine whether a fixed-effects or random-effects regression model should be applied, which concludes that Sample 1 requires a fixed-effects model ($p < 0.05$) and Sample 2 a random-effects model ($p > 0.05$). Furthermore, a Modified Wald test concludes heteroscedasticity ($p < 0.05$), and a Woolridge test concludes serial correlation ($p < 0.05$), which is why robust standard errors are included in the models. A joint *F*-test ($p < 0.05$) furthermore concludes that year fixed-effects needed to be included in both models, while industry fixed-effects are also needed for the random-effects model. Industry fixed-effects are not needed in the fixed-effects model since this model already controls for firm-specific attributes that do not vary across time. The regression analyses are performed using the statistical software package Stata.

3.4 Additional Analyses

As will be shown in the 'Results' section, the results from the initial analysis are insignificant. Therefore, additional analysis of the data is conducted with the aim to find more granular insights. This additional analysis is performed in four ways. First, an alternative measure for the independent variable *SBT Achievement* in Hypothesis 2 and 3 is tested. Second, both samples are divided based on the emission

intensity of the firms' industry, resulting in a high-emitting industry sample and a low-emitting industry sample. Third, Sample 2 is split in terms of the ambitiousness of the SBT scenario. Fourth, a subset of firms is studied which have at least 3 firm-year observations with approved SBTs.

3.4.1 Alternative Measurement of SBT Achievement

The alternative measurement of SBT achievement, defined as *SBT Achievement %*, is a continuous variable which measures the extent to which firms are on track to achieve their SBT by comparing the actual emission reduction compared to the base year with the targeted reduction, again following the straight-line depreciation assumption explained earlier. Compared to the initial measurement, this alternative measurement also takes into account the distance to the emission target, which means very under- or overperforming firms stand out more. Looking at the data, the most extreme case of underperformance was by the firm Terna S.p.A, which was supposed to have 120,582 tons of CO2 emissions in 2021 according to straight-line depreciation, however actually had 1,502,035 tons of CO2 emissions in 2021, therefore drastically underperforming. In comparison, Berkeley Group in 2020 had underperformed their target of 8,735 tons of CO2 emissions by only 3 tons, by having an actual amount of 8,738 tons of CO2 emissions. The alternative measure of *SBT Achievement %* takes the discrepancy between the two cases into account, whereas the initial measurement of *SBT Achievement* determines both cases the same since neither achieved the emission target for that respective year.

3.4.2 High- and Low-Emitting Industry samples

When examining environmental data, the type of industry can have a significant impact on results considering the typical industry activities and the possible constraints this puts on firms to be able to improve environmental performance (Etzion, 2007). In their meta-analysis, Endrikat, et al. (2014) explain that making a differentiation between high- and low-polluting industries can be useful, considering the different regulatory and stakeholder pressures in each industry. To split both samples into high- and low-emitting industries, the distribution of emissions across industries in both samples is shown in Table 1 below. Analyzing and comparing both the distribution of observations and emissions across industries shows that the 'Basic Materials', 'Energy', 'Industrials' and 'Utilities' industries have the highest emission intensity with only 45.9% of total observations but 83.9% of total emissions in Sample 1 and 27.9% of total observations but 59.8% of total emissions in Sample 2. Interestingly, both the share of observations and the share of emissions is lower in Sample 2 compared to Sample 1, indicating that firms in emission-intensive industries are less likely to set SBTs and that those that do set SBTs are less emission-intensive than their industry-counterparts. The largest discrepancy between Sample 1 and Sample 2 is visible for the 'Energy' industry, with only 8 observations in Sample 2 compared to 623 in Sample 1 and less than 0.1% of total emissions in Sample 2 compared to 19.1% of total emissions in Sample 1. The reason for this is that, as of 2022, SBTi does not allow energy companies to

set targets until the development process of the sector's methodology has been completed (SBTi, 2022). Regardless of this, the observations from these four industries are grouped together as the 'High-Emitting Industries' sample.

Table 1 Emission Distribution across Industries.

	Sample 1			Sample 2		
Industry	**Obs.**	**Distr.**	**Distr. of Emissions**	**Obs.**	**Distr.**	**Distr. of Emissions**
Basic Materials	1,100	11.1%	21.9%	108	5.2%	6.5%
Consumer Discretionary	1,541	15.5%	9.5%	449	21.5%	13.7%
Consumer Staples	831	8.4%	2.7%	367	17.6%	16.3%
Energy	623	6.3%	19.1%	8	0.4%	0.0%
Financials	630	6.4%	0.1%	26	1.2%	0.1%
Healthcare	499	5.0%	0.5%	148	7.1%	2.4%
Industrials	2,222	22.4%	16.9%	387	18.6%	16.5%
Real Estate	502	5.1%	0.0%	104	5.0%	0.7%
Technology	857	8.6%	1.9%	229	11.0%	2.0%
Telecommunications	505	5.1%	1.4%	179	8.6%	5.0%
Utilities	602	6.1%	25.9%	79	3.8%	36.7%
High-Emitting Industries	**4,547**	**45.9%**	**83.9%**	**582**	**27.9%**	**59.8%**
Low-Emitting Industries	**2,993**	**30.2%**	**3.9%**	**686**	**32.9%**	**10.2%**

From the remaining industries, the 'Financials', 'Healthcare', 'Real Estate', 'Technology' and 'Telecommunications' industries have a particularly low emission intensity, representing 30.2% of observations and only 3.9% of emissions in Sample 1 and representing 32.9% of observations and 10.2% of emissions in Sample 2. As such, these industries are grouped together as the 'Low-Emitting Industries' sample. Note that the 'Consumer Discretionary' and 'Consumer Staples' industries are not included in either sample since they are neither distinctly high- or low-emitting industries according to the data. Both the 'High-Emitting Industries' sample and the 'Low-Emitting Industries' sample are studied using the same models as the initial analysis, including both the original and alternative measurement of SBT achievement.

3.4.3 Ambitiousness of SBT Scenario

Within the SBTs found in the SBTi Progress Report 2021 there are three types of global decarbonization scenarios which a firm can align with, namely '1.5 degrees', 'well below 2 degrees' or '2 degrees'. These scenarios refer to the global targets of limiting global warming to a maximum temperature increase above pre-industrial levels. As mentioned earlier, the Paris Agreement refers to such scenarios by having the goal to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels", but also to pursue efforts "to limit the temperature increase to 1.5°C above pre-industrial levels." (UN, 2015). In recent years, more emphasis is placed on the '1.5 degrees' scenario, with the UN's Intergovernmental Panel on Climate Change (IPCC) stressing the climate risks involved with crossing this threshold. In accordance, SBTi announced in July 2021 that the new minimum ambition required for corporate target setting would increase from 'well below 2 degrees' to '1.5 degrees' (SBTi, 2021). Considering the raised ambition levels, it is worthwhile to compare observations in Sample 2 based on the level of ambition as determined by SBTi, since investors might only value those targets that are in line with the recommendations by world leaders and climate experts. From the 2,084 observations with SBTs, the majority are based on the '1.5 degrees' scenario with 1,511 (72.5%) observations, followed by the 'well below 2 degrees' scenario with 402 (19.3%) observations and lastly the '2 degrees' scenario with 171 (8.2%) observations. To test if level of ambition is a relevant factor to consider in the context of SBTs, a subset of observations from Sample 2 which are based on the '1.5 degrees' scenario is studied using the same models as the initial and other subsequent analyses.

3.4.4 Longitudinal Data

Finally, following the limitations of earlier studies on SBTs which stated that the timeframe to study the data is too short to find conclusive results based on longitudinal data (Freiberg, et al., 2021; Bendig, et al., 2022), the firms in Sample 2 are filtered based on the number of annual observations with approved SBTs. A sizeable 782 (37.5%) out of 2084 observations are from firms that have fewer than 3 years of observations with approved SBTs, which can be explained by the recent exponential growth of SBTs with over 50% of observations coming from 2020 and 2021. By only studying firms with a minimum of 3 years of data with approved SBTs, potential early longitudinal effects could become visible. As such, the subset of firms with 3 years of 'approved SBT' data from Sample 2 is studied using the models as the initial and other subsequent analyses.

3.5 Interviews

After conducting the analysis and processing results, four qualitative interviews were conducted with experts from the field to gather more detailed insights about the concepts covered in this paper, in particular to improve the author's understanding about the perspective of investors on SBTs,

considering the lack of available literature in this area. The four interviewees all have more than 5 years of work experience and are each working for Dutch organizations operating in the financial sector (a bank, a pension fund, an asset manager, and a research center) with a specific focus on sustainability/ESG in their company or department. Two interviewees focus primarily on sustainable finance, while the other two interviewees are focused on ESG investing. Considering the limited data from only four interviews, this study does not claim to apply a mixed methods approach. Relevant excerpts from the interviews are provided in the Appendix (2 to 5). Whenever information is used that was discovered in one of the interviews, a reference to the respective interview in the Appendix is provided.

4. Results

4.1 Descriptive Statistics & Correlation

The descriptive statistics and Pearson correlation coefficients for Sample 1 and Sample 2 are found in Table 2 and Table 3 respectively. The correlation coefficients for the dependent variable and independent variables in both samples are not significant as none exceed 0.5. There is some correlation between control variables, particularly *firm size*, *revenue,* and *number of employees* appear to be closely correlated, with the highest correlation between *firm size* and *revenue* in both Sample 1 and Sample 2 (0.831 and 0.866 respectively). Furthermore, the independent variables *SBT Achievement* appears not to be correlated with the potentially moderating variable *SBT Difficulty.*

Table 2 Descriptive Statistics and Correlation Matrix – Sample 1

	Variables	Obs.	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	Tobin's Q	9920	.645	.432	1.000									
(2)	SBT Adoption	9920	.093	.290	0.071	1.000								
(3)	Firm Size	9920	23.1	1.46	-0.278	0.055	1.000							
(4)	Firm Growth	8588	.069	.244	0.078	-0.020	0.023	1.000						
(5)	Revenue	9919	22.5	1.43	-0.111	0.100	0.831	0.004	1.000					
(6)	Number of Employees	9036	9.61	1.58	-0.004	0.115	0.558	-0.007	0.789	1.000				
(7)	Leverage	9919	.235	.133	-0.177	0.013	0.099	-0.009	-0.004	0.017	1.000			
(8)	Capital Intensity	9747	.044	.035	0.069	-0.066	-0.112	0.014	-0.034	-0.027	0.051	1.000		
(9)	Emission Size	9920	12.8	2.39	-0.207	-0.052	0.451	-0.038	0.529	0.421	0.172	0.299	1.000	
(10)	ESG Score	9920	66.0	14.5	0.001	0.163	0.408	-0.036	0.411	0.366	0.049	-0.044	0.204	1.000

The table reports: number of observations, means, standard deviations (SD) and Pearson correlation coefficients. Tobin's Q, firm size, revenue, number of employees, leverage, capital intensity and emission size are log-transformed.

4.2 Initial Analysis

The results from the fixed-effects regression model are found in Table 4 in the Model 1 and Model 2 columns. Model 1 shows the results of the regression model without the independent variable *SBT Adoption* for Sample 1. Model 2 shows the results of the regression model with the independent variable *SBT Adoption* for Sample 1. The results for Model 2 indicate a very small negative and insignificant (β = -0.002, p = 0.843) effect of the independent variable *SBT Adoption* on the dependent variable *Tobin's Q*, which means Hypothesis 1 is rejected. Furthermore, the R^2 value for Model 1 and Model 2 (both with R^2 = 0.169) indicate a relatively strong predictive ability of the models considering the use of real-world data. When removing the control variables *firm size, revenue*, *leverage,* and *capital intensity,* which have

a significant effect on the dependent variable *Tobin's Q* in both models, the R^2 value drops by more than 0.1 in each case, therefore indicating the strong effect of those control variables on the predictive ability of the model.

The results from the random-effects regression model for Sample 2 are found in Table 4 in the columns from Model 3 until Model 5. Model 3 shows the results of the regression model without independent variables. Every model has a good degree of predictive ability, with the R^2 value of each model above 0.1. The smaller sample size compared to the sample used in Hypothesis 1 likely explains the slightly lower R^2 value.

Model 4 shows the results of the regression model with the independent variable *SBT Achievement*. The results from Model 4 show that *SBT Achievement* has a very small negative but insignificant effect on *Tobin's Q* (β = -0.009, *p* = 0.623), which means Hypothesis 2 is rejected.

Model 5 shows the results of the regression model with both the independent variable *SBT Achievement* and the interaction effect between *SBT Achievement* and the moderating variable *SBT Difficulty*. The results from Model 5 show that *SBT Difficulty* has a small positive and insignificant moderating effect (β = 0.054, *p* = 0.681) on the relationship between *SBT Achievement* and *Tobin's Q.* Furthermore, Model 5, when including the moderating factor of *SBT Difficulty*, repeats the same findings as Model 4 by finding a very small negative and insignificant effect of *SBT Achievement* (β = -0.009, *p* = 0.840) on *Tobin's Q*. The findings from Model 5 mean Hypothesis 3 is rejected and provides additional evidence for rejecting Hypothesis 2.

Table 3 Descriptive Statistics and Correlation Matrix – Sample 2

	Variables	Obs.	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	Tobin's Q	919	.741	.469	1.000										
(2)	SBT Achievement	770	.504	.500	0.018	1.000									
(3)	SBT Difficulty	919	.488	.230	0.062	-0.182	1.000								
(4)	Firm Size	919	23.4	1.34	-0.111	0.025	0.123	1.000							
(5)	Firm Growth	891	.054	.246	0.130	0.027	-0.032	0.078	1.000						
(6)	Revenue	919	22.9	1.30	-0.058	0.079	0.094	0.866	0.022	1.000					
(7)	Number of Employees	909	10.2	1.44	-0.070	0.093	0.041	0.685	-0.045	0.864	1.000				
(8)	Leverage	919	.241	.124	-0.107	0.009	-0.004	0.163	-0.089	0.047	0.013	1.000			
(9)	Capital Intensity	916	.037	.026	0.015	-0.050	0.061	-0.118	-0.013	-0.067	-0.077	0.075	1.000		
(10)	Emission Size	919	12.4	1.93	-0.234	-0.057	-0.035	0.583	-0.059	0.626	0.552	0.231	0.156	1.000	
(11)	ESG Score	919	73.4	11.7	-0.014	0.030	0.118	0.413	-0.001	0.374	0.363	0.066	-0.104	0.226	1.000

The table reports: number of observations, means, standard deviations (SD) and Pearson correlation coefficients. Tobin's Q, firm size, revenue, number of employees, leverage, capital intensity and emission size are log-transformed.

Table 4 Regression Results

	Fixed-Effects									Random-Effects					
	Hypothesis 1									Hypothesis 2			Hypothesis 3		
DV = Tobin's Q	Model 1			Model 2			Model 3			Model 4			Model 5		
Variables	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***
SBT Adoption				-.002	.01	.843									
SBT Achievement										-.009	.018	.623	-.008	.042	.840
SBT Achievement * SBT Difficulty													.054	.131	.681
Firm Size	-.186	.018	.000***	-.185	.018	.000***	-.115	.049	.019**	-.142	.054	.008***	-.144	.054	.008***
Firm Growth	-.012	.011	.299	-.012	.011	.296	-.106	.071	.136	-.109	.071	.125	-.109	.072	.129
Revenue	.148	.015	.000***	.148	.015	.000***	.182	.044	.000***	.217	.057	.000***	.217	.058	.000***
Number of Employees	-.016	.011	.167	-.016	.011	.170	-.069	.035	.045**	-.097	.042	.021**	-.097	.042	.021**
Leverage	-.558	.064	.000***	-.558	.064	.000***	-.574	.351	.102	-.497	.398	.212	-.499	.399	.212
Capital Intensity	.438	.168	.009***	.439	.168	.009***	-.198	.482	.681	.063	.547	.909	.062	.548	.910
Emission Size	-.009	.007	.201	-.009	.007	.195	-.036	.020	.074*	-.033	.021	.129	-.032	.021	.136
ESG Score	-.001	.000	.018**	-.001	.000	.018**	-.001	.001	.335	-.002	.002	.331	-.002	.002	.320
Constant	2.08	.419	.000***	-.185	.018	.000***	.645	.714	.366	.668	.832	.422	.670	.840	.231
Observations	7646			7646			879			756			756		
Year FE	Yes			Yes			Yes			Yes			Yes		
Industry FE	No			No			Yes			Yes			Yes		
R^2	0.169			0.169			0.117			0.125			0.127		

The table reports: the estimated coefficient values (Coef.), standard deviations (SD) and p-values (*p*). Tobin's Q, firm size, revenue, number of employees, leverage, capital intensity and emission size are log-transformed. Firm and year fixed effects are included but not shown.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Additional Analyses

Table 5 shows the regression models using the alternative measurement for the independent variable in Hypothesis 2, namely *SBT Achievement %*. Model 4b shows the regression results with only the independent variable *SBT Achievement %*, while Model 5b also includes the moderating effect of *SBT Difficulty*. The results from Model 4b are similar to Model 4, showing that *SBT Achievement %* has a small but insignificant effect on *Tobin's Q* (β = -0.018, *p* = 0.313), thus reinforcing the evidence to reject Hypothesis 2.

The results from Model 5b show that *SBT Difficulty* has a positive but insignificant moderating effect (β = 0.118, *p* = 0.265) on the relationship between *SBT Achievement %* and *Tobin's Q.* When including the moderating factor of *SBT Difficulty*, Model 5b repeats the same findings as earlier models by finding a very small negative and insignificant effect of *SBT Achievement* (β = -0.064, *p* = 0.151) on *Tobin's Q*. The findings from Model 5b provide further evidence for rejecting Hypothesis 2 and Hypothesis 3. Looking at the R^2 value in both models, the predictive ability is similar to Model 4 and Model 5.

Table 5 Regression Results with 'SBT Achievement %' variable

	Hypothesis 2			Hypothesis 3		
DV = Tobin's Q	**Model 4b**			**Model 5b**		
Variables	**Coef.**	**SE**	***p***	**Coef.**	**SE**	***p***
SBT Achievement %	-.018	.018	.313	-.064	.045	.151
SBT Achievement % * SBT Difficulty				.118	.106	.265
Firm Size	-.144	.054	.008***	-.150	.054	.006***
Firm Growth	-.109	.071	.125	-.107	.071	.130
Revenue	.221	.060	.000***	.223	.060	.000***
Number of Employees	-.097	.041	.018**	-.097	.041	.020**
Leverage	-.494	.397	.213	-.500	.397	.207
Capital Intensity	.038	.539	.944	.020	.537	.971
Emission Size	-.035	.021	.097*	-.032	.022	.143
ESG Score	-.002	.002	.339	-.002	.002	.365
Constant	.656	.829	.429	.681	.830	.412
Observations	756			756		
Year FE	Yes			Yes		
Industry FE	Yes			Yes		
R^2	0.124			0.122		

The table reports: the estimated coefficient values (Coef.), standard deviations (SD) and p-values (*p*). Tobin's Q, firm size, revenue, number of employees, leverage, capital intensity and emission size are log-transformed. Firm and year fixed effects are included but not shown.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6 and Table 7 show the regression results for the 'High-Emitting Industries' and 'Low-Emitting Industries' sample respectively. Whilst Model 2, Model 4a (previously Model 4) and Model 4b provide similar insignificant results as earlier findings, both Model 5a (previously Model 5) and Model 5b provide significant results. The R^2 values vary between 0.125 and 0.225, indicating some level of predictive power.

For the 'High-Emitting Industries' sample, Model 5a shows that *SBT Achievement* has a significant positive moderating effect (β = 0.531, p = 0.004) on the relationship between *SBT Achievement* and *Tobin's Q*, with a confidence level of 99% ($p < 0.01$) whilst the direct effect of *SBT Achievement* on *Tobin's Q* is insignificant (β = -0.051, p = 0.254).

Model 5b shows that *SBT Difficulty* also has a significant positive moderating effect (β = 0.332, p = 0.083), on the relationship between *SBT Achievement %* and *Tobin's Q* albeit at a lower confidence level of 90% ($p < 0.10$). In addition, when taking into account the moderating factor, *SBT Achievement %* has a negative and significant effect (β = -0.108, p = 0.066) on *Tobin's Q*, also at a confidence level of 90% ($p < 0.10$).

As shown in Table 7, for the 'Low-Emitting Industries' sample, Model 5a provides insignificant results when using the independent variable *SBT Achievement*. However, Model 5b shows that *SBT Difficulty* also has a significant positive moderating effect (β = 0.628, p = 0.070) on the relationship between *SBT Achievement %* and *Tobin's Q,* again at a confidence level of 90% ($p < 0.10$). When taking into account the moderating factor, *SBT Achievement %* has a relatively large negative and significant effect (β = -0.341, p = 0.041) on *Tobin's Q*, at a confidence level of 95% ($p < 0.05$).

The regression results in Table 6 and Table 7 for 'High-Emitting Industries' and 'Low-Emitting Industries' provide some evidence towards accepting Hypothesis 3 under the condition that firms have either considerably high or low emission intensity. In addition, the results support the arguments by Endrikat, et al. (2014) that the emission intensity of a firm's industry is relevant to research on the environmental performance of firms.

Table 8 shows the regression results for the sample of observations where the SBTs are based on the '1.5 degrees' scenario. The results provide insignificant results across all models, indicating that the level of ambition in terms of scenario is not relevant when studying SBTs and their effect on market-based financial performance. In addition, the R^2 values around 0.125 indicate a relatively weak predictive ability of the models.

Table 6 Regression Results for High-Emitting Industries

	Fixed-Effects						Random-Effects								
DV = Tobin's Q	Model 2			Model 4a			Model 4b			Model 5a			Model 5b		
Variables	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
SBT Adoption	.009	.019	.627												
SBT Achievement				.023	.030	.446				-.051	.044	.254			
SBT Achievement %							-.005	.017	.770				-.108	.058	.066*
SBT Achievement * SBT Difficulty										.531	.186	.004***			
SBT Achievement % * SBT Difficulty													.332	.191	.083*
Observations	3598			218			218			218			218		
Year FE	Yes			Yes			Yes			Yes			Yes		
Industry FE	No			Yes			Yes			Yes			Yes		
R^2	0.143			0.167			0.169			0.228			0.174		

The table reports: the estimated coefficient values (Coef.), standard deviations (SD) and p-values (*p*). Control variables, firm and year fixed effects are included but not shown. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7 Regression Results for Low-Emitting Industries

	Fixed-Effects						Random-Effects								
DV = Tobin's Q	Model 2			Model 4a			Model 4b			Model 5a			Model 5b		
Variables	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
SBT Adoption	-.012	.018	.531												
SBT Achievement				-.031	.039	.427				-.063	.090	.481			
SBT Achievement %							-.046	.035	.192				-.341	.167	.041**
SBT Achievement * SBT Difficulty										-.161	.222	.467			
SBT Achievement % * SBT Difficulty													.628	.357	.079*
Observations	2146			243			243			243			243		
Year FE	Yes			Yes			Yes			Yes			Yes		
Industry FE	No			Yes			Yes			Yes			Yes		
R^2	0.169			0.218			0.220			0.222			0.210		

The table reports: the estimated coefficient values (Coef.), standard deviations (SD) and p-values (*p*). Control variables, firm and year fixed effects are included but not shown. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 8 Regression Results for SBTs based on the '1.5 degrees' scenario

DV = Tobin's Q	Model 4a			Model 4b			Model 5a			Model 5b		
Variables	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
SBT Achievement	.019	.020	.352				.021	.050	.678			
SBT Achievement %				-.013	.022	.542				-.076	.054	.159
SBT Achievement * SBT Difficulty							-.090	.151	.552			
SBT Achievement % * SBT Difficulty										.155	.127	.219
Observations	532			532			532			532		
Year FE	Yes			Yes			Yes			Yes		
Industry FE	Yes			Yes			Yes			Yes		
R^2	0.124			0.128			0.124			0.124		

The table reports: the estimated coefficient values (Coef.), standard deviations (SD) and p-values (*p*). Control variables, firm and year fixed effects are included but not shown. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9 Regression Results for firms with 3 or more years of approved SBTs

	Fixed-Effects			Random-Effects								
DV = Tobin's Q	Model 2			Model 4a			Model 4b			Model 5a			Model 5b		
Variables	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*	Coef.	SE	*p*
SBT Adoption	.000	.017	.993												
SBT Achievement				-.025	.020	.218				-.033	.046	.471			
SBT Achievement %							-.013	.040	.749				-.097	.090	.281
SBT Achievement * SBT Difficulty										.306	.153	.034**			
SBT Achievement % * SBT Difficulty													.188	.159	.237
Observations	1094			570			570			570			570		
Year FE	Yes			Yes			Yes			Yes			Yes		
Industry FE	No			Yes			Yes			Yes			Yes		
R^2	0.249			0.187			0.181			0.204			0.176		

The table reports: the estimated coefficient values (Coef.), standard deviations (SD) and p-values (*p*). Control variables, firm and year fixed effects are included but not shown. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Lastly, Table 9 shows the regression results for the sample of firms with 3 or more annual observations with approved SBTs. The results for Model 2, Model 4a, Model 4b and Model 5b are all insignificant. The results for Model 5a show that *SBT Difficulty* has a significant positive moderating effect (β = 0.306, p = 0.034) on the relationship between *SBT Achievement* and *Tobin's Q*, with a confidence level of 95% (p < 0.05) whilst the direct effect of *SBT Achievement* on *Tobin's Q* is insignificant (β = -0.033, p = 0.471). This provide more evidence to accept Hypothesis 3 under the condition that longitudinal data is adequate.

5. Discussion

5.1 Key Findings & Interpretations

The research question of this study, as outlined in the introduction, is: are firms' science-based targets strong signals for investors? To answer this question, the potential for a signaling role of SBTs is explored using the theoretical framework of ST provided by Connelly, et al. (2011), with SBTs as signals, firms as signalers and investors as receivers. After predicting a strong theoretical fit, a quantitative analysis of SBTs and firm's financial and non-financial performance is conducted. Despite the prediction for a strong theoretical fit and the expectations from experts that investors take SBTs into account during decision making (see Appendix 2), the findings from this study point towards the notion that investors do not place significant value on firms setting SBTs, and that SBTs cannot be considered as strong signals at the moment. These results oppose the expectation that the adoption of SBTs would reduce information asymmetry between firms and investors, thereby reducing the risk of the firms as perceived by investors which would lead to a positive effect on investor's valuation of firms and the associated firm's market-based financial performance. When controlling for financial factors which are likely to impact firms' market-based financial performance, as well as the overall ESG performance of firms, the results from the analysis indicate that the effect of SBT adoption on market-based financial performance is insignificant, even under conditions where one could expect that investors pay extra careful attention to a firm's decarbonization strategy, such as when a firm operates in an industry with relatively high emission intensity (Endrikat, et al., 2014). The findings also imply that investors are not put off by firms not setting SBTs, even though this does not reduce information asymmetry and could suggest a lack of resources such as human capital or a decarbonization plan in the firm's strategy.

Despite the lack of support for the hypotheses, observing the results from this research in the broader context of academic literature does create new insights and considerations. This study contributes to literature on ST in the context of ESG disclosure by providing nuance to the assumption that ESG disclosure reduces information asymmetry to the extent where investors put significant value on it. Looking at earlier literature on ST in the ESG disclosure context, the study by Moratis (2018) similarly found a lacking signaling role of the ISO 26000 sustainability standard. This could indicate that the underlying, unobservable quality which is signaled through such ESG disclosure (i.e., SBTs or sustainability standards) does not coincide with the concise, comprehensive, and credible information demanded from investors (Cohen, et al., 2015). In addition, the assumptions by Kirmani & Rao (2000) that high-quality firms experience a positive effect from signaling and low-quality firms experience a negative effect are not supported when studying SBT progress and achievement. This could entail that investors are potentially unaware of the costs associated with signaling through SBTs and are not vigilant

enough to punish firms that are showing signs of low-quality, or alternatively reward firms that are showing signs of high-quality. Another interpretation of this finding is that the firm's probability of (not) achieving their SBT, determined by their level of progress compared to the assumed SBT trajectory, does not influence investors' perception of the firm and their capabilities. Additionally, the expectations from Connelly, et al. (2011) that sustainability initiatives would be useful signals due to the associated investment costs and penalty costs are not supported in this study. Thus, while the theoretical fit for SBTs as potential signaling tools is promising, the conclusion from this study is that, under these research conditions, the signaling effect of SBTs is not observable.

Looking at extant literature on ESG disclosure, there is an emphasis on the growing relevance of ESG information. Nevertheless, the financial indicators included in the model as control variables are still considerably more influential in terms of market valuation. This supports the belief by Schoenmaker and Schramade (2023), who state that environmental and social factors are only weighted at around 10% of financial factors in the current economic regime. Furthermore, there is apparently no continued financial benefit for firms adopting an ESG disclosure initiative such as SBTs, which could indicate, as is supposed in several interviews (see Appendix 3 and 4), that the market perceives SBT adoption as a 'hygiene factor' which is not positively perceived but instead used as a negative screening tool for removing companies which have not adopted SBTs. A study by Trinks and Scholtens (2017) on negative screening in ESG investing found that excluding 'controversial' companies (in our case those without SBTs) lead to reduced financial return, which suggests that negative screening has little adverse effect on the financial performance of omitted companies. While their study focused exclusively on ESG investing, this research technically includes the entire public equity market, which would further reduce the negative impact of screening on financial performance since ESG investing takes up a small part of the entire market, which means relatively few players would perform such screening activities. Furthermore, according to Amel-Zadeh and Serafeim (2018), many investors are taking into account ESG issues into investment decisions, but this is mostly emission-related data or ESG ratings (MSCI, Sustainalytics, etc.) provided by rating agencies according to Interview 4 (see Appendix 5). Perhaps the forward-looking aspect of SBTs, which inform more about the firm's ambition than its current performance, is not concrete enough to be considered by investors as reducing information asymmetry.

The findings in this study may imply that the studied sample is too broad to find significant results, and that SBTs can only be seen as viable signals under specific conditions, either regarding characteristics of the SBT, the firm, or the industry. For instance, the results show that the emission intensity in the industry is relevant when studying SBTs, which follows earlier literature (Endrikat, et al., 2014) and is supported by findings from interviews (see Appendix 4 and 5), which emphasize that specific industry characteristics determine the extent to which investors value ESG information such as SBTs.

Interestingly, for the *SBT Difficulty* measurement, both the high- and low-emitting industry samples provide significant moderating effects, even though the larger sample (Sample 2) does not. This could indicate that it's not necessarily the high- or low-emitting characteristic that defines whether the moderating effect is significant, but that comparing firms with similar profiles could more accurately predict such effects.

Considering the exponential growth of SBTs and the accompanied public attention, it is possible that investors are only attributing value to SBTs in the last couple of years. This explanation provides support for the consideration to revisit the SBT data in a few years, while it also might indicate that the early years of SBT data should be ignored when studying market-based financial measures, since the market arguably did not pay enough attention to SBTs in the early years. In other words, receiver attention was potentially insufficient to create strong signals in this context. Perhaps investors will only perceive SBTs as strong signals once there is enough evidence that they accurately predict improved carbon performance. This suggestion is supported by earlier literature, which state that the effect of SBTs and other environmental initiatives on financial performance might only become evident after the investigated time frame (Bendig, et al., 2022), with such initiatives having more long-term than short-term effects (Eccles, et al., 2014) and therefore taking time to materialize in terms of financial benefits (Misani & Pogutz, 2015). We can observe whether SBTs will lead to the required decarbonization once the first wave of SBTs have expired, which is expected to be in 2025 when around 20% of current SBTs expire or in 2030 when around 65% of SBTs expire.

5.2 Theoretical Implications

As mentioned in the 'Literature Review', the academic focus on ESG disclosure through the theoretical lens of ST has been limited. Over a decade ago, Connelly, et al. (2011) recommended studying sustainability initiatives as potential signaling strategies, but only a handful of studies have made an effort to do so, with Moratis' (2018) paper being the most comprehensive and grounded in the theory. Similarly to Moratis (2018), this study does not find support for a signaling effect of ESG disclosure, with this study focusing on SBTs and conducting a quantitative analysis, whereas his study focuses on the ISO 26000 standard and performed a qualitative analysis. Through studying the signaling role of SBTs, this study finds support for the idea that ESG disclosure cannot be used as a viable signaling strategy for firms to reduce information asymmetry and improve firm valuation by investors. Considering Connelly's (2011) expectations that the cost of signaling through sustainability initiatives would lead to a signaling effect, the results from this study argues against these expectations, which can either mean there are no significant signal costs associated with signaling ESG disclosure, or that these signal costs are not readily observed and appreciated by investors. Therefore, again similar to Moratis' (2018) findings, this

study finds that the cost of signaling through ESG disclosure is not apparently significant, although Connelly's (2011) expectations could prove valid in alternative circumstances.

In exploring the theoretical fit of SBTs as a signaling tool, several interesting considerations came to the front. First, according to the author's best knowledge this study is the first to study targets as a potential medium for signaling information of intent. This study does not find support for this idea, but a different research context, such as focusing on traditional financial corporate targets, might provide more support. What makes this particularly interesting is the forward-looking nature of targets, as this regards information of intent rather than information of quality, as was explained in section 2.3.1. Compared to information of quality, which is typically the focus of ST literature, information of intent is much less frequently considered (Connelly, et al., 2011). Further exploration of the signaling role of targets and the signaling of information of intent, both within the context of ESG disclosure and outside this context, could provide a significant contribution to the extant theory.

Finally, this study emphasizes the importance of signal honesty and explores the role of third-party verification as a means to improve the truthfulness of signals. However, considering the insignificance of findings, the assumed signal honesty might be lower than initially expected. From the investor's perspective, third-party verification of SBTs might not be enough to convince them that the firm possesses the required quality to achieve the targets. Nevertheless, the possibility for firms to improve perceived signal honesty through third-party verification is first posited in this study.

5.3 Practical Implications

From a practical standpoint, the worrying element of the findings is that they might reveal the market's lack of concern towards the decarbonization goals set out by the UN in the Paris Agreement. SBTs are arguably the first tool which firms can use to signal to outsiders that they have the resources and decarbonization plans in place to reach the overarching goal of limiting global warming to 1.5°C. If investors do not consider SBTs in their valuation of firms, then it may indirectly show that they are currently not concerned about firms working towards the global decarbonization goal set out by the UN. As stated earlier, this might change in the near future, when it becomes more evident which firms are (un)able to reach that goal, both by whether they have set SBTs and whether they are able to achieve SBTs.

For firms, these findings could make them question the relevance of disclosing information about their ESG targets, as this is seemingly not taken into consideration by investors. Firms might still set and aim to achieve such targets, as research indicates that they do improve company performance if they are

sufficiently ambitious (Dahlmann, et al., 2017), but instead decide to keep them internal. The importance of having sufficiently difficult targets is further supported by the findings for Hypothesis 3, which find that a higher difficulty increases the extent to which investors consider SBTs in their investment decisions. Due to growing regulatory requirements and climate risks in the coming decades, firms should aim to improve their ESG performance regardless of the current demands of investors. Nevertheless, the apparent lack of pressure from investors, as evidenced by the absence of an effect on market-based financial performance, could reduce the perceived urgency for firms to act, as investors are often still considered the single-most important stakeholder (Schoenmaker & Schramade, 2023).

Finally, for other stakeholders in the ESG landscape, such as SBTi or other sustainability standard setters and third-party verifiers, this study could illustrate that the frameworks developed have so far not been taken into consideration by investors when making investment decisions to the extent where they impact market valuation. While this could change in the coming years due to increased investor awareness, these organizations should continue to work towards meeting investor demand by improving the quality of ESG disclosure, particularly in terms of comparability, conciseness, and credibility (Cohen, et al., 2015; Amel-Zadeh & Serafeim, 2018; Bernow, et al., 2019).

5.4 Limitations

This study aims to examine if SBTs are viable signals through a quantitative analysis of archival SBT and other firm data. Considering the novelty of this research design, which is the first to analyze archival data on SBTs in combination with financial data through quantitative analysis, there are some limitations to the present study. First of all, the method used to answer the research question might not be most suitable to determine if SBTs are viable signals for investors. Instead of studying the effect of SBTs using quantitative analysis, one could perform a qualitative analysis using interviews or case studies to determine whether investors consider SBTs in their investment decisions. Similarly, the data analyzed might not be granular enough to find significant results. For instance, there is only 1 observation a year per firm, while the effect of disclosure on SBTs might be more visible within a year, for example by comparing the month before and after the setting of SBTs or the disclosure of SBT progress. While this research design provides some insights into investor's perceptions of SBTs, other methods might be needed to arrive at a more nuanced conclusion.

The data sample used is cross-industry, which goes against recommendations in earlier literature to focus on a specific industry or region (Endrikat, et al., 2014), which is also suggested in Interview 3 (see Appendix 4) and Interview 4 (see Appendix 5)). For instance, Carnini Pulino, et al. (2022) focus on Italian firms when studying the signaling role of ESG disclosure and are able to draw conclusions based on the

characteristics specific to Italian companies. Considering the theoretical fit with ST and the lack of evidence against a cross-industry effect, this study aimed to find out if SBTs had an effect on market-based financial performance regardless of the industry or region. The findings conclude that this is not the case, and that if there is a significant relationship, it would depend on firm-, region- or industry-specific characteristics.

In this analysis, the achievement of targets is measured along a straight-line depreciating pathway, which is a method also applied by firms themselves to determine their SBT progress (see Appendix 4) and used in other SBT literature (Giesekam, et al., 2021). Nevertheless, the science-based sectoral decarbonization pathways developed by organizations such as SBTi, the Transition Pathway Initiative (TPI) or the International Energy Agency (IEA) are of a nonlinear nature. This distinction provides additional context to the findings. For instance, if the nonlinear sector-specific pathways would be used instead of the straight-line method, it could more accurately show which firms are on the right track and, more importantly, which firms are not following the right trajectory. When looking at TPI's Sectoral Decarbonization Pathway report (see Appendix 6), the automotive sector is expected to achieve most reductions at the front-end of the pathway (until 2025), while the cement sector is expected to achieve most reductions at the back-end (from 2030 onwards) (Dietz, et al., 2022). This highlights that, in certain sectors, the nonlinear pathway could differ considerably compared to the straight-line method, which means firms could be inaccurately judged (not) to be on track according to the straight-line method. Since the decarbonization pathways differ per sector and are also based on a sector-specific emission intensity metric, it is difficult for outsiders such as investors to determine whether firms are on the correct trajectory according to the pathway. Therefore, investors might refrain from drawing conclusions about a firm's progress of its SBT until the target year is reached. In this case, investors will only consider the achievement of SBTs at the conclusion of the target, meaning the effects will not be visible from the data analyzed in this study, since no SBTs have reached their target year as of yet.

Looking further into the samples used in this study, Sample 2 only contains firms with confirmed and absolute SBTs for Scope 1 and 2 emissions, while those firms in Sample 1 but not in Sample 2 are assumed not to have SBTs. However, it is possible that, within that group of firms, there are those that have set SBTs, but only relative targets or targets for Scope 3 emissions. In addition, there are firms which have disclosed that they are in the process of setting SBTs, which are potentially also included in Sample 1. The analysis of Sample 1 does not account for these discrepancies, which could have lead to skewed results.

Another limitation of this study is the type of statistical analysis performed in this study. Investors use a wide range of variables and complex mathematical models to make investment decisions, so finding an

effect based on a limited number of independent and control variables is perhaps too optimistic (see Appendix 5). As such, one could argue that the analysis performed is too simple to find any meaningful effect of the studied phenomenon. The author's limited expertise in the use of statistical methods has prevented the implementation of more complex statistical models, which could consider factors and effects that are unaccounted for in the present study.

In addition and contrasting earlier studies measuring environmental and financial performance such as by Bendig, et al. (2022), the choice was made not to include lagged variables in the analysis. This decision was made since the effect of SBTs on market-based financial performance is expected to be found within close proximity in terms of time, rather than in a year's time which is what a lagged variable would represent. For example, Hypothesis 2 expects that the market would react to firms (not) achieving their intermediate SBT. Considering the speed with which financial markets operate, this reaction would happen near instantly, meaning that a 1-year lagged variable would not capture this reaction effectively. Nevertheless, there are several reasons why lagged variables are beneficial in statistical analysis, hence the decision not to include them could be considered a limitation of this research.

Furthermore, the study aims to replicate the theoretical analysis performed by Moratis (2018), who studied the ISO 26000 sustainability standard using the theoretical concepts of ST, by studying the same concepts for the SBT phenomenon. However, in the process of exploring the theoretical fit, several assumptions are made. These include that signaling using SBTs is more difficult for low-quality firms compared to high-quality firms, that observability of SBT setting is high and that investors are actively searching for signals of SBTs. These assumptions contribute to the prediction that there is a strong theoretical fit between ST and the SBT phenomenon. Also taking in mind the findings from the analysis which contradict this prediction, some assumptions made could therefore be incorrect.

To determine the effect of SBTs, several variables were created which aimed to measure SBTs. However, there is no evidence that these measurements accurately represent SBTs. For instance, both measurements of target achievement are based on a straight-line depreciation method, which has been used in earlier literature (Giesekam, et al., 2021) and in practice by firms (see Appendix 4), but not as a basis for measuring the independent variable in quantitative research. In addition, this variable is defined as *SBT Achievement (%)*, despite only determining the intermediate progress of SBTs and not the actual 'final' achievement of the target, since no SBT was completed during the studied time period. Alternative definitions of this variable were considered, but no other term was identified which more accurately represented the studied concept. Nevertheless, the author acknowledges the relatively ambiguous definition of this variable.

In summary, the present study contains several limitations with regards to the methodology (i.e., statistical methods, variables, population) and the assumptions from the theoretical framework. Considering the novelty of this research design, future studies should be able to overcome these limitations and thereby provide more academic insights into the studied phenomenon.

5.5 Future Research

This study aims to answer if SBTs can present a viable signaling strategy for firms through a quantitative analysis of the effect of SBTs on market-based financial performance. However, as touched upon when discussing the limitations of this research, there are many ways to try to answer this question. First, while this study includes a theoretical analysis of the SBT phenomenon and interviews with experts, the focus is on the quantitative research method. By focusing more on a qualitative analysis through conducting (semi-)structured interviews, more granular insights could be gained as to whether investors think SBTs reduce information asymmetry, whether this leads to improved firm valuation and under what conditions this could occur. Such research could also provide more detailed guidance for further quantitative analysis by focusing on possible identified relationships and previously unidentified and unexplored variables. For example, findings from Interview 4 indicate the potential reputational effects of (not) setting SBTs (see Appendix 5), which could be explored using qualitative research. After such discovery, further quantitative analysis could confirm the existence of a significant effect. Such findings on what type of ESG disclosure and which underlying factors are most useful for investors, could guide firms and managers to make better informed decisions.

Similarly, a case study analysis could be conducted by focusing on one or a handful of firms which have set SBTs. This method allows for a focus on a specific region and industry, which could uncover conditions for a positive relationship. By focusing on a specific case, it becomes possible to gain insights from both the perspective of the firm and the perspective of the investor(s), which could indicate the extent of information asymmetry between both parties, as well as allow for the development of a multifaceted argument for or against the signaling role of SBTs. A case study analysis could observe the direct and indirect, as well as short- and long-term, effects of SBT setting and identify the factors that influence a firm's ability to reach its decarbonization targets. Considering findings from Interview 2, in which the participant shared that their company was setting company-wide targets to have a percentage of the portfolio with adopted SBTs (see Appendix 3), a case study analysis could be conducted to observe the effectiveness of such a strategy for financial institutions.

Findings from Interview 3 uncovered an interesting avenue for future research, namely the difference in behavior between public and private companies with regards to ESG disclosure (see Appendix 4). Publicly-listed firms are already expected to have a certain level of disclosure, which is not currently

expected for private companies, and are therefore expected to be more likely to be further ahead in terms of sustainability performance and thus in setting SBTs according to Interview 3 (see Appendix 4). The difficulty for this research avenue is the lack of publicly available financial and non-financial data on private firms. This might become more feasible once the upcoming CSRD regulation is in place, since this will also require ESG disclosure for large private firms, which would lead to more disclosure for private companies as well.

A fourth method which could be used to study the effects of SBT setting would be to analyze the direct effect on firm's stock performance. For example, if a firm sets an SBT or if it reports progress on SBT, is there any visible direct (presumably positive) effect on the firm's stock price. This method would resolve the problem of lagged variables, since it could use time intervals of a day or week, instead of a year, which means lagged variables could still represent the short-term impact and simultaneously determine if there is a causal relationship between SBT setting and stock price.

Besides focusing on alternative research methods, focusing on an alternative theoretical framework could also prove valuable. From the perspective of the firm, the findings from this study do not necessarily conclude that setting SBTs has no financial benefit. While ST expects improved market-based financial performance, another theory, namely the Natural Resource-Based View (NRBV) could explain possible improved internal, accounting-based financial performance as a result of setting SBTs (Bendig, et al., 2022). In earlier literature, the NRBV has been extensively used to explain a positive effect of environmental performance on financial performance, since this theory assumes that a firm's ability to improve environmental performance could lead to rare, inimitable resources which could give the firm a competitive advantage (Endrikat, et al., 2014). For example, high environmental performance improves the firm's chances of acquiring new high-quality employees, since a majority of young talent would prefer to work for a sustainable employer (Gaskell, 2021). Firms that set SBTs are likely to have rare and inimitable resources according to findings from Interview 2 (see Appendix 3), since firms require specific resources to be able to set SBTs, such as detailed decarbonization plans and experienced employees. These resources could provide the firm with a long-term competitive advantage, which according to NRBV should lead to improved internal financial performance (Bendig, et al., 2022). As such, the NRBV might provide a more viable theoretical framework, compared to ST, when determining the financial benefits of SBT setting.

Finally, the most interesting avenue for future research is to study SBTs upon their completion. As stated earlier, this could already be in 2025, although most SBTs are set for 2030. By then, conclusions can be drawn over their effectiveness, and since the attention given to ESG disclosure by investors is only expected to grow, the chance that investors would consider SBTs as strong signals is expected to increase considerably.

5.7 Conclusions

This research aims to answer if SBTs present strong signals for investors, thereby revealing to firms if they can use SBTs as a tool to communicate to investors. Considering previous literature on ESG disclosure and assuming the theoretical framework of ST, the hypotheses are that the adoption and achievement of SBTs would reduce information asymmetry and improve market-based financial performance, and that target difficulty would moderate the effect of target achievement. The results from the regression analyses lead to the rejection of the hypotheses, apart from the finding that target difficulty has a moderating effect on the relationship between target achievement and market-based financial performance for both low- and high-emitting industries. This means SBTs do not have the expected signaling effect for investors, which more broadly supports the notion that ESG disclosure initiatives are not (yet) interpreted as important signals by investors, while it also indicates that targets are not a useful medium for signaling information of intent. More practically, the findings send a distressing message that the market does not value firms having and disclosing detailed and ambitious decarbonization plans. Time will tell whether this will hinder the imperative global movement towards to a net-zero society, but it certainly does not do the cause any favors.

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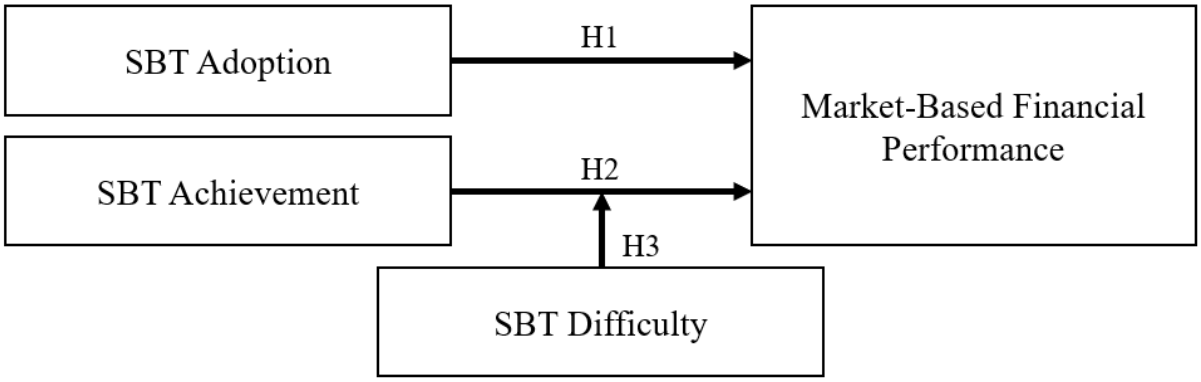
Appendix

Appendix 1: Conceptual Research Model



Appendix 2: Excerpts from Interview 1

Question: what is your experience with science-based targets?

> Answer: At my previous job I was involved in helping financial institutions to set targets and reduction pathways. So with a focus on financial institutions, and not the underlying companies. In my current position, we are analyzing climate targets for large Dutch banks, and we have written input for a committee debate which took place in March, where the finance committee debated about how to make the financial sector operate sustainably. We looked at what target those banks set and if they comply with certain guidelines such as science-based targets, but also more robust frameworks that say you need specific goals by 2025 for example. From this we made several observations, including absolute vs. relative targets, which is also a part of science-based targets, also short-term targets and the extent to which banks include their whole portfolio or only a part. So I'm more broadly involved in the climate plans and transition to net zero, but not necessarily specifically in relation to science-based targets.

Question: Do you think the market automatically links science-based targets to the initiative (SBTi)? Or can science-based targets be viewed on a broader scale?

> Answer: **Many people first think about the initiative**, but there's other reports such as the McKenna report which states the requirements for transition plans, who also state, similar to many other frameworks, that the reduction targets need to be science-based. I think depending on who you talk to, they will connect the term science-based targets to different organizations and initiatives.

Question: Do you think investors, such as pension funds who you speak to regularly, value science-based targets?

Answer: I think so. Although I haven't looked at climate plans. Pension funds invest a lot in state obligations and indices such as MSCI, where it may be less relevant. But they also invest in private markets such as companies, and there they look at specific ESG criteria and **I can imagine that investors take a company's goals into account during investment decisions**. A bank does the same, where their own targets and transition pathways are dependent on the actions of their clients. They also engage with companies, and **SBTs could be a good tool to influence companies to become more sustainable and set climate ambitions**.

Question: Do you think investors demand from firms that they set science-based targets?

Answer: Yes, going even a step further, **regulation such as CSRD is starting to require firms to have transition plans in place and have science-based targets**. That sort of regulation is coming.

Question: Do you think investors are also valuing whether companies are on track to achieve their targets?

Answer: I think it's becoming more important. Companies are starting to set targets or have recently set targets, so it's not yet clear how far off targets some companies are. It remains to be seen how companies and the market will react once it becomes clear that companies are far off their target.

Question: Do you think both investors and companies truly believe that targets will be reached?

Answer: That's difficult. Many people have good faith that it will turn out good. But I think in the current system with the growth mindset, some companies and sectors will not achieve the transition and will have to stop or shrink. So I'm skeptical because a lot is happening but there's still an increase in emissions, even though there must be people out there who know whether it's possible.

Question: Yes or no, do you think investors value target setting more than target achievement?

Answer: No, currently I don't think so. In this phase target setting is more prominent because we're at the start of this process. The question is what counts as target achievement? Will carbon offsets be allowed or will there be different scenarios or methodologies used?

Appendix 3: Excerpts from Interview 2

Question: What is your experience with science-based targets in your current position in your company?

Answer: 2 years ago, one of our clients asked us to come up with a climate target for our sector-specific fund. All the other funds were using CO2 reduction targets, which resulted in them shaving off certain companies from their portfolio to reach their targets. After understanding the data and believing that divestment was not having the real-world impact beyond a signaling effect, we believe that the best way for us to be effective was to use science-based targets. So instead of having a target to reduce the CO2 emissions of our portfolio, for our fund **we decided to make a target to have a percentage of our assets under management in companies that have science-based targets**. At the moment we're strongly stimulating clients to set targets, but in the near future **it will become a binding component of how we construct the portfolio**. … Further, for the entire company, we need to have key risk indicators on climate risk. So, we start thinking about what the most effective key risk indicators are for us to understand, at a total portfolio level, the transition risk that is in our portfolio right now. What we decided to do was to also **use the percentage of the portfolio with a Paris-aligned target as a key risk indicator that we need to begin steering on and monitoring very actively as part of the risk management program**.

Question: How much value does your company put on firms setting science-based targets?

Answer: For real estate companies, we value the underlying properties, in terms of what the appraisers are going to value them at or what investors are going to buy them at. On top of that, because we invest in whole companies, you can add a premium or a discount on this value in terms of a corporate wrapper, based on the professionality of the team, how well they capture growth opportunities, etc. For now, **science-based targets are mostly considered in this corporate wrapper**. Currently not as a way to indicate to us a rising or falling valuation of the underlying assets.

Question: Is it becoming a necessity for firms to set science-based targets?

Answer: [Once more companies set targets] it becomes an upward trend and entrenched in the market, and **it becomes hygiene**. So the signaling factor starts to weaken. Then you need to raise the bar again to improve the signaling factor.

Question: Is it more about setting the targets than achieving the targets

Answer: Yeah, could be. We saw that with other initiatives as well. It became how to play the game and how to play it well, instead of using it as a business intelligence tool. So that's a risk, but we still have a way to go before we're there because most companies don't have SBTs. And not all science-based targets are created equal, since SBTi raises the bar every year some targets are based on old methodologies. Every five years companies have to revalidate targets, but for now they get to keep the stamp of approval. But **I think it's going to be really hard for them to get it again**.

Question: Do you pay attention to SBTs after firms have set the targets?

Answer: The thing is, there's so much work to do in getting the laggards, who have not even measured their carbon footprint, up to a minimum baseline. That the question becomes: where do we make the biggest impact? Is it taking the ones who already have the target and have good conviction are going to do the work correctly? Or should we be putting our engagement to firms who haven't done anything?

Question: can investors assume that because they have set a target through SBTi, that they have the right people in place to achieve the target?

Answer: I think it's a good start. Regarding analyzing the progress, it's still so new and there's limited lookback period to make assumptions.

Question: What do you think about the risk of companies setting targets without having the resources or plan in place to achieve it?

Answer: Yes, it's possible. But when I talk to the companies that have or are submitting the targets, they say it's quite onerous, **it's not a simple process, there's several rounds of feedback and negotiation, and they have to support it with evidence**. So I think it would be very challenging to even set the target. It's not easy for large companies to get validated. So it shows that **if they are able to get through those hurdles, they probably have sufficient expertise to do that [achieving the targets**].

Question: Do you think SBTs signal to investors that the firm will be operating sustainably in the future? Or does it primarily signal that the company is aware of the need to decarbonize and use SBTs also as a reputational tool?

Answer: **[SBTs] forces the company to build genuine transition plans**. There will be investors that approach SBTs differently for different reasons and the level of intimacy with the content. For us, the reason why we did it is (A) because it effects change in the real world since it puts everyone in the company in the same direction and it builds the infrastructure that they need to transition and (B) the transition risk is very serious and the systemic risk of not doing it is also very big. We can sell 'dirty' stocks but then we are still exposed to the same systemic risk since we operate in the same global marketplace since those companies remain. So it's better for us to approach it in a way that we use all the shareholder rights available to get them moving. But it's just the start.

Appendix 4: Excerpts from Interview 3

Question: How do you view the role of SBTs in company strategy? And how do you communicate this to your clients?

Answer: We regard it as a good framework, very robust framework. The pathways are very well considered and well researched. Compared to TPI, SBTi also validate company targets. As a bank, **knowing that your company has gone through this process of benchmarking themselves against this well-researched methodology and then have their targets validated as a sort-of third-party review, gives comfort to the bank**. The alternative is very difficult, a company just saying they're going to reduce the emission by a certain percent means there's no temperature-aligned pathway. It also means that the bank has to do a lot of work to find out if it's ambitious or not, and it's also not benchmarked third-party reviewed.

Question: Do you see any common characteristics between firms that have set SBTs compared to those companies that have not set SBTs?

Answer: Yes, I would definitely say **that clients that go through the SBTi process are much more sophisticated**. If a client has set SBTs, even though all it means they have set it through SBTi and have it validated, it is indicative to us that they have quite an advanced approach to sustainability. It means they have enough emission data to be able to comfortably set themselves those kinds of targets. That they have institutional capacity to be able to handle the 18-month process of validation of SBTs. So **it is a soft proxy for quite an advanced sustainability approach**.

Question: Do you think there are barriers of entry for companies that would want to set targets but don't have the capacity to?

Question: Yes, I think that is a thing. Although SBTi goes out their way to have relatively easy-to-use tools, you do need to have a sustainability department with the right type of data to be able to use those tools.

Question: Do you think because of disclosure requirements for publicly listed companies, that there is a large discrepancy between how far they are in terms of sustainability disclosure and science-based target setting compared to private companies?

Answer: Yes, I would say that **my expectation would be that there's a lot more public companies with SBTi-validated targets than the proportional private companies**. Just because they tend to be more advanced in their sustainability journey.

Question: Do you think setting science-based target is becoming common practice and a requirement for companies?

Answer: **I think in certain sectors it is becoming expected, but it depends on the sector**. For example, in the utility sector, where the methodology has been out for a very long time and there's been a large uptick in the sector, it starts to become the question why a company hasn't set a target? So it's becoming a hygiene factor for certain industries. Other industries hasn't responded to SBTi as expected. For example in the shipping sector there has been very few companies aligned with SBTi. I think that's because the shipping sector has the Poseidon Principles, and they tend to be following that. But my expectation is that even those companies will start switching or start to look at it.

Question: Do you think companies pay attention to their SBTs after they have set them? So for the respective years after that?

Answer: Yes, definitely. **A lot of companies report it in their sustainability report and report their progress against those targets**.

Question: Do they report it in terms of their sector specific pathway?

Answer: They will. But it's not an annual target. It tends to be a single year benchmark target. **A lot of companies will linearly interpolate** that, but they do say this is our target and this is where we are versus that target.

Question: Do you think investors look at a company's progress on its targets?

Answer: I'd like to think that they also check the progress against SBTs. I think it's a very important component. I'd like to think that they are developing the systems internally to be able to track that like our company is. It probably depends investor per investor and the resources available. **If it's a smaller team, they probably look at the SBTi brand alone. But a larger investor team will look at it in more detail**.

Question: What do expect will happen if by 2030, when most long-term SBTs will have expired, more than 50% of targets are not achieved? And how will the market react?

Answer: I think the world does not have the luxury to say: oh well, we tried! I think it's a case of you have to use every tool in your toolbox. We're trying to do everything to help companies achieve their targets. If they don't we shouldn't give up. We have to hammer again and figure out why they weren't achieved. There would be a review case to see why targets weren't achieved and what technologies are pending that you're currently still needing. 2030 will be a very interesting year from that perspective.

Appendix 5: Excerpts from Interview 4

Question: Historically, carbon emissions are primarily used as a proxy for environmental performance, do you see any change in the market which shows that also other kind of ESG data is starting to be used to create portfolios?

Answer: Yes, absolutely. That is one of the two developments in the market. One development is that **investors are becoming more aware of their ESG preferences and want to include them in their decisions**. This leads to the question of how to measure these preferences. **There is ESG data and emissions data, which are the most common data used at the moment**. We think that is very limited and uses a lot of assumptions. For ESG data for example, you assume that each investor used the same considerations when determining their sustainability values for an investment. This is completely inconsistent with my own personal experience. Clients in the U.S., the Middle East or Australia have completely different needs in the context of sustainability. So having one score on ESG which determines whether a company is doing good or bad is ridiculous.

Question: Would you expect investors to increase their valuation of a company if this company were to set science-based targets?

Answer: Yes, but you need to be very careful with what you are supposedly measuring. It's possible that firms that set science-based targets have increased value because of other

underlying reasons. **I can imagine that a relationship exists, but that's different than achieving a systematic return by investing in companies that adopt SBTs**.

Question: My results show that there is no significant effect, would you be hesitant in drawing conclusions from those findings?

Answer: Yes, also not finding a significant effect should be carefully considered. The subject has become very popular, with many people searching for the finding that simply investing in sustainable companies leads to positive returns.

After explaining my research methods, particularly the cross industry and longitudinal approach:

Answer: I think it's very difficult [to draw conclusions] and that you should compare companies within subindustries and that subindustries will differ considerably.

Question: Do you think that once results show whether SBTs are effective, there will be a different reaction by the market?

Answer: I think that valuation of a company is much more complex and that this is only a limited part of the complete valuation of a company. **I think it could have an effect for particular subindustries, and that for many subindustries it is not relevant**. Emissions are concentrated in a small group of companies globally.

Question: So the reputational aspect is not as relevant?

Answer: **For many companies it can be used as a branding effect**. In the long-term It could be a complex relationship that the reputation and brand of a company is viewed positively, that consumers buy more products and that employees enjoy working at the company.

Question: Do you think companies believe they can achieve the targets they set?\

Answer: From anecdotal evidence I can recall several instances where companies have publicly set such targets and my experience is that those companies were very carefully analyzing whether they were able to achieve those targets. **For many companies the reputational aspect of publicizing the target there is a downside that it can be used against you, which could have serious negative effect in terms of reputational damage**. They carefully research if they set such a target that they can achieve it.

Question: But this contrasts the fact that initiatives such as SBTi are becoming common practice. Meaning that companies will have to decide between not setting a target or not achieving a target, right?

> Answer: Yes, but I think that the reputational damage of not achieving a publicly set target is seriously considered by companies at the moment. At the same time the **targets are more relevant for some sectors than others, in sectors where its more relevant companies could find it much more difficult to join in**. The impact of some companies using SBTs is only marginal, so the effect of them setting SBTs is also not large.

Appendix 6: TPI's Sectoral Decarbonization Pathways report

The pathways for the automotive (left) and cement (right) sectors, with most reductions for cement expected at the back-end and for automotive at the front-end. Source: Dietz, et al. (2022)