Carbon Liquidity

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Abstract

We study the impact of disclosing greenhouse gas emissions (CO_2) on the liquidity of firms' equity. We find that firms that emit more carbon are less liquid. However, firms that disclose emissions have lower bid-ask spreads than firms that do not. This is partially because when firms first disclose their emissions their bid-ask spreads decrease by roughly 13%. These results hold for high information asymmetry firms, for high and low carbon intensity firms, and for early and late disclosing firms. These results should encourage regulators and firms to move quickly towards more, more robust, and more granular environmental disclosures.

JEL Classification: G12, G14, Q54

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Carbon emissions are the main driver of climate change and a by-product of most economic activity. For decades carbon was emitted without cost to emitters. Firms that could increase profits by increasing emissions were rewarded by capital markets with higher asset prices while those that balanced emissions and profits were often not. But, in 1997 the Kyoto Accord was adopted and entered into force in 2005 and required countries "to adopt policies and measures on mitigation and to report greenhouse gas emissions periodically." As countries were required to report on emissions, firms were also encouraged to report carbon emissions. We study the impact of firms' carbon emissions disclosure and the relationship between firms' emissions and equity market liquidity from 2003 to 2020.

In this paper, we use the disclosure of carbon emissions[1] by firms to explain equity market liquidity. We show that more carbon emissions lead to lower equity market liquidity, in the form of wider bid-ask spreads. But, firms that do disclose emissions have higher equity market liquidity than firms that do not disclose emissions. When, focusing on the 6 months before and 6 months after the disclosure of carbon emissions for a firm, we find that the bid-ask spreads of disclosing firms fall sharply by roughly 13%. These results contribute to our understanding of how the disclosure of emissions can help to resolve information asymmetry between managers and intermediaries and that intermediaries view emissions as an important source of risk.

We use the disclosure of carbon emissions in three industry standard environmental, social, and governance (ESG) databases, CDP, Refinitiv and Sustainalytics. The CDP database is available throughout our sample period of 2003 to 2020.[2]

[1] Carbon emissions are encompassing the direct (Scope 1) and indirect (Scope 2) carbon dioxide (CO_2) and CO_2 equivalents emission in tonnes.

[2] Sustainalytics is available from 2010 to 2017. Prior to 2010 Sustainalytics did not report emissions, this leads to a large increase in disclosing firms in 2010. Refinitiv is available from 2002 to 2017, at the beginning, however, only very few firms are reporting.

Our results hold when using any of the database's emissions disclosures alone and when using all three. We use these three databases as they are likely to represent the information set of intermediaries at the time of disclosure. All three databases are widely used by institutional investors to evaluate the environmental impacts of firms' activities. The CDP data is gathered via voluntary firm questionnaires and currently covers more than 9,600 firms worldwide and is used as the baseline for most other data providers. Refinitiv and Sustainalytics also collect additional corporate carbon emissions data with the help of analysts who extract it from further sources such as annual reports, NGO websites, CSR reports, stock exchange filings and new sources. Figure 1 plots the percentage and the number of disclosing firms within our U.S. sample. We focus on 7,730 U.S. firms of which 1,759 initiate emissions disclosure in our 17 year sample period.[3]

Figure 1 ABOUT HERE

We find that the more carbon a firm emits the less liquid is their equity, thereby establishing a link between emissions and liquidity. A one-standard deviation increase in carbon emissions widens bid-ask spreads by between 2.7 and 5.4 cents. When comparing disclosing to non-disclosing firms, we find that disclosing firms have significantly lower spreads. Disclosing firms are considerably larger than non-disclosing firms in terms of their market capitalization 3.5 versus 15.2 billion US$ and in terms of employees with 6,890 versus 28,220. The number suggest that the decision to disclose is likely to be an endogenous function of firm characteristics. To account for this and to help explain the characteristics of disclosing firms, we estimate a probit regression that uses firm-level characteristics to predict emissions disclosure. In a second stage, we estimate the impact of emissions on bid-ask

[3]We remove firms that report emissions before 2003 due to data quality issues.

spreads after controlling for the endogenous decision to disclose emissions. We find that more carbon emissions still lead to wider bid-ask spreads. This result is consistent with market intermediaries viewing carbon emissions as a source of risk independent of other firm characteristics.

In an event-study we compare the bid-ask spreads of firms that disclose emissions 6-months before and 6-months after their first disclosure of emissions. [4] Our sample begins in 2000 and the first disclosures are in 2003. Disclosures increase slowly from 0% to a maximum of 43% by the end of 2017. Figure 1 plots disclosure over the sample period and highlights the slow increase in disclosure. The staggered nature of the disclosure makes this a powerful setting to test for disclosure effects on liquidity. Given the staggering of events over 17 years, it is unlikely that our results are correlated with a single simultaneous event. Our setting does not necessarily suffer from the problems highlighted in Baker, Larcker, and Wang (2021) as there isn't a regulatory change that will have a heterogeneous impact on firms. However, we do attempt to account for heterogeneous impacts by studying disclosure events from early and late disclosers in our sample, from high and low carbon intensity firms, and for low and high information asymmetry events. We also add test for high and low estimation error disclosures. We also control for secular trends by analyzing spreads around the disclosure period in a sample of ten industry and size matched peer firms. All of our results remain statistically and economically significant across settings.

We show that firms that disclose their emissions decrease the bid-ask spread of their equity. The bid-ask spreads falls by 49 cents or roughly 3.3 basis points after the disclosure of emissions. A 49 cent decrease in a 2.68 spread represents 18% and 3.3 basis points of a 10 basis point relative spread represents a 33% decrease inn

[4] The results hold when using a 6-month (-3/+3) window, or a 10-day (-5 day / +5 day) window.

relative terms.

We also compute other often used measures of liquidity, the log of the bid-ask spread, the log of traded volume and the Amihud Illiquidity measure Amihud (2002). When using these measures of liquidity, we show that the log of the bid-ask spread falls by 13%, log volume increases, and the illiquidity measure decreases as well. All of these results are consistent with theoretical predictions of Diamond and Verrecchia (1991) that suggest that the resolution of information asymmetry will increase liquidity and trading after disclosure of valuation relevant information.

Using a matched sample of disclosing and the 10 nearest non-disclosing firms and repeat our analysis. We show that the relative bid-ask spread for disclosing firms is statistically significantly lower than for non-disclosing firms. This suggests that firms hoping to hide their emissions in the mass of non-reporting firms exhibit higher spreads than for similar firms that do disclose emissions. Disclosing firms have lower bid-ask spreads than non-disclosing firms before disclosing emissions. This difference doubles after disclosure and all of the difference are statistically significant.

To test the predictions of Diamond and Verrecchia (1991) we include a number of proxies for information asymmetry. We use the sign of the event period return and the absolute value of event (carbon disclosure) period returns (-30/+30) and compare the liquidity changes for positive and negative announcement returns and above median (high information asymmetry) and below median (low asymmetry) event period returns. We find that firms where the stock price reacts negatively has a larger decrease in spreads. A cleaner test of the predictions is splitting the returns into above and below median absolute stock returns. If the stock price changes are large (small) then the assumption is that the amount of asymmetric information was also large (small). Consistent with theory, we find a larger decrease in spreads for

high information asymmetry firms than for low information asymmetry firms. Low information asymmetry firms' spreads fall by 42 cents whereas high information asymmetry firms' spread fall by 59 cents.

Firms with high carbon intensity may be concerned that disclosing emissions will not be viewed positively by intermediaries (Luo and Tang (2014)). We test this hypothesis by studying the liquidity effects of above and below median carbon intensity firms' disclosures. The results show that above median carbon intensity firms bid-ask spread decreases more (liquidity increases more) than below median carbon intensity firms. A similar hypothesis for disclosing firms could be that all of the benefits of disclosing accrues to the early disclosers. These firms may have better than expected carbon emissions, and hence endogenously report early. The remaining non-disclosing firms may assume that intermediaries have already updated their estimates of the emissions of the non-disclosers and then incurring the disclosure costs is not beneficial. We show that early disclosers liquidity improves less than late disclosing firms. These results should encourage non-disclosers to disclose even if they are high carbon intensity and / or late disclosers.

Financial markets participants are likely to estimate firms' emissions based on the emissions of already disclosing firms within a non-disclosing firms' industry. We perform the same estimation to measure the potential accuracy of market expectations. We estimate the carbon emissions and carbon intensity of a firm expected by investors by industry and compute the difference between a naive estimate and the disclosed values. We show that firms for which intermediaries likely overestimated the amount of carbon emitted by that firm, have larger decreases in the bid-ask spread. For instance, for firms with an above median unexpected carbon emissions intensity, the bid-ask spread falls by 81 cents, versus firms with lower unexpected emissions intensity with a decrease of 42 cents. Most of our results point towards

the positive impact on firm liquidity of information asymmetry reduction with respect to carbon emissions.

The results thus far are focused on U.S. firms. We re-confirm these results using a sample of U.K. firms for a similar sample period. We find economically similar results in terms of spreads of disclosing versus non-disclosing firms and for changes in liquidity around emissions disclosure. This suggests that intermediaries generally view carbon risk as relevant and that information asymmetry related to undisclosed emissions harms liquidity. In the appendix we include tests of the predictions of disclosure on firm value.[5] In some settings we find a positive impact and in others a negative impact.

This paper follows a large literature on the impact of firm disclosures on a number of important financial variables including liquidity. Diamond and Verrecchia (1991) show theoretically that firms' disclosures can reduce information asymmetry between managers or insiders and intermediaries leading to increased liquidity. Easley and O'hara (2004) show that increased disclosure reduces information gathering costs and as a result, monitoring costs. Balakrishnan, Billings, Kelly, and Ljungqvist (2014) use an exogenous decrease in analysts to show that firms can causally impact the liquidity of their equity via voluntary disclosure. In a study of the impact of carbon disclosure on stock returns Bolton and Kacperczyk (2020) find that the voluntary disclosure leads to lower stock returns for disclosing firms relative to non-disclosing firms. **?** find that the median value of firms that disclose their carbon emissions is about $2.3 billion higher than that of comparable non-disclosing firms. The corporate value increasing findings of Saka and Oshika (2014) point out that firms should reduce carbon emissions and disclose their carbon management activities.

[5] Table A.6 in the appendix.

This paper also contributes to the literature on how financial markets process information about the environmental impact of firms. Bolton and Kacperczyk (2021) show that U.S. firms with higher CO_2 emissions earn higher returns. Ilhan, Sautner, and Vilkov (2021) show that carbon emissions increase downside risk. Using high polluting firms Hsu, Li, and Tsou (2020) show that these firms also exhibit higher returns. Rehse, Riordan, Rottke, and Zietz (2019) show that environmental uncertainty is reflected in the bid-ask spread of firms. Schiemann and Sakhel (2019) show that disclosing climate change-related physical risk leads to lower information asymmetry. Fan, Tang, and Pan (2021) discuss the information asymmetry decreasing impact of assurance in carbon disclosure. In this paper we focus less on how investors view carbon emissions and more on how carbon emissions and and their disclosure affects how intermediaries set buy and sell prices for firms' equity.

The United States and the rest of the world, is currently discussing environmental disclosure. Financial disclosure regimes like TCFD[6] and SASB[7] are competing disclosure frameworks being discussed by the SEC[8]. Greenhouse gas (GHG) emissions are a relatively straightforward laboratory to study the impacts and importance of these disclosures. More GHG emissions are bad for the environment, are likely to be taxed, are eschewed by investors, and are therefore directly relevant for financial market participants. Studying the impact of these disclosures on liquidity provides insight into the importance of disclosing environmental impacts more broadly. The idea that capital market participants are ignorant of the importance of these variables and that non-disclosers can hide in a sea of other non-disclosers is not borne out in our data. Our results should encourage regulators and firms

[6]See https://www.fsb-tcfd.org
[7]See https://www.sasb.org/about/sasb-and-other-esg-frameworks/
[8]See https://www.sec.gov/news/public-statement/lee-climate-change-disclosures

to move quickly towards more, more robust, and more granular environmental disclosures.

1 Data

We construct two samples for the empirical analyses. Our main sample includes all U.S. firms between 2000 and 2020 that are present in CRSP and Compustat. The second sample includes all UK firms for the same period. In total, the US sample includes more than 11,500 firms and the UK sample more than 700 firms.

We collect all financial data from CRSP and Compustat. Daily data used from CRSP is the bid price, ask price, and the close price and also trading volumes. We calculate the bid-ask spread as the difference between the bid and the ask price and the relative bid-ask spread as the bid-ask spread divided by the mid price.[9] Firm characteristics from Compustat are collected annually and include size, value, profitability, as well as other balance sheet and income statement data. We calculate tangibility, Tobin's Q or cash flow according to common convention.

Our carbon data results from a combination of three major ESG databases. Therefore, we are ensuring broad coverage and reducing errors in the carbon emissions data (e.g., (Busch, Johnson, and Pioch 2020)). First, we use the data from the CDP Questionnaire. CDP is a non-profit organization that operates a global disclosure system for investors, firms, cities, states, and regions to manage their environmental impacts. Although successful and longstanding, several studies have raised concerns about the quality of the data collected and published by CDP (Matisoff et al., 2013; Stanny, 2018; Busch et al., 2020). Second, we include two

[9] We also calculate a relative Bid-Ask Spread* which is defined as bid-ask spread divided by price. Our results throughout all analyses remain robust.

additional providers of carbon emissions data, Refinitiv ESG (formerly Thomson Reuters) and MSCI-Sustainalytics. With the these two databases, we check for consistency in reported carbon emissions across the databases. These checks include, the examination of individual time series of firms for consistency, taking into account corporate actions, or the correction of outliers by considering typos or obviously incorrect values. In total, we can provide reliable carbon emissions data for 1,759 US firms and 427 UK firms within our sample period. We match the firm characteristic data and the carbon emissions data per fiscal year and carbon reporting year using identifiers such as Permno, CUSIP and ISIN. Descriptive statistics for the US main sample can be seen in Table 1. We aggregate daily liquidity to monthly values and match them to the combined data set.[10] This results in a 240 firm-month observations from January 2000 to December 2020.

TABLE 1 ABOUT HERE

Panel A of Table 1 reports the descriptive statistics of the main U.S. sample. It provides the number of observations, mean, median and standard deviation for the used variables. Panel A. reports liquidity variables such as (log) bid-ask spread, relative bid-ask spread, Amihud Illiquidity Measure, and Log Volume. Panel B. reports carbon emissions, carbon intensity (defined as carbon emissions divided by sales), and the number of carbon disclosers. In addition, Panel C. reports numerous firm characteristics that are used directly or as control variables in our analyses.

[10] We use the information in which month the fiscal year ends or in which month the carbon emissions are reported.

2 Emissions and Liquidity - Results

The purpose of our empirical analysis is to investigate the relationship between carbon emissions and disclosure on stock liquidity. First, we analyze the relationship between carbon emissions and bid-ask spreads via regressions. Second, we compare the group of carbon and non-carbon disclosers with their different firm characteristics. Third, we analyze the factors that lead to carbon disclosure and use them, fourth, to measure the impact of carbon emissions on bid ask spreads using Heckman regressions Fifth, we estimate the impact of carbon disclosure on liquidity. We also show graphically that there are significant differences in bid-ask spreads between disclosers and non-disclosers in the whole period as well as in the event period before and after their carbon disclosure. Sixth, we provide results on alternative liquidity measures, e.g., the Amihud Illiquidity Measure. Seventh, we pair firms with similar characteristics and compare the main differences in liquidity. Eight, we consider the carbon disclosure to liquidity relationship in a further panel regression analysis, taking into account the event returns that arose at disclosure. Ninth, we have an additional analysis incorporating the impact of carbon intensity and timing of carbon disclosure. Tenth, we take information asymmetry proxied by investor estimation errors on firms' carbon emissions into account. Eleventh, and finally, we investigate whether we can find the carbon disclosure effect also in the United Kingdom.

2.1 Impact of Carbon Emissions on Liquidity

In our first analysis, we look at the relationship between carbon and liquidity by explaining (relative) bid-ask spreads on carbon issues and common control variables such as price, volume, size, or value. In addition, we use firm fixed effects and

cluster the standard errors by firm. The results can be found in Table 2.

TABLE 2 ABOUT HERE

A significant influence of carbon emissions on bid-ask spreads can be found in all model specifications. In contrast, the size measured as log total assets and the invest-to-total assets ratio still play a significant positive role. Furthermore, negative correlations are found for volume, leverage, and property, plant, and equipment. A fundamental influence of carbon emissions on bid-ask spreads therefore seems to exist.

2.2 Impact of Carbon Disclosure on Liquidity

To examine the effect of carbon emission disclosure, we start with a mean comparison. Here, the two groups carbon discloser and non-carbon discloser are compared in terms of differences in their mean values. In addition to liquidity measures, numerous common firm characteristics are examined for significant differences. The results can be found in Table 3.

TABLE 3 ABOUT HERE

Looking first at the bid-ask spread, the value is three times higher for non-carbon disclosers (0.10 cents) compared to carbon disclosers (0.03 cents). There is also a significant difference of 84 basis points in the relative bid-ask spread. In addition, carbon disclosers are significantly larger on average, have a lower book-to-market ratio, are more indebted, generate more revenue and spend more on

research, development and SGAE. They are also more highly valued, hold more cash and are more profitable according to various key figures. Overall, it can be said that the two groups are reasonably indistinguishable over the entire period.

2.3 Determinants of Carbon Disclosure

We take these differences as an opportunity to investigate characteristics that have an impact on the disclosure probability of carbon data. [11] For this purpose, we run four differently specified probit models. In all of them, the decision to make carbon disclosures is analyzed with different firm characteristics. The results of the analyses can be found in Table 4.

TABLE 4 ABOUT HERE

The results show that size, value, leverage and profitability play a significant role in the decision to report carbon emissions. Size plays a role especially due to the increasing pressure from investors in the largest firms to disclose. In addition, key figures on investment, PPE or sales also play a significant role, as these are directly linked to emissions. High investments, especially in long-term assets, are often emissions-intensive, just as high sales lead to more emissions over the production and life cycle of the product. Asset tangibility is positively correlated with the decision to disclose. Firms with more tangible assets likely also emit more carbon than firms with more intangible assets.

[11] There are many papers that analyze various determinants of carbon disclosure, e.g. governance effects (Bui, Houqe, and Zaman (2020)) or environmental performance, ownership structure, and verification of climate change initiatives (Giannarakis, Zafeiriou, Arabatzis, and Partalidou (2018).

2.4 Impact of Carbon Disclosure on Liquidity Dependent on Determinants of Carbon Disclosure

In the following we focus on the six months before and after the disclosure of carbon emissions. This allows us to directly study the impact of disclosure on liquidity. The regression of liquidity on emissions reported in Table 2 controls for observable differences between disclosing and non-disclosing firms. There may be unobservable firm characteristics that affect liquidity and the decision to disclose. To account for the endogenous decision to disclose the standard approach is to estimate a two-stage Heckman switching model. The first stage is a probit estimation that models the decision to disclose. The results are reported in column two of Table 5. The first stage results confirms that large firms are more likely to disclose than small firms.

TABLE 5 ABOUT HERE

In the second stage we estimate the "true" impact of carbon emissions on liquidity after adjusting for the endogenous decision to disclose. Here we find that firms with higher emissions have wider bid-ask spreads than firms with lower emissions. While this analysis is not definitive and can still be affected by unobserved firm characteristics, is does provide evidence that intermediaries take carbon emissions into consideration when setting buy and sell prices. The inverse mills ratio is negative and significant suggesting that unobserved factors are unlikely to be driving the relationship between emissions and liquidity.[12]

[12] In addition, we conducted a mean comparison test instead of a regression in Table A.6. The results support the same interpretation.

This paper is the first to establish a relationship between carbon emissions and liquidity. Clearly environmental factors play a role in how market participants allocate capital. Later we show that resolving information asymmetry with respect to carbon emission also plays an important role in how intermediaries provide liquidity.

2.5 Carbon Disclosure Event-Study

Table 6 estimates an event study of the impact of disclosing carbon for the first time on firm liquidity. We regress the bid-ask spread on a carbon disclosure dummy that takes the value of 0 in the 6-months prior to disclosure and 1 in the 6-months post disclosure. In the regression we control for price, trading volume, market capitalization and firm characteristics. We also include firm-level fixed effects to control for firm specific liquidity independent of other firm-level characteristics.

TABLE 6 ABOUT HERE

The regressions show that after forms disclose their carbon emissions that the bid-ask spread falls by roughly 1/2 of a cent. Disclosing firms have roughly 2.5 cent spreads and a 1/2 cent represents a 20% reduction. Figure 2 documents this decrease graphically. There is a clear drop in bid-ask spreads at the time of disclosure. This effect continues in the following six months and leads to further decreasing bid-ask spreads.

Figure 2 ABOUT HERE

2.6 Impact of Carbon Disclosure on Other Liquidity Measures

Carbon disclosure has an impact on bid-ask spreads and also on other liquidity measures. We include three additional liquidity measures; (1) the log bid-ask spread, (2) log volume, and (3) the Amihud illiquidity measure Amihud (2002). We run panel regressions with the same control variables and fixed effects for the 12-month period around the disclosure date. The results can be found in Table 8.

TABLE 7 ABOUT HERE

We find that log bid-ask spreads are also significantly negatively affected by carbon disclosure. And, consistent with the predictions of Diamond and Verrecchia (1991) we also find that firms are traded more frequently after disclosure, so we observe a higher volume here. To confirm that the liquidity results are not restricted to bid and ask prices we calculate the Amihud illiquidity measure. Here, we see a negatively significant effect, i.e. that illiquidity also decreases after a carbon disclosure. Overall, we can consistent results regardless of liquidity measure used.

2.7 Carbon Disclosure and Non-Disclosure Pairs

The decision to disclose emissions could be driven by firm specific factors correlated with liquidity and the decision to disclose emissions. This could poison our results towards finding an increase in liquidity that is present but unrelated to the disclosure decision. We can control for this by matching disclosing firms with similar non-disclosing firms. Matches are firms that operate in the same industry with similar size and trading volumes.[13] This matching is performed monthly. To ensure good matches a caliper of 0.1 is applied. We match a disclosing firm the 10 closest firms.

[13] We also matched firms instead of trading volumes by their price and our results remain robust.

Using these matched firms, we now examine the difference in liquidity for the entire sample period and for 12 months around the carbon disclosure period. We report the results in Table 8. We find a significantly higher bid-ask spread for the non-disclosers compared to the disclosers, despite matching on market capitalization, trading volume, and industry. This is true when comparing firms across the entire sample period, and for the 6-months before and after disclosure. The decrease in bid-ask spreads is also significant higher after the disclosure date (Post-Pre).

TABLE 8 ABOUT HERE

We also plot the evolution of the two groups graphically in Figure 3. We compare the median levels of bid-ask spreads six months before and after the disclosure. For the non-disclosers and disclosers, the bid-ask spread level is almost constant before the disclosure date of a matched firm. At the time of the discloser, both show a significant drop in bid-ask spreads, and this is especially pronounced in the case of the disclosers. The decrease for disclosing firms is sharp and permanent, whereas the decrease for non-disclosing firms is minor and transitory. The small spread decrease for matched firms could be market participants expecting a similar disclosure from the matched firm, or the disclosure could be used to update emissions expectations in non-disclosing firms, a theory we test later in the paper. While the non-disclosers show a slight increase and then a constant bid-ask spread level, the disclosers remain at the new lower level and show slightly decreasing spreads six months after the disclosure.

Figure 3 ABOUT HERE

2.8 Liquidity and Event-Period Returns

The change in stock price around the disclosure of emissions may contain information about market expectations. The information disclosed could be positive or negative and the level of information asymmetry could be high or low. To proxy for information asymmetry, we use the (absolute) event return around the disclosure date. We calculate the event return over a ± 30 day window around the event.[14] Subsequently, we place firms into two groups with respect to their event return and whether or not their absolute return was below or above the median return. We the now familiar the panel regression specification and report the results in Table 9.

TABLE 9 ABOUT HERE

The first two columns report the event returns and the last two report absolute event returns. Surprisingly, we find that liquidity increases more for stocks with negative event returns than for stocks with higher event returns. This may be explained by the fact that higher information asymmetry tends to exist for firms that have particularly high carbon emissions and intensity within their industry and try to hide these from their investors. This explanation would be consistent with the information asymmetry predictions of Diamond and Verrecchia (1991). If markets expect lower emissions overall, this will lead to negative event period returns. The high information asymmetry, resulting from low emissions expectations, could lead to negative disclosure surprises as carbon emissions and intensity are reported significantly higher than expected. Firms with lower than expected emissions, and therefore positive event period returns, may therefore have spreads that change less than for negative event period return firms.

[14] In Table A.3 in the appendix we use ±5 day window around the event and find similar results.

A much cleaner test of Diamond and Verrecchia (1991) is to use the absolute value of the event-period returns as a proxy for information asymmetry. Firms with large event period returns surprise the market more with their disclosure than firms with lower absolute event period returns. Large returns suggest that a large information asymmetry exists between insiders and markets with respect to emissions. In line with the theory of Diamond and Verrecchia (1991), we find that the absolutely higher event returns lead to a larger decline in bid-ask spreads. The larger decline in spreads usggests that more information asymmetry existed and was resolved by disclosing emissions. The spreads of high information asymmetry firms falls by roughly 30% more than for information asymmetry firms.

2.9 Liquidity, Carbon Intensity and Early Disclosure

Disclosure in our setting is mostly voluntary. Firms with high CO_2 intensity may be concerned that disclosing emissions will not be rewarded by intermediaries. It can also be argued that high CO_2 intensity firms are likely to have more information asymmetry with respect to low intensity firms. For instance, we can assume that firms will lower intensities are more likely to disclose than firms with higher intensities compared to the industry median. [15] This could increase the information asymmetry about high intensity firms relative to low intensity. We test this hypothesis by dividing stocks into two groups, above and below the median, based on their intensities. This test also sheds light on the question of whether or not high intensity firms benefit from disclosing emissions. Similar results have also already been shown when CSR performance is examined (Cho, Lee, and Pfeiffer

[15] The relation between carbon performance and carbon disclosure was also studied by e.g., Luo and Tang (2014). They find that firms' voluntary carbon disclosure is indicative of their underlying actual carbon performance.

(2013).

TABLE 10 ABOUT HERE

Table 10 reports in the first two columns the corresponding results for the regression results of bid-ask spreads on the disclosure variable and our controls. The results show that low intensity firms spreads fall, but they fall less strongly than the spreads for high CO_2 intensity firms. Bid-ask spreads fall by almost 20% more for high intensity firms relative to low intensity firms.

Firms that are among the first to disclose in their industry should have higher information asymmetry than firms that disclose later. Market participants may have no way to estimate the emissions of early disclosing firms. Forming expectations about the emissions of late disclosing firms should be easier as some firms have disclosed allowing for the development of emissions estimation techniques. However, early disclosers may have better than expected carbon emissions or may have emissions that are relatively easy to predict and therefore prefer to report them earlier. This may mean that the remaining non-disclosing firms have harder to predict emissions and that market participants may assume that they have lower overall emissions because the early disclosers reported lower than expected emissions. [16]

We examine this by dividing our disclosing stocks into early disclosers, i.e. firms that are among the 10% earliest disclosers within their industry. In contrast, late disclosers are firms that are among the 50% last to disclose their emissions. The results of this analysis can be found in the last two columns of Table 10. We find a significant negative impact on bid-ask spreads for both groups of disclosers. When

[16] In a similar way with a different objective Yan, Li, Huang, and Li (2020) show that also the consistency of carbon performance and carbon information disclosure has a significant impact on enterprise value.

comparing these two groups, we find that the bid-ask spread falls almost twice as much for late disclosers relative to early disclosers. This suggests that late disclosing firms had harder to predict emissions. The results also show that firms that have yet to report can still experience an increase in their stock liquidity by disclosing emissions. The results are not concentrated in early disclosing or low CO_2 intensity stocks.

2.10 Carbon Estimation Error and Liquidity

The level of information asymmetry between financial market participants and firms may vary based the expectations formed by observing correlated information. For example, markets may estimate a firms' emissions based on the emissions reported by other firms' in the same industry. Market expectations regarding a firm's carbon emissions can be a key driver of information asymmetry between insiders and the market. In the following, we will analyze this by estimating the carbon emissions and carbon intensity for all firms on a monthly basis as an average value of the respective industry. We then calculate the estimation error between expected and disclosed values. In a first step, we determine which firms have been over- or underestimated in terms of their emissions, and in a second step we divide them into two groups according to the estimation error using the median.

TABLE 11 ABOUT HERE

Table 11 reports the results. Panel A compares carbon emissions and Panel B carbon intensity in the same window of ± 6 months around the disclosure date of emissions. First, we find that in both panels overestimation of a firm's carbon emissions leads to a higher impact of disclosures on liquidity than underestimation.

Apparently, there is a stronger correction of investors due to a higher information asymmetry. Second, this is more evident when looking at the estimation error. The effect of carbon disclosure on liquidity is half to twice as high for firms with more clearly mis-estimated carbon emissions than for those with more accurate investor expectations about their carbon emissions or carbon intensity. We can show that as information asymmetry increases, measured as the distance between expected and actual emissions and emissions intensity, the positive impact on liquidity (lower bid-ask spreads) increases.

2.11 Impact of Carbon Disclosure on U.K. stocks

Our analyses so far have focused on a large sample of US firms. To confirm that our results are generalizable in at least two jurisdictions we repeat our main analyses on a set of U.K. stocks from 2000 to 2020. In 2013 carbon emissions disclosure became mandatory in the U.K. This means that for some of the U.K. stocks they disclose voluntarily whereas other firms disclosed under a mandatory disclosure regime. [17] We repeat the main analysis of Table for U.K. only. The results are described in Table 12.

TABLE 12 ABOUT HERE

Although there are some fundamental differences in carbon disclosure in the US versus the UK, we find very similar results to the US firm sample. Carbon disclosure has a similarly significantly negative effect on bid-ask spreads and a similarly high effect in economic terms.[18] Spreads fall by roughly .4 cents. These results suggest

[17] There are also other studies that focus on different disclosure regimes, e.g., Liu, Zhou, Yang, and Hoepner (2017) focus on the relationship of carbon emissions and financial performance.

[18] We provide further insights into the impact of carbon disclosure on liquidity in the United Kingdom in the Table A.1 and A.2 of the appendix. We find similar results also if we analyse the whole sample period.

that type of disclosure is less important than the fact that firms disclose emissions.

3 Conclusion

That we need to reduce carbon emissions quickly is not seriously debated. How emissions are best reduced is up for debate. Numerous reports put the emissions of just 100 firms at roughly 71% of global emissions. Documenting firms' emissions is the first step towards lowering firm emissions. Capital markets can play an important role. Allocating more capital to firms that can reduce emissions will help to achieve our reductions goals quickly. In this paper we show that firms that disclose emissions are rewarded by capital markets in the form of lower bid-ask spreads. This suggests that intermediaries commit more capital to supply liquidity in firms where emissions are known relative to firms where emissions or unknown.

Carbon emissions are the main driver of climate change and a by-product of most economic activity. For decades carbon was emitted without cost to emitters. Firms that could increase profits by increasing emissions were rewarded by capital markets with higher asset prices while those that balanced emissions and profits were often not. But, in 1997 the Kyoto Accord was adopted and entered into force in 2005 and required countries "to adopt policies and measures on mitigation and to report greenhouse gas emissions periodically." As countries were required to report on emissions, firms were also encouraged to report carbon emissions. We study the impact of firms' carbon emissions disclosure and the relationship between firms' emissions and equity market liquidity from 2003 to 2020.

The current discussions around the nature and importance of environmental disclosure do not yet highlight the potentially positive side-effects for disclosing

firms. While collecting and reporting emissions may be partially costly, our results show that they lead to more trading and liquidity in disclosing firms. These disclosures and increased liquidity will make it easier to attract future investors and retain current investors in a firms' equity. Using a long time-series of disclosure events in a large sample of U.S. firms, we find that emissions disclosure leads to increased liquidity. Firms that disclose emissions have lower bid-ask spreads than firms that do not. And, firms that initiate disclosure experience a roughly 13% decrease in their bid-ask spreads. These results hold for disclosures that exhibit high information asymmetry, for high and low carbon intensity, and for early and late disclosers within an industry. The results also hold for firms the disclose with unexpectedly high emissions and emissions intensity. In fact, for these firms the spread reduction (liquidity increase) is larger than for firms with low unexpected emissions. This means that even if you disclose higher than average emissions your equity becomes more liquid. This is consistent with the predictions in Diamond and Verrecchia (1991) that show that high information asymmetry firms spreads fall more than low information asymmetry firms after disclosing pricing relevant information. Our results also hold for a sample of U.K. stocks that undergo mandatory emissions disclosure in 2013.

Our results should encourage firms to disclose emissions as soon as possible. Additionally, it should encourage regulators debating the implementation of TCFD or SASB to speed up the implementation of these disclosure framework. At the very least requiring firms to disclose their CO_2 emissions does not appear to have any negative effects on firm liquidity and trading.

References

Y. Amihud. Illiquidity and stock returns: cross-section and time-series effects. *Journal of financial markets*, 5(1):31–56, 2002.

A. Baker, D. F. Larcker, and C. C. Wang. How much should we trust staggered difference-in-differences estimates? *Available at SSRN 3794018*, 2021.

K. Balakrishnan, M. B. Billings, B. Kelly, and A. Ljungqvist. Shaping liquidity: On the causal effects of voluntary disclosure. *The Journal of Finance*, 69(5):2237–2278, 2014.

P. Bolton and M. Kacperczyk. Do investors care about carbon risk? *Journal of Financial Economics*, 2021.

P. Bolton and M. T. Kacperczyk. Signaling through carbon disclosure. *Available at SSRN 3755613*, 2020.

B. Bui, M. N. Houqe, and M. Zaman. Climate governance effects on carbon disclosure and performance. *The British Accounting Review*, 52(2), 2020.

T. Busch, M. Johnson, and T. Pioch. Corporate carbon performance data: Quo vadis? *Journal of Industrial Ecology*, 2020.

S. Y. Cho, C. Lee, and R. J. Pfeiffer. Corporate social responsibility performance and information asymmetry. *Journal of Accounting and Public Policy*, 32:71–83, 2013.

D. W. Diamond and R. E. Verrecchia. Disclosure, liquidity, and the cost of capital. *The Journal of Finance*, 46(4):1325–1359, 1991.

D. Easley and M. O'hara. Information and the cost of capital. *The Journal of Finance*, 59(4):1553–1583, 2004.

H. Fan, Q. Tang, and L. Pan. An international study of carbon information asymmetry and independent carbon assurance. *The British Accounting Review*, 53(1), 2021.

G. Giannarakis, E. Zafeiriou, G. Arabatzis, and X. Partalidou. Determinants of Corporate Climate Change Disclosure for European Firms. *Corporate Social Responsibility and Environmental Management*, 25(3):281–294, 2018.

P.-H. Hsu, K. Li, and C.-Y. Tsou. The pollution premium. *Available at SSRN 3578215*, 2020.

E. Ilhan, Z. Sautner, and G. Vilkov. Carbon tail risk. *The Review of Financial Studies*, 34(3):1540–1571, 2021.

Y. Liu, X. Zhou, J. Yang, and A. G. F. Hoepner. Corporate Carbon Emissions and Financial Performance: Does Carbon Disclosure Mediate the Relationship in the UK? *Available at SSRN 2941123*, 2017.

L. Luo and Q. Tang. Does voluntary carbon disclosure reflect underlying carbon performance? *Journal of Contemporary Accounting & Economics*, 10(3):191–205, 2014.

D. Rehse, R. Riordan, N. Rottke, and J. Zietz. The effects of uncertainty on market liquidity: Evidence from hurricane sandy. *Journal of Financial Economics*, 134(2): 318–332, 2019.

C. Saka and T. Oshika. Disclosure effects, carbon emissions and corporate value. *Sustainability Accounting, Management and Policy Journal*, 5(1):22–45, 2014.

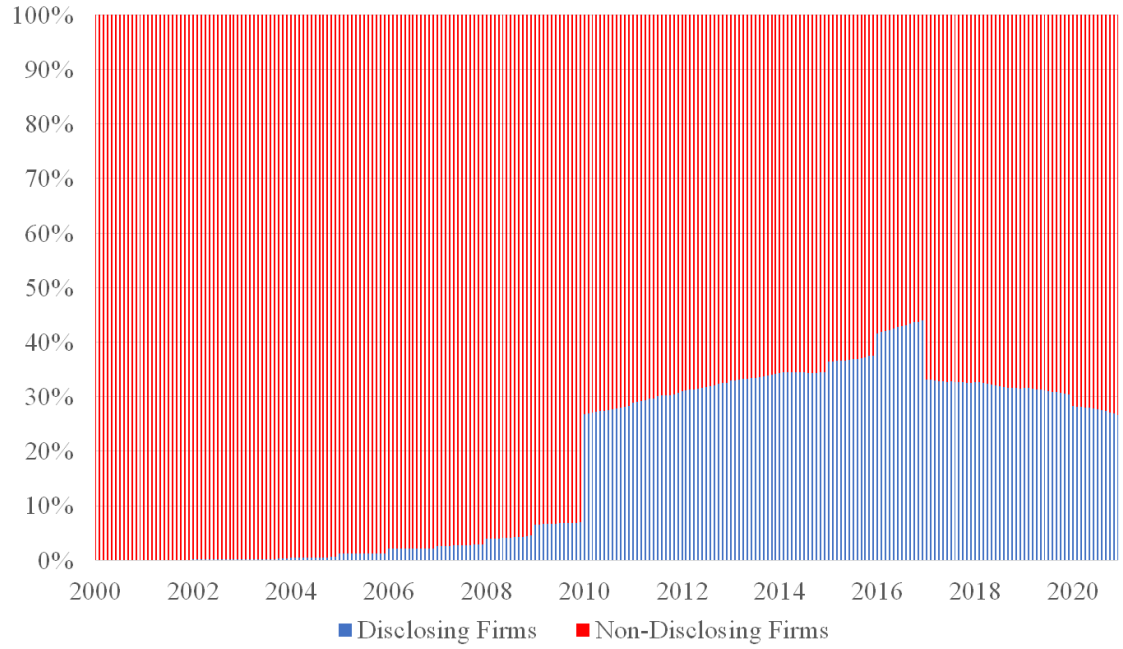
F. Schiemann and A. Sakhel. Carbon disclosure, contextual factors, and information

asymmetry: The case of physical risk reporting. *European Accounting Review*, 28 (4):791–818, 2019.

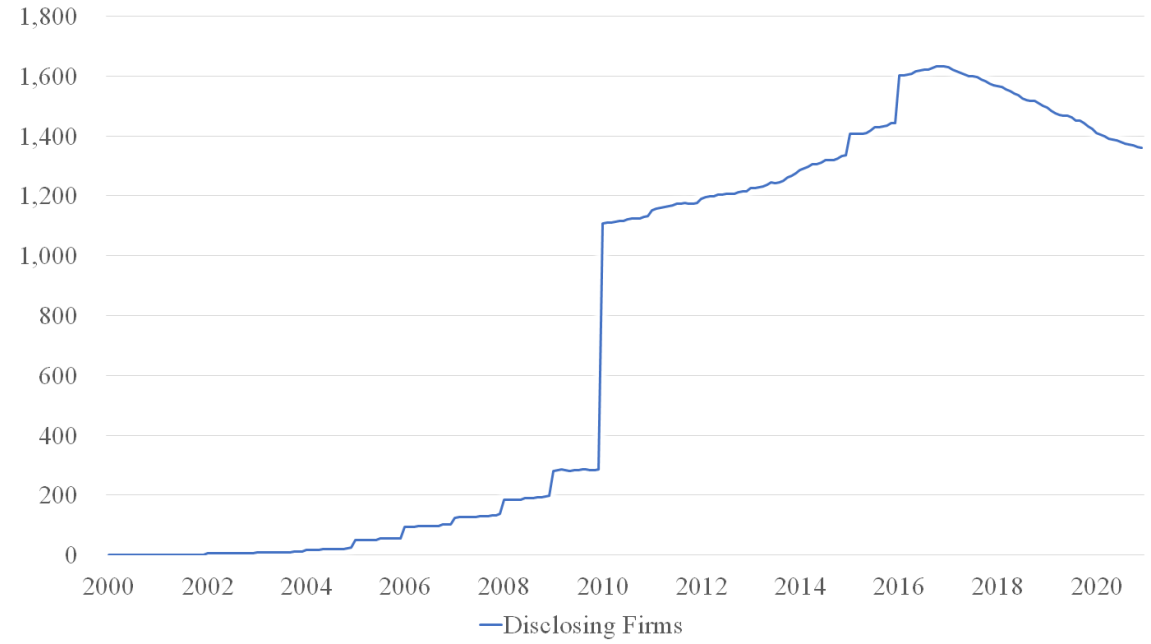
H. Yan, X. Li, Y. Huang, and Y. Li. The impact of the consistency of carbon performance and carbon information disclosure on enterprise value. *Finance Research Letters*, 37, 2020.

Figure 1: Carbon Disclosure over Time

Panel A. Percentage of Disclosing Firms

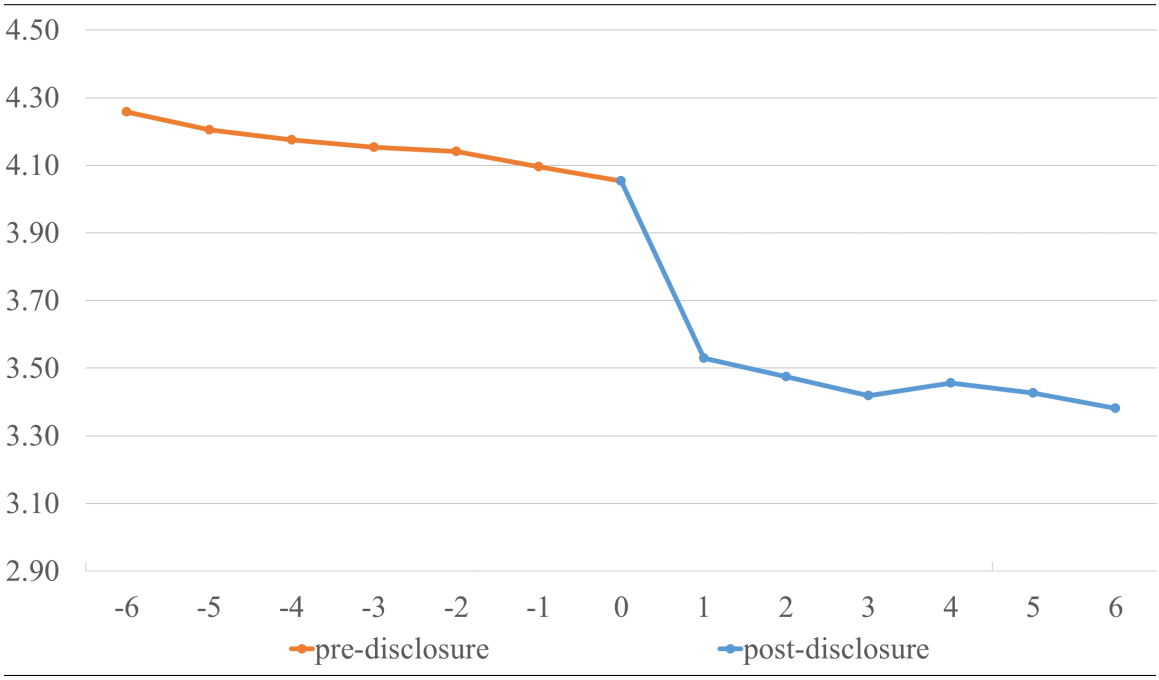


Panel B. Number of Disclosing Firms



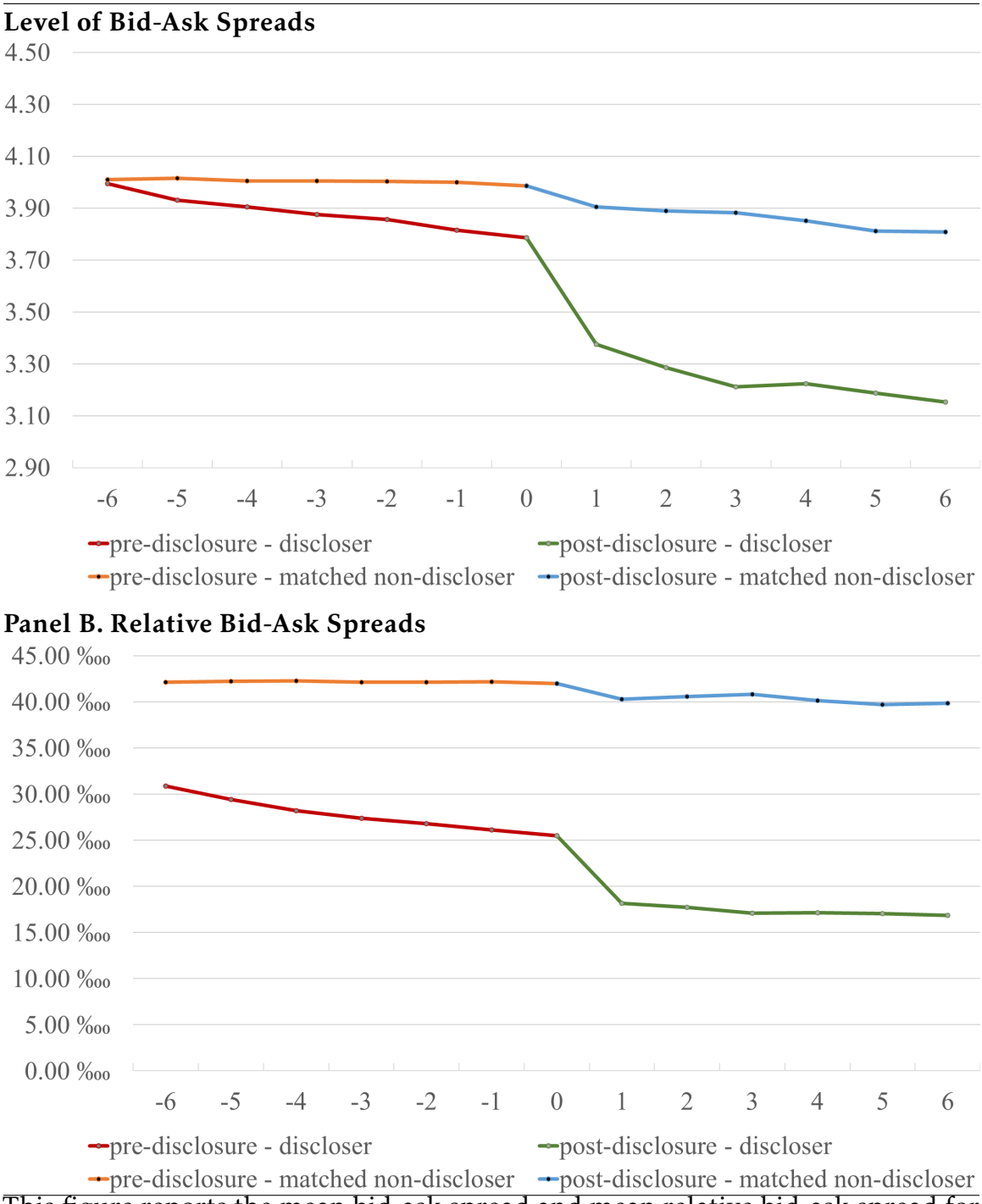
This figure reports the percentage (Panel A.) and number (Panel B.) of all carbon disclosing firms in our US sample for the period from January 2000 to December 2020. The introduction of the disclosed carbon emissions data into the databases of various data providers took first place in 2002. The decrease in disclosing firms in recent years is mainly due to the fact that the corresponding reporting has not yet been published. In addition, the authors are no longer able to access the Sustainalytics database for data from 2017 onwards.

Figure 2: Impact of Carbon Disclosure on Liquidity



This figure reports the mean bid-ask spread within a ±6-month timeframe around the carbon emissions disclosing date for the period from January 2003 to December 2020.

Figure 3: Development of Liquidity around Disclosure



This figure reports the mean bid-ask spread and mean relative bid-ask spread for the matched pair of disclosing and non-disclosing firms over a ±6-month time frame around the carbon emissions disclosing date for the period from January 2003 to December 2020. In order to identify a pair of firms, size, volume, industry, and time of observation are taken into account. We match a disclosing firm with the ten nearest neighbors.

Table 1: Descriptive Statistics

Variable	N	Mean	Median	SD
Panel A. Liquidity				
Bid-Ask Spread	962,948	9.22	3.53	14.65
Rel. Bid-Ask Spread	962,948	0.82	0.26	1.32
Log Bid-Ask Spread	962,948	1.47	1.26	1.16
Amihud Illiquidity	931,696	0.73	0.01	4.33
Log Volume	962,948	11.87	12.11	2.21
Panel B. Carbon				
Carbon Emissions	128,178	1.87	0.13	6.37
Carbon Intensity	127,676	0.31	0.05	0.84
	Yes	No		
Carbon Discloser	1,759	7,730		
Panel C. Characteristics				
Price	962,948	24.03	14.86	28.73
Log Total Assets	925,160	6.44	6.43	2.18
Log Market Capitalization	924,895	6.15	6.11	2.15
Book-to-Market Ratio	924,501	0.53	0.49	17.38
Leverage Ratio	921,060	0.8	0.38	2.16
Invest-to-Total Assets Ratio	900,342	0.1	0.05	0.21
Log PPE	908,258	4.03	3.97	2.67
Number of Employees	915,374	9.73	1.07	45.72
Log Sale	903,977	5.76	5.83	2.35
Log SGAE	791,086	4.45	4.33	1.84
Log R&D Expenditures	399,139	2.87	2.94	2.02
R&D Intensity	477,406	0.11	0.04	0.17
Capital Expenditures	900,482	198.03	10.49	1,066
Tangibility	918,298	0.2	0.11	0.23
Tobin's Q	886,909	1.92	1.36	1.52
Cash Flow	893,047	-0.02	0.05	0.26
EBIT	923,380	429.53	24.95	2,443
EBITDA	921,681	587.84	40.27	3,001
Log Cash	922,483	4.02	4.09	2.25
Return on Assets	924,667	-0.05	0.01	0.27
Return on Equity	924,254	-0.09	0.03	0.45

Table 1: This table reports the descriptive statistics for all financial and carbon-related variables in the US data sample grouped for the period from January 2000 to December 2020. Panel A. shows three different liquidity measures: The Bid-Ask Spread is given in US-Dollar and the relative Bid-Ask Spread in percentage points. The relative Bid-Ask Spread is defined as Bid-Ask Spread divided by price. Panel B. reports the Carbon Emissions (CO_2 equivalents emission) in tonnes, Carbon Intensity in tonnes per million US Dollar, and the number of Carbon Disclosing Firms. Carbon Intensity is defined as Carbon Emissions divided by Net Sales. Panel C. presents the firm characteristics. All variables that are logarithmized labeled accordingly (Log).

Table 2: Relation between Carbon Emissions and Liquidity

	Bid-Ask Spread	Bid-Ask Spread	Rel. Bid-Ask Spread	Rel. Bid-Ask Spread
Carbon Emissions	0.27***	0.54***	0.022***	0.018***
	(2.65)	(3.44)	(5.60)	(5.20)
1/Price	0.47	-0.70***	0.42	0.19
	(1.29)	(-6.15)	(1.54)	(1.10)
Log Volume	-1.90***	-0.05***	-0.027***	-0.045***
	(-8.44)	(-10.15)	(-3.51)	(-6.46)
Log Total Assets	1.10***	0.48***	-0.024**	-0.075***
	(5.53)	(5.00)	(-2.30)	(-6.46)
Book-to-Market Ratio	-0.026	-0.028	0.0013	0.0019
	(-0.33)	(-1.16)	(0.39)	(0.54)
Leverage Ratio	-0.11**	-0.047	0.0018	0.0018
	(-1.99)	(-1.55)	(1.13)	(1.46)
Invest-to-TA Ratio	1.30*	0.46	-0.028	-0.030*
	(1.77)	(1.00)	(-1.45)	(-1.88)
Log PPE	-0.15**	-0.32***	-0.0039*	-0.0077
	(-1.97)	(-3.42)	(-1.68)	(-1.53)
Constant	0.20***	0.094***	0.0065***	0.014***
	(9.76)	(9.30)	(9.83)	(9.12)
Firm fixed effects	No	Yes	No	Yes
Adjusted R^2	0.16	0.76	0.26	0.61
N	127,030	127,025	127,544	127,539

Table 2: This table shows results of panel regressions for the relation between carbon emissions and liquidity. The dependent variable is in the first two columns the Bid-Ask Spread and in the last two columns the relative Bid-Ask Spread. The main explanatory variable is Carbon Emissions (mio. tonnes). Control variables are: Price, Volume, Total Assets, Book-To-Market Ratio, Leverage Ratio, Invest-to-Total Assets Ratio, and Property, Plant, and Equipment. Firm-fixed effects are added at the second and the fourth column. Standard errors are clustered by firms. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 3: Carbon and Non-Carbon Discloser

Variable	Non-Disclosing	Disclosing	Difference
Bid-Ask Spread	10.22	2.68	7.55***
Rel. Bid-Ask Spread	0.94	0.10	0.84***
1/Price	0.21	0.05	0.16***
Log Volume	11.60	13.54	-1.94***
Log Total Assets	6.18	8.00	-1.82***
Log Mcap	5.82	8.17	-2.34***
Book-to-Market Ratio	0.52	0.40	0.12**
Leverage Ratio	0.80	0.82	-0.02***
Invest-to-TA Ratio	0.10	0.13	-0.04***
Log PPE	3.67	6.20	-2.53***
Employees	6.89	28.22	-21.33***
Log Sale	5.42	7.72	-2.30***
Log SGAE	4.16	6.13	-1.96***
Log R&D	2.58	4.41	-1.83***
R&D Intensity	0.12	0.06	0.06***
Capital Expenditures	130.05	615.93	-485.88***
Tangibility	0.19	0.27	-0.07***
Tobin's Q	1.88	2.18	-0.30***
Cash Flow	-0.03	0.07	-0.11***
EBIT	308.13	1,205	-897.34***
EBITDA	413.13	1,699	-1,286***
Log Cash	3.78	5.48	-1.70***
Return on Assets	-0.07	0.03	-0.10***
Return on Equity	-0.11	0.02	-0.13***

Table 3: This table provides the results of mean comparison tests of carbon emission disclosing and non-disclosing firms for the period from January 2000 to December 2020. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 4: Carbon Disclosure Characteristics

	Disclosure	Disclosure	Disclosure	Disclosure
Log Mcap	0.36***	0.27***	0.59***	0.26***
	(345.64)	(152.97)	(133.25)	(27.24)
Book-to-Market Ratio	-0.069***	-0.056***	0.88***	-0.24***
	(-15.03)	(-12.30)	(24.36)	(-18.10)
Leverage Ratio	-0.015***	-0.041***	0.023***	-0.0083***
	(-16.60)	(-37.41)	(16.48)	(-3.35)
EBITDA	-0.033***	-0.035***	-0.029***	-0.028***
	(-58.68)	(-56.48)	(-46.72)	(-36.51)
Invest-to-TA Ratio		0.36***	0.0015	0.095***
		(32.76)	(0.10)	(3.73)
Log PPE		0.013***	0.14***	0.027***
		(8.39)	(35.13)	(4.58)
Log Sale		0.091***	0.13***	0.13***
		(43.41)	(46.58)	(22.70)
Employees			-0.081**	-0.049
			(-2.32)	(-1.26)
Tangible			-0.25***	-0.31***
			(-12.41)	(-9.08)
Tobin's Q			-0.15***	-0.061***
			(-54.99)	(-16.58)
Log Cash			0.016***	0.036***
			(9.87)	(13.73)
Log Total Assets			-0.52***	-0.076***
			(-123.82)	(-6.50)
R&D Intensity				-0.25***
				(-5.65)
Log SGAE				0.28
				(0.06)
Constant	-3.57***	-3.58***	-2.79***	-3.03***
	(-475.66)	(-416.04)	(-194.02)	(-112.26)
Log Pseudolikelihood	-299,739	-289,787	-268,055	-147,335
N	934,801	877,676	830,581	396,302

Table 4: This table shows results of probit regressions for the decision to disclose carbon emissions data for the period from January 2000 to December 2020. Used determinants of disclosure are Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, PPE, Sale, Employees, Tangible, Tobin's Q, Cash, Total Assets, R&D Intensity, and SGAE. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 5: Impact of Carbon Disclosure on Liquidity using Heckman

	Disclosure	Bid-Ask Spread	Bid-Ask Spread
Carbon Emissions		0.47**	0.50*
		(2.07)	(1.69)
1/Price		-0.072	-0.073
		(-1.38)	(-1.34)
Log Volume		-0.75	-0.69
		(-0.33)	(-0.29)
Log Mcap	0.093***		-0.0021
	(7.93)		(-0.21)
Book-to-Market Ratio	-0.062***		0.00029
	(-2.59)		(0.03)
Leverage Ratio	0.41		0.11
	(0.59)		(0.84)
Invest-to-TA Ratio	-0.20**		-0.0022
	(-2.53)		(-0.10)
Log PPE	-0.34		-0.058
	(-0.40)		(-0.11)
EBITDA	-0.012**		
	(-2.52)		
Log Sale	-0.025**		
	(-2.40)		
Inverse Mills Ratio		-0.045	-0.081
		(-0.44)	(-0.46)
Constant	-0.30***	0.078	0.12
	(-4.58)	(0.93)	(0.75)
Firm fixed effects	No	Yes	Yes
Log (pseudo)likelihood	-10,426	3,048	3,270
N	15,261	15,261	15,195
Uncensored N		8,383	8,383

Table 5: This table shows results of two-stage Heckman regressions for the bid-ask spread and carbon emissions within a ± 6-month window around the carbon disclosure date for the period from January 2003 to December 2020. In the first columns, we estimate a probit regression for the decision to disclose carbon emissions as the first stage using the following firm characteristics: Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, PPE, EBITDA, and Sales. Then, we calculate the inverse Mills ratio. In the last two columns, we estimate a panel regression model as the second stage using additional firm characteristics: Price and Volume as well as firm-fixed effects and the calculated inverse Mills ratio. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 6: Impact of Carbon Disclosure on Liquidity

	Bid-Ask Spread	Bid-Ask Spread	Rel. Bid-Ask Spread	Rel. Bid-Ask Spread
Carbon Discloser	-0.49***	-0.50***	-0.033***	-0.022***
	(-8.74)	(-8.51)	(-6.92)	(-4.61)
1/Price	0.079	-2.50	0.12	0.68***
	(0.08)	(-0.95)	(0.42)	(4.98)
Log Volume	-0.34***	-0.24*	-0.075***	-0.024***
	(-3.07)	(-1.66)	(-2.04)	(-2.76)
Log Mcap		0.20		-0.033*
		(1.11)		(-1.68)
Book-to-Market Ratio		-0.063		-0.0017
		(-0.57)		(-0.05)
Leverage Ratio		-0.029		-0.006
		(-0.91)		(-1.04)
Invest-to-TA Ratio		0.62		0.046
		(1.44)		(0.96)
Log PPE		-0.38		-0.025
		(-1.38)		(-1.46)
Constant	8.10***	7.60***	0.0048***	0.0085***
	(5.61)	(2.95)	(3.50)	(4.28)
Firm fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.86	0.86	0.78	0.82
N	15,530	15,301	15,666	15,437

Table 6: This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. We estimate a regression with firm fixed effects and explain the (relative) bid-ask spread by the characteristic of being a carbon discloser and the control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. Firm-fixed effects are additional applied. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 7: Carbon Disclosure and Alternative Liquidity Measures

	Log Spread	Log Volume	Amihud
Carbon Discloser	-0.12***	0.068***	-0.0063**
	(-15.77)	(7.13)	(-2.19)
1/Price	-0.63***	0.11	0.26*
	(-4.10)	(1.43)	(1.78)
Log Volume	-0.046***		-0.032***
	(-4.09)		(-4.72)
Log Market Capitalization	0.034	0.10***	0.0057
	(1.59)	(2.80)	(0.77)
Book-to-Market Ratio	-0.0057	0.053	0.0080
	(-0.25)	(1.26)	(1.15)
Leverage Ratio	0.00046	-0.013*	-0.0028
	(0.08)	(-1.81)	(-0.77)
Invest-to-TA Ratio	0.026	0.19**	0.040
	(0.41)	(2.01)	(0.84)
Log PPE	-0.039	0.081*	0.0013
	(-1.26)	(1.68)	(0.06)
Constant	-3.06***	11.90***	0.38***
	(-12.46)	(39.88)	(2.84)
Firm fixed effects	Yes	Yes	Yes
Adjusted R^2	0.87	0.96	0.74
N	15,289	15,424	14,823

Table 7: This table shows results of panel regressions for various liquidity measures and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In each column we estimate a regression with firm fixed effects and explain the liquidity measure by the characteristic of being a carbon discloser. In the first column, we explain logarithmized Bid-Ask Spread; in the second logarithmized volume; and in the third the Amihud Illiquidity Measure. The control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 8: Paired Carbon and Nearest 10 Non-Carbon Disclosers

Variable	Non-Disclosing	Disclosing	Difference
Bid-Ask Spread - Pre	3.83	3.57	0.26***
Bid-Ask Spread - Post	3.69	3.19	0.50***
Post-Pre	0.14***	0.38***	
Relative Bid-Ask Spread - Pre	40.34	20.46	19.88**
Relative Bid-Ask Spread - Post	37.99	17.06	20.93***
Post-Pre	-2.35***	-3.40***	

Table 8: This table provides the results of a paired comparison tests of carbon and non-carbon discloser with regard to liquidity for the period from January 2003 to December 2020. The years prior to 2003 were excluded because here the publication of the carbon emissions data is due in particular to the provision of the databases and not necessarily to the disclosure by the company. In order to identify a pair of firms, size, volume, industry, and time of observation are taken into account. We match a disclosing firm with the ten nearest neighbors. The test was carried over a ± 6-month window around the disclosing date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 9: Carbon Disclosure, Liquidity, and Absolute Event Returns

	Bid-Ask Spread Neg. Ret.	Bid-Ask Spread Pos. Ret.	Bid-Ask Spread Low $\lvert Ret. \rvert$	Bid-Ask Spread High $\lvert Ret. \rvert$
Carbon Discloser	-0.57***	-0.40***	-0.42***	-0.59***
	(-7.57)	(-3.85)	(-5.03)	(-6.62)
1/Price	-2.90***	1.30	-2.60**	-0.82
	(-3.80)	(0.26)	(-2.42)	(-0.28)
Log Volume	-0.22*	-0.46***	-0.29***	-0.39**
	(-1.93)	(-2.89)	(-3.29)	(-2.37)
Log Market Capitalization	0.080	0.39	0.40	0.10
	(0.44)	(1.20)	(0.93)	(0.56)
Book-to-Market Ratio	-0.15	0.0021	-0.039	-0.015
	(-0.54)	(0.02)	(-0.12)	(-0.11)
Leverage Ratio	-0.027	-0.042	0.031	-0.063
	(-0.63)	(-0.82)	(0.71)	(-1.53)
Invest-to-TA Ratio	0.56	0.83	0.35	0.82
	(1.06)	(1.10)	(0.45)	(1.56)
Log PPE	-0.41	-0.31	-0.16	-0.48
	(-1.13)	(-0.88)	(-0.55)	(-1.13)
Constant	8.30***	8.40**	5.30	11.01***
	(3.65)	(1.97)	(1.39)	(3.26)
Firm fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.87	0.86	0.88	0.85
N	7,607	7,676	7,643	7,640

Table 9: This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In the first two columns, we estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser and the control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. In addition, we now classify the firms according to their event returns around the disclosure date in below (Column 1) or above (Column 2) the median, respectively their absolute event returns below (Column 3) or above (Column 4) above the median and separately consider the impact of disclosing on the bid ask spread. The event returns are calculated over a ± 30-day window. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 10: Carbon Intensity, Early Disclosers and Liquidity

	Bid-Ask Spread Low	Bid-Ask Spread High	Bid-Ask Spread Early	Bid-Ask Spread Late
Carbon Discloser	-0.44***	-0.53***	-0.36**	-0.67***
	(-4.96)	(-4.79)	(-2.33)	(-4.40)
1/Price	6.90	-7.30**	-20.00**	-5.90*
	(1.25)	(-2.22)	(-2.41)	(-1.88)
Log Volume	-0.20	-0.14	0.45	-0.59
	(-1.44)	(-0.38)	(1.51)	(-1.29)
Log Market Capitalization	0.48	0.012	-0.006	-0.48
	(1.23)	(0.06)	(-0.01)	(-1.43)
Book-to-Market Ratio	-0.19	0.060	-1.50*	0.26
	(-0.46)	(0.40)	(-1.72)	(0.99)
Leverage Ratio	-0.061	0.019	0.095	0.016
	(-0.75)	(0.48)	(0.76)	(0.18)
Invest-to-TA Ratio	1.40	-0.036	0.26	-0.0074
	(1.17)	(-0.08)	(0.16)	(-0.01)
Log PPE	0.017	-0.94*	1.20	-0.74
	(0.10)	(-1.76)	(0.94)	(-1.38)
Constant	1.80	11.00**	-11.00	18.00***
	(0.51)	(2.12)	(-0.98)	(2.76)
Firm fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.91	0.81	0.86	0.85
N	8,216	5,428	1,725	3,289

Table 10: This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In the first two columns, we estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser with low or high carbon intensity. A low (high) carbon intensity firm has a lower (higher) carbon intensity then their industry median. In the last two columns, we provide deeper insights into the relationship between disclosing and liquidity by using the time of disclosing. Early (late) discloser are firms, that disclose their carbon emissions as one of the 10% first (50% latest) discloser within their industry. The control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 11: Carbon Estimation Error and Liquidity

Panel A. Carbon Emissions				
	Bid-Ask Spread Over Est.	Bid-Ask Spread Under Est.	Bid-Ask Spread Low |Diff.|	Bid-Ask Spread High |Diff.|
Carbon Discloser	-0.50***	-0.43***	-0.44***	-0.64***
	(-6.19)	(-4.10)	(-6.01)	(-3.87)
1/Price	-2.28	-4.76***	0.068	-12.9
	(-0.79)	(-2.69)	(0.01)	(-1.31)
Log Volume	-0.25	-0.2	-0.42***	0.61
	(-1.33)	(-0.82)	(-2.84)	(0.77)
Log Market Capitalization	0.058	0.43*	0.34	-0.69
	(0.25)	(1.70)	(1.35)	(-1.60)
Book-to-Market Ratio	-0.32	0.24	0.12	-0.29
	(-1.62)	(1.46)	(0.70)	(-0.73)
Leverage Ratio	-0.065	0.035	0.022	0.28*
	(-1.58)	(0.85)	(0.48)	(1.94)
Invest-to-TA Ratio	1.20**	-0.23	-0.23	-1.13
	(-2.00)	(-0.49)	(-0.45)	(-0.82)
Log PPE	-0.16	-1.55	-1.22**	0.02
	(-0.68)	(-1.60)	(-2.21)	-0.06
Constant	7.54**	13.0**	13.0***	2.34
	(2.45)	(2.29)	(3.61)	(0.28)
Firm fixed effects	Yes	Yes	Yes	Yes
adj. R2	0.84	0.90	0.91	0.86
N	11,118	3,359	9,618	2,014

Table 11: Carbon Estimation Error and Liquidity (continued)

Panel B. Carbon Intensity

	Bid-Ask Spread Over Est.	Bid-Ask Spread Under Est.	Bid-Ask Spread Low |Diff|	Bid-Ask Spread High | Diff|
Carbon Discloser	-0.55***	-0.52***	-0.42***	-0.81***
	(-6.11)	(-5.33)	(-4.59)	(-6.37)
1/Price	-2.25	-1.24**	-8.81*	-2.80***
	(-0.29)	(-2.17)	(-1.86)	(-3.07)
Log Volume	0.18	-0.80***	-0.11	-0.57**
	(0.89)	(-2.96)	(-0.45)	(-2.34)
Log MCap	0.57	-0.12	-0.098	-0.072
	(1.49)	(-0.56)	(-0.46)	(-0.30)
Book-to-Market Ratio	0.11	-0.046	-0.19	-0.11
	(0.33)	(-0.41)	(-1.01)	(-0.74)
Leverage Ratio	-0.06	0.012	0.015	-0.017
	(-1.00)	(0.23)	(0.39)	(-0.23)
Invest-to-TA Ratio	0.97	0.1	0.021	0.48
	(1.08)	(0.18)	(0.05)	(0.50)
Log PPE	-0.90*	-0.13	-0.19	-0.49
	(-1.81)	(-0.26)	(-0.54)	(-0.97)
Constant	1.85	15.9***	7.45**	14.6***
	(0.48)	(2.96)	(2.09)	(3.15)
Firm fixed effects	Yes	Yes	Yes	Yes
adj. R2	0.87	0.85	0.9	0.84
N	9,438	3,779	9,191	3,461

Table 11: This table shows results of panel regressions for the bid-ask spread and carbon emissions and carbon intensity estimates within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In the first two columns of Panel A., we estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser with an over- or underestimation of their carbon emissions. The overestimation (underestimation) is derived from the difference between the disclosed and the estimated carbon emissions. Estimated carbon emissions are calculated per month as the respective industry average. In the last two columns, we provide deeper insights into the relationship between disclosing and liquidity by using the carbon emissions estimation difference. For this purpose, we calculate the absolute difference of the estimate of carbon emissions from the disclosed data. The control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 12: Impact of Carbon Disclosure on Liquidity in the United Kingdom

	Bid-Ask Spread	Bid-Ask Spread
Carbon Discloser	-0.37***	-0.40***
	(-5.40)	(-4.99)
1/Price	-0.19**	-0.16*
	(-2.34)	(-1.96)
Log Volume	-0.29***	-0.27***
	(-5.01)	(-3.77)
Log Market Capitalization		0.27
		(1.60)
Book-to-Market Ratio		0.56
		(0.85)
Leverage Ratio		-0.030
		(-0.55)
Invest-to-TA Ratio		0.41
		(0.76)
Log PPE		-0.65
		(-0.75)
Constant	5.30***	2.80
	(12.88)	(0.52)
Firm fixed effects	Yes	Yes
Adjusted R^2	0.90	0.89
N	3,987	2,990

Table 12: This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020 in the United Kingdom sample. We estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser and the control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. Firm-fixed effects are additional applied. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Appendix

Table A1: Impact of Carbon Disclosure on Liquidity in the United Kingdom

	Bid-Ask Spread	Bid-Ask Spread
Carbon Discloser	-0.56***	-0.59***
	(-4.88)	(-5.42)
1/Price	-3.50***	-3.90***
	(-3.83)	(-4.84)
Log Volume	0.48***	0.46***
	(2.64)	(2.61)
Log Market Capitalization		-0.18
		(-0.57)
Book-to-Market Ratio		-0.84*
		(-1.87)
Leverage Ratio		-0.19
		(-1.49)
Invest-to-TA Ratio		3.00*
		(1.96)
Log PPE		0.66
		(1.25)
Constant	-2.90	-5.70
	(-1.12)	(-1.34)
Firm fixed effects	Yes	Yes
Adjusted R^2	0.80	0.80
N	4,499	4,433

This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020 without using data from Sustainalytics. We estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser and the control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. Firm-fixed effects are additional applied. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table A2: Impact of Carbon Disclosure on Liquidity in the United Kingdom using Heckman

	Carbon Disclosure	Bid-Ask Spread	Bid-Ask Spread
Carbon Emissions		0.031**	0.030**
		(2.00)	(2.17)
1/Price		-0.0026**	-0.0025**
		(-2.42)	(-2.52)
Log Volume		-0.0025**	-0.0026**
		(-2.51)	(-2.55)
Log Market Capitalization	0.096***		0.0069
	(3.17)		(0.19)
Book-to-Market Ratio	-30747.5		18236.2
	(-0.88)		(1.10)
Leverage Ratio	-0.022		0.013
	(-1.29)		(1.48)
Invest-to-TA Ratio	0.41**		-0.075
	(2.47)		(-0.48)
Log PPE	-0.028		-0.019
	(-1.51)		(-1.29)
EBITDA	-0.000017*		
	(-1.67)		
Log Sale	-0.012		
	(-0.45)		
Inverse Mills Ratio		0.039	-0.21
		(0.41)	(-0.32)
Constant	-1.64***	-0.023	0.11
	(-3.10)	(-0.26)	(0.09)
Firm fixed effects	No	Yes	Yes
Log (pseudo)likelihood	-2,052.15	1,210.44	1,817.95
N	2,998	2,982	2,982
Uncensored N		1,629	1,629

This table shows results of two-stage Heckman regressions for the bid-ask spread and carbon emissions within a ± 6-month window around the carbon disclosure date for the period from January 2003 to December 2020. In the first columns, we estimate a probit regression for the decision to disclose carbon emissions as the first stage using the following firm characteristics: Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, PPE, EBITDA, and Sales. Then, we calculate the inverse Mills ratio. In the last two columns, we estimate a panel regression model as the second stage using additional firm characteristics: Price and Volume as well as firm-fixed effects and the calculated inverse Mills ratio. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table A3: Carbon Disclosure, Liquidity, and Absolute Event Returns

	Bid-Ask Spread	Bid-Ask Spread	Bid-Ask Spread	Bid-Ask Spread
Carbon Discloser	-0.50***	-0.44***	-0.42***	-0.59***
	(-6.59)	(-4.92)	(-5.03)	(-6.62)
1/Price	-2.20***	-0.29	-2.60**	-0.82
	(-3.13)	(-0.08)	(-2.42)	(-0.28)
Log Volume	-0.26**	-0.43***	-0.29***	-0.39**
	(-2.15)	(-2.78)	(-3.29)	(-2.37)
Log Market Capitalization	0.49	-0.039	0.40	0.10
	(1.44)	(-0.24)	(0.93)	(0.56)
Book-to-Market Ratio	0.070	-0.18	-0.039	-0.015
	(0.48)	(-0.88)	(-0.12)	(-0.11)
Leverage Ratio	-0.033	-0.069	0.031	-0.063
	(-0.51)	(-1.63)	(0.71)	(-1.53)
Invest-to-TA Ratio	0.73	1.10*	0.35	0.82
	(0.88)	(1.92)	(0.45)	(1.56)
Log PPE	-0.71	0.076	-0.16	-0.48
	(-1.54)	(0.27)	(-0.55)	(-1.13)
Constant	7.30**	9.10***	5.30	1.10***
	(1.97)	(2.85)	(1.39)	(3.26)
Firm fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.84	0.88	0.88	0.85
N	7,629	7,654	7,643	7,640

This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In the first two columns, we estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser and the control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. In addition, we now classify the firms according to their event returns around the disclosure date in below (Column 1) or above (Column 2) the median, respectively their absolute event returns below (Column 3) or above (Column 4) above the median and separately consider the impact of disclosing on the bid ask spread. The event returns are calculated over a ± 5-day window. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table A4: Impact of Carbon Disclosure on Liquidity across different databases

	Bid-Ask Spread Sustainalytics	Bid-Ask Spread CDP	Bid-Ask Spread Refinitiv
Carbon Discloser	-0.48***	-0.73***	-0.62***
	(-7.67)	(-6.64)	(-5.98)
1/Price	-5.20***	-1.60***	-9.60***
	(-2.79)	(-4.55)	(-4.24)
Log Volume	-0.36***	0.68***	0.44***
	(-3.74)	(3.71)	(3.18)
Log Market Capitalization	0.097	0.25	0.40
	(0.60)	(0.76)	(1.45)
Book-to-Market Ratio	-0.14	-1.10	-0.41
	(-1.24)	(-1.64)	(-1.40)
Leverage Ratio	-0.033	-0.23**	-0.22**
	(-1.01)	(-2.37)	(-2.28)
Invest-to-TA Ratio	0.60	3.20**	3.00**
	(1.35)	(2.33)	(2.55)
Log PPE	-0.48	1.20	0.79
	(-1.48)	(1.33)	(1.36)
Constant	10.00***	-16.00**	-11.00**
	(4.05)	(-2.42)	(-2.56)
Firm fixed effects	Yes	Yes	Yes
Adjusted R^2	0.85	0.69	0.71
N	14,044	4,041	4,909

This table shows results of panel regressions for the bid-ask spread and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In each column, only one database is used for the analysis: In the first column, Sustainalytics, in the second CDP, and in the third, Refinitiv. We estimate a regression with firm fixed effects and explain the bid-ask spread by the characteristic of being a carbon discloser and the control variable sets consisting of Price, Volume, Market Capitalization, Book-To-Market Ratio, Leverage Ratio, Invest-To-Total Assets Ratio, and PPE. Firm-fixed effects are additional applied. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table A5: Liquidity before and after Carbon Disclosure

Variable	Non-Disclosing	Disclosing	Difference
Bid-Ask Spread	0.04	0.03	0.01***
Rel. Bid-Ask Spread	0.21	0.17	0.04***
1/Price	0.08	0.08	0.00
Log Volume	13.15	13.26	-0.11***
Log Total Assets	7.29	7.41	-0.12***
Log Market Capitalization	7.30	7.52	-0.22***
Book-to-Market Ratio	0.49	0.45	0.04***
Leverage Ratio	0.72	0.64	0.08**
Invest-to-TA Ratio	0.12	0.11	0.01***
Log PPE	5.42	5.54	-0.12***
Employees	17.26	18.04	-0.78
Log Sale	7.04	7.14	-0.11***
Log SGAE	5.50	5.61	-0.11***
Log R&D	3.72	3.86	-0.14***
R&D Intensity	0.07	0.08	-0.01***
Capital Expenditures	312.35	339.90	-27.55
Tangibility	0.26	0.26	0.00
Tobin's Q	1.98	2.09	-0.11***
Cash Flow	0.04	0.06	-0.01***
EBIT	542.60	616.56	-73.96**
EBITDA	799.10	895.08	-95.97**
Log Cash	4.88	5.03	-0.15***
Return on Assets	0.00	0.02	-0.01***
Return on Equity	-0.01	0.01	-0.03***

This table provides the results of mean comparison tests of carbon emission disclosing and non-disclosing firms within a ± 6-month window for the period from January 2003 to December 2020. The years prior to 2003 were excluded because here the publication of the carbon emissions data is due in particular to the provision of the databases and not necessarily to the disclosure by the company. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table A6: Carbon Disclosure, Liquidity, and Firm Value

Panel A. CAPM and FF	Return	Return	Return	Return
Carbon Discloser	0.0035***	0.00089	-0.0026**	-0.00037
	(2.81)	(0.30)	(-2.07)	(-0.12)
Market	0.92***	0.93***	0.79***	0.78***
	(53.33)	(51.72)	(43.47)	(39.64)
Size			0.59***	0.60***
			(22.69)	(22.56)
Value			0.021	0.021
			(0.82)	(0.80)
Constant	-0.00084	0.00055	0.00077	-0.00048
(-0.85)	(0.33)	(0.79)	(-0.29)	
Firm fixed effects	No	Yes	No	Yes
Adjusted R^2	0.23	0.30	0.26	0.33
N	14,762	14,762	14,762	14,762
Panel B. CH4 and FF6	Return	Return	Return	Return
Carbon Discloser	-0.0025**	-0.00012	-0.0030**	0.00064
	(-2.01)	(-0.04)	(-2.26)	(0.21)
Market	0.79***	0.77***	0.81***	0.79***
	(44.40)	(38.92)	(44.76)	(39.66)
Size	0.56***	0.57***	0.55***	0.55***
	(21.03)	(20.62)	(20.81)	(20.34)
Value	0.066**	0.086***	-0.13***	-0.12***
	(2.45)	(2.93)	(-3.07)	(-2.79)
Momentum	0.081***	0.091***	0.081***	0.092***
	(5.14)	(5.03)	(4.98)	(4.87)
Investment			-0.039	-0.071
			(-0.82)	(-1.29)
Profitability			0.29***	0.32***
			(3.76)	(3.75)
Constant	0.0010	-0.00023	0.00083	-0.0010
	(1.06)	(-0.14)	(0.76)	(-0.60)
Firm fixed effects	No	Yes	No	Yes
Adjusted R^2	0.26	0.33	0.26	0.33
N	14,762	14,762	14,762	14,762

This table shows results of panel regressions for the monthly returns and carbon disclosers within a ± 6-month window around the disclosure date for the period from January 2003 to December 2020. In the first two columns of Panel A., we estimate a regression explaining monthly returns by the characteristic of being a carbon discloser and the market factor (CAPM). In the last two columns of Panel A., we estimate the same regression adding a size and a value factor (FF3). In Panel B., we continue with the inclusion of the momentum factor (CH4), followed by adding an investment and an operating profitability factor (FF6). All factors are provided by Kenneth French. *, **, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.